Bharati Vidyapeeth's
College of Engineering, New Delhi

celebrating Golden Jubilee 1964-2014
BHARATI VIDYAPEETH
Hon'ble Founder Dr. Patangrao Kadam

(APPLIED PHYSICS - I) Lectures

Presented by

Applied Physics group

Applied Science Dept.

Bharati Vidyapeeth's
College of Engineering, New Delhi

Lectures

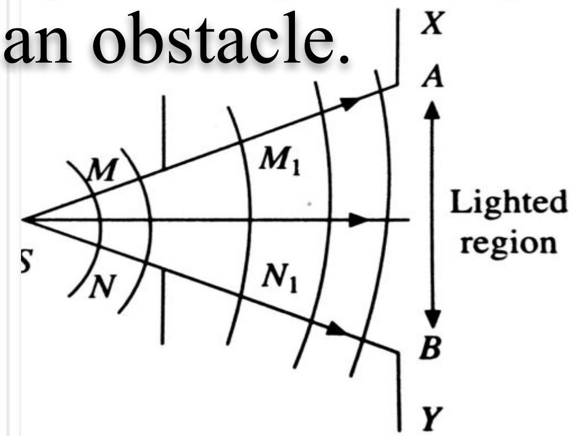
UNIT-I	Interference Diffraction
UNIT-II	Polarisation Laser; Optical Fibre
UNIT-III	Special Theory Of Relativity Ultrasonics
UNIT-IV	Nuclear Physics

Contents

- Diffraction: Introduction and definition
- Fresnel and Fraunhofer diffraction - difference
- Fraunhofer diffraction:
  - due to single slit diffraction (using phasor notation),
  - due to N slits, diffraction grating, Absent spectra
- resolving power
- dispersive power of grating (qualitative only)
- determination of wavelength using diffraction grating

Diffraction of light

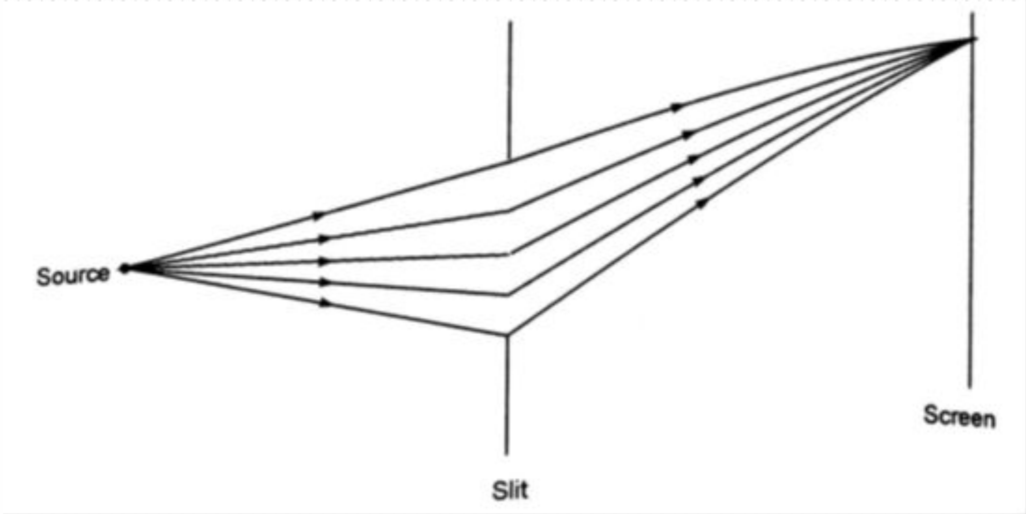
It is a phenomena of bending of light around the corners of an obstacle and spreading of light into the geometrical shadow region of an obstacle.



Cause: It due to the mutual interference of secondary wavelets originating from the various points of the exposed part of the same wave front.

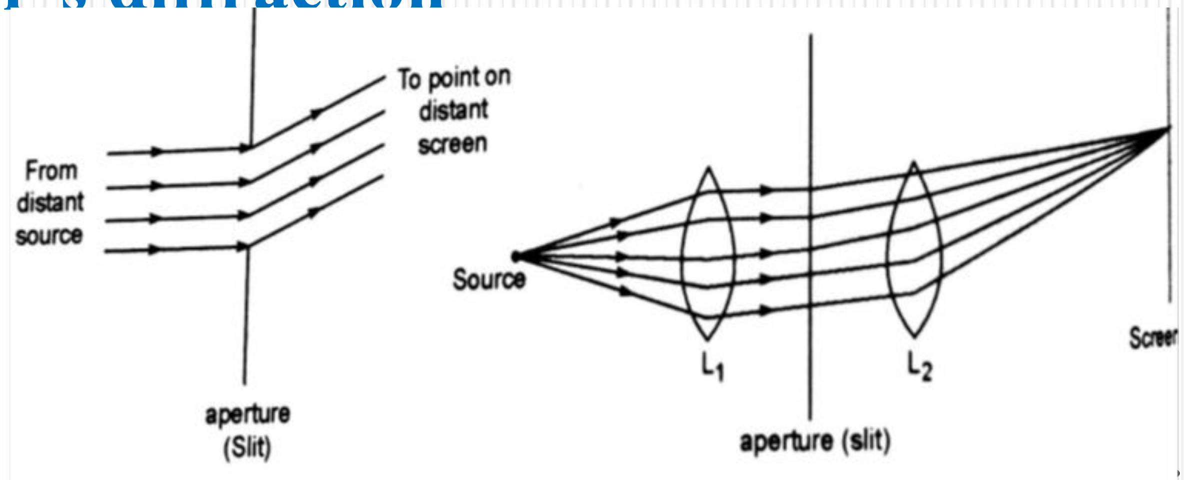
Types: Fresnel diffraction and Fraunhoffer diffraction

Fresnal's diffraction



- Source and Screen both are at finite distance from the grating element.
- No lenses or mirrors are required
- The wave fronts are either spherical or cylindrical.

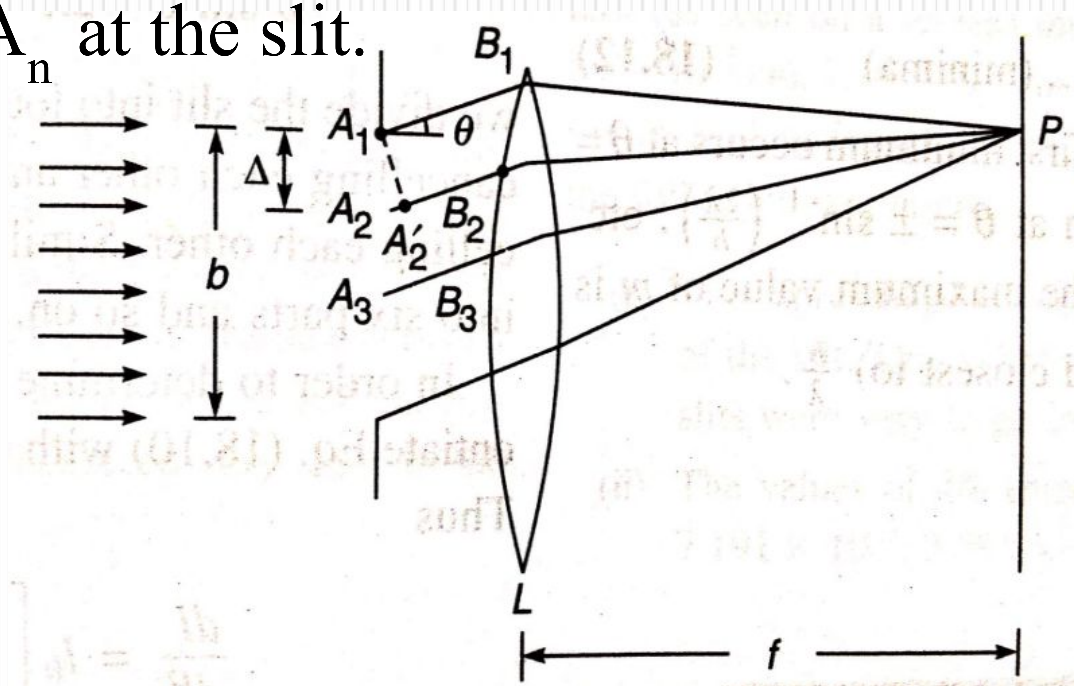
Fraunhofer's diffraction



- Distance of the Source and Screen from the diffracting element is infinite.
- Convex lenses are used to make the light fall parallel from source to aperture and from aperture to screen for focus on the screen.
- The wave fronts incident on the aperture is plane.

Fraunhofer's diffraction due to single slit diffraction

At the exposed part of slit, each point is a source of secondary wavelets which interfere with each other. Let there are 'n' number of equally spaced point sources A_1, A_2, -----, A_n at the slit.



If Δ is distance b/n consecutive source points on the wave front, then path difference b/n the waves will be Δsinθ and the corresponding phase difference b/n the fields from consecutive source point will be

$$\emptyset = \frac{2\pi}{\lambda}(\Delta \sin\theta)$$

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If E_1, E_2,-----,E_n are the Electric field components of the wave from each source waves reaching at point P and '**a**' is amplitude of each source, then Resultant field E, at point P is given by

E=E1+E2+.......+En

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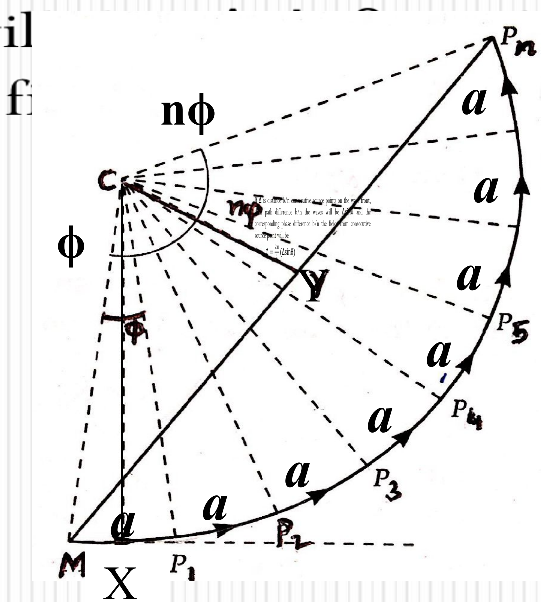

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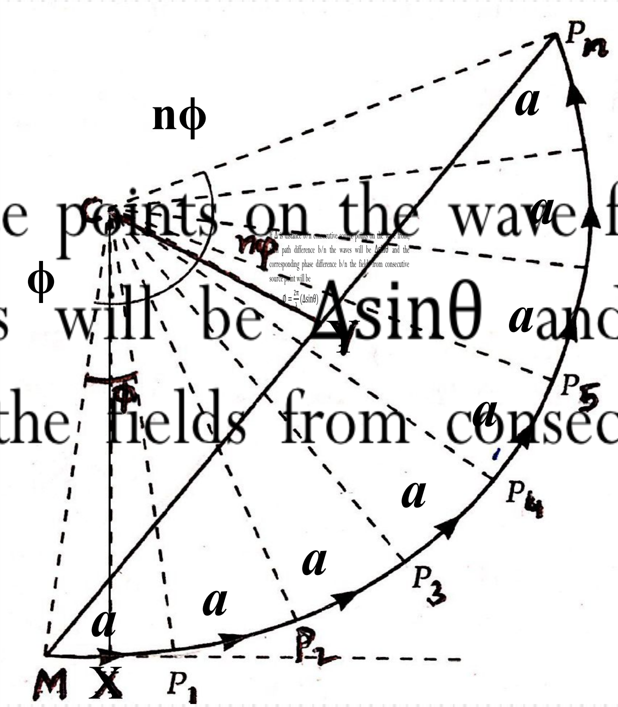

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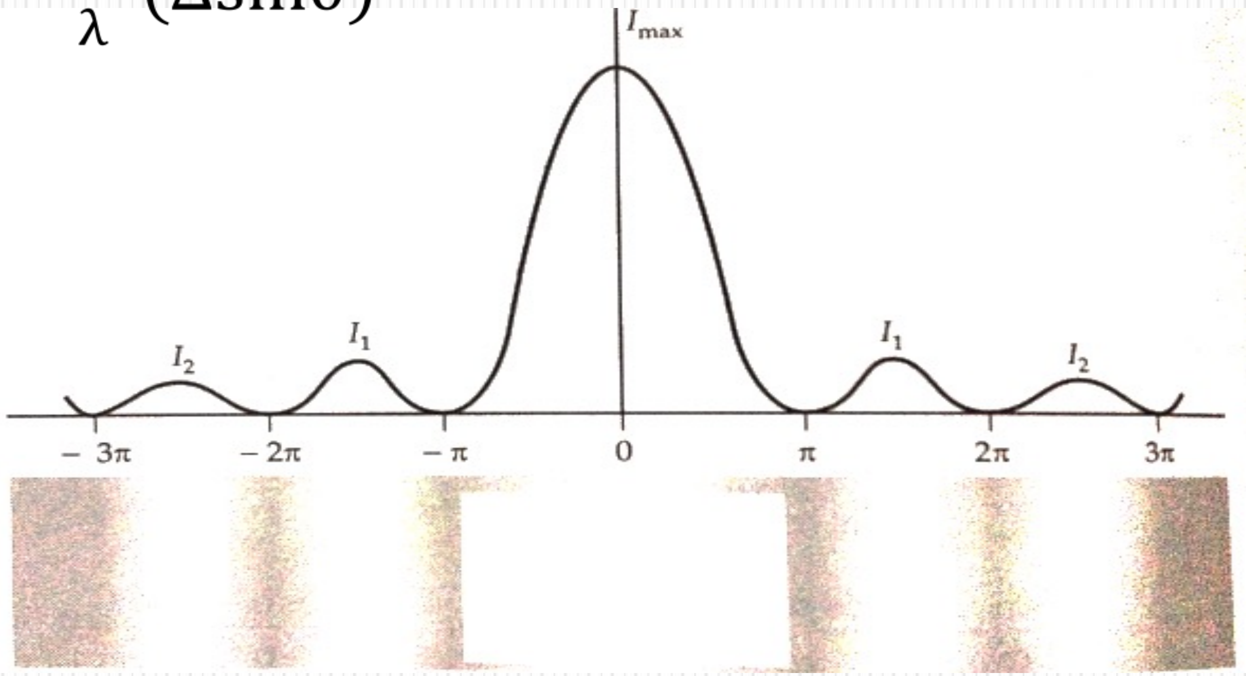

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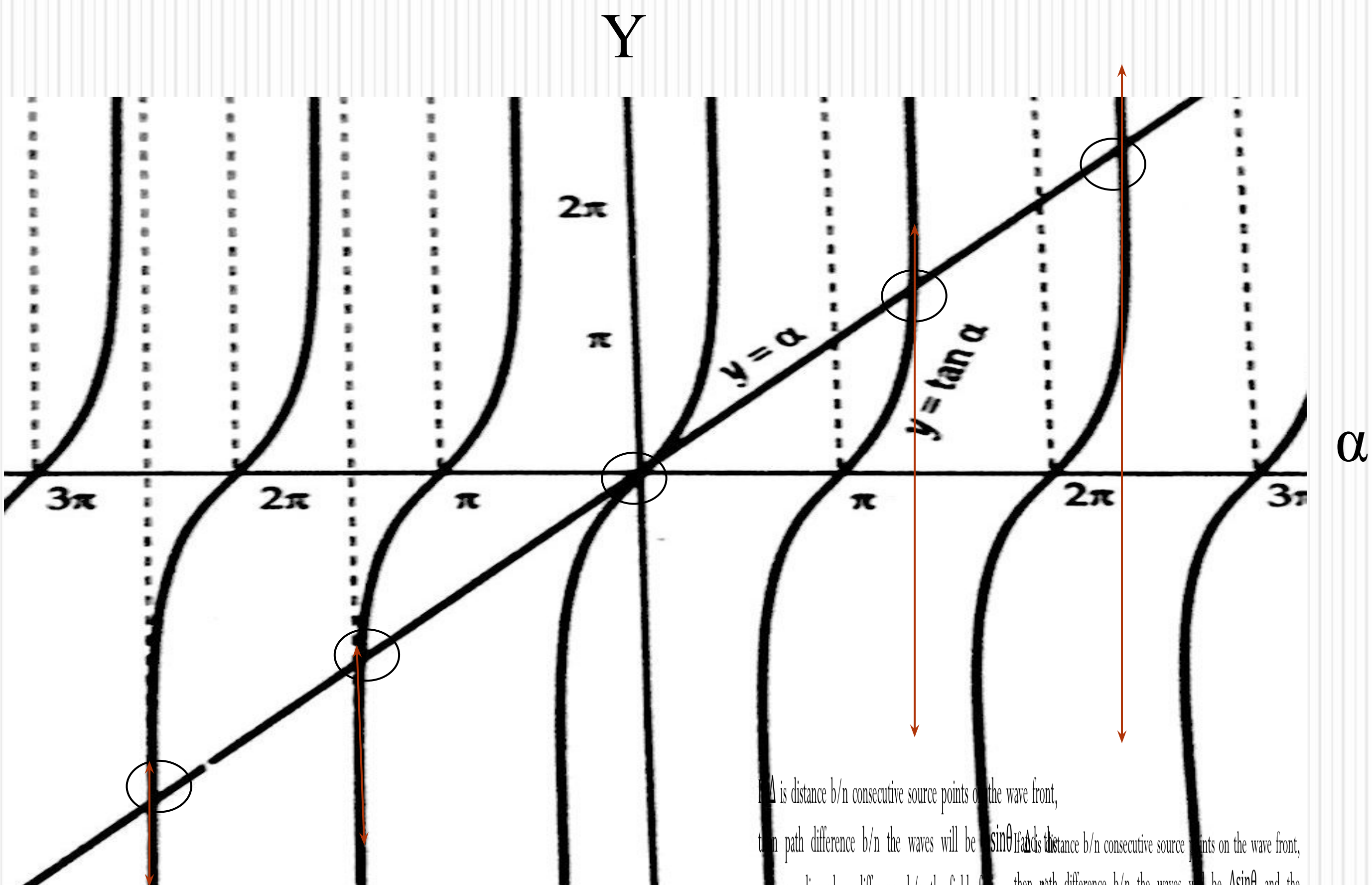

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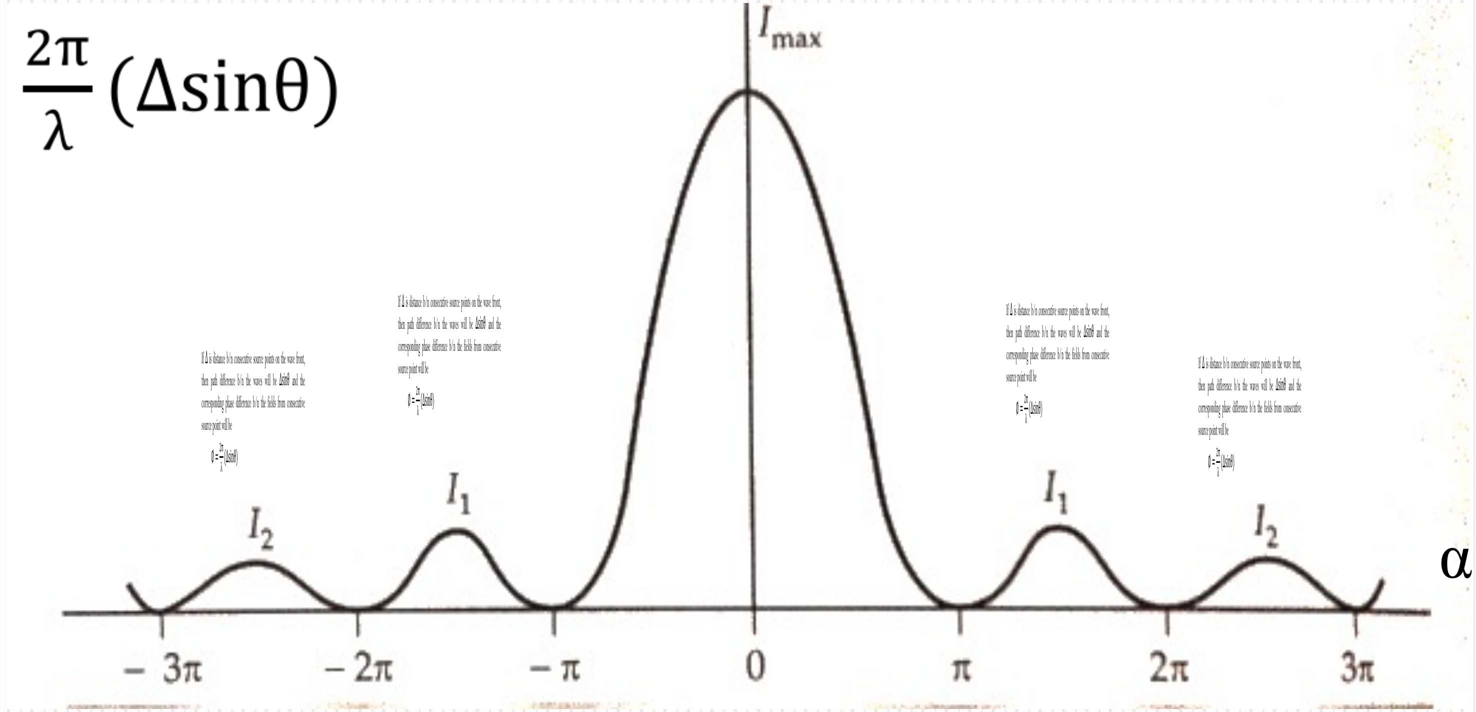

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m[th] minima appears at $\alpha = \pm m\pi$ along $\theta_m = \pm\sin^{-1}\left(\frac{m\lambda}{b}\right)$

1[st] minima appears at $\alpha = \pm\pi$ along $\theta_1 = \pm\sin^{-1}\left(\frac{\lambda}{b}\right)$

2[nd] minima appears at $\alpha = \pm 2\pi$ along $\theta_2 = \pm\sin^{-1}\left(\frac{2\lambda}{b}\right)$

and so on

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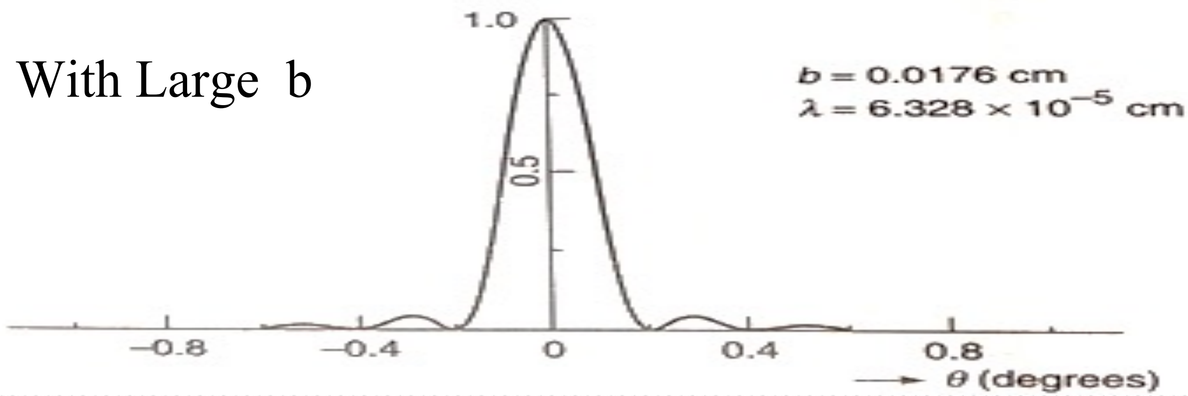
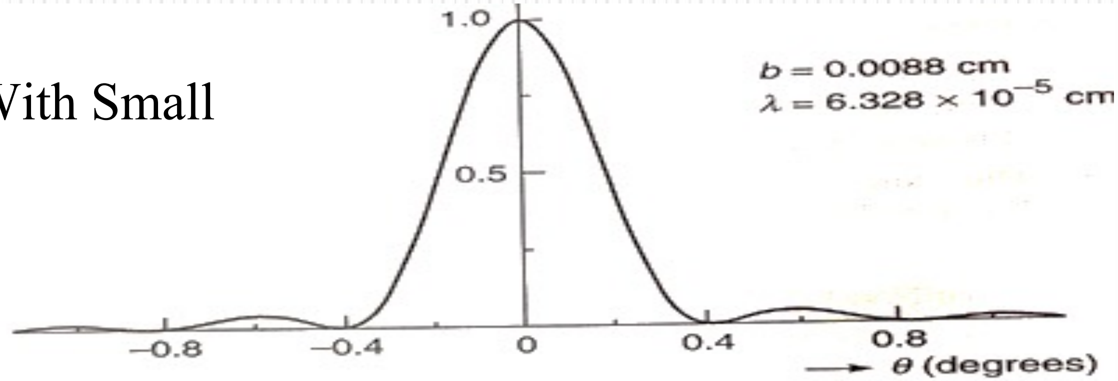
Spread of central maxima increases with decreasing slit width b.

With Large b



With Small b



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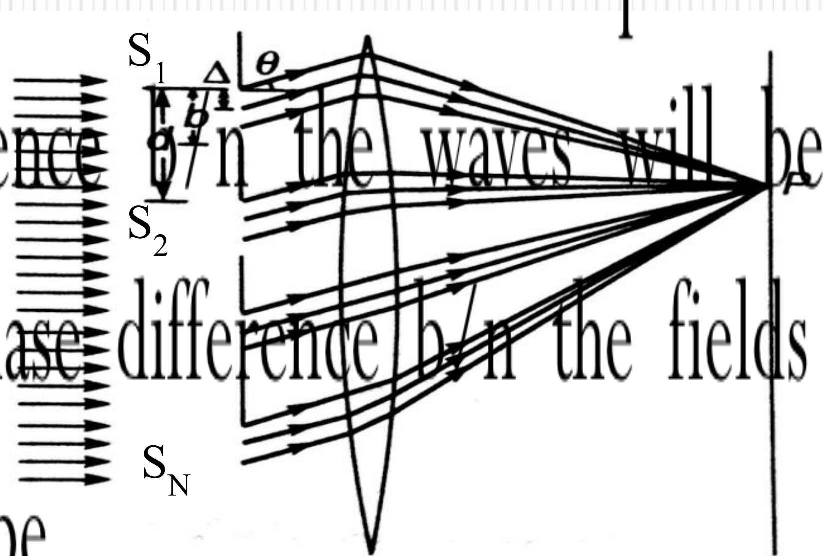

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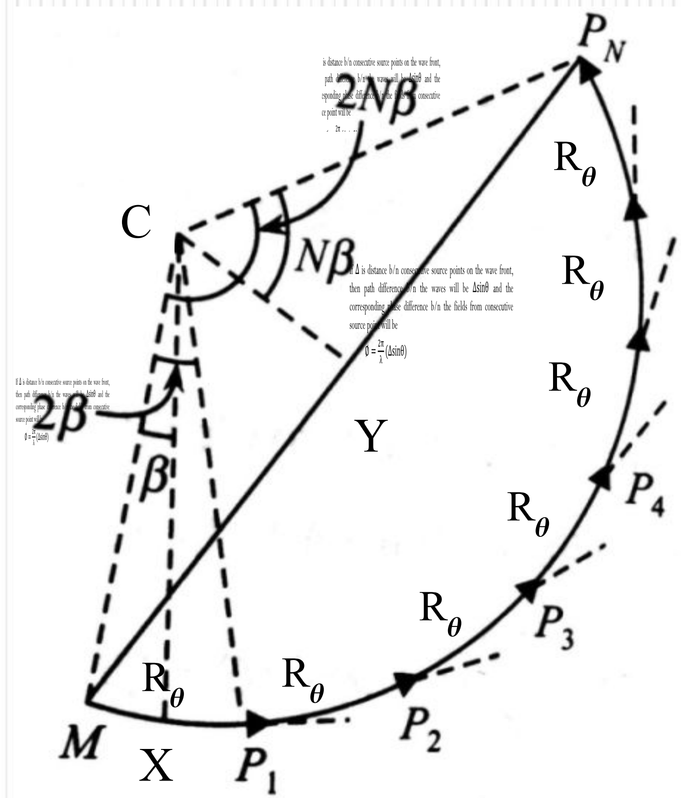

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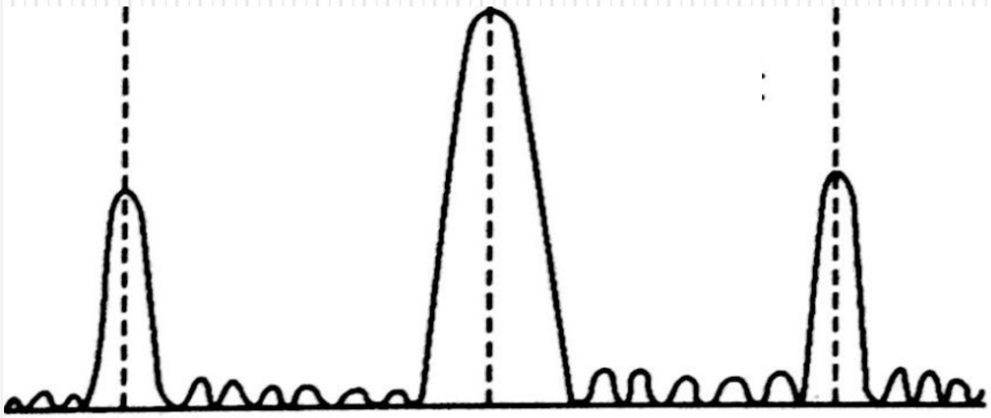

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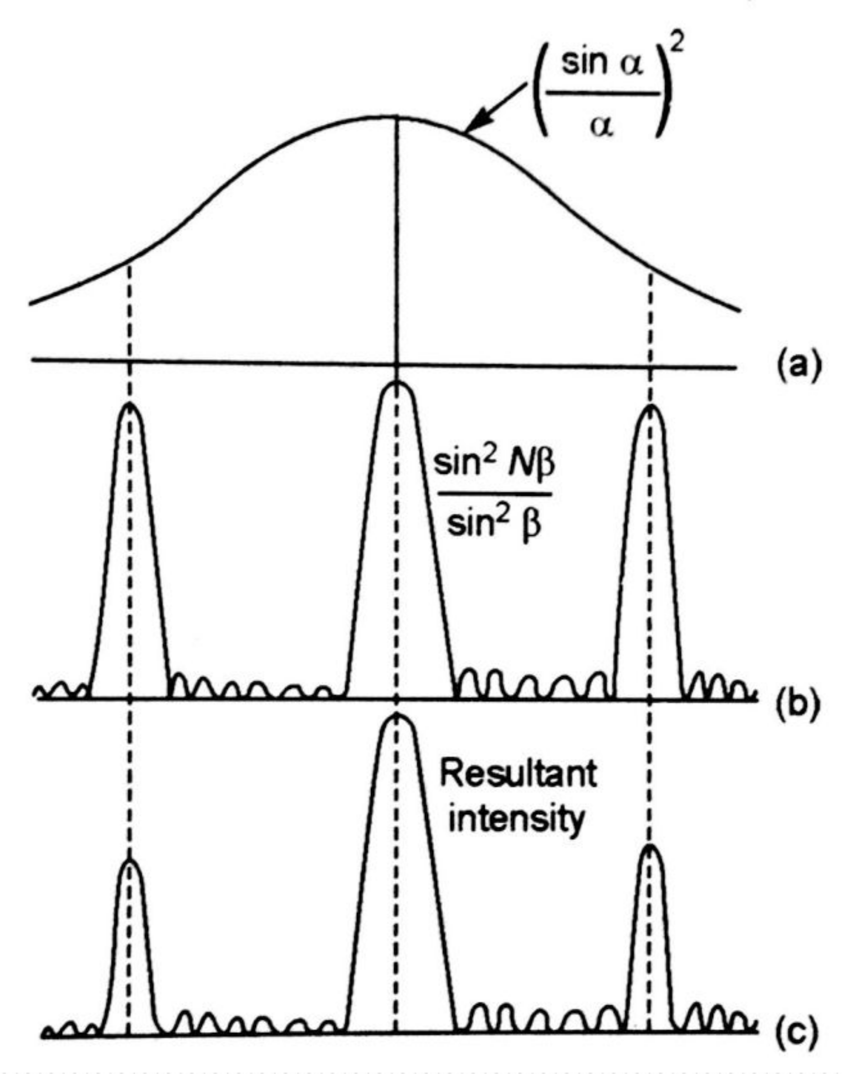

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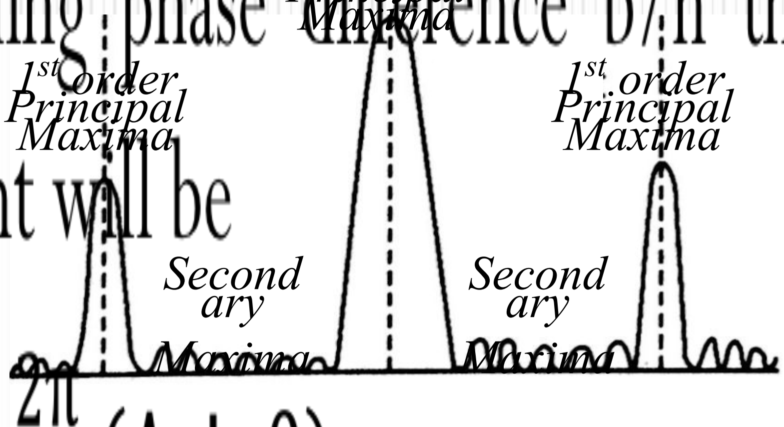

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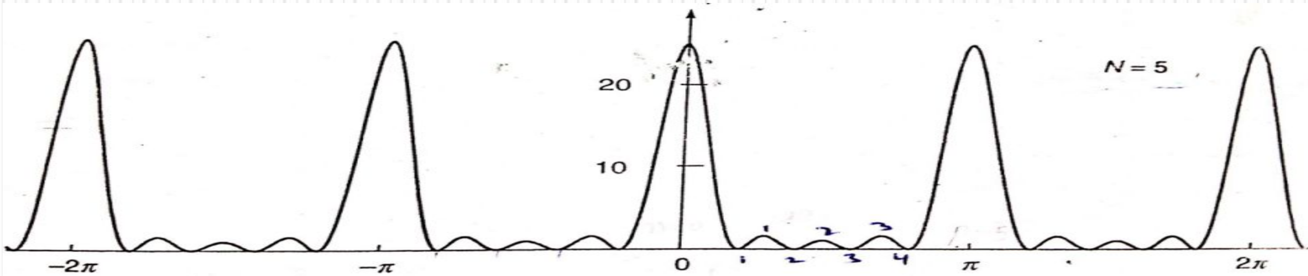
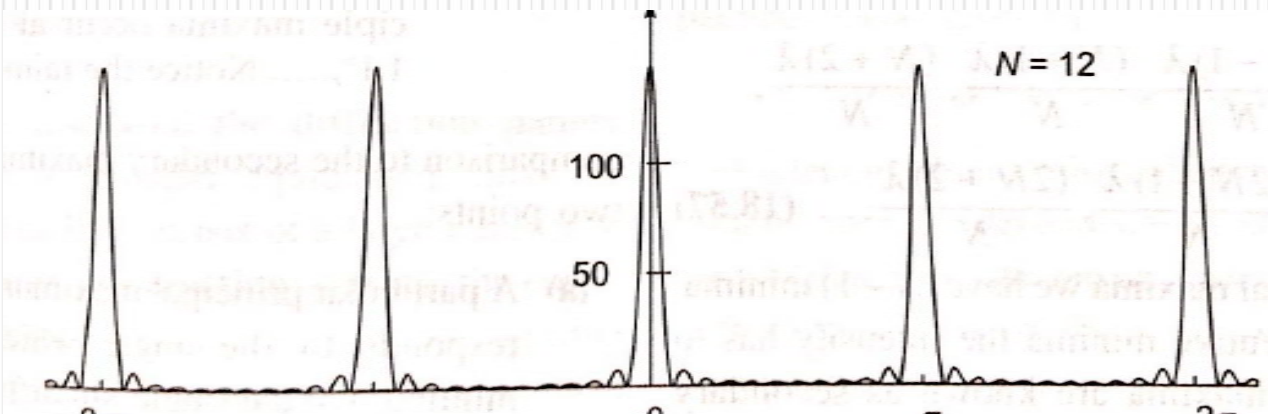


N=5

For N=5, between 2 Principal Maxima, there are 4 minima, and 3 Secondary Maxima.



N=12

For N=12, between 2 Prin. Maxima, there are 11 minima, and 10 Secondary Maxima.

Absent or Missing order spectra (when N >1)

In diffraction grating spectrum, when diffraction minima from single slit and interference maxima from N-slits are simultaneously lying along a common angle θ, then those particular orders of principle maxima disappears from the grating spectrum. The resultant spectra is known as absent or missing order spectra. It depends on the value of width of slit (b) and opaque spaces (a).

Condition of absent spectra

When the widths of opaque region (a) & transparent region (b) in a grating are such that both the conditions i.e

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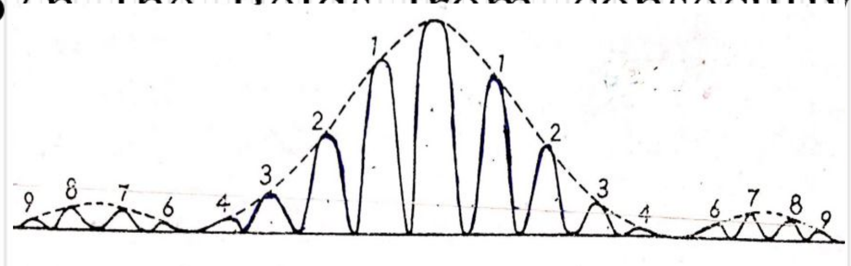

5th,10th,15th,….orders of Principal Maxima will be absent from the grating spectra, corresponding to diffraction minima at m=1,2,3…

Similarly for a=b, n=2m,

2nd,4th,6th,….orders of Principle maxima will be absent from the grating spectra, corresponding to diffraction minima at m=1,2,3…

Q: For a given slit width If n=3m, what is inter-slit separation

(2016)

Q: Deduce the missing orders for double slits Fraunhoufer diffraction pattern, if the slit widths are 0.16mm and they are 0.8mm apart.

Ans: n=6,12,18,….(corresponding to m=1,2,3….)will be missing

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Resolving power is defined as the ability of an optical instrument to produce separate patterns of two close lying objects (or to measure the angular separation between two images that are close to each other. To see distinctly, two closely spaced objects which are placed at a very large distance, optical instruments are required such as: (Prism, Grating), (Telescope, Microscope).

- Prism & Grating are used **to see spectral lines distinctly** of slightly different wavelength.
- Telescope & Microscope help **to see images distinctly** of close-lying objects.

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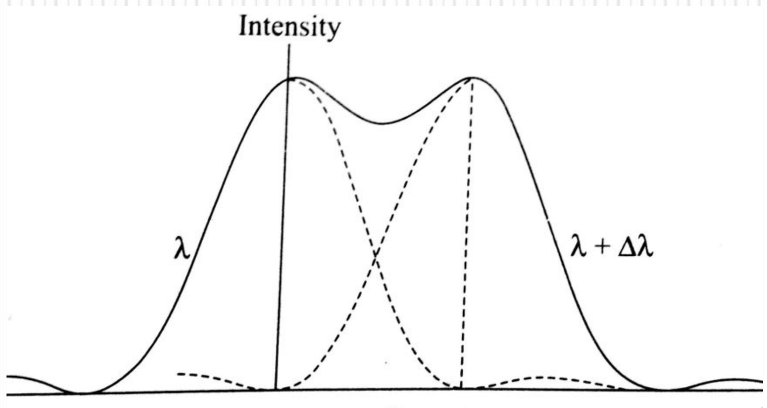
Resolving power is measured by $(\lambda/d\lambda)$, where $d\lambda$ is the smallest wave length difference that just can be resolved.

Criterion for resolution, proposed by Lord Rayleigh is as follows:



"Two spectral lines of equal intensities are just resolved by an optical instrument when the principal maximum of the diffraction pattern due to one wave length (say, λ_1) falls on the first minima of the diffraction pattern of other wavelength (say, λ_2) (adjacent to its n^{th} principal

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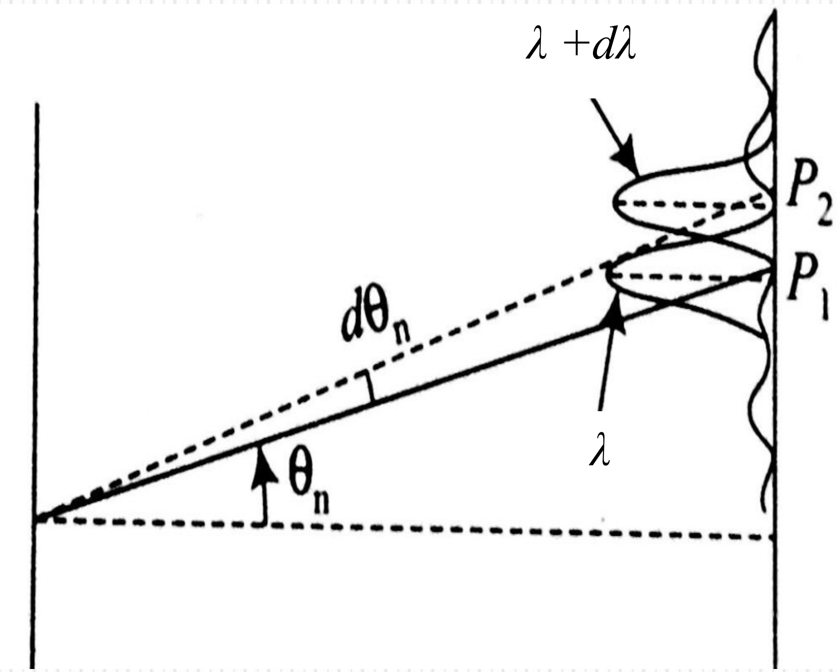

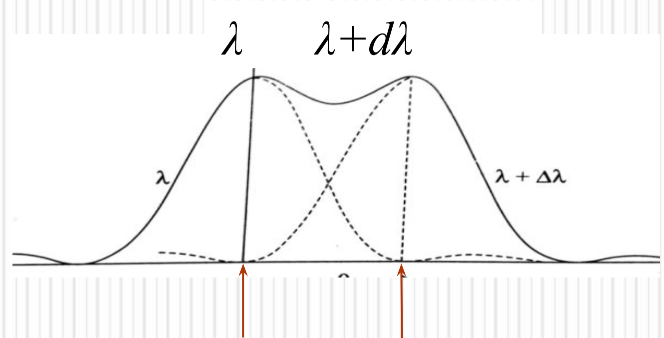

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From Rayleigh's criterion for resolution:

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