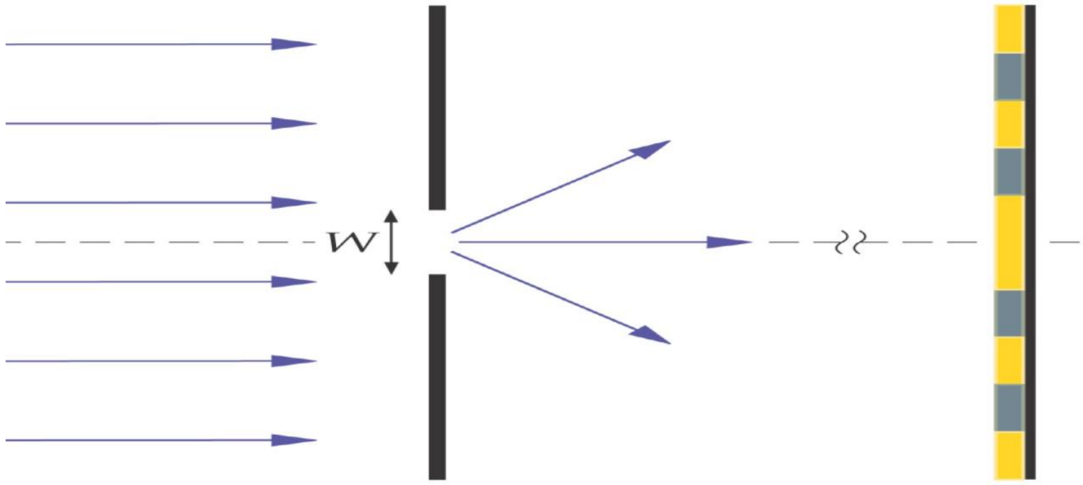
DIFFRACTION

Diffraction: is the bending of waves as they pass by an object or through an aperture.



Conditions of obtaining bright fringes and dark fringes:

d sin**θ** ***= m λ***	***the condition for obtaining a dark*** fringe
dsin**θ*****=(m+½)λ***	***the condition for obtaining a bright*** fringe

where d:is the slit width

Fresnel and Fraunhofer diffraction by a single slit:

Diffraction phenomena are conveniently divided into two general classes,

(1) Fraunhofer diffraction: those in which the source of light and the screen on which the pattern is observed are effectively at infinite distances from the aperture causing the diffraction.

(2) Fresnel diffraction: those in which either the source or the screen, or both are at finite distances from the aperture.

Differences between Fresnels diffraction and Fraunhofer diffraction

Fresnel diff.	Fraunhofer diff.
1-thesource and the screen are at finite distance from the diffracting aperture	1-the source and the screen are at infinite distance from the diffracting aperture
2-for obtaining fresnel diff. zone plates are used.	2- for obtaining fraunhofer diff. plane diffracting gratings are used
3-the wave fronts are divergent either spherical or cylindrical	3-the wave fronts are plane which is released by using convex lens.
4-no mirror or lenses are used for observation	Diffracted light is collected by lens
5-difficult treat theoretically	5- much simple treat theoretically

Diffracting grating:

It is a device that reflects or refracts light by an amount varying to the wavelength.

It consists of amount of a large number of N of slits each of width (a) and separated from the next by a distance d.

the condition for the principal maxima:

$$d\sin\theta = m\lambda$$

m= 0, 1, 2, 3,........

Rectangular aperture

A beam of light emerging through a small hole or aperture spreads out as it propagates. This spreading of light beam or bending of light rays is called **diffractio**n. The diffracted rays interfere constructively and destructively to form fringes. The diffraction pattern has constructive bright and dark fringes. The diffraction carries the shape of the aperture through which it is diffracting. Diffraction through a circular aperture form circular fringes, diffraction through a long thin slit from straight – line fringes and diffraction through a rectangular opening form rectangular fringes.

The dimension of the slit through which light is diffracting is of the order of few millimeter (0.1 to 2mm).hence, the product of slit dimension and wavelength is very small compared to the distance between source and slit, slit and screen. Such diffraction process is known as fraunhofer diffraction.

The light intensity of the diffraction pattern is:

$$I= I\,(0)\sec^2(\alpha)\sec^2\beta$$

Where: I(0) is the intensity at the center of the pattern

α costants called interference factor

β constant called diffraction factor

the width of the central bright fringe (0^{th} order)of the diffraction pattern is given by:

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

the height of the central bright fringe (0^{th}order)of the diffraction pattern is:

$$y=\frac{2\lambda f}{b}$$

where a: is the width of slit, λ: is the wavelength

b: is the height of slit, f: is the distance between slit and screen

Resolving power with a rectangular aperture

Resolving power: is the ability of a microscope or telescope to measure the angular separation of images that are close together .

All optical instruments give images that are affected by the diffraction at the objective lens, so if we have two points on the object that are close together it is possible that their images may possess diffraction patterns that will overlap. If they are too close the images of these two points will be indistinguishable from one another. This is especially important in astronomy where the images of two stars that are very close together need to be separated. The aperture of the telescope needs to be as large as possible to give as little diffraction as possible.

For two images of equal intensity to be resolved the central maximum (constructive interference – maximum brightness) of one diffraction pattern must fall no closer than the first minimum (destructive interference – darkness) to the centre of the second diffraction pattern (Figure 1). Using the formula for a rectangular aperture we have:

$$\lambda = a \sin \Theta \text{ for the first minimum}$$

where a is the aperture of the objective and λ the wavelength of radiation used
For a circular aperture and a small angle the formula has to be modified to give:

$$\text{Smallest resolvable angle } (\varphi) = 1.2\lambda/a$$

The theoretical and practical resolving powers are given by
Theoretical resolving power = λ/a and
Practical resolving power = d/D
Where λ = mean wavelength of light employed,
a = width of the rectangular slit for just resolution of two objects,
d = separation between two objects,
D = distance of the objects from the objective of the telescope hence
$\lambda/a = d/D$.

Ex: Light with a wavelength of 511 nm forms a diffraction pattern after passing through a single slit of width 2.20x10-6m. Find the angle associated with (a) the first and (b) the second dark fringe above the central bright fringe.

Solution:

(a) First Dark Fringe, m=1

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

$2.2*10^{-6} \sin\theta = (1)\ (511*10^{-9})$

$\Theta = 13.4^{0}$

(b) Second Dark Fringe, m=2

$a\sin\theta = m\lambda$

$2.2*10^{-6} \sin\theta = (2)(511*10^{-9})$

$\theta = 27.7^{0}$

Ex: Monochromatic light passes through a slit of width 1.2 x 10-5 mm. If the first dark fringe of the resulting diffraction pattern is at angle $\theta=3.25^{o}$, what is the wavelength of the light?