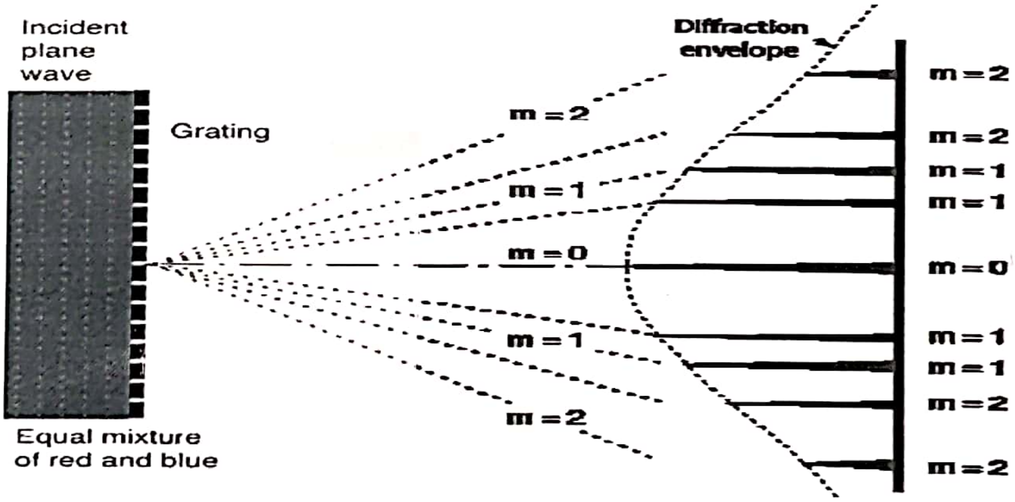
AIM: **TO STUDY THE DIFFRACTION PATTERN BY SLITS AND GRATING USING LASER LIGHT.**

APPARATUS: Laser source, Diffraction Grating, Screen Wall.

THEORY: Diffraction grating is a thin film of clear glass or plastic that has a large number of line per (mm) drawn on it. A typical grating has density of 500 lines/mm. using more expensive laser techniques; it is possible to create line densities of 3000 lines/mm or higher. A diffraction grating is an extremely useful device and one of its forms it consist of a very large no of narrow slits side by side. The slit is separated by opaque spaces. When a front is incident on a grating surface, light is transmitted though the slit and obstructed by opaque portion. Such a grating is called a transmission grating. Gratings are prepared by ruling equidistant parallel lines on a glass surface. The lines are drawn with fine diamond point. The space between any two lines is transparent to light and lined portion is opaque to light. Such surface act as transmission grating. The very thin spaces between every two adjacent lines of the grating become an independent source. These sources are coherent source meaning that they emit in phase waves with same wavelength. These sources act independently such that each source sends out wave in all the direction. On a screen a distance D away, points can be found whose distance differences from these sources are different multiples of wavelength causing bright fringes. One difference between the interference of many slits (diffraction grating) and double slit (Young experiment) is that a diffraction grating makes a number of principle maxima along with lower intensity maxima in between. The principle maxima occur on both side of the central maximum for which a formula similar to Young' s formula holds true.

BRIGHT FRINGES: $d \sin \theta_k = k\lambda$ (where k = 0, 1, 2, 3...)

DARK FRINGES; $d \sin \theta_k = \frac{(k-1)}{2}\lambda$ (where k = 1, 2, 3...)



D =the distance from the grating to the screen.

d = the spacing between every two lines (Same as every two sources).

If there are N lines per mm of grating, then d, the space between every two adjacent sources is:

$$d = 1 / N \quad \text{or} \quad N = 1 / d$$

The diffraction grating formula for the principal maxima is:

$$d \sin \theta_k = k \lambda \quad \text{(where } k = 1, 2, 3\ldots)$$

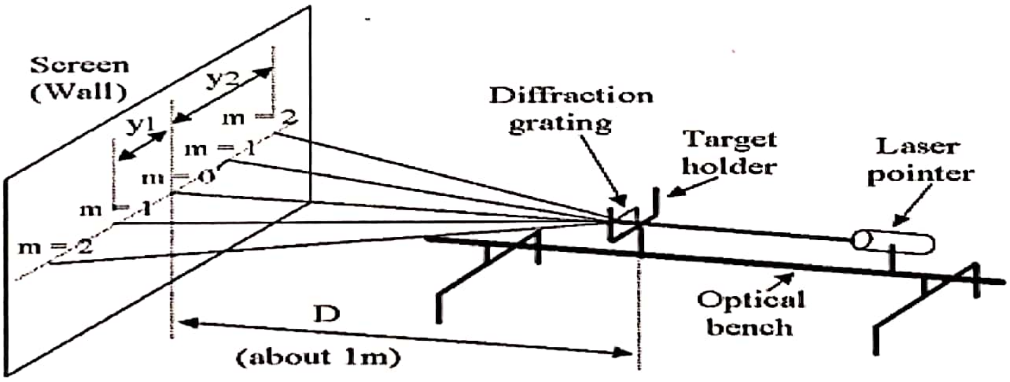
<u>PROCEDURE:</u> Determination of (lines/mm) of the diffraction grating:

a) Fix a laser pointer and diffraction grating (placed in a target holder) on an optical bench as shown. Try to make a distance D (grating to wall) of about 75 cm.
b) Make sure that the direction of the optical bench is normal (at right angle) to the wall and you are measuring the perpendicular distance D from the wall.
c) Measure Y_1, y_2 and D with the precision of mm and record the values.
d) Angles $\theta 1$ and $\theta 2$ may now be calculated from the measured values as follows:

$$\tan \theta 1 = y_1 / D \quad \text{and} \quad \tan \theta 2 = y_2 / D$$

e) Use the inverse tan function to calculate θ_1, θ_2.
f) Use angles θ_1, θ_2 along with the wavelength given on your laser pointer (in mm) and the diffraction grating formula to calculate d, the distance between adjacent spaces (sources) on the grating. Find d once on the basis of k = 1 and once on basis k = 2. Theoretically, the two values you obtain for d must be equal; however, due to measurement errors, they might be slightly different. Find the average value for d in meters.
g) From d, determine N, the number of lines per mm of the grating

DIAGRAM OF DIFFRACTION GRATING:



Theory of plane transmission grating:

In fig, MN is the grating surface and XY is the screen, both perpendiculars to the plane of the paper. The slits are all parallel to one another and perpendicular to plane of the paper. Here AB is a slit and BC is an opaque portion. The width of each slit is (a) and the opaque spacing between any two consecutive slits is (b). Let a plane wave front be incident on the grating surface. Then all the secondary waves traveling in the same direction as that of the incident light will come to focus at all point P on the screen. The screen is placed at the focal plane of the collecting lens. The point P where all the secondary waves reinforce one another corresponds to the position of the central bright maximum.

Now, consider the secondary waves traveling in a direction inclined at angle θ with the direction of the incident light, the collecting lens also is suitably rotated such that the axis of lens is parallel to the direction of the secondary waves. These secondary waves come to focus at point P_1 on the screen. The intensity at P_1 will depend on the path difference between the secondary waves originating from the corresponding points A and C of two neighboring slits. In fig AB = a and BC = b. the path difference between the secondary waves starting from A and C = AC sin θ.

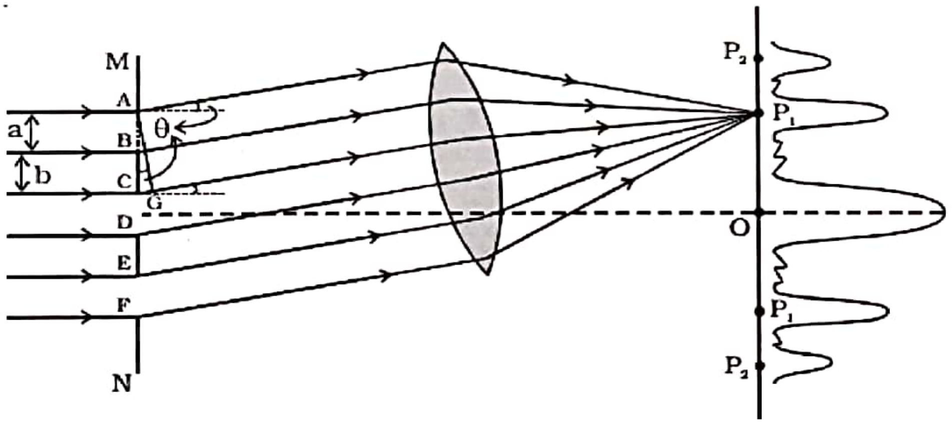


Fig 5.21 Diffraction grating

But AC=AB+ BC = a + b

Path difference =AC sin θ=(a + b) sin θ

The point P1 will be of maximum intensity if this path difference is equal to integral multiples of λ where λ is the wavelength of light. In this case, all the secondary waves originating from the corresponding points of the neighboring slits reinforce one another and the angle θ gives the direction of maximum intensity. In general

$$(a + b) \sin \theta_n = k \lambda$$

Where θ is the direction of the nth principal maximum. Putting n= 1, 2, 3, etc, the angles θ_1, θ_2, θ_3, etc corresponding to the directions of the principal maximum can be obtained.

If the incident light consists of more than one wavelength, the beams get dispersed and the angles of the diffraction for different wavelength will be different. Let λ and $\lambda + d\lambda$ be two nearby wavelengths present in the incident light and θ and $(\theta + d\theta)$ are the angles of diffraction corresponding to these wavelengths. Then, for the first order principal maxima

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

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

Thus, an any order, the number of principal maxima corresponds to the number of wavelengths present. A number of parallel slits images corresponding to the different wavelengths will be observed on the screen. In equation k=1 gives the direction of the first order of the image, k=2 gives the direction of the second order image and so on. When white light is used, the diffraction pattern on the screen consists of a white central bright maximum and on both sides of the maximum a spectrum corresponding to the different wavelengths of light present in the incident beam will be observed in each order.

OBSERVATION TABLE:

Sr .No	Order of Spectrum	Graph	Angle of diffraction
1	1st order	left right	left right Mean
2	2nd order	left right	left right Mean