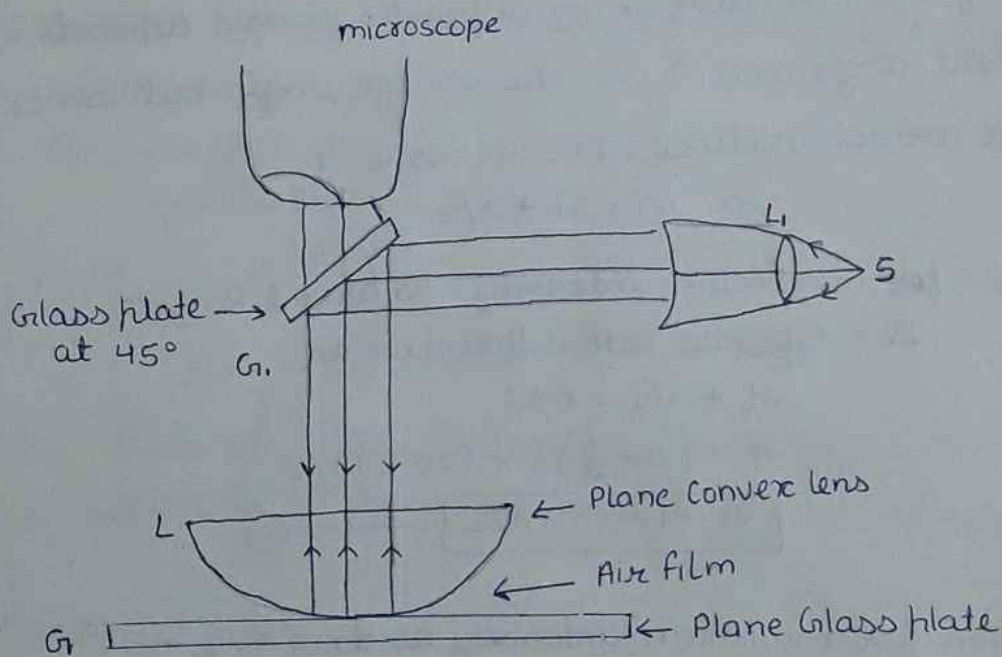


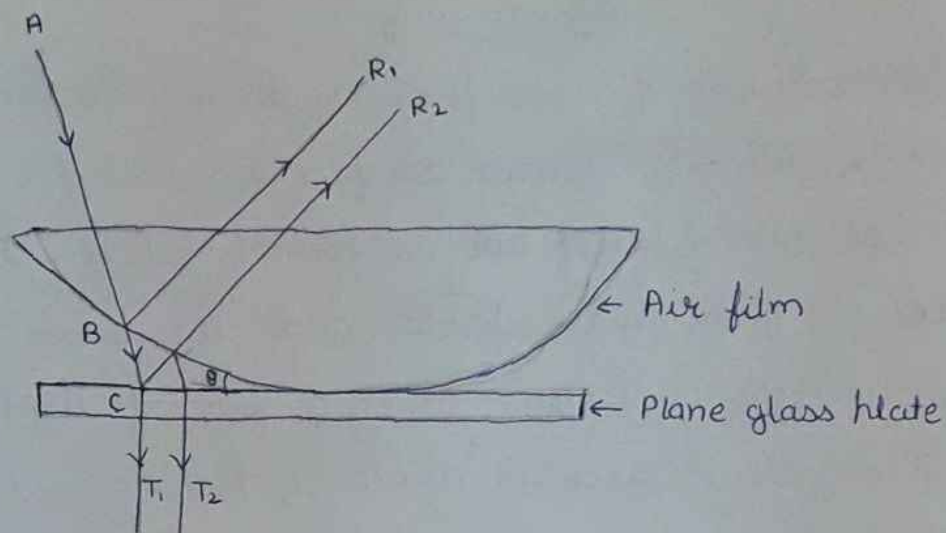
Newton's ring

①

When a convex lens of long focal length is placed on a plane glass plate with its convex surface in contact with glass plate, a thin film of air is formed between the upper surface of plane glass plate and the lower surface (convex surface) of lens. When a beam of light from a monochromatic source is made to fall normally on the combination of convex lens and plane glass plate. The fringes are circular because the air film has a circular symmetry. These are known as Newton's ring. These rings are formed due to the interference between the wave reflected from the top and bottom surfaces of the air film.



S is a source of monochromatic light. A horizontal beam of light falls on the glass plate G_1 at 45° .



AB is the incident ray and R_1 and R_2 are the reflected rays which produce interference. The path difference between the reflected rays R_1 and R_2 is

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

Here μ is refractive index of the film for air $\mu=1$, t is the thickness of the air film, r is refracting angle depends upon the incident angle and θ is the wedge angle but since θ small

For normal incidence, $r=0 \Rightarrow \cos r = 1$

$$\text{so } \Delta = 2t + \lambda/2$$

(a) Condition for maximum intensity as bright Rings -

$$\Delta = \text{Effective path difference} = n\lambda$$

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

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

$$\boxed{2t = (2n-1)\lambda/2} \quad \text{--- (1)}$$

(b) Condition for minimum intensity as dark rings -

$$\Delta = \text{path difference} = (2n+1)\lambda/2$$

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

$$\boxed{2t = n\lambda} \quad \text{--- (2)}$$

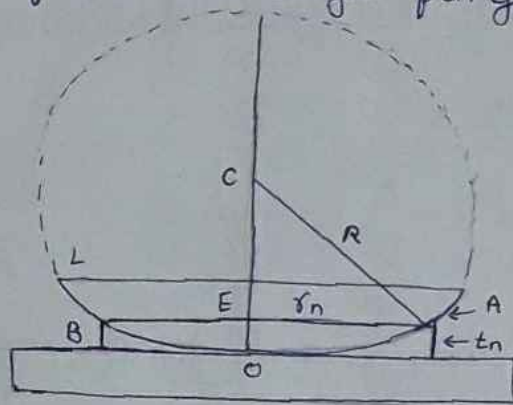
(c) Condition for central spot -

(3)

At the point of contact between the lens and the plate $t=0$

Therefore the path difference is $\lambda/2$ and we get a dark spot at the centre.

(d) Diameter of dark and bright fringes



Let AOB is a vertical section of the convex lens surface with its centre of curvature at C having radius of curvature $CA=R$. The thickness of air film at A is t_n where the interference fringe at radius $r_n=EA$ is formed.

from Pythagoras theorem

$$(EA)^2 = (CA)^2 - (CE)^2$$

$$r_n^2 = R^2 - (CO - EO)^2$$

$$= R^2 - (R - t_n)^2$$

$$r_n^2 = 2Rt_n - t_n^2$$

Since the thickness of air is negligible in comparison of the radius of curvature of lens, so neglecting t_n^2 in comparison of $2Rt_n$.

$$\therefore r_n^2 = 2Rt_n$$

Hence diameter of n^{th} ring is

$$D_n = 2r_n$$

$$= 2\sqrt{2Rt_n}$$

$$= \sqrt{8Rt_n} \text{ ————— (3)}$$

dark fringes

$$2t = n\lambda \text{ — (2)}$$

(1) Diameter of dark rings -

for dark fringes from eqⁿ(2) and eqⁿ(3)

$$D_n = 2\sqrt{n\lambda R}$$

Thus diameter of dark fringes is directly proportional to the under roots of (i) n positive natural integer

(ii) wavelength λ of light used (iii) the radius of curvature R of the lens

(ii) Diameter of bright rings -

from eqⁿ(1) and (3)

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

Thus the diameter of bright ring is directly proportional to the square root of (i) positive odd integer $(2n-1)$.

-----xxxx-----

(A) Determination of wave length of Monochromatic light using Newton's

Rings:-

from eqⁿ(4) the diameter of n^{th} dark ring is given by

$$D_n^2 = 4nR\lambda \text{ --- (6)}$$

Similarly the diameter of $(n+p)^{\text{th}}$ dark ring is given by

$$D_{n+p}^2 = 4(n+p)R\lambda \text{ --- (7)}$$

subtracting eqⁿ(7) & (6)

$$\begin{aligned} D_{n+p}^2 - D_n^2 &= 4(n+p)R\lambda - 4nR\lambda \\ &= 4pR\lambda \end{aligned}$$

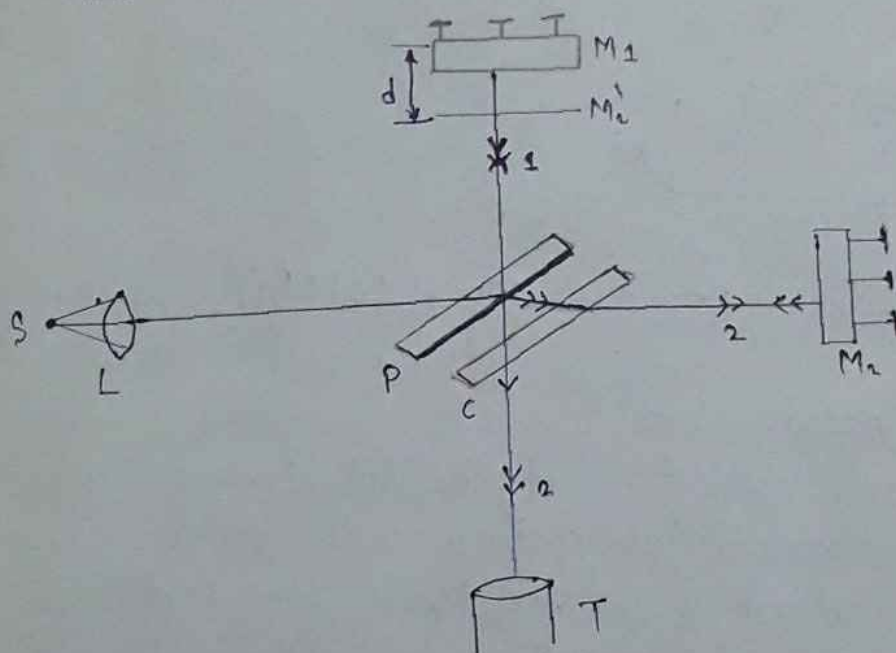
$$\boxed{\lambda = \frac{D_{n+p}^2 - D_n^2}{4pR}}$$

for air film $\mu = 1$

Michelson's Interferometer :-

Principle & Working :- When a beam of light from a monochromatic source is incident on a half silvered glass plate, it is divided into two parts. One part is a reflected wave and other part is a refracted wave.

After reflection from mirrors (M_1 & M_2), when they superpose each other, they produce interference fringes. P & C, are two optically parallel glass plate of same thickness and same material at an angle of 45° .



The surface of plate P towards C is half silvered. There is no polish on the plate C. This plate is called Compensatory plate.

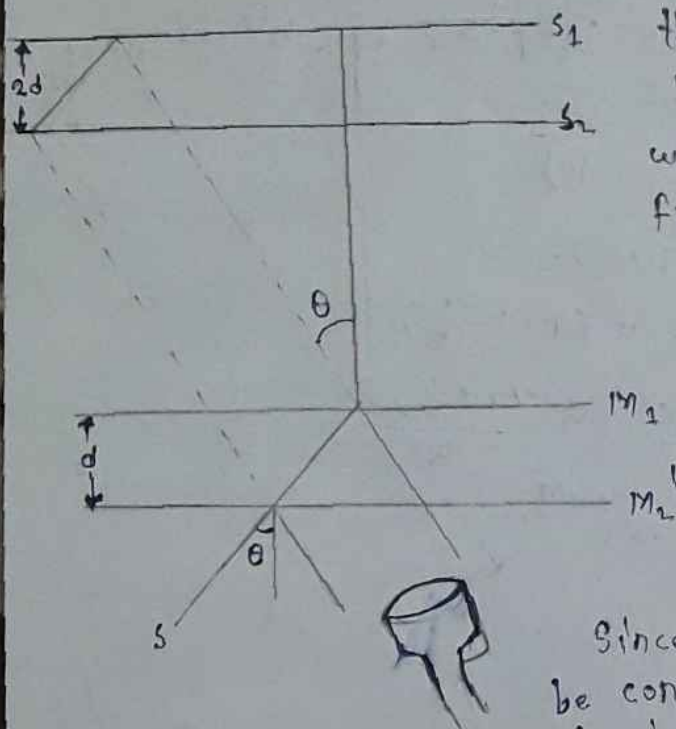
Action of compensatory plate :- In absence of plate C the reflected wave passes the plate P twice where as the refracted wave does pass even once through the plate P.

Therefore the optical path of the reflected and refracted waves not equal when mirrors M_1 & M_2 are at equal distance from plate P. In order to equalize the optical path of these waves a plate C is placed parallel to plate P.

This plate C is called compensatory plate.

formation of fringes :- In Michelson Interferometer the fringes may be straight, circular & elliptical depending upon distance between mirror M_1 & M_2 .

is Circular fringes :- Mirror M_1 is parallel to M_2 then the air film between M_1 & M_2 . If the



thickness of film is d , then light reflected from M_1 & M_2 will be look as if is coming from virtual sources S_1 & S_2 .

Distance between S_1 & S_2 is $2d$.

Then path difference

$$2d \cos \theta + \frac{\lambda}{2} = n\lambda \dots (i)$$

(maxima)

$$2d \cos \theta + \frac{\lambda}{2} = (2n+1) \frac{\lambda}{2} \dots (ii)$$

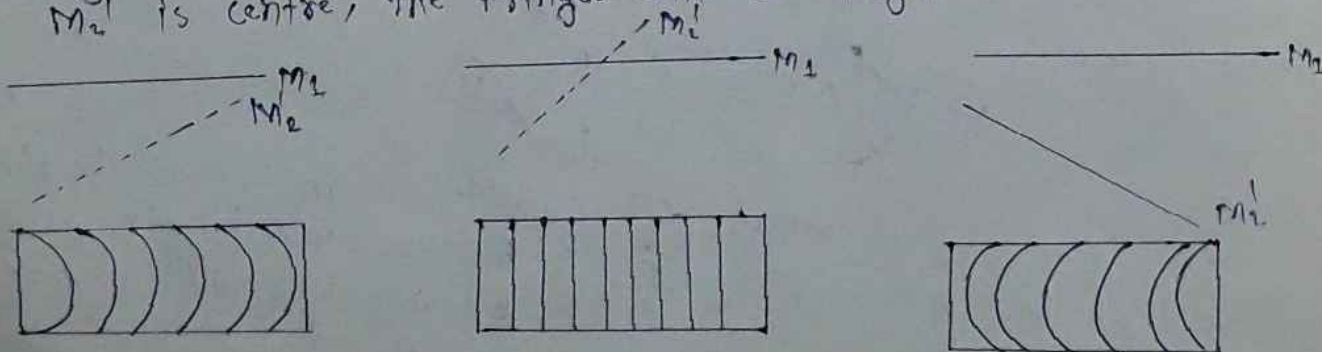
(minima)

Since for given value of n, λ, d, θ will be constant so fringes produced will be in the form of circle.

These fringes are called Haidinger's fringes.



ii) Localised fringes :- When mirror M_1 & M_2 are not perpendicular then M_1 & M_2 is wedge shape film is formed. These fringes are known as localised fringes. When M_1 intersects M_2 is centre, the fringes will be straight.



Determination of difference in wavelength between two nearly equal wavelengths: -

Let the light emitted by source with two wavelengths λ_1 & λ_2 , which are nearly equal. The fringe pattern formed by two wavelengths λ_1 & λ_2 is separate but as the difference between two wavelengths is very small then two pattern overlap. Let for λ_1 , n^{th} fringe coincides with $(n+1)^{\text{th}}$ fringe of λ_2 .

$$\therefore 2d \cos \theta \approx \frac{\lambda_2}{2} = n\lambda_1$$

$$\Rightarrow 2d = n\lambda_1 = (n+1)\lambda_2$$

$$\text{or } 2d = (n - \frac{1}{2})\lambda_1 = (n + 1 - \frac{1}{2})\lambda_2$$

$$d = \frac{(n - \frac{1}{2})\lambda_1}{2} = \frac{(n + \frac{1}{2})\lambda_2}{2}$$

$$(n - \frac{1}{2}) = \frac{2d}{\lambda_1} \dots \dots (1)$$

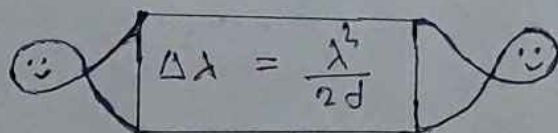
$$(n + \frac{1}{2}) = \frac{2d}{\lambda_2} \dots \dots (2)$$

$$\text{eq}^n(2) - \text{eq}^n(1)$$

$$\text{then } \frac{2d}{\lambda_2} - \frac{2d}{\lambda_1} = 1$$

$$2d \left(\frac{\lambda_1 - \lambda_2}{\lambda_1 \lambda_2} \right) = 1$$

$$\lambda_1 - \lambda_2 = \frac{\lambda_1 \lambda_2}{2d}$$



where $\Delta\lambda$ = difference in two wavelengths
 λ = Average wavelength
 d = distance by which mirror is moved

Determination of wavelength of monochromatic light by Michelson Interferometer:-

Now if mirror M_1 is placed through a distance d , then the path difference introduced in the path of rays will be $2d$.

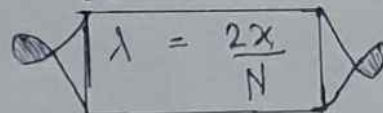
Let N fringes cross the field of view when the mirror M_2 is displaced through a distance x .

Hence $2d = n\lambda \dots\dots (1)$

$$2(d+x) = (n+N)\lambda \dots\dots (2)$$

(1) & (2)

$$2x = N\lambda$$

$$\lambda = \frac{2x}{N}$$


Diffraction :-

The phenomenon of bending of light waves around the obstacle and entering in the region of the geometrical shadow of the obstacle, is called diffraction of light.

Dependence of the diffraction of waves on the size of the obstacle and the wavelength of the waves.

Types OF Diffraction :

i) fresnel diffraction :- When the light source and the observation point are at finite distance from the obstacle, diffraction so produced is called Fresnel diffraction.

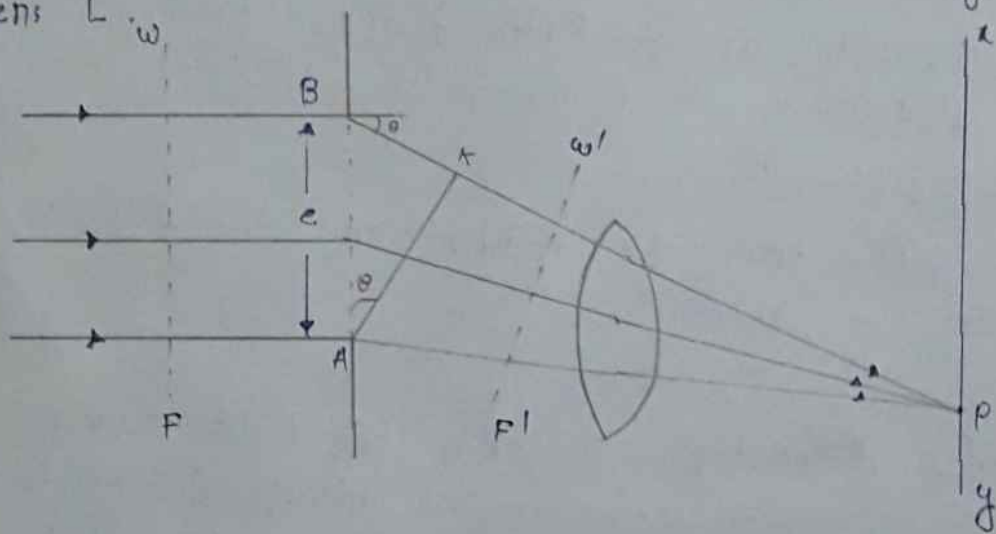
In this diffraction the incident and the diffracted wavefronts are spherical.

ii) fraunhofer diffraction :- When the light source and observation point are at infinite distance from the obstacle that is, the incident and diffracted wavefronts are plane, diffraction so produced is called fraunhofer diffraction.

Fraunhofer Diffraction at a Single Slit :-

(2)

Let a plane wavefront WF produced by a monochromatic light source of wavelength λ be incident upon a slit AB of width e . According to Huygen's wave theory each point of the wavefront at the slit AB acts as a secondary source of light and sends out secondary wavelets in forward directions. Now consider those wavelets which are diffracted at an angle θ from the direction of incident ray. The diffracted plane wavefront $W'F'$ is incident at a point P on the screen by a convex lens L .



To determine the resultant intensity at the point P , [let us consider a large number of secondary sources on the wavefront at the slit AB which emit wavelets of same phase and same amplitude a .]

Thus path difference between the wavelets generated at A & B is given by

$$BK = e \sin \theta$$

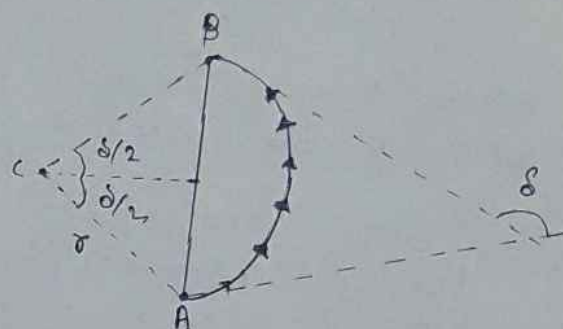
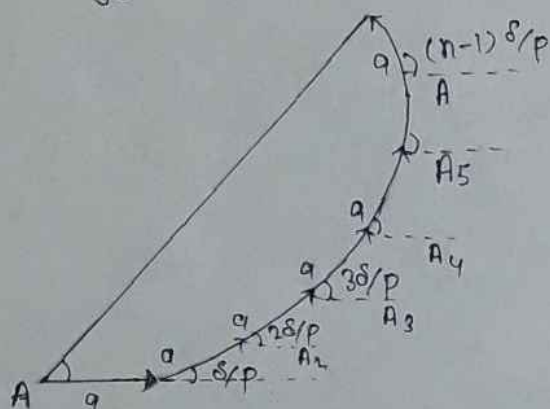
As, AK is perpendicular to BK and the optical paths from the AK to P are equal. Then phase difference

$$= \frac{2\pi}{\lambda} (BK) = \frac{2\pi}{\lambda} e \sin \theta = \delta \text{ (let)} \dots (1)$$

Let the width AB of the slit be divided into p equal parts. The amplitude of wavelets at P due to the wavelets from each part will be the same (suppose a) but their initial phase increases gradually from A to B in steps of δ/p .

The resultant amplitude due to all equal parts of slit AB at the point P can be determined by the method of vector addition of amplitude.

(Polygon Method)



Now construct a polygon of each side of length a representative the amplitude of wavelets coming from a small part of the slit AB and keeping the phase angle δ/p between the successive amplitude vector of the wavelets.

Resultant amplitude vector is represented by $\vec{AB}$ due to all the wavelets. The phase difference between the first and the last amplitude vector is δ which will be equal to the tangents drawn at the points A & B .

$$\text{Angle } \delta = \frac{\text{arc } AB}{\text{radius}} = \frac{Pa}{r}$$

$$r = \frac{Pa}{\delta} \dots (2)$$

Now a perpendicular CG is drawn from the centre C of arc on the line AB which will bisect the line AB in two equal parts.

$$\text{Thus } \angle ACG = \angle BCG = \delta/2$$

$$\text{and } \sin \delta/2 = \frac{AG}{r}$$

$$\therefore \text{length of line } AB, AB = 2AG = 2r \sin \delta/2 \dots (3)$$

Substituting the value of r in eqⁿ (3) we have

$$A = \frac{2P_0}{\delta} \sin \frac{\delta}{2} = P_0 \frac{\sin \delta/2}{\delta/2}$$

$$= P_0 \frac{\sin \alpha}{\alpha}$$

where $\alpha = \delta/2 = \pi \sin \theta / \lambda$ {from eqⁿ (1)}

Hence the resultant intensity at point P

$$I = KA^2 = KP_0^2 \frac{\sin^2 \alpha}{\alpha^2}$$

$$\boxed{I = I_0 \frac{\sin^2 \alpha}{\alpha^2}} \quad \dots (4)$$

where $I_0 = KA_0^2 = KP_0^2$ is the maximum intensity, at the point where all the waves reach in the same phase.

(i) Central Maximum :-

For the central point O on the screen i.e. $\theta = 0$ and hence $\delta = 0$ or $\alpha = 0$

$$\lim_{\alpha \rightarrow 0} \frac{\sin \alpha}{\alpha} = 1$$

Hence intensity at O

$$I = I_0 \left(\frac{\sin \alpha}{\alpha} \right)^2 = I_0 = \text{maximum intensity} \dots (5)$$

The maximum intensity at $\theta = 0$ is called central maximum.

(ii) Principal minima :-
from eqⁿ (4)

$$I = 0 \text{ if } \sin \alpha = 0$$

Thus for minimum intensity $\sin \alpha = \sin \frac{\delta}{2} = 0$ but $\alpha \neq 0$

$$\frac{\delta}{2} = \pm \pi, \pm 2\pi$$

$$\delta = \pm 2n\pi$$

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

from eqⁿ (1) $\delta = \frac{2\pi \sin \theta}{\lambda} = \pm 2n\pi$

$$\sin \theta = \pm n\lambda \quad \dots (6)$$

Thus the positions of I^{st} , I^{nd} , I^{rd} , ... etc. minima are given by $\pm \lambda/2$, $\pm 2\lambda/2$, $\pm 3\lambda/2$, ... from various value of $\sin \theta$.

(iii) Secondary Maxima :- To find other direction of maximum intensity differentiate eq (4) with respect to α and equate to zero.

Thus

$$\frac{dI}{d\alpha} = 0$$

$$\frac{d}{d\alpha} (\pm \sin^2 \frac{\alpha}{2}) = 0$$

$$\pm \left[\sin^2 \alpha \left(-\frac{2}{\alpha^3} \right) + \frac{1}{\alpha^2} (2 \sin \alpha \cos \alpha) \right] = 0$$

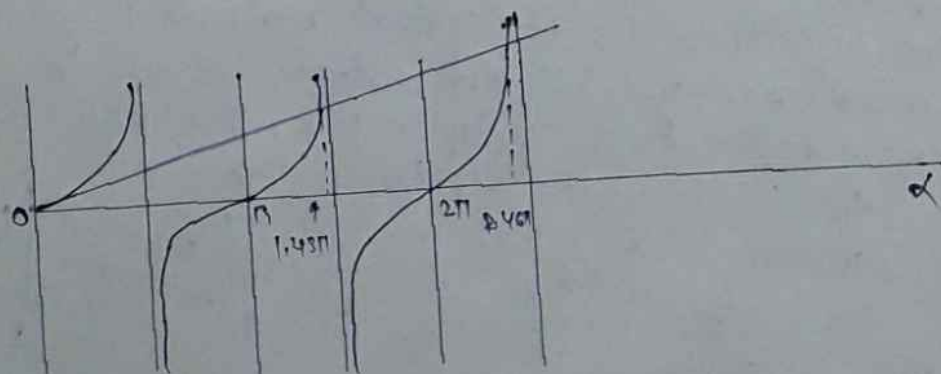
$$\pm \frac{2 \sin \alpha}{\alpha^3} (\alpha \cos \alpha - \sin \alpha) = 0$$

Hence either $\sin \alpha = 0$ or $\alpha \cos \alpha - \sin \alpha = 0$
 Since $\sin \alpha = 0$ gives the positions of minimum intensity,
 so for the secondary maxima

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

$$\tan \alpha = \alpha \quad \dots \dots (7)$$

This is the condition of secondary maxima & can be solved by plotting graphs for $y = \alpha$ & $y = \tan \alpha$ taking α as x-coordinate. The curve $y = \alpha$ is a straight line passing through the origin & inclined to x-axis at 45° and the curves $y = \tan \alpha$ are the discontinuous curve from $y = -\infty$ to $y = \infty$.



The point of intersections of the two curve give the solⁿ of eqⁿ (7). The solⁿ of eqⁿ (7) are $0, \pm 1.43\pi, \pm 2.46\pi, \pm 3.47\pi, \dots$
 $\alpha = 0$ shows the position of central maximum.

Thus for other secondary maxima

$$\alpha = \pm 1.43\pi, \pm 2.46\pi, \pm 3.47\pi, \dots$$

$$= \pm 3\frac{1}{2}\pi, 5\frac{1}{2}\pi, \pm 7\frac{1}{2}\pi, \dots$$

$$= \pm (2n+1)\frac{1}{2}\pi \quad \text{where } n = 1, 2, 3, \dots$$

or $e \sin \theta = \pm (2n+1) \frac{\lambda}{2}$ from eqⁿ (1) $\{ \alpha = \delta/2 \}$

Substituting (put) the value of α in eqⁿ (4)

The intensity of Secondary maxima is given by

$$I = \frac{4I_0}{(2n+1)^2 \pi^2} \dots \dots (8)$$

(a) for first Secondary maximum

$$\alpha = \pm \frac{3\pi}{2} = \frac{\pi e \sin \theta}{\lambda}$$

$$e \sin \theta = \pm 3 \frac{\lambda}{2} \dots \dots (9)$$

The intensity of first Secondary maximum

$$I = I_0 \left[\frac{\sin(3\pi/2)}{(3\pi/2)} \right]^2 = \frac{4I_0}{9\pi^2} = \frac{I_0}{22} \dots \dots (10)$$

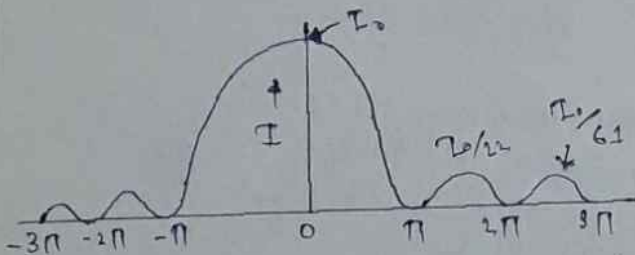
(b) For Secondary Secondary maximum :-

$$\alpha = \pm \frac{5\pi}{2} = \frac{\pi e \sin \theta}{\lambda}$$

$$e \sin \theta = \pm 5 \frac{\lambda}{2}$$

The intensity of second Secondary maximum

$$I = I_0 \left[\frac{\sin(5\pi/2)}{(5\pi/2)} \right]^2 = \frac{4I_0}{25\pi^2} = \frac{I_0}{61} \dots \dots (11)$$



Width of central maximum :- The distance between the first minima on either side of central maximum is called width of central maximum. If the distance between the central maximum & the first minimum is x , then $\sin \theta = x/f$.

Where f is the focal length of the convex lens.

[But $\sin \theta = \pm \lambda/e$

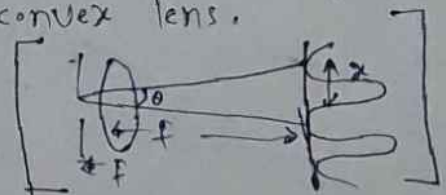
$$\sin \theta = \frac{x}{f} = \pm \lambda/e$$

$$x = \pm \frac{\lambda f}{e}$$

$\therefore$ The width of central maximum, $2x = \frac{2\lambda f}{e}$

The angular width of central maximum

$$\theta = \frac{2x}{f} = \frac{2\lambda}{e}$$

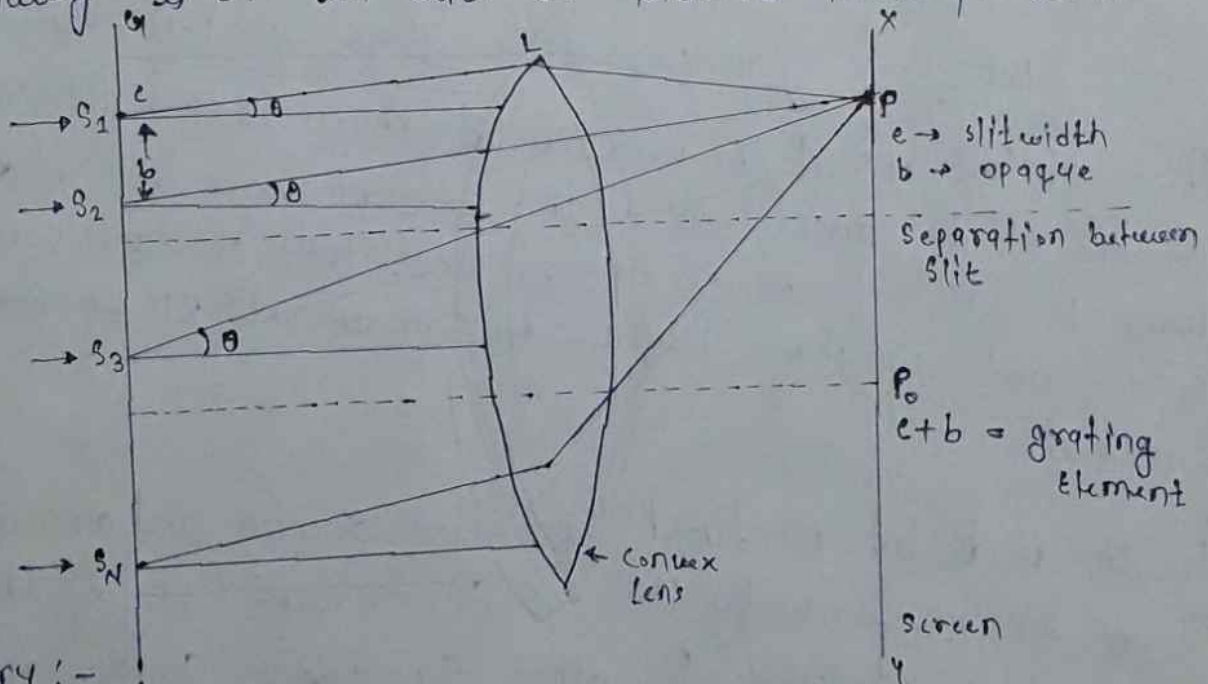


Thus it is clear that the width of central maximum is proportional to the wavelength of incident light and inversely proportional to the width of the slit

Plane transmission grating:-

7

A Plane transmission grating is a transparent material plate such as glass plate on which a large number of equidistant parallel and fine lines are drawn by means of a fine diamond point, worked with a ruling engine. When the light is incident on this plate, the ruled lines act like opaque and the space between the ruled lines act like slit so that light can pass through them. Such type of transparent glass plate, is called plane transmission grating. The number of lines on a plane transmission grating is of the order of 10,000 to 15,000 per inch.



Theory:-

Let a plane wave front be incident normally on N slits. Then according to Huygen's Principle, all points in each slit become a source of secondary wavelets. By the

theory of diffraction at a single slit the resultant amplitude in the direction θ is given by

$$A_{\theta} = \frac{A_0 \sin \alpha}{\alpha} \quad \text{--- (1) where } \alpha = \frac{\pi e \sin \theta}{\lambda}$$

The resultant wave in each slit may be supposed to be coming from the middle point of the slit now suppose $S_1, S_2, S_3, \dots, S_N$ be the middle point of the successive slits. then we have N diffracted parallel waves one each from $S_1, S_2, \dots, S_N$ producing interference.

Path difference between the successive wavelets diffract at an angle θ from each slit is same and is equal to $(e+b) \sin \theta$.

The equivalent phase difference will be $\frac{2\pi}{\lambda} (e+b) \sin \theta$

$$\text{Let } 2\beta = \frac{2\pi}{\lambda} (e+b) \sin \theta \Rightarrow \beta = \frac{\pi}{\lambda} (e+b) \sin \theta$$

The resultant of all the wavelets at the point P is the vector sum of all the amplitudes of the coherent wavelets obtained from N identical source. The e^{th} amplitude of each wavelet is A_0 and its phase increase by an amount 2β in successive wavelets.

If the wavelet produced by a first source and arriving at P is represented by the eqⁿ $E_1 = A_0 \exp i(\omega t - \alpha)$ then the wavelets produced by other successive source and arriving at point P can be represented by

$$E_2 = A_0 \exp i(\omega t - \alpha - 2\beta), E_3 = A_0 \exp i(\omega t - \alpha - 4\beta) \dots$$

$$E_N = A_0 \exp i(\omega t - \alpha - 2(N-1)\beta)$$

Resultant of waves is given by

$$E = E_1 + E_2 + E_3 + \dots + E_n$$

$$E = A_0 \exp J(\omega t - \alpha) (1 + e^{-2J\beta} + e^{-4J\beta} + \dots + e^{-2J(N-1)\beta})$$

Since R.H.S of this eqⁿ is a geometric series so

$$E = A_0 \frac{(1 - e^{-J_2 N \beta})}{(1 - e^{-J_2 \beta})} \exp J(\omega t - \alpha)$$

$$= A_0 \frac{e^{-JN\beta}}{e^{-J\beta}} \frac{(e^{-JN\beta} - e^{JN\beta})}{(e^{-J\beta} - e^{J\beta})} \exp J(\omega t - \alpha)$$

$$= A_0 e^{-J(N-1)\beta} \frac{\sin N\beta}{\sin \beta} \exp J(\omega t - \alpha)$$

$$E = A \exp J(\omega t - \alpha) \quad (A = A_0 \frac{\sin N\beta}{\sin \beta} \exp J(N-1)\beta)$$

$$\text{Intensity } I = k A A$$

$$= k A_0^2 \frac{\sin^2 N\beta}{\sin^2 \beta} \exp J(N-1)\beta \exp(-J(N-1)\beta)$$

$$I = k A_0^2 \frac{\sin^2 N\beta}{\sin^2 \beta} \quad \text{Put } A_0 = A_0 \frac{\sin \alpha}{\alpha}$$

$$\therefore \text{Resultant Intensity } I = I_0 \left(\frac{\sin \alpha}{\alpha} \right)^2 \left(\frac{\sin N\beta}{\sin \beta} \right)^2$$

$$\text{where } I_0 = k A_0^2$$

It is clear from eqⁿ (2) that the first factor $(\sin \alpha / \alpha)^2$ gives the diffraction due a single slit while the second factor $(\sin N\beta / \sin \beta)^2$ gives the interference pattern

due to N slits.

(10)

Dependence of interference component of resultant intensity on $(\sin N\beta / \sin \beta)^2$:-

(i) Principal maxima:-

when $\sin \beta = 0$ or $\beta = \pm n\pi$ where $n = 0, 1, 2, 3, \dots$

$\sin N\beta$ is also equal to zero, thus $\frac{\sin N\beta}{\sin \beta}$ comes out to be indeterminate

$$\text{Hence } \lim_{\beta \rightarrow \pm n\pi} \frac{\sin N\beta}{\sin \beta} = \lim_{\beta \rightarrow \pm n\pi}$$

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

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

$$I = I_0 \frac{\sin^2 \alpha}{\alpha^2} N^2 = \text{maximum}$$

The intensity at these positions are called principal maxima for these position

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

$$\text{or } \pi (e+b) \sin \theta = \pm n\pi$$

$$\boxed{(e+b) \sin \theta = \pm n\lambda} \quad \text{--- (3) where } n = 0, 1, 2, 3, \dots$$

(ii) minima :- when $\sin N\beta = 0$ then the intensity at p will be ⁽¹¹⁾

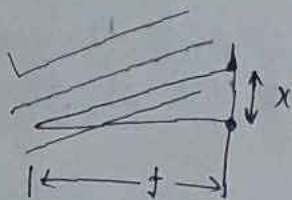
$I = 0$ thus for minima $N\beta = \pm p\pi$

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

$$(e+b) \sin \theta = \pm \frac{p\lambda}{N} \quad \text{--- (4)}$$

The minima can be obtained are

$$(e+b) \sin \theta = \pm \frac{\lambda}{N}, \pm \frac{2\lambda}{N}, \pm \frac{3\lambda}{N} \dots$$



$$a \sin \theta = h\lambda$$

$$h = 1$$

$$a \sin \theta = \lambda$$

$$\theta \rightarrow \text{small}$$

$$a\theta = \lambda$$

$$\theta = \frac{\lambda}{a}$$

$$\frac{x}{\lambda} = \frac{\lambda}{a}$$

$$x = \frac{\lambda^2}{a} = 2x = \frac{2\lambda^2}{a}$$

∴ Resolving Power ! -

Two close objects just as separate is called resolution and the ability or the power of the optical instruments to see **two close objects** just as separate is called Resolving power.

$$\text{Resolving power} = \frac{1}{\text{Resolution limit}}$$

Rayleigh's Criterion for Resolution ! -

According to Rayleigh, two close point sources of nearly equal intensity are said to be just resolved by an optical instrument, when the central maximum of the diffraction pattern of ~~the~~ one source falls on the first minimum of the diffraction pattern of the other.

In case of just resolution the distance between the two sources is called resolution limit.

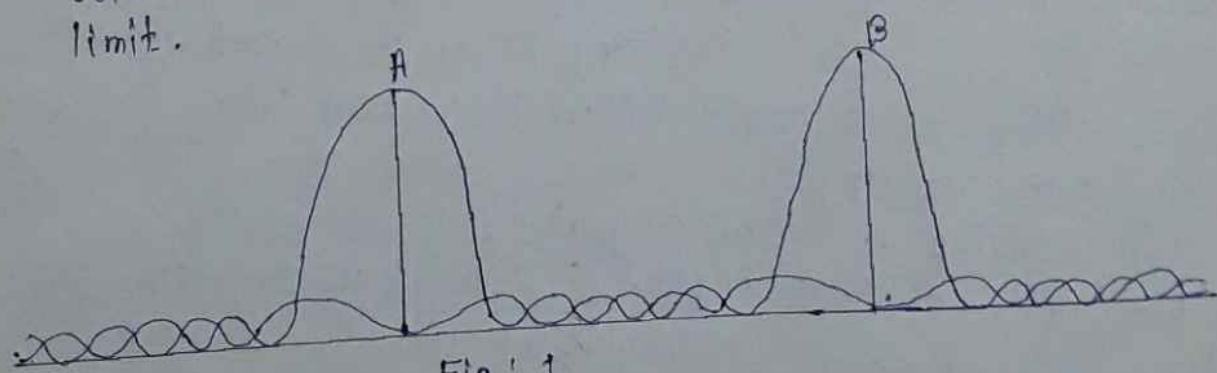
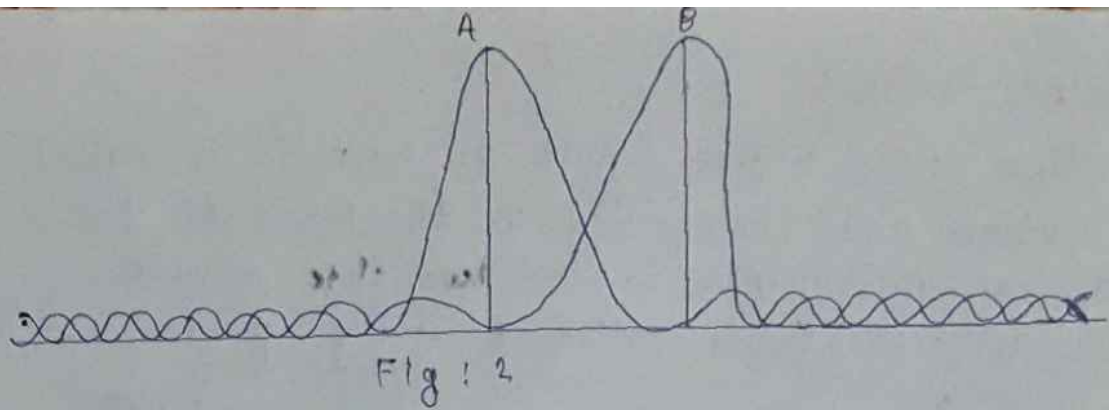


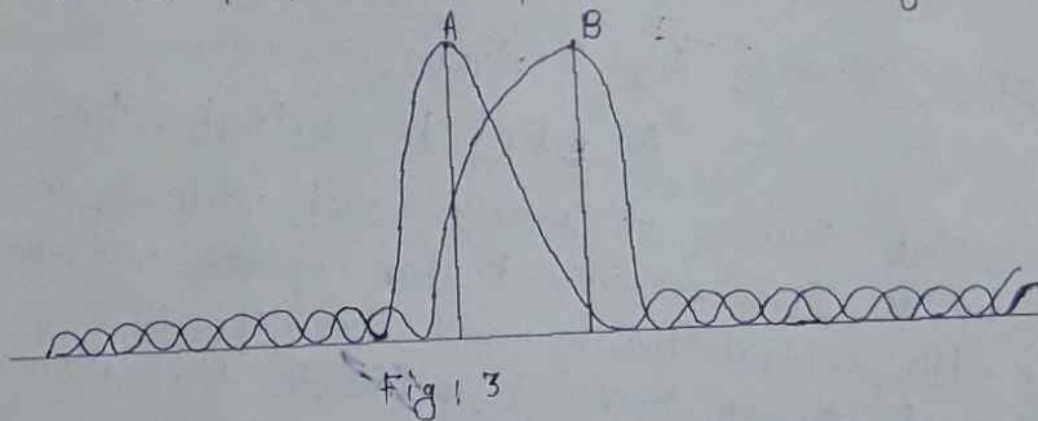
Fig: 1

Let A & B are the central maxima of diffraction pattern due to two lines of wavelengths λ_1 & λ_2 respectively.

The objects are said to be well resolved if the diffraction pattern overlaps as shown in fig: 1



The objects are said to be just resolved if the diffraction pattern overlaps as shown in fig: 2



The objects are said to be unresolved if the diffraction pattern overlaps as shown in fig: 3.

Resolving power of plane transmission grating :-

Resolving power of a grating is its ability to separate different spectral lines of nearly same wavelength.

The resolving power of a grating is also defined as the ratio of wavelength, λ of any spectral line to the difference in wavelength of this line & next nearest line that can be seen separate.

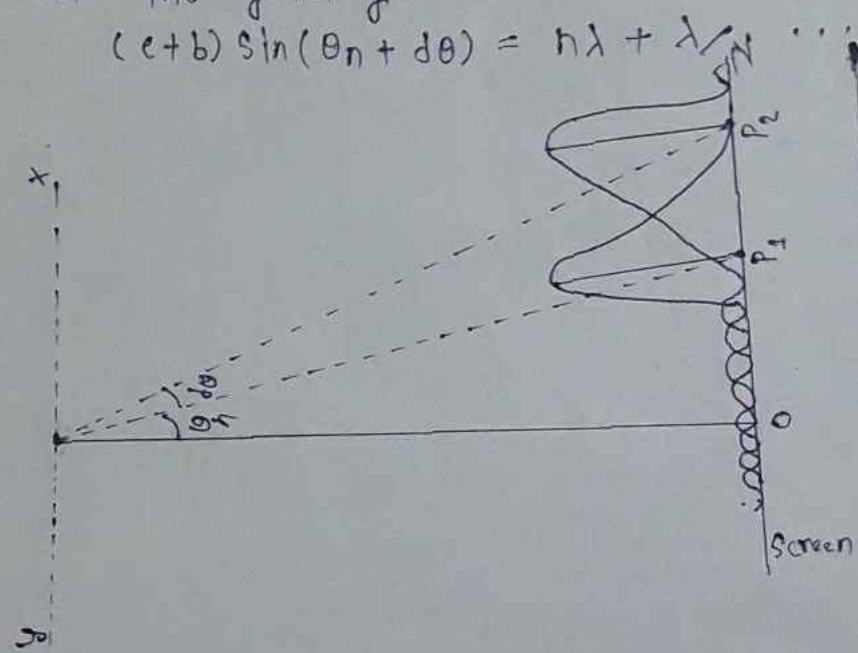
- * let xy is plane transmission grating let a beam of wavelength λ & $\lambda + d\lambda$ incident normally on the grating.
- * let P_1 is the position of n th principal maxima of spectrum of wavelength λ diffracted at angle θ_n .
- * let P_2 is the position of n th principal maximum of spectrum of wavelength $(\lambda + d\lambda)$ diffracted at an angle $(\theta_n + d\theta)$.

The direction of n^{th} principal maxima for wavelength λ is given by $(e+b) \sin \theta_n = n\lambda \dots\dots (1)$

The direction of n^{th} principal maxima for wavelength $(\lambda + d\lambda)$ is given by $(e+b) \sin(\theta_n + d\theta) = n(\lambda + d\lambda) \dots\dots (2)$

The first minima is obtained if extra path difference of λ/N is introduced where N is the total number of lines on the grating.

$$(e+b) \sin(\theta_n + d\theta) = n\lambda + \lambda/N \dots\dots (3)$$



The ratio of the wavelength difference $d\lambda$ & the mean wavelength λ of the spectral lines is called resolution limit of the diffraction grating & its reciprocal is called resolving power of the grating

from eq (2) & (3) we get
 $n(\lambda + d\lambda) = n\lambda + \lambda/N$
 $n d\lambda = \lambda/N$

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

 $\dots\dots (4)$

from eq (4) resolving power of grating is directly proportional to

- i) the order of the spectrum.
- ii) the total number of lines on grating & independent of grating element $(e+b)$

The dispersive power of grating is given by

$$\frac{d\theta}{d\lambda} = \frac{nN}{\cos \theta} = \frac{n}{(e+b) \cos \theta} \dots\dots (5)$$

from eq (4) & (5)

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

High dispersive power means a wide separation of spectral lines & high resolving power means the ability to separate two near by spectrum.

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