## Experiment No- 5

## DIFFRACTION GRATING USING LASER

**AIM: -** To determine the wavelength of the Laser source using grating.

**APPARATUS: -** Grating, screen, microscope and LASER sources.

**DESCRIPTION:**

The laser consists of a mixture of in the ration of about 10:1, placed inside a long narrow Discharge tube. The pressure inside the tube is about 1 mm of Hg.

The gas system is enclosed between a pair of plane mirror or pair of concave mirror so that a resonator system is formed. One of the mirrors is of very high reflectivity while the other is partially transparent so that energy may be coupled out of the System. The 6328

A˚ transition of beam corresponding to the well-known red light of laser. Lasers are light amplification by stimulated emission of radiations.

**THEORY: -**

The grating may be treated as a large number of equally spaced point sources and each point on the grating is source of Huygens secondary wavelets, which interfere with the wavelets emanating from other points. The secondary wavelets traveling with the wavelets traveling in the direction parallel to the slit comes to focus on the screen at a point. Since all the rays are in the same phase, diffraction pattern is a point of maximum intensity. The secondary waves traveling in a direction making an angle θ converge to some other point on the screen. The intensity of this point will be maximum or minimum depending upon the path difference between the secondary waves orienting from the corresponding wave fronts.

The path difference is given by ------------ $(e+d)\sin\theta = n\lambda$

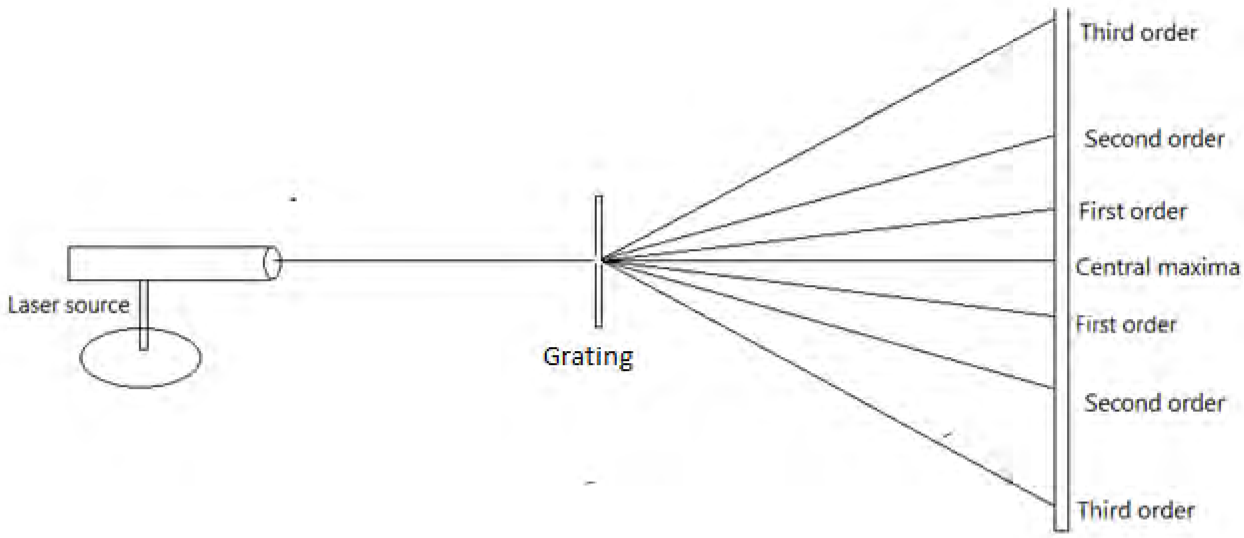
$$\left( \lambda = \frac{\sin\theta}{Nn} \right)$$

N=Lines per Inch on grating
e = Thickness of each line
d= distance between two successive lines
n = the order of diffraction (n= ±1, ±2, ±3-------)
λ is the wavelength of the source a is the slit width
θ is the angle of diffraction.

If the path difference is odd multiple of wavelength then it is given by-- $(e+d)\sin\theta = (2n+1)\lambda$
where n = 1,2,3…………

The formula given above is derived using the small angle approximation.

For the experiment fig shown above this means that $\sin\theta \approx y/L$ Place the single slit parallel to the laser source such that the rays are incident on the slit width. Adjust the slit width such that we see clear diffraction of the slit on screen or wall. Measure the distance of slit from wall let it be L and the distance between the maxima is y. Take the readings on left and right side. Vary the slit distance from the screen i.e take the reading at different L. The corresponding y is to be measured. Measure the slit width (a) by microscope.



Third order
Second order
First order
Central maxima
First order
Second order
Third order
Laser source
Grating

**Observation Table:**

**Grating specification 15000 LPI per inch**

**15000 lines are in 2.54 cm**

**So, One line will be equal to 2.54/15000=$1.69x10^{-4}$ cm=$1.69x10^{-6}$ mtr**

**C=Grating Constant =1/N= $1.69x10^{-6}$ mtr**

**Formula used- Wavelength λ=Sinθ.C**

| Sr.No | Distance D mtr | Distance between two spots on either side of central spot 2X mtr | Distance between central and immediate next spot X mtr | Angle of Deviation Θ= $tan^{-1}$(X/D) | Wavelength λ=Sinθ.C |
|---|---|---|---|---|---|
| | | | | | |
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**RESULT: - The wavelength of the given LASER is____________**

EXPT. NO. | NAME: | Page No. | Date | YOUVA

# Experiment 6

Aim: To determine the wavelength of the laser source using grating.

formula used $n\lambda = d \cdot \sin\theta$

$d$ = Grating Constant $= \frac{1}{N} = 1.69 \times 10^{-6}$ Mtr.

for first order $n=1$

second order $n=2$

| | Sr No | Distance D 'Mtr' | Distance between two spots on either side of central spot $2x$ mtr | Distance between central & immediate next spot $x$ mtr | Angle of deviation $\theta = \tan^{-1}\left(\frac{x}{D}\right)$ |
|---|---|---|---|---|---|
| n=1 | 1 | 0.55 | 0.48 | 0.24 | ~~23.57~~ |
| 2 | 2 | 0.55 | 1.52 | 0.76 | ~~26.56~~ |
| n=1 | 3 | 0.6 | 0.54 | 0.27 | ~~26.56~~ |
| 2 | 4 | 0.6 | 1.74 | 0.87 | ~~26.56~~ |
| n=1 | 5 | 0.65 | 0.58 | 0.29 | ~~26.56~~ |
| 2 | 6 | 0.65 | 1.78 | 0.89 | |
| | | | | | 23.57 |
| | | | | | 54.10 |
| | | | | | 24.22 |
| | | | | | 55.40 |
| | | | | | 24.044 |
| | | | | | 53.85 |

Teacher's Signature:

# Calculations

(1) $\theta = \tan^{-1}\left(\frac{x}{D}\right)$

$\theta = \tan^{-1}\left(\frac{0.24}{0.55}\right)$

$= 23.57$

$= 23^\circ 34' 12''$

$n\lambda = d \cdot \sin\theta$.

$n = 1$

$\lambda = 1.69 \times 10^{-6} \times \sin(23^\circ 34' 12'')$

$= 675.77$ nm.

(2)

$\theta = \tan^{-1}\left(\frac{0.76}{0.55}\right)$

$= 54.10$.

$= 54^\circ 6' 0''$

$n\lambda = d \cdot \sin\theta$

$n = 2$

$\lambda = \frac{1.69 \times 10^{-6} \times \sin(54^\circ 6')}{2}$

$= 684.48$ nm.

(3) $\theta = \tan^{-1}\left(\frac{0.27}{0.6}\right)$

$= \cancel{0.45}\ 24.22$

$= 24^\circ 13' 39.88''$

$n\lambda = d \cdot \sin\theta$

for $n = 1$.

$\lambda = \frac{1.69 \times 10^{-6} \times \sin(24^\circ 13' 39.88'')}{1}$

$= 693.51$ nm.

(4) $\theta = \tan^{-1}\left(\frac{0.87}{0.6}\right)$

$= 55.40$

$= 55^\circ 24' 27.76''$

$n\lambda = d \cdot \sin\theta$

for $n = 2$

$\lambda = \frac{1.69 \times 10^{-6} \times \sin(55^\circ 24' 27.76'')}{2}$

$= 695.61$ nm

EXPT. NO. NAME: Page No. Date:

(5) $\theta = \tan^{-1}\left(\frac{x}{D}\right)$

$= \tan^{-1}\left(\frac{0.29}{0.65}\right)$

$= 24.044$

$= 24^{\circ} 2' 39.20''$

$n\lambda = d \cdot \sin\theta$

$n = 1.$

$\lambda = d \cdot \sin\theta$

$= 1.69 \times 10^{-6} \times \sin(24^{\circ} 2' 39.26'')$

$= 688.57$ nm.

(6) $\theta = \tan^{-1}\left(\frac{x}{D}\right)$

$= \tan^{-1}\left(\frac{0.89}{0.65}\right)$

$= 53.85$

$= 53^{\circ} 51' 28.65''$

$n\lambda = d \cdot \sin\theta$

$n = 2$

$\lambda = \frac{d \cdot \sin\theta}{2}$

$= \frac{1.69 \times 10^{-6} \times \sin(53^{\circ} 51' 28.65'')}{2}$

$= 682.38$ nm

Result-

Wavelength of laser light - Red laser

Experimentally = 682.72 nm

Theoritically = 660 nm

Teacher's Signature: