Unit-III

Wave optics

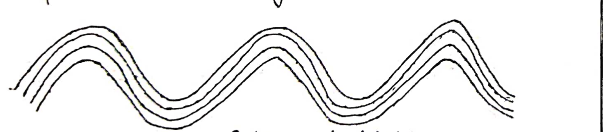
Interference :→ Interference is the superposition of two or more waves of light. Interference is based on principle of superposition of waves. There are two types of interference.

(i) Constructive interference.
(ii) Destructive interference.

⇒ Due to superposition of two or more waves, intensity is maximum at some points. Interference at these points called Constructive interference.

⇒ Due to superposition of two or more waves, intensity is minimum at some points. Interference at these points called Destructive interference.

Coherent source :→ Two sources of light are said to be coherent if they emit light which have always a constant phase difference between them. It means that two sources must emit radiation of same wavelength.



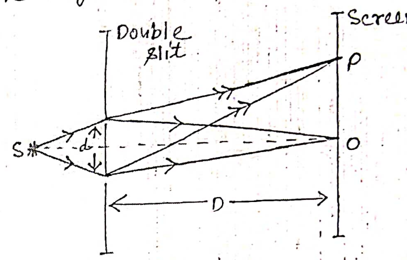
Coherent light

Question :→ Write main condition for sustained interference. (2015-16) Imp

Answer :→ Condition of sustained interference :→

(i) The two interferring waves should be coherent.
(ii) Light source should be monochromatic.

(iii) Two coherent source must be narrow.
(iv) The separation between the coherent sources should be as small as possible.
(v) The distance of screen from two sources should be quite large.



Question :→ What happens when young double slit experiment immersed in water. (2015-16)

Answer :→ If the young double slit experiment immersed in water, fringe width will be narrower.

fringe width $\beta = \frac{D\lambda}{d}$

where
$d \rightarrow$ slit seperation
$\lambda \rightarrow$ wavelength of light.
$D \rightarrow$ distance between slit & screen.

Refractive index $\mu = \frac{c}{v}$

$v = f\lambda \Rightarrow \lambda = \frac{v}{f} = \frac{c}{\mu f}$

where $f \rightarrow$ frequency

$\mu_{water} > \mu_{Air}$

→ The wavelength of light is less in water than in air.

$\lambda_{water} < \lambda_{air}$

V. Imp

Question :→ Two independent sources cannot produces interference. why? (2015-16, 2018-19, 2020-2021)

Answer :→ Two independent sources cannot produce interference because they are not coherent

* The phase difference between the two waves will not be constant. The wavelength and frequency of the waves also will be different.

Snell's law :→ Snell's law gives relation between angle of refraction and angle of incidence. Snell's law defined as the "ratio of sine of angle of incidence to the sine of angle of refraction is constant."

$$\boxed{\frac{\sin i}{\sin r} = \mu = \text{Constant}}$$

Where -
$i \rightarrow$ Angle of incidence
$r \rightarrow$ Angle of refraction.

* Phase difference can not remain constant because light is emitted due to millions of atoms and their number goes on changing in a quite random manner.

Types of Interference (Formation of coherent sources)

Based on the formation of two coherent sources, interference are two types.
(i) Division of wavefront
(ii) Division of amplitude

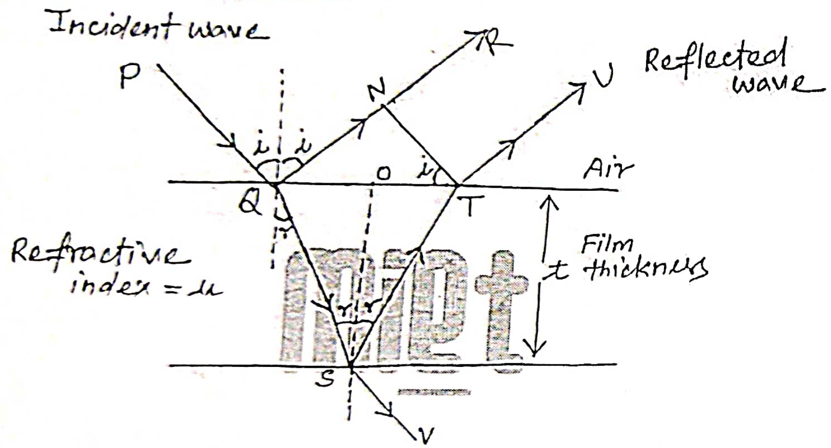
(i) Division of wavefront :→
Coherence sources are obtained by dividing the wavefront, originating from a common sources by employing mirror, biprism or lenses.

(ii) Division of Amplitude :→
In this method, amplitude of the incident beam is divided into two or more parts either by partial reflection or refraction.

Thin film :-> A thin film is a layer of material ranging from one nanometer (1 nm) to 100 nm in thickness. Film thickness is constant in whole film from one end to other end.

Question :-> Discuss the phenomenon of interference in thin film due to reflected light. (2015-16)

Answer :-> Interference due to reflected light in thin film :-> Imp



Consider a film of thickness 't' and refractive index μ (>1). PQ be incident wave on the upper surface of thin film. PQ ray is partly reflected along QR and refracted along QS. At point S, ST again reflected and SV refracted. This process is continue through-out the film.

The optical path difference,

$$\Delta = \text{Path } (QS+ST) \text{ in medium} - \text{Path } QN \text{ in air}$$

$$\Delta = \mu(QS+ST) - QN \quad \text{—— (1)}$$

In right angle ΔQSO, $\cos r = \frac{SO}{QS}$ or $QS = \frac{t}{\cos r}$ —(2)

Similarly in right ΔSOT,
$\cos r = \frac{SO}{ST}$ or $ST = \frac{SO}{\cos r} = \frac{t}{\cos r}$ —(3)

In right angle ΔQTN,

$$\sin i = \frac{QN}{QT}$$

$$QN = QT \sin i$$

$$QN = (QO+OT)\sin i \quad \text{—— (4)}$$

Putting the value of eq^n (2), (3) & (4) into eq^n (1)

$$\Delta = \mu\left(\frac{t}{\cos r} + \frac{t}{\cos r}\right) - (QO+OT)\sin i$$

$$\Delta = \frac{2\mu t}{\cos r} - (QO+OT)\sin i \quad \text{—— (5)}$$

Now again ΔQSO & ΔSOT,

$\tan r = \frac{QO}{OS}$ $\qquad$ $\tan r = \frac{OT}{OS}$

$QO = OS\tan r$ —(6) $\qquad$ $OT = OS\tan r$ —(7)

Putting these values (eq^n (6) & eq^n (7)) in eq^n (5)

$$\Delta = \frac{2\mu t}{\cos r} - (OS\tan r + OS\tan r)\sin i$$

$$\Delta = \frac{2\mu t}{\cos r} - 2(OS\tan r)\sin i$$

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

$$\Delta = \frac{2\mu t}{\cos r} - 2t(\tan r)\sin i \quad \text{—(8)} \quad (\because OS = t)$$

From Snell's law

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

$$\sin i = \mu \sin r$$

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

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

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

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

According to stoke's law, when light is reflected from surface of optically denser medium, a phase change π, path difference $\lambda/2$.

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

Condition for maxima :→

Path difference, $\Delta = 2n\lambda/2$

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

$$\boxed{2\mu t \cos r = (2n-1)\lambda/2} \; ; n = 1, 2, \ldots$$

Condition for minima :→

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

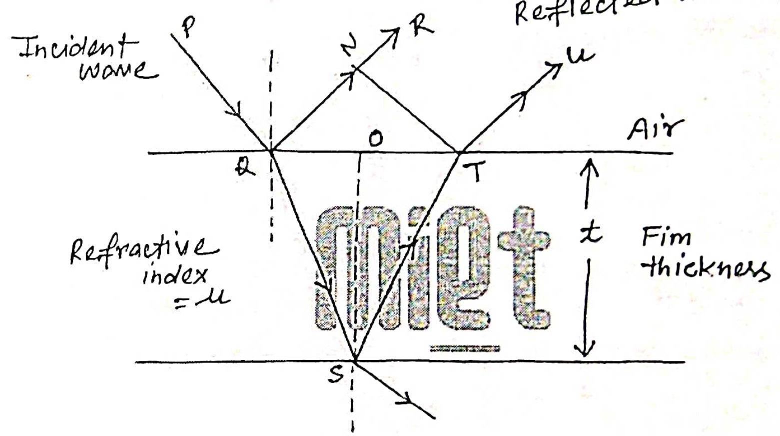
$$2\mu t \cos r + \lambda/2 = (2n+1)\lambda/2$$

$$\boxed{2\mu t \cos r = n\lambda} \; ; n = 0, 1, 2, 3 \ldots$$

Question :→ Discuss the phenomenon of interference of light due to thin films and find the conditions of maxima and minima. Show that reflected and transmitted system are complementary in thin films. (2018-19).

Answer :→ Interference of light due to thin film :→

(i) Interference due to reflected light :→



(Solution discussed in previous question)

Path difference

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

Condition for maxima :→

Path difference $\Delta = 2n\lambda/2$

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

$$\boxed{2\mu t \cos r = (2n-1)\lambda/2} \; ; n = 1, 2, 3 \ldots$$

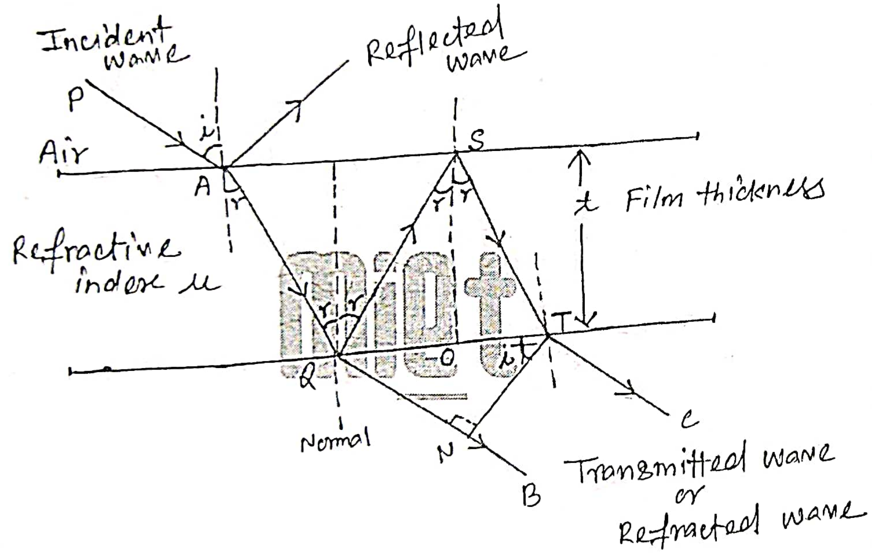
Condition for minima :→

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

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

$$\boxed{2\mu t\cos r = n\lambda} \quad ; n = 0,1,2,3\ldots$$

Interference due to transmitted light in thin film :→



Consider a transparent film of thickness t and refractive index μ. PA ray is refracted along AQ at angle r. AQ ray partly reflected along QS and refracted along QB. Again QS reflected in ST direction and finally TC ray out.

The optical path difference,

$$\Delta = \mu(QS+ST) - QN \quad — (1)$$

In right angled ΔQSO,

$$\cos r = SO/QS \quad \text{or} \quad QS = \frac{t}{\cos r} \quad — (2)$$

In right angle $\cos r = \frac{SO}{ST}$

$$ST = \frac{t}{\cos r} \quad — (3)$$

Putting value of eqn (2) & (3) into equation (1)

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

$$\Delta = \frac{2\mu t}{\cos r} - QN \quad — (4)$$

From right angle ΔQTN,

$$\sin i = \frac{QN}{QT} \quad \text{or} \quad QN = QT\sin i$$

$$QN = (QO+OT)\sin i \quad — (5)$$

Putting the value of eqn (5) in equation (4),

$$\Delta = \frac{2\mu t}{\cos r} - (QO+OT)\sin i \quad — (6)$$

Now again triangle QSO & Δ SOT,

$$\tan r = \frac{QO}{OS} \qquad \tan r = \frac{OT}{OS}$$

$$QO = OS\tan r \qquad OT = OS\tan r$$

Putting these value in eqn (6),

Path difference

$$\Delta = \frac{2\mu t}{\cos r} - (OS\tan r + OS\tan r)\sin i$$

$$\Delta = \frac{2\mu t}{\cos r} - 2(OS\tan r)\sin i \quad — (7)$$

According to Snell's law,

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

$$\sin i = \mu \sin r$$

Putting these value in eqn (7)

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

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

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

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

Condition for Maxima :→

$$\Delta = 2n\lambda/2$$

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

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

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

Where, $\mu \rightarrow$ refractive index
$t \rightarrow$ Film thickness
$\lambda \rightarrow$ wavelength of light.

Condition for Minima :→

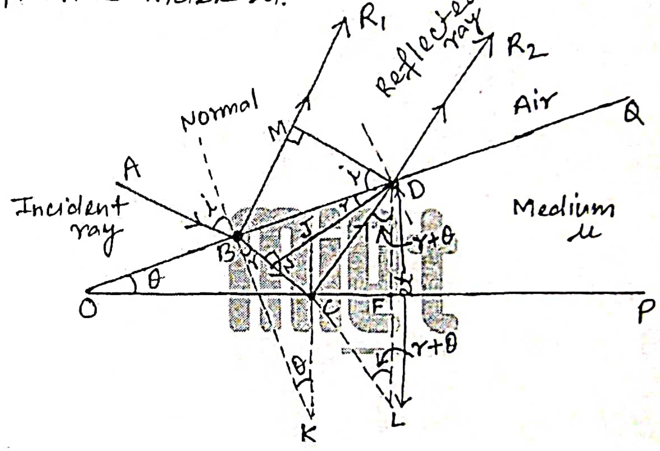
$$\Delta = (2n+1)\lambda/2$$

$$\boxed{2\mu t \cos r = (2n+1)\lambda/2} \quad ; \; n = 0, 1, 2, 3 \ldots$$

Therefore, the point of film which appears bright in reflected light, appear dark in transmitted light. So we can say that the interference pattern of reflected and transmitted monochromatic light are complementary to each other.

Question :→ Discuss the formation of interference fringes due to wedge shaped film seen by normally reflected monochromatic light and derive an expression for fringe width in wedge shaped films. (2015-16, 2017-18) Imp

Answer :→ The thickness of film increases from one end to another end, called wedge shaped film. consider a non-uniform thickness of film of refractive index μ.



The thickness of film gradually increases from O to P. The angle θ between the surfaces OP and OQ is known as angle of wedge.

The optical path difference between the two reflected rays R_1 & R_2 will be,

$$\Delta = \mu(BC + CD) \text{ in film} - BM \text{ in air}$$

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

In ΔBMD and ΔBND,

$$\sin i = \frac{BM}{BD}, \quad \sin r = \frac{BN}{BD} \quad \text{——— (2)}$$

According to Snell's law,

$$\mu = \frac{\sin i}{\sin r} = \frac{BM/BD}{BN/BD}$$

$$\mu = \frac{BM}{BN}$$

$$BM = \mu BN \quad \text{—— (3)}$$

Putting the value of eqn (3) in eqn (1)

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

$$\Delta = \cancel{\mu BN} + \mu NC + \mu CD - \cancel{\mu BN}$$

$$\Delta = \mu(NC + CD) \quad \text{—— (4)}$$

Now draw perpendicular DF from D on OP and produce BC. They meet at L.

ΔCDF & ΔCFL are congruent.

$\angle CDF = \angle CLF = r+\theta$

$\angle DFC = \angle CFL = 90$, CF is common,

$DF = FL = t$

$CD = CL$

Substituting value of CD in eqn (4)

$$\Delta = \mu(NC + CL)$$

$$\Delta = \mu NL \quad \text{—— (5)}$$

The angle of incidence BCJ at C is $(r+\theta)$ because angle enclosed between normal to surface at B & C must be θ.

CJ and DL are normal to surface OP, therefore CJ || DL and CL cut these two parallel lines.

So, $\angle BCJ = \angle CLD = (r+\theta)$

In triangle NDL, $\cos(r+\theta) = \frac{NL}{2t}$

$$\therefore \quad NL = 2t\cos(r+\theta) \quad \text{—— (6)}$$

Substituting value of NL from eqn (6) in eqn (5)

Path difference

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

Applying stoke law, Effective path difference,

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

Condition for maxima :→

$$\Delta = 2n\lambda/2$$

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

$$\boxed{2\mu t\cos(r+\theta) = (2n-1)\lambda/2} \quad ; n = 1,2,3\cdots$$

Condition for minima :→

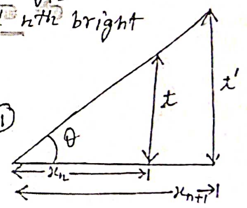
$$\Delta = (2n+1)\lambda/2$$

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

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

Fringe width :→ For bright fringes –

Consider x_n is distance of n^{th} bright from the edge of film,



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

$$x_n \tan\theta = t \quad \text{—— (1)}$$

Putting eqn (1) in condn of maxima of wedge shape film

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

Similarly for $(n+1)^{th}$ bright fringe

$$\tan\theta = \frac{t'}{x_{n+1}}$$

$$t' = x_{n+1}\tan\theta \quad \text{—— (3)}$$

Putting these value in condn of maxima of wedge film

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

Subtracting eqn (2) from eqn (4)

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

$$W = \frac{\lambda}{2\mu \tan\theta \cos\theta}$$

For normal incidence
$i = r = 0$
$\cos(r+\theta) = \cos\theta$

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

For very small value of θ, $\sin\theta = \theta$

$$\therefore \boxed{W = \frac{\lambda}{2\mu\theta}}$$

For air-film $\mu = 1$

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

Question :-> Explain the factor responsible for changing fringe width in wedge shaped thin film. (2016-17)

Answer :-> Fringe width in wedge shaped thin film,

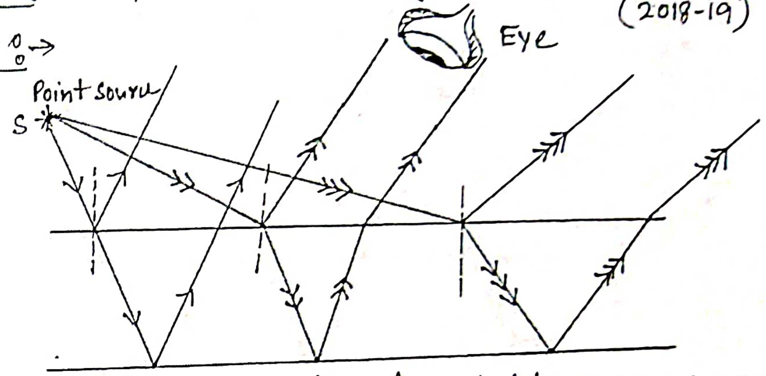
$$W = \frac{\lambda}{2\theta}$$

Width depend on two factors:

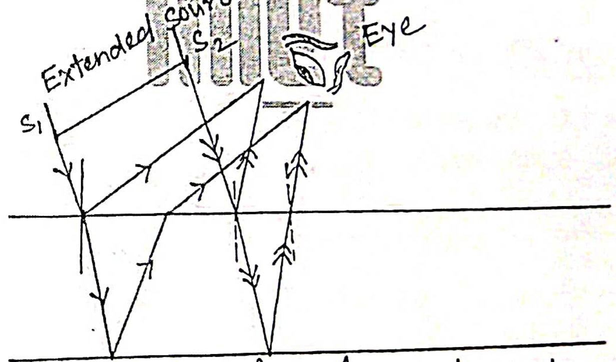
(i) Fringe width directly proportional to wavelength.
(ii) Fringe width inversely proportional to angle θ.

Question :-> Explain the necessity of extended source. (2018-19)

Answer :->



When light incident on film from point source, a small portion of film will be visible. To observe the different part of film we should move to sideways. Hence with a narrow source it is not possible to observe the whole film simultaneously.



When light incident on film from extended source, a big portion (may be whole film) of film will be visible. To observe the different part of film, no need to move to sideways. Hence with a extended source possible to observe whole film simultaneously.

Question :-> What are Newton's rings? (2015-16, 2018-19)

Answer :-> Newton's rings are said to be a phenomenon in which an interference pattern is created by the light's reflection between two surfaces. Alternate dark & bright fringes obtained.

Question :-> Why the centre of Newton's ring is dark in reflected system? (2015-16) V. Imp

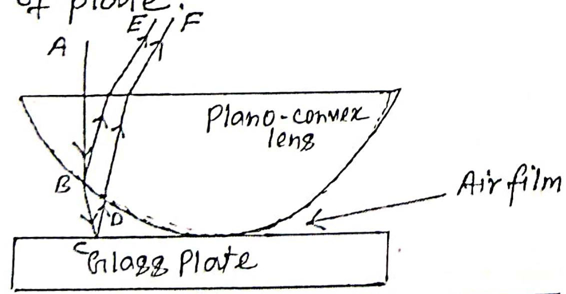
Answer :-> The centre of Newton's ring is dark with reflected light because at the point of contact the path difference is zero but one of the interfering ray is reflected so the effective path difference becomes $\lambda/2$, the condition of minimum intensity is created. So centre of Newton ring is dark.

Path difference $\boxed{\Delta = 2\mu t + \lambda/2}$ at contact surface

$t = 0$, so $\Delta = 0 + \lambda/2 = \lambda/2$

Question :-> What do you understand by newton's ring? Explain their experimental arrangement. How can you determine the wavelength of light with this experiment. (2016-17) Imp

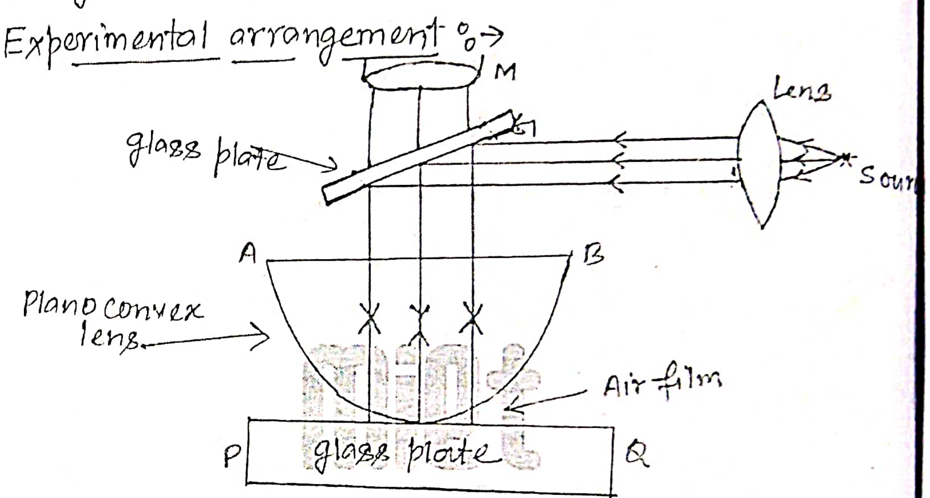
Answer :-> Newton's Ring :-> When a plano-convex lens of large radius of curvature is placed on a plane glass plate, an air film created and gradually increases from point of contact to end of plate.



When monochromatic light is allowed to fall normally on this device, alternate bright & dark concentric rings with their centre dark formed. These rings are known as Newton's rings.

Newton ring's are formed because interference done by top & bottom surface of air-film.

Experimental arrangement :->



- → Planoconvex lens placed on glass plate.
- → Monochromatic source of light from S falls on plate inclined at 45° to incident beam.
- → Reflected light from glass plate incident on plano convex lens.
- → Light reflected from plano convex lens and superimpose each other and interference pattern obtained.

- → Due to interference of these rays, alternate bright & dark concentric rings are obtained.

Effective path difference $= 2\mu t \cos r + \lambda/2$

For normal incidence $r = 0$

$\boxed{\text{Path difference} = 2\mu t + \lambda/2}$

Calculation of Wavelength of light using Newton's ring :→ For dark rings

Consider D_n & D_{n+p} be the diameters of the n^{th} & $(n+p)^{th}$ dark rings respectively, then

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

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

where $R \rightarrow$ radius of curvature of lens.
$p \rightarrow$ any number.

Subtracting equation (1) from eqn (2)

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

$$= \cancel{4n\lambda R} + 4p\lambda R - \cancel{4n\lambda R}$$

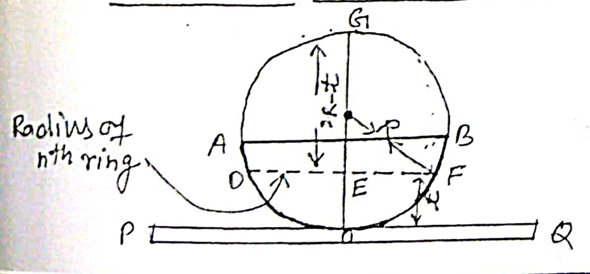
$$D_{n+p}^2 - D_n^2 = 4p\lambda R$$

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

The same result shall be obtained for bright ring.

Question :→ Show that diameter for bright rings are proportional to square root of odd natural number and for dark ring, diameters are proportional to square root of natural number. (2018-19, 2019-20) V. Imp.

Ans. :→ Diameter of Bright & Dark rings :→



Consider R be the radius of curvature of the lens and r be the radius of a Newton's ring where film thickness is 't'.

From the property of a circle,

$$DE \times EF = OE \times EG$$

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

$$r^2 = 2Rt - t^2 \quad \text{——— (1)}$$

Since t is very small as compared to R.

$$r^2 = 2Rt$$

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

For Bright rings → Substituting the value of t in equation ($2\mu t + \lambda/2 = 2n\lambda/2$),

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

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

$$\mu r^2 = (2n-1)\lambda/2$$

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

For nth ring,

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

$$\left(\frac{D_n}{2}\right)^2 = (2n-1)\frac{\lambda R}{2\mu} \qquad \text{where } r = \frac{D}{2}$$

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

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

$$\boxed{D_n = \sqrt{2(2n-1)\frac{\lambda R}{\mu}}} \quad \text{.... (3)}$$

For air film, $\mu = 1$

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

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

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

Thus the diameters of bright rings are proportional to the square root of the odd natural number.

For Dark rings :→ Substitute the value of t in equation $2\mu t = 2n\lambda/2$,

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

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

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

For n^{th} ring,

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

$$\left(\frac{D_n}{2}\right)^2 = \frac{n\lambda R}{\mu} \qquad \text{where, } \left(r = \frac{D}{2}\right)$$

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

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

$$\boxed{D_n = \sqrt{\frac{4n\lambda R}{\mu}}}$$

For air film $\mu = 1$

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

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

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

Thus diameter of dark rings are proportional to the square root of the natural number.

Question :→ 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. (2020-21)

Ans :→ We know that condition for constructive interference

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

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

For minimum thickness $n=1$, $\cos r = 1$ $(\because r = 0)$ For normal incidence

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

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

$$t = \frac{5\times10^{-7}m}{5.8} = 0.86\times10^{-7}m$$

$$t = 8.6\times10^{-8}m$$

Question :→ Light of wavelength 6000 Å falls normally on a thin wedge shaped film of refractive index 1.4 forming the fringes that are 2mm apart. Find the angle of wedge. (2018-19).

Ans :→ According to wedge shaped film, fringe width

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

$\lambda = 6000\,\text{Å} = 6000\times10^{-10}m$, $\mu = 1.4$, $\beta = 2mm = 2\times10^{-3}m$

$$2\times10^{-3} = \frac{6000\times10^{-10}}{2\times1.4\times\theta}$$

$$\theta = \frac{6000\times10^{-10}}{4\times1.4\times10^{-3}} = \frac{6\times10^{-7+3}}{5.6}\text{ radian}$$

(1 radian $= \frac{180'}{\pi}$ degree)

$$\theta = 1.07\times10^{-4}\times\frac{180'}{\pi}\text{ degree}$$

$$\boxed{\theta = 0.0061^\circ}$$

Question :- 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. (2015-16)

Ans :- We know diameter of newton' rings

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

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

$$\frac{D_{liquid}}{D_{air}} = \sqrt{\frac{1}{1.33}} = 0.867$$

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

Question :- In Newton ring experiment, the diameter of 4th and 12th dark ring are 0.4 cm and 0.7 cm respectively. Deduce the diameter of 20th dark ring. (2015-16) Imp

Ans :- If D_{n+p}^2 and D_n^2 be the diameter of $(n+p)^{th}$ and nth dark ring, then

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

Given. $n = 4$, $n+p = 12$

so $D_4 = 0.4$ cm, $D_{12} = 0.7$ cm

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

Suppose the diameter of 20th ring is D_{20}.

$$D_{20}^2 - D_4^2 = 4 \times 16 \lambda R \quad \text{—— (3)}$$

Dividing equation (2) by (3),

$$\frac{D_{12}^2 - D_4^2}{D_{20}^2 - D_4^2} = \frac{32 \cancel{\lambda R}}{64 \cancel{\lambda R}}$$

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

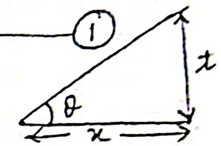
$$D_{20}^2 = 2D_{12}^2 - D_4^2$$

$$D_{20}^2 = 2 \times 0.49 - 0.16 \Rightarrow \boxed{D_{20} = 0.906\text{ cm}}$$

Question :- Two plane glass surface in contact along one edge are separated at the opposite edge by a thin wire. If 25 interference fringes are observed between these edges in sodium light of wavelength 5898 Å of normal incidence, then find the thickness of the wire. (2015-16).

Answer :- The fringe width in air wedge for normal incidence

$$W = \frac{\lambda}{2\theta} \quad \text{—— (1)}$$



Consider t is thickness of wire and x be the length of the glass surface from the point of contact.

Then wedge angle $\theta = \frac{t}{x}$ —— (2)

Therefore,

$$W = \frac{\lambda x}{2t}.$$

If n fringes are seen in the entire film then $x = nW$

$$W = \frac{\lambda n W}{2t} \text{ or } \frac{n\lambda}{2} = t$$

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

$n = 25$, $\lambda = 5898 \times 10^{-10}$ m

$$t = \frac{25 \times 5898 \times 10^{-10}}{2}$$

$$t = 7.37 \times 10^{-6}\text{ m}$$

$$\boxed{t = 7.37 \times 10^{-6}\text{ m.}}$$ Ans.

Question:- A parallel beam of sodium light of wavelength $5880 A^\circ$ is incident on a thin glass plate of refractive index 1.5 such that the angle of refraction in the plate which will make it appear dark by reflection.

Solution:- The condition of destructive interference (dark) in reflected light is given by

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

given: $\mu = 1.5$, $r = 60^\circ$, $\lambda = 5880 A^\circ = 5880 \times 10^{-10} m$.

$$2 \times 1.5 \times t \cos 60 = \frac{2 \times 1 \times 5880 \times 10^{-10}}{2}$$

$$3.0 \times t \times \frac{1}{2} = 5880 \times 10^{-10}$$

$$t = \frac{5880 \times 10^{-10} \times 2}{3.0} = 3920 \times 10^{-10} m = 3920 A^\circ$$

Question: A soap film of refractive index 1.43 is illuminated by white light incident at an angle of 30°. The refractive light is examined by spectroscope in which dark band corresponding to the wavelength $6 \times 10^{-7} m$ is observed. Calculate the thickness of film.

Soln: Condition for destructive Interference

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

given: $i = 30^\circ$, $\mu = 1.43$, $n = 1$, $\lambda = 6 \times 10^{-7} m$

$$\mu = \frac{\sin i}{\sin r} \Rightarrow \sin r = \frac{\sin i}{\mu} = \frac{\sin 30}{1.43} = \frac{0.5}{1.43} = 0.3496$$

$$\cos r = \sqrt{1 - \sin^2 r} = \sqrt{1 - (.3496)^2} = 0.8777$$

$$t = \frac{n\lambda}{2\mu \cos r} = \frac{1 \times 6 \times 10^{-7}}{2 \times 1.43 \times 0.8777}$$

$$t = 2.39 \times 10^{-7} m$$

Hence thickness of film $(t) = 2.39 \times 10^{-7} m$

lecture - 28

Question: A parallel beam of sodium light ($\lambda = 5890 A^\circ$) strike a film of oil floating on water. when viewed at an angle of 30° from the normal, 8^{th} dark ring is seen. Determine the thickness of film (μ for oil $= 1.5$)

Soln:- Condition for destructive interference (dark band) is give by $2\mu t \cos r = 2n \cdot \frac{\lambda}{2}$ —①

given: $i = 30^\circ$, $\mu = 1.5$, $n = 8$

from snell's law -

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

$$\cos r = \sqrt{1 - \sin^2 r} = \sqrt{1 - \left(\frac{\sin i}{\mu}\right)^2}$$

$$\cos r = \sqrt{1 - \left(\frac{0.5}{1.5}\right)^2} = 0.943$$

from eqn ①

$$t = \frac{n\lambda}{2\mu \cos r} = \frac{8 \times 5890 \times 10^{-10}}{2 \times 1.5 \times 0.943} = 1.67 \times 10^{-6} m$$

Question: white light is incident on a soap film at an angle $\sin^{-1}\frac{4}{5}$ and the reflected light is observed with a spectroscope. It is found that two consecutive dark band corresponds to wavelength 6.1×10^{-5} and $6.0 \times 10^{-5} cm$. If the refractive index of the film be $\frac{4}{3}$. Calculate the thickness.

Soln: The condition for dark band or fringes in the reflected light

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

if n^{th} and $(n+1)^{th}$ are order of consecutive dark band of wavelength λ_1 & λ_2

lecture-28

$2\mu t\cos r = n\lambda_1$ — (1) $\qquad 2\mu t\cos r = (n+1)\lambda_2$ — (2)

on Comparision of eq^n (1) & (2)

$$n\lambda_1 = (n+1)\lambda_2$$
$$n\lambda_1 = n\lambda_2 + \lambda_2$$
$$n(\lambda_1 - \lambda_2) = \lambda_2$$
$$n = \frac{\lambda_2}{(\lambda_1-\lambda_2)}$$

Substituting value of n in eq^n (1)

$$2\mu t\cos r = n\lambda_1 = \frac{\lambda_2\lambda_1}{(\lambda_1-\lambda_2)}$$

$$t = \frac{\lambda_2\lambda_1}{(\lambda_1-\lambda_2)\,2\mu\cos r} \quad \text{— (3)}$$

Given ⇒ $\mu = \frac{4}{3}$, $i = \sin^{-1}\frac{4}{5} \Rightarrow \sin i = \frac{4}{5}$

from Snell's law. $\mu = \frac{\sin i'}{\sin r} \Rightarrow \sin r = \frac{\sin i'}{\mu}$

$$\sin r = \frac{\frac{4}{5}}{\frac{4}{3}} = \frac{3}{5}$$

we know that

$$\cos r = \sqrt{1-\sin^2 r} = \sqrt{1-\left(\frac{3}{5}\right)^2} = \sqrt{\frac{16}{25}}$$

$$\cos r = \frac{4}{5} \quad \text{— (4)}$$

from eq^n (3)

$$t = \frac{\lambda_1\lambda_2}{(\lambda_1-\lambda_2)\,2\mu\cos r}$$

$$= \frac{6.1\times10^{-5}\times6\times10^{-5}}{(6.1-6.0)\times10^{-5}\times2\times\frac{4}{3}\times\frac{4}{5}}$$

$$= \frac{36.6\times10^{-10}}{0.1\times10^{-5}\times2.1333} = 17.156\times10^{-4}\,\text{Cm}$$
$$= 0.001715\,\text{Cm}$$

Question: Newton's ring are observed normally in reflected light of wavelength 6000A°. The Diameter of the 10th ring is 0.5Cm. Find the radius of Curvature of lens and thickness of film.

Sol^n: The Diameter of n^{th} dark ring is given by

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

Given: $D_n = D_{10} = 0.5\,\text{Cm}$, $\lambda = 6000\,A^\circ = 6000\times10^{-10}\text{m}$ & $n = 10$

$$R = \frac{(D_{10})^2}{4\times10\times\lambda} = \frac{(0.5\,\text{Cm})^2}{4\times10\times6000\times10^{-8}\text{Cm}}$$

$$= \underline{104.16\,\text{Cm}}$$

If t is thickness of the film Corresponding to a ring of D diameter, then

$$2t = \frac{D_n^2}{4R}$$

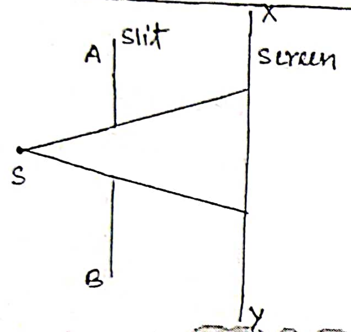
$$t = \frac{D^2}{8R} = \frac{(0.5\,\text{Cm})^2}{8\times104.16\,\text{Cm}}$$

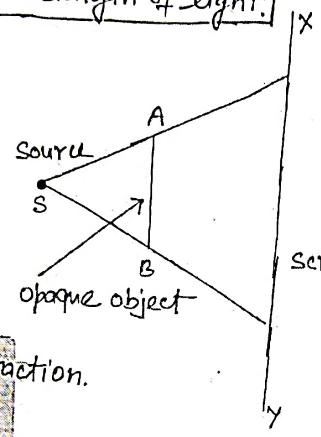
$$\boxed{t = 3\times10^{-4}\,\text{Cm}}$$

Diffraction :→ The bending of light around the sharp corner of opaque obstacle and spreading of light within the geometrical shadow of opaque obstacles is called diffraction of light.

Condition for diffraction :→

$$\boxed{\text{Particles size} \approx \text{wavelength of light.}}$$





⇒ There are two types of diffraction.
(i) Fraunhofer diffraction.
(ii) Fresnel diffraction.

Question :→ Discuss the phenomena of Fraunhofer's diffraction at a single slit and show that relative intensities of the successive maximas are nearly

$$1 : \frac{4}{9}\pi^2 : \frac{4}{25}\pi^2 : \dots\dots$$

(2015-16, 2018-19)

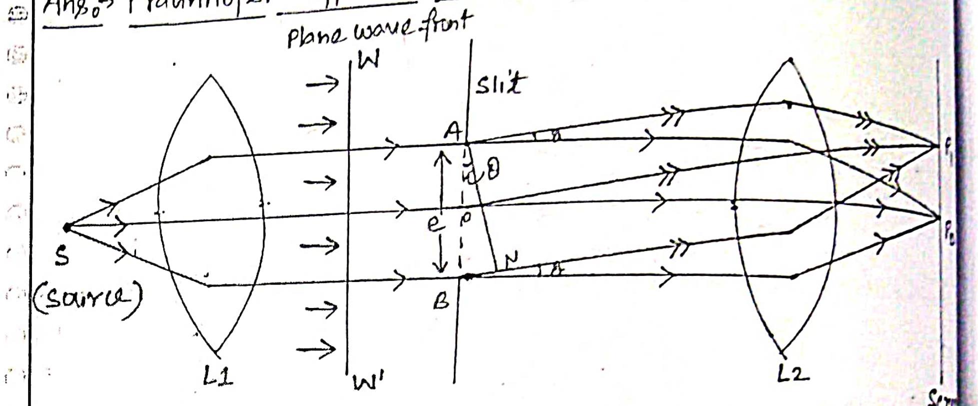
or

Obtain intensity expression for single slit Fraunhofer diffraction pattern. (2015-16)

or

Obtain an expression for intensity distribution due to Fraunhofer diffraction at single slit.
(2017-18, 2019-20)
V. Imp

Ans :→ Fraunhofer diffraction at a single slit :→



Consider a parallel beam of monochromatic light of wavelength λ produced by a point source S be incident upon a converging lens L_1 and emerging light from it falls upon a slit AB of width 'e' where it get diffracted. If a converging lens L2 is placed in the path of the diffracted beam, a real image of the diffraction pattern is formed on the screen in the focal plane of the lens.

Path difference, $BN = AB \sin\theta$

$$\boxed{BN = e \sin\theta} \quad \text{——— (1)}$$

$$\text{Phase difference} = \frac{2\pi}{\lambda} \times \text{Path difference}$$

$$\boxed{\text{Phase difference} = \frac{2\pi}{\lambda} e \sin\theta} \quad \text{——— (2)}$$

If slit width AB divided into n part, each part become a elementry source. So phase difference between successive wavefront is

$$\frac{\text{Total phase}}{n} = \frac{2\pi e \sin\theta}{n\lambda} = \delta \quad \text{——— (3)}$$

According to theory of composition of n simple harmonic motions of equal amplitude a and common phase difference between successive vibrations, the resultant amplitude at P_1 is given by

$$R = a\frac{\sin(n\delta/2)}{\sin(\delta/2)} = a\frac{\sin\{(\pi e\sin\theta)/\lambda\}}{\sin\{(\pi e\sin\theta/n\lambda\}}$$

$$R = a\frac{\sin\alpha}{\sin(\alpha/n)} = \frac{a\sin\alpha}{(\alpha/n)}$$

$$R = \frac{na\sin\alpha}{\alpha}$$

where $\alpha = \frac{\pi}{\lambda}e\sin\theta$

& for large value of n, $\sin\left(\frac{\alpha}{n}\right) = \left(\frac{\alpha}{n}\right)$

Resultant amplitude,

$$\boxed{R = A\frac{\sin\alpha}{\alpha}} \quad \text{— (4)}$$

Resultant intensity at P_1,

Intensity $\propto$ (amplitude)^2

$$I = R^2 = A^2\left(\frac{\sin\alpha}{\alpha}\right)^2$$

$$\boxed{I = A^2\left(\frac{\sin\alpha}{\alpha}\right)^2} \quad \text{— (5)}$$

Positions of Maxima & Minima :-> The resultant amplitude given by eqn (4) can be written as,

$$R = \frac{A}{\alpha}\left[\alpha - \frac{\alpha^3}{\underline{|3}} + \frac{\alpha^5}{\underline{|5}} - \frac{\alpha^7}{\underline{|7}} + \cdots\right]$$

$$R = A\left[1 - \frac{\alpha^2}{\underline{|3}} + \frac{\alpha^4}{\underline{|5}} - \frac{\alpha^6}{\underline{|7}} + \cdots\right] \quad \text{— (6)}$$

If $\alpha = 0$, the value of R will be maximum.

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$$\therefore \alpha = \frac{\pi}{\lambda}(e\sin\theta)$$

$$0 = \frac{\pi}{\lambda}(e\sin\theta)$$

$$\sin\theta = 0$$

$$\theta = 0$$

Thus the maximum value of resultant intensity at P_0. This maxima is called Principal maxima.

Position of minima :-> Differentiate eqn (5) with respect to α, and equate to zero.

i.e.

$$\frac{dI}{d\alpha} = \frac{d}{d\alpha}\left[A^2\left(\frac{\sin\alpha}{\alpha}\right)^2\right]$$

$$0 = \frac{d}{d\alpha}\left[A^2\left(\frac{\sin\alpha}{\alpha}\right)^2\right]$$

$$A^2\, 2\frac{\sin\alpha}{\alpha}\left(\frac{\alpha\cos\alpha - \sin\alpha}{\alpha^2}\right) = 0$$

i.e. either $\frac{\sin\alpha}{\alpha} = 0$ or $\frac{\alpha\cos\alpha - \sin\alpha}{\alpha^2} = 0$

$\Rightarrow$ If $\frac{\sin\alpha}{\alpha} = 0$, gives the position of minima

$$\sin\alpha = 0$$

$$\alpha = \pm n\pi$$

$$\frac{\pi}{\lambda}e\sin\theta = \pm n\pi$$

$$\boxed{e\sin\theta = \pm n\lambda}$$

$\Rightarrow$ If $\frac{\alpha\cos\alpha - \sin\alpha}{\alpha^2} = 0$ gives the secondary maxima.

$$\frac{\alpha\cos\alpha - \sin\alpha}{\alpha^2} = 0$$

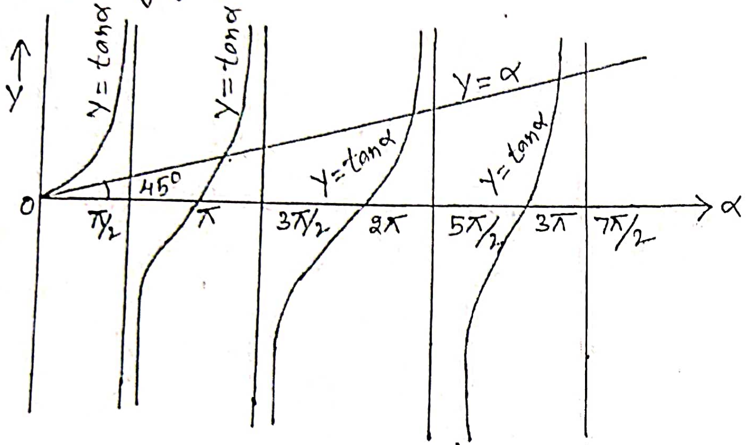
$$\alpha\cos\alpha - \sin\alpha = 0$$

$$\alpha\cos\alpha = \sin\alpha$$

$$\alpha = \frac{\sin\alpha}{\cos\alpha}$$

$$\boxed{\alpha = \tan\alpha}$$

On plotting graph, $Y=\alpha$ and $Y=\tan\alpha$



$Y=\alpha$ show equation of straight line making angle 45° with axis.

$Y=\tan\alpha$ show discontinuous curve having a number of branches with asymptotes at an interval $\alpha=\pi$

⇒ on graph, points of intersection are the points of maxima.

$$\alpha = 0, \pm 3\pi/2, \pm 5\pi/2, \ldots$$

$\alpha=0$ Principal maxima or central maxima.

∴ For secondary maxima -

$$\alpha = \frac{\pi}{\lambda}(e\sin\theta)$$

$$\pm(2n+1)\pi/2 = \frac{\pi}{\lambda}(e\sin\theta)$$

$$\boxed{e\sin\theta = \pm(2n+1)\lambda/2}$$

$n = 1, 2, 3, 4 \ldots$

(i) For principal maxima $\alpha=0$, $I = A^2 = I_0$ (Principal maxima)

(ii) 1st Secondary maxima -

$$I_1 = A^2\left(\frac{\sin 3\pi/2}{3\pi/2}\right)^2 = A^2\frac{4}{9\pi^2} = \frac{I_0}{22}$$

Thus intensity of first secondary maxima is 4.5% of central or principal maxima.

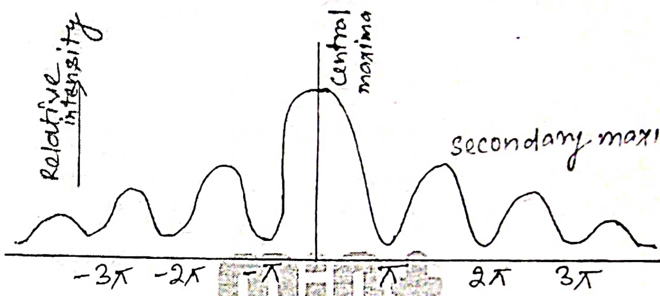
(iii) The intensity of second secondary maxima

$$I_2 = A^2\left(\frac{\sin 5\pi/2}{5\pi/2}\right)^2 = A^2\frac{4}{25\pi^2} = \frac{I_0}{61}$$

Thus intensity of second secondary maxima is about 1.61% of central or principal maxima.

Thus,

$$I_0 : I_1 : I_2 : I_3 \ldots = 1 : \frac{4}{9\pi^2} : \frac{4}{25\pi^2} \ldots$$

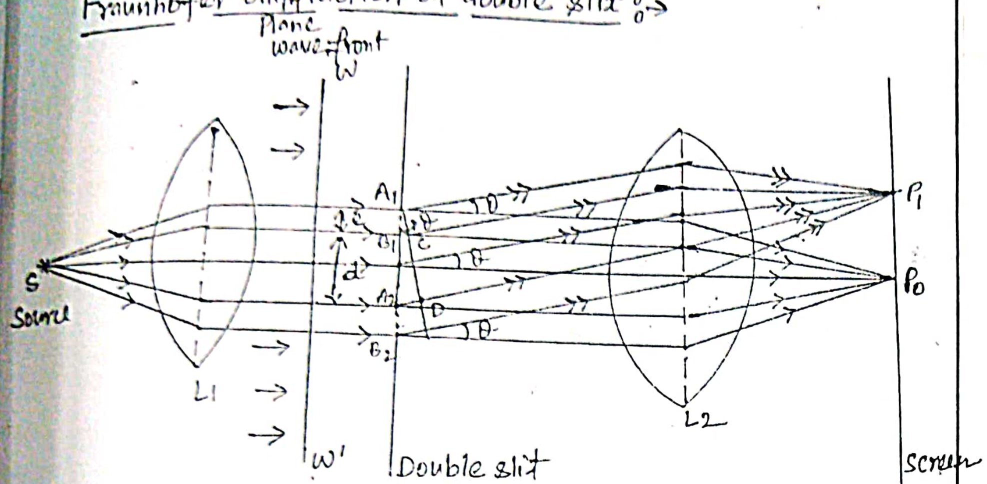


Intensity distribution due to single slit.

Question :→ What happen to diffraction pattern when width of single slit experiment increases. (2016-17)

Answer :→ If we increases the width of single slit then the central maxima (Principal maxima) in the diffraction pattern get narrower and gradually we cannot differentiate between dark & bright fringes as they will merge.

Fraunhofer diffraction at double slit :->



Let a monochromatic plane wave front of wavelength λ is incident normally on the slits. A_1B_1 & A_2B_2 are two slits respectively.

From the triangle A_1B_1C,

$$\sin\theta = \frac{B_1C}{A_1B_1} = \frac{B_1C}{e}$$

Path difference $\boxed{B_1C = e\sin\theta}$ ——— (1)

Phase difference -

$$2\alpha = \frac{2\pi}{\lambda} e\sin\theta$$

$$\boxed{\alpha = \frac{\pi}{\lambda} e\sin\theta} \quad \text{——— (2)}$$

Path difference A_2D (double slit)

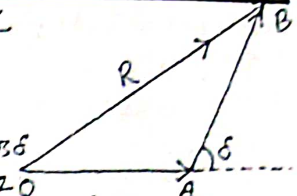
$$A_2D = (e+d)\sin\theta \quad \text{——— (3)}$$

The corresponding phase difference,

$$\delta = 2\beta = \frac{2\pi}{\lambda}(e+d)\sin\theta \quad \text{——— (4)}$$

Applying the theory of interference on the wave amplitudes $\left(\frac{A\sin\alpha}{\alpha}\right)$ at the two slits gives the resultant wave amplitude R.

$$OA = \frac{A\sin\alpha}{\alpha}, \quad AB = \frac{A\sin\alpha}{\alpha}$$



From figure,

$$(OB)^2 = (OA)^2 + (AB)^2 + 2(OA)(AB)\cos\delta$$

$$R^2 = \left(\frac{A\sin\alpha}{\alpha}\right)^2 + \left(\frac{A\sin\alpha}{\alpha}\right)^2 + 2\left(\frac{A\sin\alpha}{\alpha}\right)\left(\frac{A\sin\alpha}{\alpha}\right)\cos\delta$$

$$R^2 = \left(\frac{A\sin\alpha}{\alpha}\right)^2\left[(2+2\cos\delta)\right]$$

$$R^2 = \frac{A^2\sin^2\alpha}{\alpha^2} 4\cos^2(\delta/2)$$

Intensity at P_1 is

$$I = R^2 = 4A^2\frac{\sin^2\alpha}{\alpha^2}\cos^2\beta$$

$$\boxed{I = 4I_0\frac{\sin^2\alpha}{\alpha^2}\cos^2\beta} \quad \text{——— (5)}$$

where $I_0 = A^2$

Interference Maxima & minima :-> If path difference

$$\boxed{(e+d)\sin\theta = \pm n\lambda} \quad \text{——— (6)}$$

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

θ gives the direction maxima.

$$\boxed{(e+d)\sin\theta = \pm(2n-1)\lambda/2} \quad \text{——— (7)}$$

θ gives the direction minima.

Diffraction maxima & minima :->

For diffraction minima

$$\boxed{e\sin\theta = \pm m\lambda} \quad \text{——— (8)}$$

For diffraction maxima

$$\boxed{e\sin\theta = \pm(2m-1)\lambda/2} \quad \text{——— (9)}$$

The $\pm$ sign indicates maxima on both sides with respect to central maxima.

Missing orders in double slit :→

The direction of interference maxima are given as

$$(e+d)\sin\theta = n\lambda \quad \text{——— (1)}$$

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

The direction of diffraction minima,

$$e\sin\theta = m\lambda \quad \text{——— (2)}$$

Equation (1) divided by eqn (2)

$$\boxed{\left(\frac{e+d}{e}\right) = \left(\frac{n}{m}\right)}$$

(i) If $e = d$, then $\frac{n}{m} = 2$

$n = 2m$

If $m = 1, 2, 3$

$\boxed{n = 2, 4, 6}$ (missing order)

(ii) If $2e = d$, then

$\frac{n}{m} = 3$

$n = 3m$

$m = 1, 2, 3 \ldots$

$\boxed{n = 3, 6, 9}$ ...... (missing order).

Question :→ What do you understand by grating? (2018-19)

Answer :→ A grating is an arrangement consist of a large number of close, parallel, straight, transparent and equidistant slits of same width 'e' with neighboring slits being separated by an opaque region of width 'd'. e+d called grating element.

$\boxed{(e+d) = \text{Grating element}}$

where $e \to$ slit width
$d \to$ opaque width

Question :→ Give the construction and theory of plane diffraction grating? Explain the formation of spectra by it. (2015-16)

OR

Give the construction and theory of plane transmission grating. (2017-18)

OR

What is diffraction grating? Discuss the phenomenon of diffraction due to plane diffraction grating. (2020-21)

Answer :→ **Diffraction grating :→** A plane diffraction grating is an arrangement consist of large number of close, parallel, straight, transparent and equidistant slit of same width 'e' with neighbouring slits being separated by an opaque region of width d. (e+d) is called as grating element.

Consider a monochromatic light incident on a plane diffraction grating consist of large number of N parallel slits, each of width 'e' and separation 'd'

Question :→ What do you understand by grating? (2018-19)

Answer :→ A grating is an arrangement consist of a large number of close, parallel, straig transparent and equidistant slits of same width 'e' with neighboring slits being separated by an opaque region of width 'd'. e+d called grating element.

$$\boxed{(e+d) = \text{Grating element}}$$

where e → slit width
d → opaque width

Question :→ Give the construction and theory of plan diffraction grating? Explain the forma of spectra by it. (2015-16)

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Give the construction and theory of plane transm grating. (2017-18)

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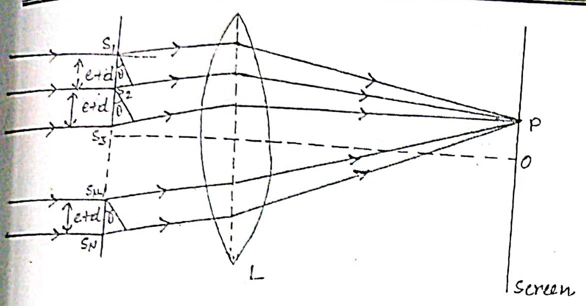
Consider a monochromatic light incident on a plan diffraction grating consist of large number of N, parallel slits, each of width 'e' and separation 'd'



The waves diffracted from each slit is equivalent to a single wave of amplitude.

$$R = \frac{A\sin\alpha}{\alpha} \quad \text{——— (1)}$$

The path difference between the consecutive wave is same and equal to $(e+d)\sin\theta$.

$$\text{Path difference} = (e+d)\sin\theta \quad \text{——— (2)}$$

$$\text{Phase difference } (2\beta) = \frac{2\pi}{\lambda} \times \text{Path difference}$$

$$2\beta = \frac{2\pi}{\lambda}(e+d)\sin\theta \quad \text{——— (3)}$$

where $\rightarrow (e+d) \rightarrow$ Grating element.

$$\beta = \frac{\pi}{\lambda}(e+d)\sin\theta$$

Resultant amplitude at point P is resultant of amplitude of N waves, each have amplitude R and common phase difference 2β.

Resultant amplitude at P, $R' = \frac{R\sin(N\delta/2)}{\sin\delta/2}$, Here $\delta = 2\beta$

$$R' = \frac{R\sin N\beta}{\sin\beta} = \frac{A\sin\alpha}{\alpha}\cdot\frac{\sin N\beta}{\sin\beta} \quad \text{— (4)}$$

Resultant intensity at P

$$I' = R'^2 = \frac{A^2\sin^2\alpha}{\alpha^2}\cdot\frac{\sin^2 N\beta}{\sin\beta} \quad \text{——— (5)}$$

$\downarrow$ Intensity pattern due to single slit

$\downarrow$ Intensity pattern due to all N point

Principal maxima :→ From equation (5), intensity will be maximum when

$$\sin\beta = 0$$

$$\beta = \pm n\pi \qquad \text{where } n = 0, 1, 2, 3 \ldots$$

$\sin N\beta$ also equal to zero but $\frac{\sin N\beta}{\sin\beta} \rightarrow$ indeterminate.

It is solved by L Hospital rule;

$$\lim_{\beta=\pm n\pi}\frac{\sin N\beta}{\sin\beta} = \lim_{\beta=\pm n\pi}\frac{\frac{d}{d\beta}(\sin N\beta)}{\frac{d}{d\beta}(\sin\beta)}$$

$$= \lim_{\beta=\pm n\pi}\frac{N\cos N\beta}{\cos\beta} = N$$

Therefore intensity at $\beta = \pm n\pi$

$$\boxed{I_{max} = A^2\left(\frac{\sin\alpha}{\alpha}\right)^2 N^2} \quad \text{——— (6)}$$

$$\boxed{I_{max} \propto N^2}$$

⇒ The direction of principal maxima,

$$\beta = \pm n\pi$$

$$\frac{\pi}{\lambda}(e+d)\sin\theta = \pm n\pi$$

$$\boxed{(e+d)\sin\theta = \pm n\lambda} \quad \text{——— (7)}$$

For $n=0$, $\theta=0$ gives the zero order principal maxima. The value of $n = 1, 2, 3 \ldots$ gives the direction of first, second, third order... principal maxima.

Secondary minima :→ For minimum intensity,

$$\sin N\beta = 0$$

$$N\beta = \pm m\pi$$

As we know,

$$\beta = \frac{\pi}{\lambda}(e+d)\sin\theta,$$

$$\frac{\pi N}{\lambda}(e+d)\sin\theta = \pm m\pi$$

$$\boxed{(e+d)\sin\theta = \pm \frac{m\pi}{N}} \quad \text{—— (8)}$$

where m can take all integral values except $0, N, 2N, 3N \ldots$

Secondary maxima :→ For secondary maxima,

$$\frac{dI}{d\beta} = \frac{d}{d\beta}\left(\frac{A^2\sin^2\alpha}{\alpha^2}\cdot\frac{\sin^2 N\beta}{\sin^2\beta}\right)$$

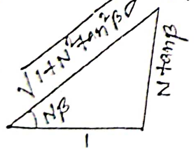
$$0 = \frac{d}{d\beta}\left(\frac{A^2\sin^2\alpha}{\alpha^2}\cdot\frac{\sin^2 N\beta}{\sin^2\beta}\right)$$

$$\frac{A^2\sin^2\alpha}{\alpha^2}\cdot 2\left[\frac{\sin N\beta}{\sin\beta}\right]\cdot\left[\frac{N\cos N\beta\sin\beta - \sin N\beta\cos\beta}{\sin^2\beta}\right] = 0$$

$$N\cos N\beta\sin\beta - \sin N\beta\cos\beta = 0$$

$$\boxed{\tan N\beta = N\tan\beta} \quad \text{—— (9)}$$

For intensity of secondary maxima, we make triangle



$$\sin N\beta = \frac{N\tan\beta}{\sqrt{1+N^2\tan^2\beta}}$$

$$\frac{\sin^2 N\beta}{\sin^2\beta} = \frac{(N^2\tan^2\beta)/(1+N^2\tan^2\beta)}{\sin^2\beta}$$

$$\frac{\sin^2 N\beta}{\sin^2\beta} = \frac{(N^2\tan^2\beta)}{(1+N^2\tan^2\beta)\sin^2\beta} = \frac{N^2}{1+(N^2-1)\sin^2\beta} \quad \text{—— (10)}$$

Putting this value of eqn (10) in eqn (5).

$$I' = R'^2 = \frac{A^2\sin^2\alpha}{\alpha^2}\cdot\frac{N^2}{1+(N^2-1)\sin^2\beta} \quad \text{—— (11)}$$

Dividing eqn (11) by eqn (6),

$$\frac{\text{Intensity of secondary maxima}}{\text{Intensity of primary minima}} = \frac{I'}{I_{max}} = \frac{1}{1+(N^2-1)\sin^2\beta}$$

$$\boxed{\frac{I'}{I_{max}} = \frac{1}{1+(N^2-1)\sin^2\beta}}$$

Hence, the greater the value of N, the weaker are secondary maxima.

Question :→ What will be the effect on the intensity of principle maxima of diffraction pattern when single slit is replaced by double slit? (2015-1

Answer :→ Intensity at single slit

$$I = \frac{A^2\sin^2\alpha}{\alpha^2} \quad \text{—— (1)}$$

Intensity at double slit

$$I = 4A^2\frac{\sin^2\alpha}{\alpha^2}\cos^2\beta \quad \text{—— (2)}$$

From eqn (1) & (2) intensity is increased by fact 4.

Question :→ Explain the formation of spectra by diffraction grating. (2015-16, 2017-18)

Answer :→ The direction of nth principal maxima, is given by $(e+d)\sin\theta_n = n\lambda$

Where $(e+d)$ called grating element.
$n \rightarrow$ order
$\lambda \rightarrow$ wavelength of light.

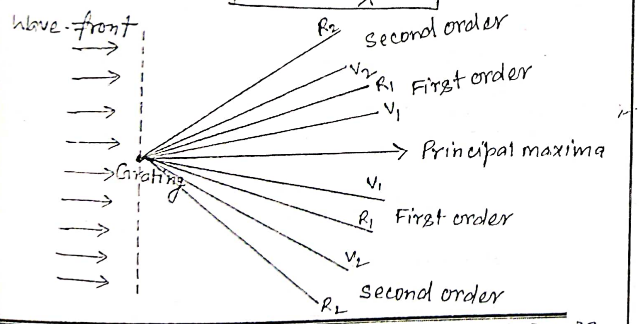
(i) For a given wavelength λ the angle of diffraction θ is different for principal maxima of different order.

(ii) For white light and for particular order n, the light of different wavelength will be diffracted in different directions.

(iii) In grating spectra, violet color is in the innermost position and red is outermost position. As the order increases, the intensity decreases.

(IV) Maximum order can be obtained by
$(e+d)\sin\theta = n\lambda$

$$\boxed{n = \frac{(e+d)\sin\theta}{\lambda}}$$



Question :→ What do you understand by missing or absent order spectrum? What particular spectra would be absent if the width of transparencies twice of opacities of grating? (2015-16, 2016-17)

Answer :→ According to diffraction grating, Path difference, is equal to $n\lambda$ for principal maxima.

$$(e+d)\sin\theta = n\lambda \quad \text{--- (1)}$$

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

By single slit

$$e\sin\theta = m\lambda \quad \text{--- (2)}$$

where $m = 1, 2, 3 \ldots$

Divided eqn (1) by eqn (2)

$$\frac{(e+d)}{e} = \frac{n}{m}$$

$$\boxed{n = \left(\frac{e+d}{e}\right)m}$$

This is condition for missing order spectra in the diffraction pattern.

Here $d = 2e$

$$n = \left(\frac{e+2e}{e}\right)m$$

$$\boxed{n = 3m}$$

Therefore, when $m = 1, 2, 3 \ldots$ missing orders are $3, 6, 9 \ldots$

Question :→ What particular spectra would be absent if the width of the transparencies and opacities of the grating are equal. (2018-19)

Answer :→ According to condition of missing order spectra in the diffraction pattern,

$n = \left(\frac{e+d}{e}\right)m$, Here $e = o$

$\boxed{n = 2m}$ $m = 1, 2, 3 \ldots$ missing order are $2, 4, 6 \ldots$ Ans.

Question :→ What do you mean by resolving power of an optical instrument. (2018-19, 2020-21)

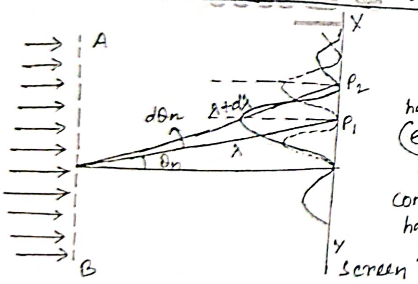
OR

What is resolving power of grating. (2015-16) Imp

Ans :→ Resolving power :→ The capacity of an optical instrument to show two close objects separately is called resolution and the ability of an optical instrument to just resolve the images of two close point objects is called its resolving power.

Resolving power of a grating :→ The ratio of the wavelength of any spectral line to smallest wavelength difference between neighboring lines for which spectral can just resolved at wavelength λ, called resolving power of grating.

$$\boxed{\text{Resolving power of grating} = \frac{\lambda}{d\lambda}}$$



AB represent plane transmission grating having grating element $(e+d)$ and total number of slits $= N$

consider beam of light having two wavelength λ & $\lambda+d\lambda$ incident on grating.

P_1 is nth maxima for λ, & P_2 is nth maxima for $\lambda+d\lambda$ at diffracting angle $(\theta+d\theta)$.

Principal maxima of λ in the θ direction

$$(e+d)\sin\theta = n\lambda \quad \text{—(1)}$$

The equation of minima is

$$N(e+d)\sin\theta = m\lambda \quad \text{—(2)}$$

where m takes all integer except 0, N, 2N.... nN because of these value condition of maxima got.

So first minima adjacent to nth principal maxima in the direction $\theta+d\theta$ can be obtained by $m = (nN+1)$

Therefore first minima in direction $(\theta+d\theta)$ is given

$$N(e+d)\sin(\theta+d\theta) = (nN+1)\lambda$$

$$(e+d)\sin(\theta+d\theta) = \left(n+\frac{1}{N}\right)\lambda \quad \text{—(3)}$$

Principal maxima of $\lambda+d\lambda$ in direction of $\theta+d\theta$ is

$$(e+d)\sin(\theta+d\theta) = n(\lambda+d\lambda) \quad \text{—(4)}$$

dividing equation (3) by equation (4)

$$\left(n+\frac{1}{N}\right)\lambda = n(\lambda+d\lambda)$$

$$\cancel{n\lambda}+\frac{\lambda}{N} = \cancel{n\lambda}+nd\lambda$$

$$\frac{\lambda}{N} = nd\lambda$$

Resolving power, $\boxed{\frac{\lambda}{d\lambda} = nN}$

Thus resolving power is directly proportional to

(i) The order of spectrum n

(ii) the total number of lines on the grating 'N'. V.I

Question :→ What is Rayleigh criterion of resolution.? (2015-16, 2016-17, 2020-21)

Answer :→ According to Rayleigh, the two point sources or two equally intense spectral lines are just resolved by an optical instrument when the central maxima of the diffraction pattern due to one source falls exactly on the first minima of the diffraction

The equation of minima is

$$N(e+d)\sin\theta = m\lambda \quad \text{--- (2)}$$

where m takes all integer except 0, N, 2N .... nN because of these value of condition of maxima satisfy

So first minima adjacent to nth principal maxima in the direction $\theta+d\theta$ can be obtained by $m = (nN+1)$

Therefore first minima in direction $(\theta+d\theta)$ is given by

$$N(e+d)\sin(\theta+d\theta) = (nN+1)\lambda$$

$$(e+d)\sin(\theta+d\theta) = \left(n+\frac{1}{N}\right)\lambda \quad \text{--- (3)}$$

Principal maxima of $\lambda+d\lambda$ in direction of $\theta+d\theta$ is

$$(e+d)\sin(\theta+d\theta) = n(\lambda+d\lambda) \quad \text{--- (4)}$$

dividing equation (3) by equation (4)

$$\left(n+\frac{1}{N}\right)\lambda = n(\lambda+d\lambda)$$

$$\cancel{n\lambda}+\frac{\lambda}{N} = \cancel{n\lambda}+nd\lambda$$

$$\frac{\lambda}{N} = nd\lambda$$

Resolving power, $\boxed{\dfrac{\lambda}{d\lambda} = nN}$

Thus resolving power is directly proportional to

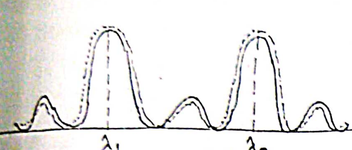
(i) The order of spectrum n

(ii) the total number of lines on the grating 'N'.

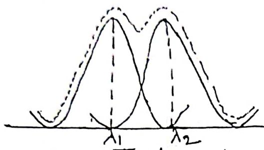
Question :→ What is Rayleigh criterion of resolution.? V.I

(2015-16, 2016-17, 2020-21)

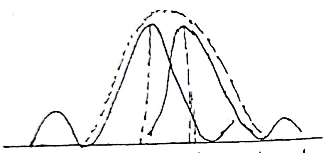
Answer :→ According to Rayleigh, the two point sources or two equally intense spectral lines are just resolved by an optical instrument when the central maxima of the diffraction pattern due to one source falls exactly on the first minima of the diffraction pattern of the other and vice-versa.



Fully resolved



Just resolved



Not resolved.

Question :→ Define dispersive power of plane transmission diffraction grating. (2017-18, 2018-19, 2019-20)

Answer :→ Dispersive power :→ The dispersive power of a diffraction grating is defined as the rate of change of the angle of diffraction with the change in the wavelength of light.

$$\boxed{\omega = \frac{d\theta}{d\lambda}}$$

For plane diffraction grating

$$(e+d)\sin\theta = n\lambda \quad \text{——— (1)}$$

Differentiate this equation with respect to λ,

$$(e+d)\cos\theta \frac{d\theta}{d\lambda} = n$$

$$\frac{d\theta}{d\lambda} = \frac{n}{(e+d)\cos\theta}$$

$$\frac{d\theta}{d\lambda} = \frac{n}{(e+d)(1-\sin^2\theta)^{1/2}} \quad \text{——— (2)}$$

From equation (1)

$$\sin\theta = \frac{n\lambda}{(e+d)}$$

Substitute the above value of $\sin\theta$ in eqn (2),

$$\boxed{\frac{d\theta}{d\lambda} = \frac{n}{(e+d)\left[1-\left(\frac{n\lambda}{e+d}\right)^2\right]^{1/2}}}$$

→ ω is directly proportional to order of spectrum.
→ ω is inversely proportional to $(e+d)$.
→ ω is inversely proportional to the $\cos\theta$, i.e larger the value of θ, higher is the dispersive power.

Question :→ A diffraction grating used at normal incidence gives a yellow line ($\lambda = 6000 Å$) in a certain spectral order superimposed on a blue line ($\lambda = 4800 Å$) of next higher order. If the angle of diffraction is $\sin^{-1}\left(\frac{3}{4}\right)$. Calculate the grating element. V.Imp (2015-16)

Answer :→ The direction of principal maxima for normal incidence for wavelength λ_1 is

$$(e+d)\sin\theta = n\lambda_1 \quad \text{--- (1)}$$

Let n^{th} order of λ_1 coincide with $(n+1)^{th}$ order of λ_2, then

$$(e+d)\sin\theta = n\lambda_1 = (n+1)\lambda_2$$

$$n = \frac{\lambda_2}{\lambda_1 - \lambda_2}$$

From equation (1)

$$(e+d)\sin\theta = \frac{\lambda_2}{(\lambda_1-\lambda_2)} \cdot \lambda_1$$

$$(e+d)\sin\theta = \frac{\lambda_1\lambda_2}{\lambda_1-\lambda_2}$$

$$(e+d) = \frac{\lambda_1\lambda_2}{(\lambda_1-\lambda_2)\sin\theta}$$

$$(e+d) = \frac{6000\times10^{-10}\times4800\times10^{-10}}{(6000-4800)\times10^{-10}\times\left(\frac{3}{4}\right)}$$

$$(e+d) = \frac{\cancel{6000}^{2000}\times\cancel{4800}^{4}\times4\times10^{-10}}{\cancel{1200}\times\cancel{3}}$$

$$(e+d) = 32000\times10^{-10}\,m$$

$$\boxed{e+d = 3.2\times10^{-6}\,m}$$

Question :→ Light of wavelength 5500 Å falls normally on slit of width 22.0×10^{-5} cm. Calculate the angular position of two minima on either of central maxima. (2015-16)

Answer :→ For single slit diffraction, the angular position of minima is

$$e\sin\theta = n\lambda$$

$$\sin\theta = (2\lambda/e) \qquad (n=2)$$

$$\theta = \sin^{-1}\left(\frac{2\lambda}{e}\right)$$

$$\theta = \sin^{-1}\left(\frac{2\times5500\times10^{-10}}{22\times10^{-5}\times10^{-2}}\right)$$

$$\theta = 30^\circ \quad \text{Ans.}$$

Question :→ A light of wavelength 6000 Å falls normally on a slit of width 0.10 mm. Calculate total angular width of the central maximum. (2017-18)

Ans :→ $\lambda = 6000 Å = 6000\times10^{-10}m$

slit width $e = 0.10mm = 0.1\times10^{-3}m$

Angular width of central maxima,

$$\sin\theta = \frac{\lambda}{e} \qquad (n=1)$$

$$\theta = \sin^{-1}\frac{6000\times10^{-10}}{0.1\times10^{-3}}$$

$$\theta = \sin^{-1}(6000\times10^{-6})$$

$$\theta = \sin^{-1}(6\times10^{-3})$$

Question :→ A diffraction grating used at normal incidence gives a green line ($\lambda = 5450\,Å$) in a certain spectral order superimposed on a voilet-line ($\lambda = 4100\,Å$) of next higher order. If the angle of diffraction is 30, then how many lines per cm are there in grating? (2015-16).

Ans :→ For grating $(e+d)\sin\theta = n\lambda$ ——— (1)

n^{th} order maxima of λ_1 coincide with $(n+1)^{th}$ of λ_2.

$$(e+d)\sin\theta = n\lambda_1 = (n+1)\lambda_2$$

$$\lambda_1 n = (n+1)\lambda_2$$

$$n = \frac{\lambda_2}{\lambda_1 - \lambda_2}$$

Put this value in eqn (1)

$$(e+d)\sin\theta = \frac{\lambda_1\lambda_2}{(\lambda_1-\lambda_2)}$$

$$(e+d) = \frac{\lambda_1\lambda_2}{\sin\theta(\lambda_1-\lambda_2)} = \frac{5450\times10^{-10}\times4100\times10^{-10}}{(5450-4100)\times10^{-10}\times\sin30}$$

$$(e+d) = \frac{5450\times4100\times10^{-10}}{1350\times\left(\frac{1}{2}\right)}$$

$$(e+d) = \frac{22345\times10^{-7}\times2}{1350}$$

$$(e+d) = 33.10\times10^{-7}\,m \quad \text{Ans.}$$

Number of lines per m $= \frac{1}{(e+d)}$

$$= \frac{1}{33.10\times10^{-7}}$$

$$= 0.030\times10^{7}$$

$$= 3.0\times10^{5} \quad \text{Ans.}$$

No of line/cm

$$= \frac{1}{33.10\times10^{-5}}$$

$$= 0.030\times10^{5}$$

$$= 3.0\times10^{3}$$

Question :→ A plane transmission grating has 15000 line per inch. Find the resolving power of grating and the smallest wavelength difference that can be resolved with a light of 6000 Å wavelength in second order. (2016-17) Imp

Ans :→ The number of line per inch on the grating = 15000 and $n = 2$

Resolving power, $\frac{\lambda}{d\lambda} = nN$

$$= 2\times15000$$

$$\frac{\lambda}{d\lambda} = 30{,}000 \quad \text{Ans}$$

Smallest wavelength difference ($d\lambda$) is given by

$$\frac{\lambda}{d\lambda} = nN$$

$$d\lambda = \frac{\lambda}{nN}$$

$$= \frac{6000\times10^{-8}}{30000} = \frac{1}{5}\times10^{-8}\,cm$$

$$= 0.2\times10^{-8}\,cm$$

$$d\lambda = 0.20\,Å \quad \text{Ans.}$$

Question :→ Find the angular separation of 5048 Å and 5016 Å wavelength in second order spectrum obtained by a plane diffraction grating having 15000 lines per inch. (2018-19)

Ans :→ Here $\lambda_1 = 5016\,Å = 5016\times10^{-8}\,cm$

$\lambda_2 = 5048\,Å = 5048\times10^{-8}\,cm$

$n = 2$

$$e+d = \frac{2.54}{15000}\,cm = 1.69\times10^{-4}\,cm$$

we know that nth order spectrum obtained by plane diffraction grating the angular separation $d\theta$ is

$$d\theta = \frac{n\,d\lambda}{\sqrt{(e+d)^2-(n\lambda)^2}}$$

$$d\theta = \frac{n\,d\lambda}{(e+d)}$$

$$d\lambda = \lambda_2-\lambda_1 = (5048-5016)\times10^{-8}\,cm$$

$$d\lambda = 32\times10^{-8}\,cm$$

$$\therefore\quad d\theta = \frac{2\times32\times10^{-8}}{1.69\times10^{-4}}$$

$$\boxed{d\theta = 3.79\times10^{-4}\ \text{radian}}$$

Question :→ In a greeting spectrum, which spectral line in 4th order will overlap with 3rd order line of 5461 Å. (2018-19)

Ans :→ we know grating equation

$$(e+d)\sin\theta = n\lambda$$

If the nth order of wavelength λ_1 coincides with the $(n+1)^{th}$ order of λ_2, then

$$(e+d)\sin\theta = n\lambda_1 = (n+1)\lambda_2$$

For $n=3$, $\lambda_1 = 5461\,Å = 5461\times10^{-8}\,cm$

$(n+1)=4$

$$\lambda_2 = \frac{n\lambda_1}{(n+1)}$$

$$= \frac{3\times5461\times10^{-8}}{4}$$

$$\lambda_2 = 4096\times10^{-8}\,cm$$

$$\boxed{\lambda_2 = 4096\,Å}$$

Question :→ A plane transmission grating has 16000 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

(ii) small wavelength difference that can be resolved. (2019-20) Imp

Ans :→ we know resolving power of grating

$$\frac{\lambda}{d\lambda} = nN$$

$$d\lambda = \frac{\lambda}{nN} \quad \text{——(1)}$$

Number of lines/inch = 16000

length of grating = 5 inches.

Therefore, the total number of lines on the grating i.e. $N = 5\times16000 = 80000$

(ii) $\lambda = 6000\,Å = 6000\times10^{-8}\,cm$, $n=2$

$$d\lambda = \frac{\cancel{6000}\times10^{-8}}{2\times80\cancel{000}}$$

$$d\lambda = \frac{3\times10^{-8}}{80}$$

$$d\lambda = 0.0375\times10^{-8}\,cm$$

$$\boxed{d\lambda = 3.75\times10^{-10}\,cm}$$

(i) Resolving power

$$\frac{\lambda}{d\lambda} = 2\times80000$$

$$= 16\times10^4$$

5 Years AKTU University Examination Questions		Unit: III	
S. No	Questions	Session	Lecture No
1	Write the main condition for sustained interference.	2015-16	25
2	What happens when Young double slit experiment immersed in water.	2015-16	25
3	Two independent sources cannot produce interference. Why?	2015-16, 2018-19, 2020-21	25
4	Discuss the phenomenon of interference in thin film due to reflected light.	2015-16	26
5	Discuss the phenomenon of interference of light due to thin films and find the conditions of maxima and minima. Show that reflected and transmitted systems are complementary in thin films.	2018-19	26
6	Discuss the formation of interference fringes due to a wedge shaped film seen by normally reflected monochromatic light and derive an expression for fringe width in wedge shaped films.	2015-16, 2017-18	26
7	Explain the factor responsible for changing fringe width in wedge shaped thin film.	2016-17	26
8	Explain the necessity of extended sources.	2018-19	27
9	What are Newton's rings?	2015-16, 2018-19	27
10	Why the centre of Newton's ring is dark in reflected system?	2015-16	27
11	What do you understand by Newton's ring? Explain their experimental arrangement. How can you determine the wavelength of light with this experiment?	2016-17	27
12	Show that diameter for bright rings are proportional to square root of odd natural number and for dark ring diameters are proportional to square root of natural number.	2018-19, 2019-20	27
13	Explain the formation of Newton's ring. Prove that in reflected light the diameter of dark rings are proportional to the square root of natural numbers.	2018-19, 2019-20	27
14	Calculate the thickness of soap bubble thin film that will result in constructive interference in reflected light. The film is illuminated with light of wavelength 5000Å and refractive index of film is 1.45.	2020-21	28
15	Light of wavelength 6000 Å falls normally on a thin wedge shaped film of refractive index 1.4 forming the fringes that are 2 mm apart. Find the angle of wedge.	2018-19	28
16	If in a Newton's ring experiment, the air in the inter space is replaced by a liquid of refractive index 1.33 in what proportion would the diameter of the rings changed?	2015-16	28
17	In Newton's ring experiment the diameter of 4th and 12th dark ring are 0.4 cm and 0.7 cm respectively. Deduce the diameter of 20th dark ring.	2015-16	28
18	Two plane glass surfaces in contact along one edge are separated at the opposite edge by a thin wire. If 25 interference fringes are observed between these edges in sodium light of wavelength 5898 A^0 of normal incidence, then find the thickness of the wire.	2015-16	28
19	Obtain intensity expression for single slit Fraunhofer diffraction pattern.	2015-16	29

20	Discuss the phenomena of Fraunhofer's diffraction at a slit and show that relative intensities of the successive maximas are nearly $1:(4/9\pi^2):(4/25\pi^2):\ldots\ldots$	2015-16, 2018-19, 2018-19	29
21	Obtain an expression for the intensity distribution due to Fraunhofer diffraction at a single slit.	2017-18	29
22	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.	2019-20	29
23	What happen to diffraction pattern when slit width of single slit experiment increases?	2016-17	29
24	What will be the effect on the intensity of principle maxima of diffraction pattern when single slit is replaced by double slit?	2015-16	30
25	Give the construction and theory of plane transmission grating? Explain the formation of spectra by it.	2015-16	30
26	Give the construction and theory of plane transmission grating.	2017-18	30
27	What do you understand by grating?	2018-19	30
28	What is diffraction grating? Discuss the phenomena of diffraction due to plane diffraction grating.	2020-21	30
29	What do you understand by missing order spectrum? What particular spectra would be absent if the width of transparencies twice of opacities of grating?	2015-16, 2016-17	31
30	What particular spectra would be absent if the width of the transparencies and opacities of the grating are equal.	2018-19	31
31	Explain the formation of spectra by diffraction grating.	2015-16, 2017-18	31
32	What do you mean by resolving power on an optical instrument?	2018-19	31
33	What is a Rayleigh criterion of resolution?	2015-16, 2016-17	31
34	State Rayleigh criterion of resolution .Also define resolving power.	2020-21	31
35	Show the intensity ration of mass $\frac{I_{mid}}{I_{max}}$ for resolution limit.	2015-16	31
36	What is resolving power of grating?	2015-16	31
37	Define dispersive power of a plane transmission diffraction grating.	2017-18, 2018-19, 2019-20	31
38	A diffraction grating used at normal incidence gives a yellow line (λ = 6000Å) in a certain spectral order superimposed on a blue line (λ = 4800Å) of next higher order. If the angle of diffraction is sin-1(3/4), calculate the grating element.	2015-16	32
39	Light of wavelength 5500 A falls normally on slit of width 22.0 $\times 10^{-5}$ cm. Calculate the angular position of two minima on either side of central maxima.	2015-16	32
40	A light of wavelength 6000Å falls normally on a slit of width 0.10 mm. Calculate thetotal angular width of the central maximum.	2017-18	32
41	A diffraction grating used at normal incidence gives a green line (λ = 5450Å) in a certain spectral order superimposed on a violet line (λ = 4100Å) of next higher order. If the angle of diffraction is 30°, then how many lines per cm are there in grating?	2015-16	32
42	A plain transmission grating has 15000 lines per inch. Find the resolving power of grating and the smallest wavelength difference	2016-17	32

	that can be resolved with a light of 6000Å in the second order.		
43	A light of wavelength 6000Å falls normally on a slit of width 0.10 mm. Calculate the total angular width of the central maximum.	2017-18	32
44	Find the angular separation of 5048 A and 5016 A wavelength in second order spectrum obtained by a plane diffraction grating having 15000 lines per inch.	2018-19	
45	In a grating spectrum, which spectral line in 4^{th} order will overlap with 3^{rd} order line of 5461Å?	2018-19	32
46	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.	2019-20	32

5 Years AKTU University Examination Questions		Unit-3	
S. No	Questions	Session	Lecture No
1	Describe energy distribution in black body radiation?	2016-17	17-26
2	What is Wien's law?	2016-17 2017-18	17-26
3	State Wien's displacement law and Rayleigh-jeans law?	2020-21	17-26
4	Write the assumptions of Planck's hypothesis.	2018-19	17-26
5	Derive Planck's radiation law. Show that Planck's formula for the energy distribution in a thermal spectrum is applicable for all wavelengths.	2017-18	17-26
6	Derive Planck's law of radiation. How does it explain Wien's displacement and Rayleigh jeans law?	2018-19	17-26
7	What is the concept of de-Broglie matter waves	2017-18	17-26
8	Interpret Bohr's quantization rule on the basis of de-Broglie concept of matter wave	2019-20	17-26
9	What are matter waves associated with a particle generated when only it is in motion?	2020-21	17-26
10	What is the difference between electromagnetic wave and matter wave?	2019-20	17-26
11	Determine the de-Broglie wavelength of photon.	2018-19	17-26
12	Give physical interpretation of wave function. Also explain eigenvalue and eigenfunction?	2016-17 2018-19	17-26
13	Show that $\Psi(x,y,z,t) = \Psi(x,y,z,t)\ e^{iwt}$ is a function of stationary state	2018-19	17-26
14	Derive time independent Schrodinger wave equation	2016-17 2020-21	17-26
15	Obtain time dependent and time independent wave equation?	2018-19	17-26
16	Find an expression for the energy states of a particle in a one – dimensional box.	2017-18	17-26
17	Write down Schrodinger wave equation for particle in a one-dimensional box and solved it to find out the Eigen value and Eigen function.	2019-20	17-26
18	A particle is in motion along a line X=0 and X=L with zero potential energy.At point for which X<0 and X>L,the potential energy is infinite.Solving Schrodinger equation obtain energy eigenvalues and Normalized wavefunction for the particle.	2018-19	17-26
19	Explain the modified and unmodified radiations in Compton scattering?	2016-17	17-26
20	What is Compton effect? Derive the necessary expression for Compton shift.	2018-19 2020-21 2016-17	17-26
21	What is Compton effect? Derive a suitable expression for Compton shift $\lambda' - \lambda = \frac{h}{m_0 c}(1 - \cos\theta)$.	2018-19	17-26
22	What is Compton Effect? How does it support the photon nature of light?	2019-20	17-26

23	Calculate the energy of oscillator of frequency 4.2×10^{12} Hz at 27^0 C treating it as (a) classical oscillator (b) Planck's oscillator.	2018-19	17-26
24	Calculate the de-Broglie wavelength of a neutron having kinetic energy of 1eV. (Mass of the neutron = 1.67×10^{-27} kg, h= 6.62×10^{-34} Joule sec)	2019-20	17-26
25	Determine the probability of finding a particle trapped in a box of length L in the region from 0.45L to 0.55L for the ground state.	2017-18	17-26
26	Find the two lowest permissible energy states for an electron which is confined in one dimensional infinite potential box of width 3.5×10^{-9} m	2020-21	17-26
27	X-rays of Wavelength 2 Å are Scattered from a black body and x-rays are scattered at an angle of 450.Calculate Compton shift, wavelength of scattered photon λ'.	2018-19	17-26