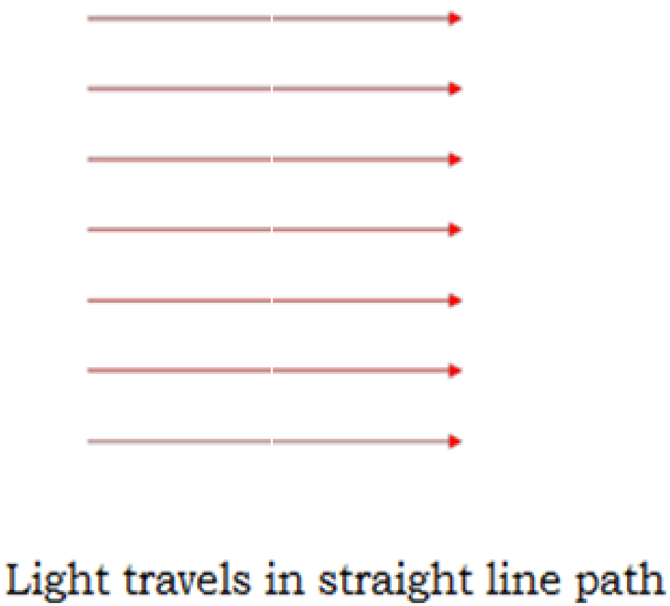
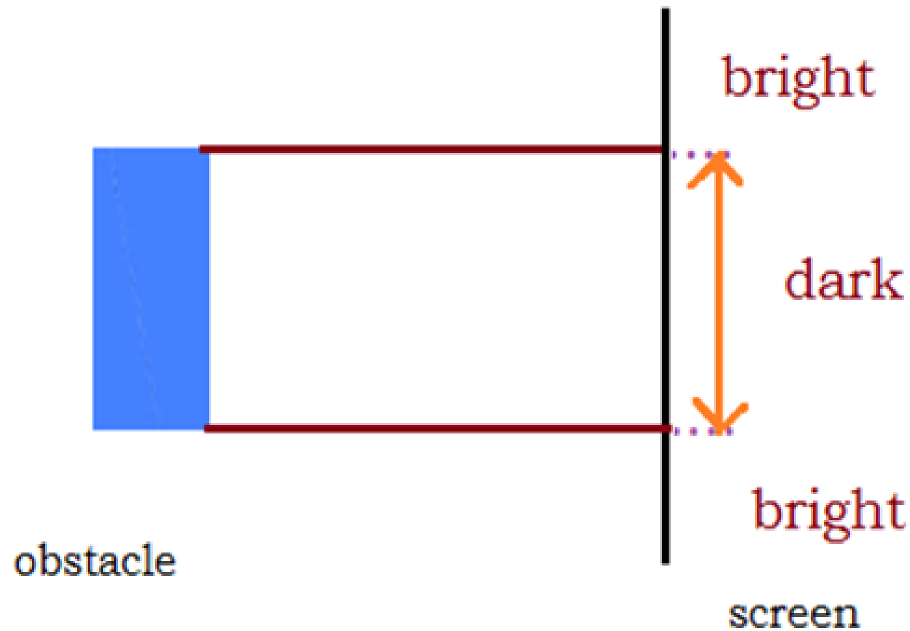
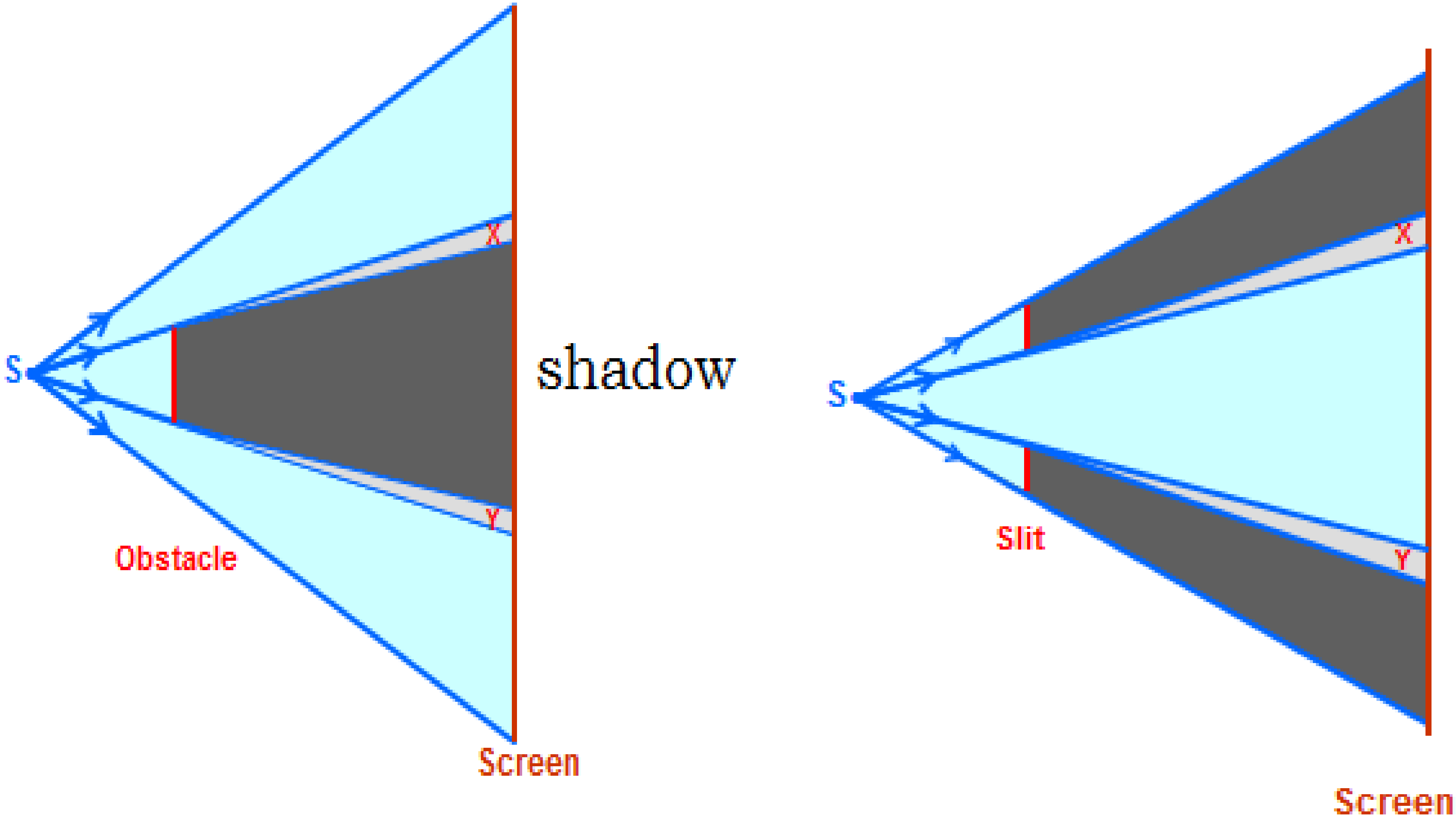
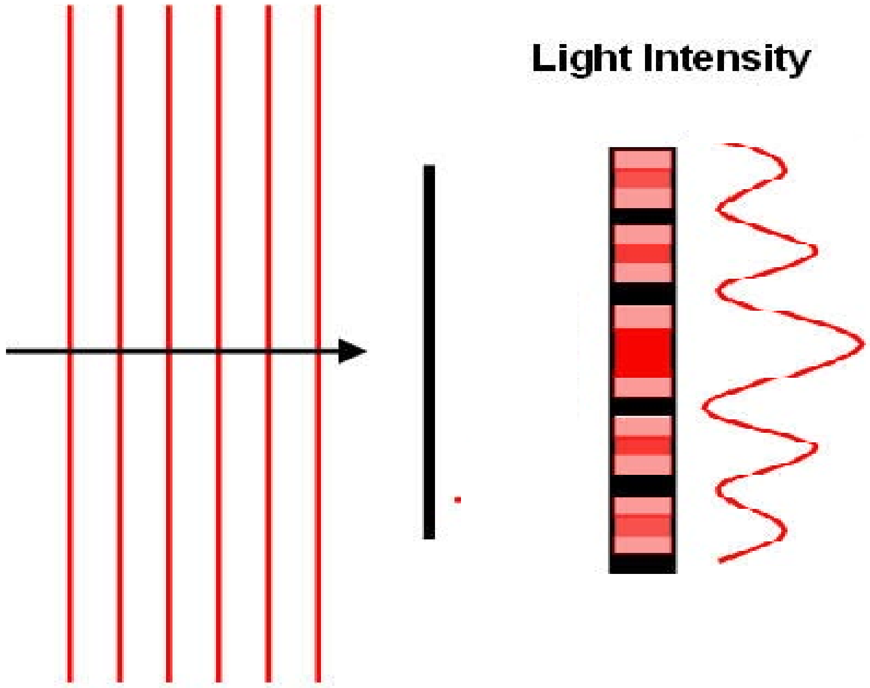
Diffraction of light







- **But in reality, the size of shadow is different than that of obstacle.**
- **This is possible due to bending of light around the corners.**



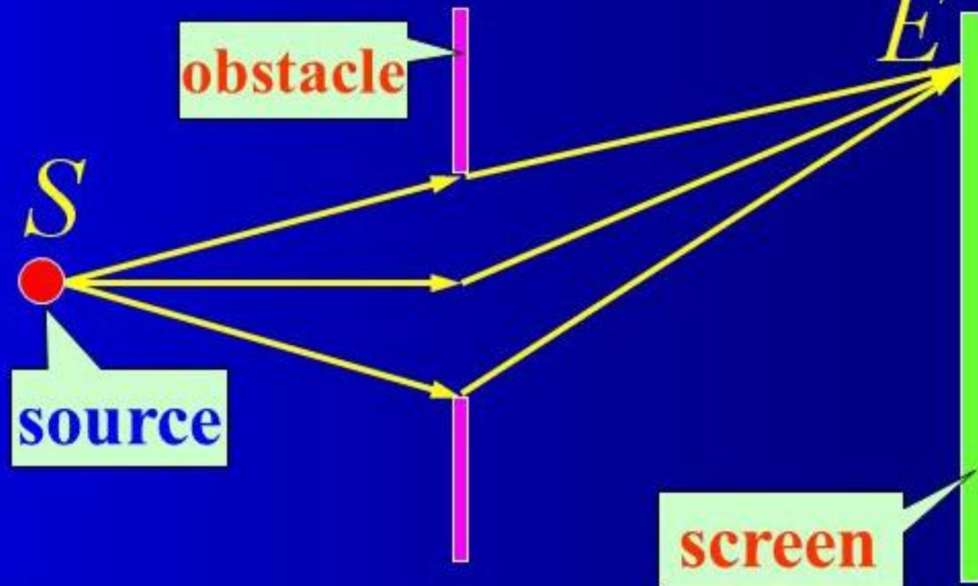
- Scientist , Grimaldi also found that when size of obstacle is of the order of wavelength of light , maxima and minima are obtained within the region of the geometrical shadow.

- **The phenomenon of bending of light around the corners of the obstacle and formation of maxima and minima within the region of the geometrical shadow is called diffraction.**

II. Classification

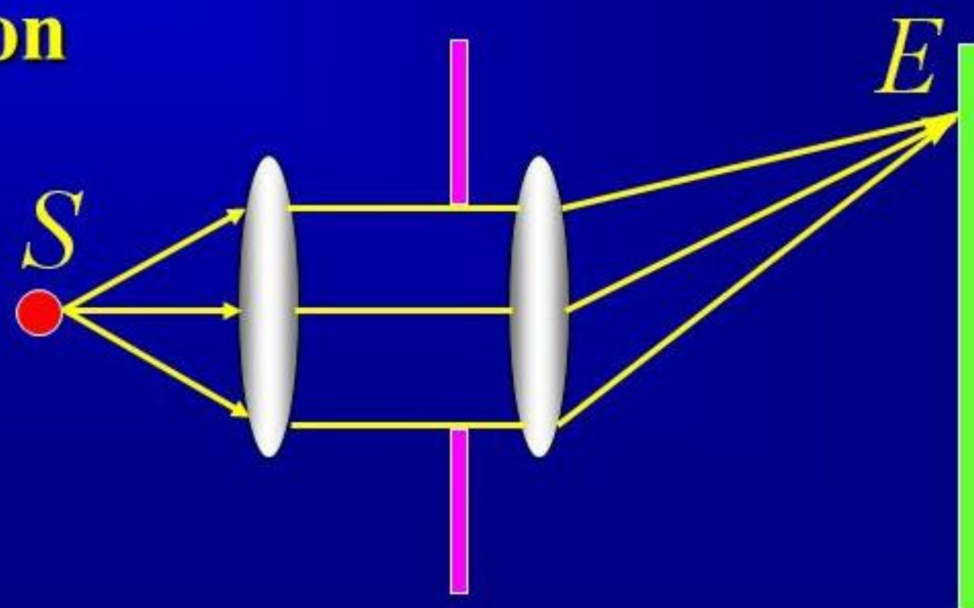
❶ Fresnel diffraction

--the source or the screen or both are at finite distance from the diffracting obstacle.

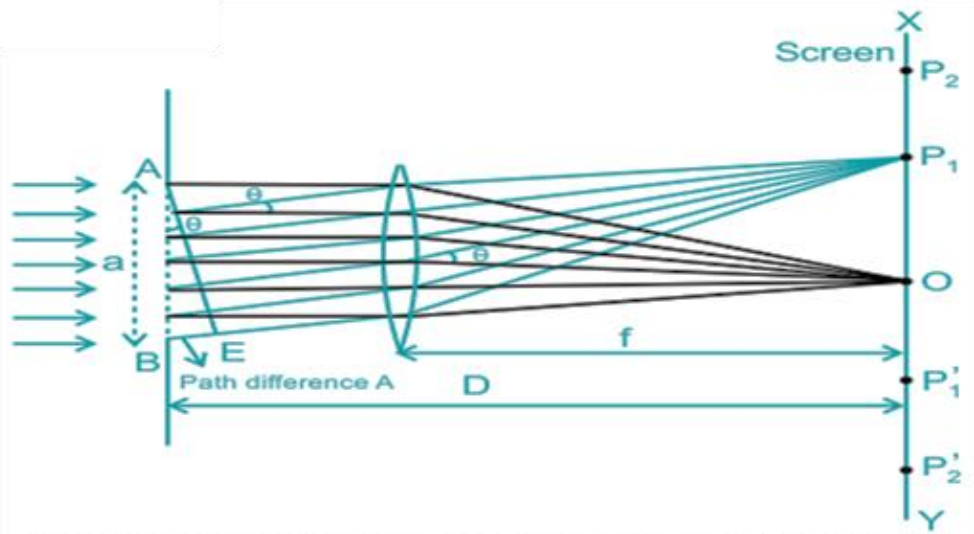


❷ Fraunhofer diffraction

--the source and the screen are at infinite distance from the diffracting obstacle.



Fraunhofer Diffraction at a Single Slit



Fraunhofer Diffraction of a Plane Wave at Single Slit

For minima,

$\sin\theta_1 = \lambda/a$ (for first minima/dark)

$\sin\theta_2 = 2\lambda/a$ (for second minima/dark)

$\sin\theta_3 = 3\lambda/a$ (for third minima/dark)

and so on ………………………………

It is natural to expect, maxima /bright half way between two minima

$\sin\theta_1' = 3\lambda/2a$ (for first maxima/bright)

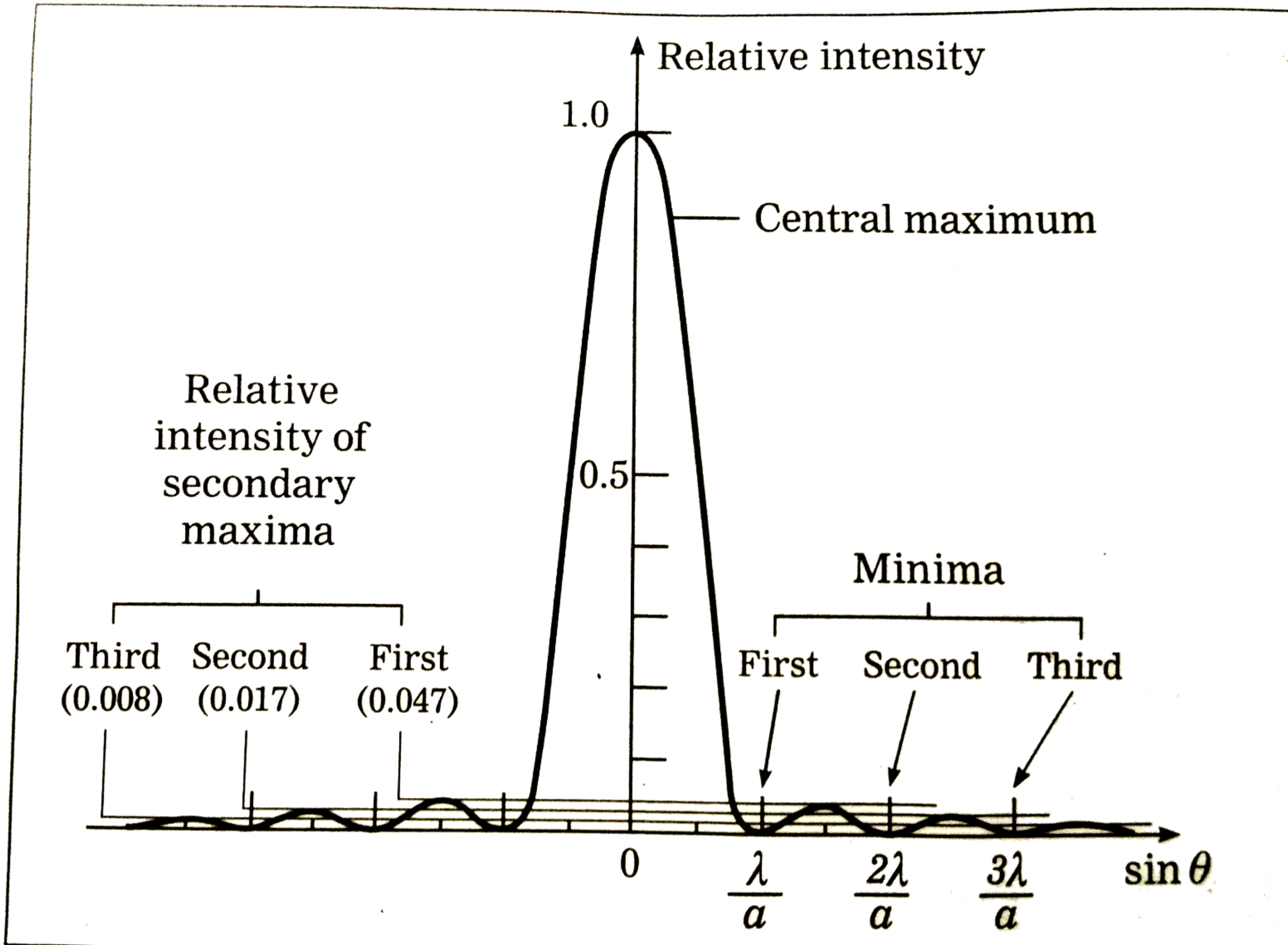
$\sin\theta_2' = 5\lambda/2a$ (for second maxima/bright)

$\sin\theta_3' = 7\lambda/2a$ (for third maxima/bright)

and so on………

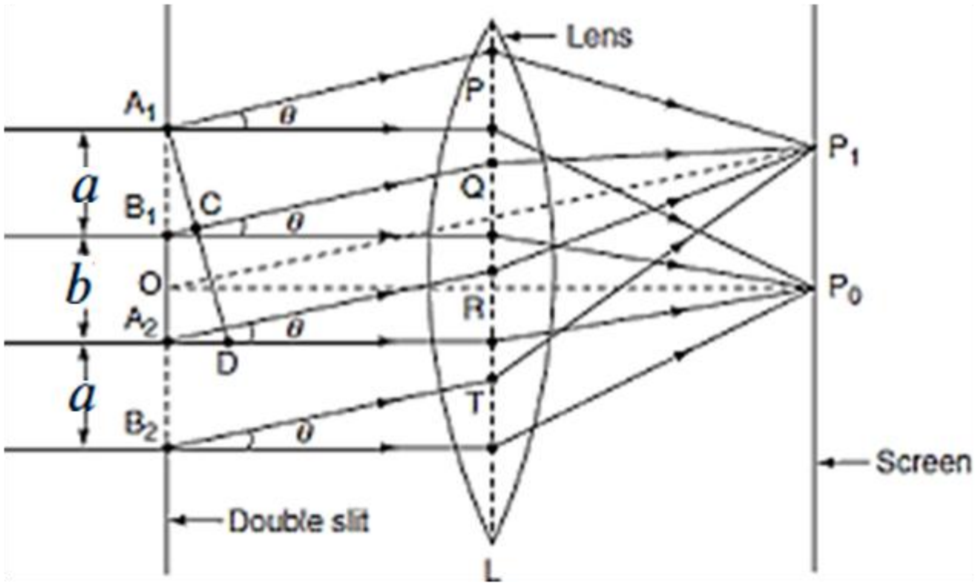
We can write, $\sin\theta_n = (2n+1)\lambda/2a$ (for nth maxima/bright)

$$a \sin\theta' = (2n+1)\lambda/2$$



Intensity variation in a single slit diffraction pattern plotted against $\sin\theta$, where θ is the angular spread from the centre of the pattern

Fraunhofer Diffraction at a Double Slit



It involves both diffraction from individual slits and interference between the waves from the two slits. The resulting intensity pattern is a combination of these two phenomena.

The condition for interference maxima is given by

$$(a+b)\sin\theta = n\lambda$$

where n=0,1,2,…represents the order of the maximum.

The condition for interference minima is given by

$$(a+b)\sin\theta = \left(n+\frac{1}{2}\right)\lambda$$

where, n=0,1,2,…represents the order of the minimum

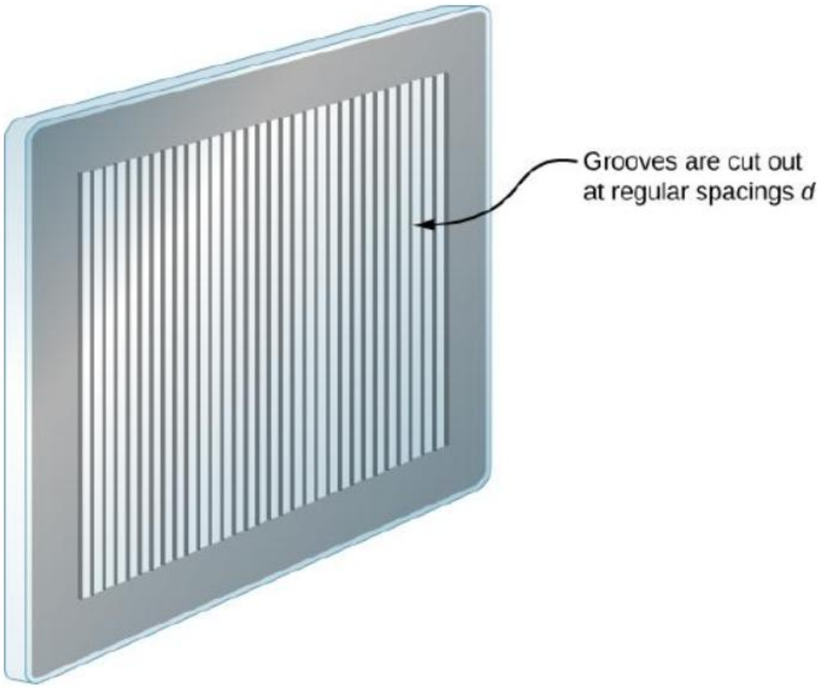
The condition for Diffraction minima is given by:

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

where, n=0,1,2,…represents the order of the minimum

Diffraction Grating

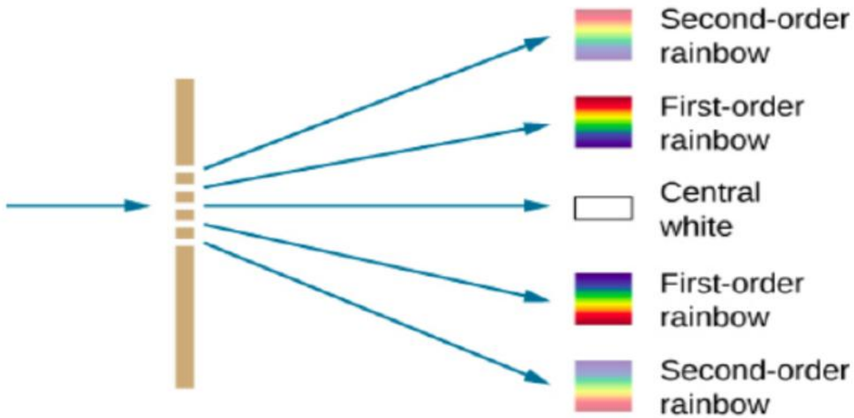
A **grating** is an arrangement consisting of a large number of parallel slits of same width and separated by equal opaque spaces. ... (a+b) is called **grating element** or **grating** constant. It can be seen that distance between two consecutive slits is **grating element**.



The grating constant (a+b) and the number of lines per centimeter (N) on a diffraction grating are inversely related by the formula

$$(a+b) = 1/N$$

For example, a grating with 5000 lines per centimeter would have a grating constant of 1/5000 cm.



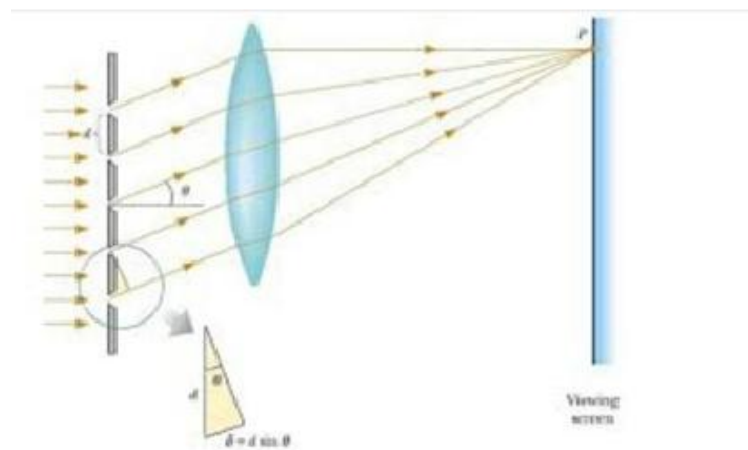
$$(a+b)\sin\theta = n\lambda$$

Where,

n = order of wavelength

λ = wavelength of laser beam

$(a+b)$ = grating element



Resolving Power

1. When two objects/wavelengths are very close to each other or far away from us we **NOT BE ABLE** to distinguish.

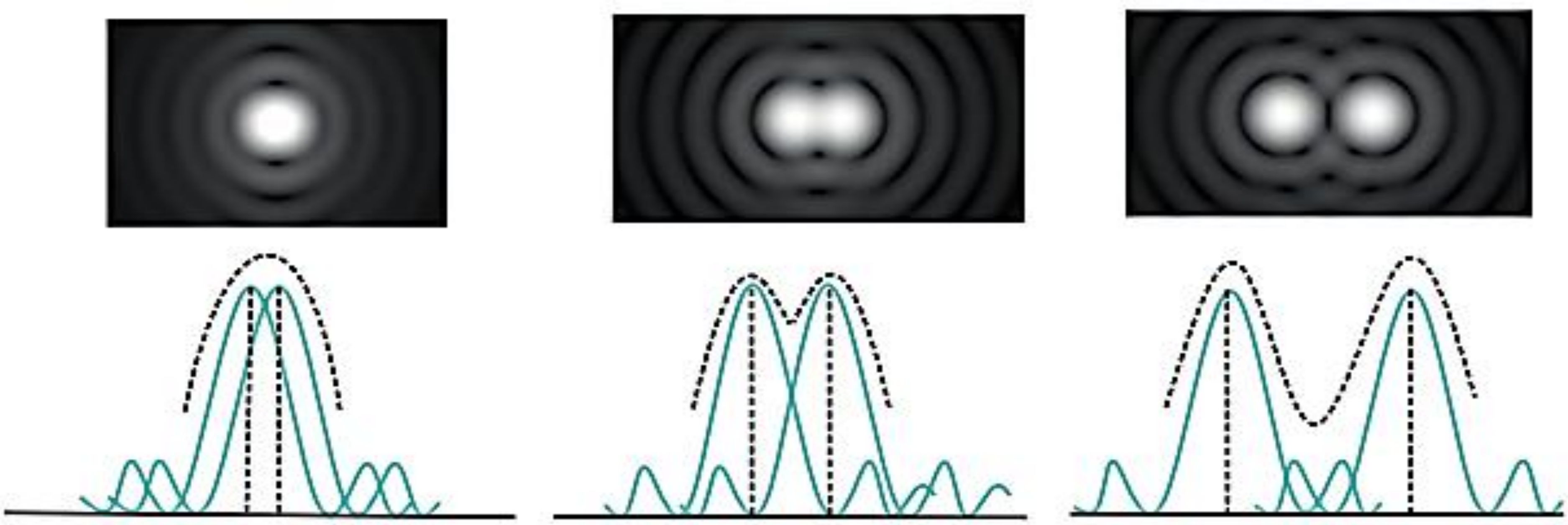
2. To distinguish them we need optical instruments like microscope, telescope, grating etc.

3. The resolving power of an objective lens is measured by its ability to differentiate two object/ wavelengths. The greater the resolving power, the smaller the minimum distance between two lines or points that can still be distinguished.

Rayleigh’s Criterion for Limit of Resolution (or for Resolving Power)

1. According to Rayleigh, the ability of an optical instrument to distinguish between two closely spaced objects depends upon the diffraction patterns of the two objects.

2. According to this criterion, two objects are just resolved when the first minimum of the diffraction pattern of one source coincides with the central maximum of the diffraction pattern of the other source, and vice versa.



(a) Unresolved (b) Just resolved (c) well resolved

Resolving Power of a grating

The resolving power of a diffraction grating is its ability to distinguish between two closely spaced wavelengths and is defined as the ratio of the wavelength (λ) to the smallest resolvable difference in wavelength ($d\lambda$),

i.e., **R.P = $\lambda/d\lambda$.**

The resolving power is directly proportional to the order of the spectrum (n) and the total number of illuminated lines (**N**′) on the grating, expressed as **R.P = nN′**

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