Experiment – 4 LASER GRATING

Aim :-

To determine the number of lines in a given grating using a laser source of light.

Apparatus required :-

He-Ne laser or semiconducting laser, grating, scale, grating stand.

Formula :

$$N = \frac{\sin\theta}{n\lambda} \quad \text{lines per meter}$$

where

λ = Wavelength of laser light used in ane experiment.

θ = Angle of diffraction

n = Order of diffraction

N - Density of lines in grating.

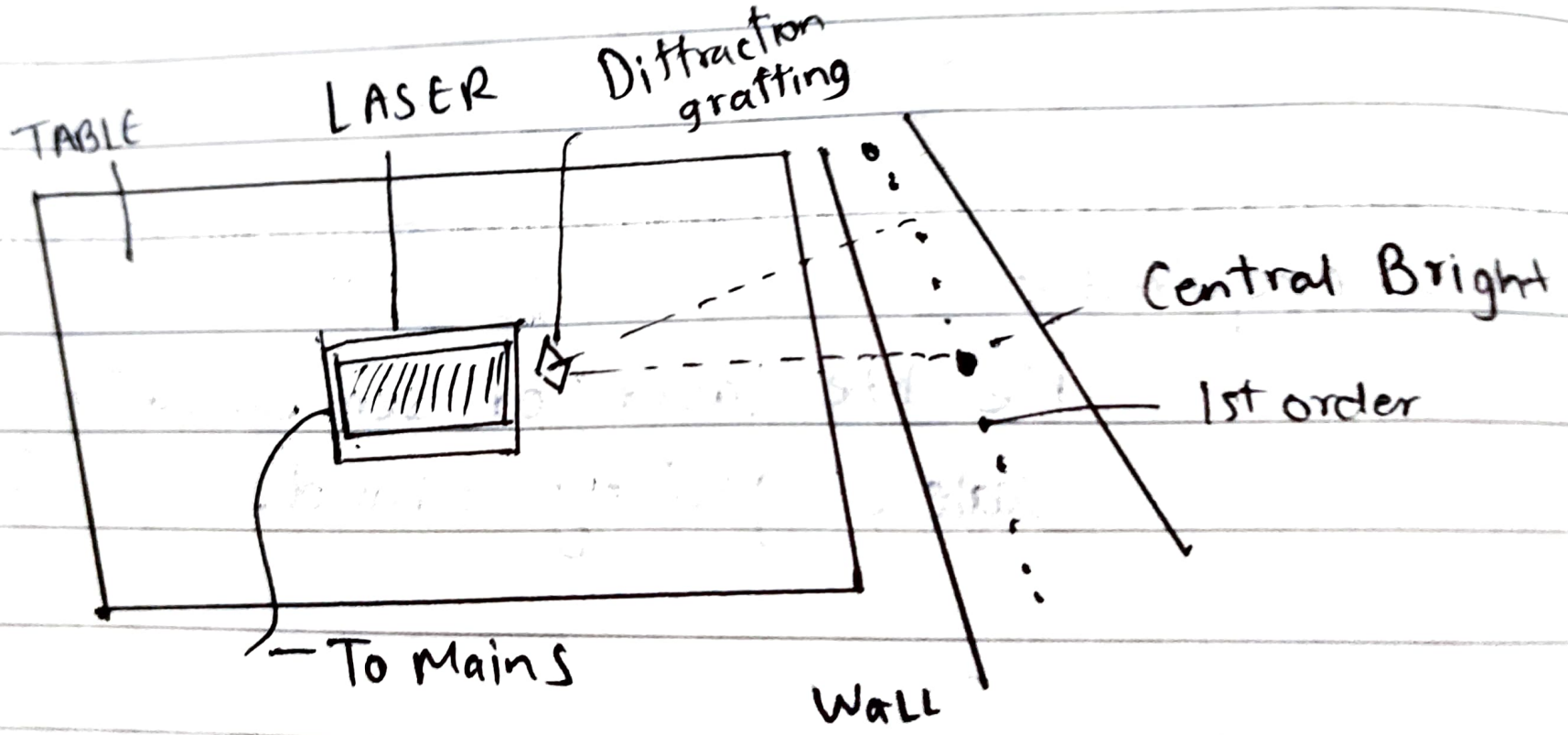
TABLE
LASER
Diffraction grafting
Central Bright
1st order
To Mains
WALL

Tabulation :-

$\lambda = 532\,nm$

Diffraction Order n	D cm	2L cm	L cm	tan θ L/D	θ	sin θ	Mean sin θ	N
1	30	3.3	1.65	0.055	3.148	0.0549	$= \frac{0.2748}{5}$	$\frac{103308.27}{39.37}$
	35	3.9	1.95	0.0557	3.188	0.0556		
	40	4.4	2.2	0.055	3.148	0.0549		
	45	5	2.5	0.0556	3.182	0.0555	$= 0.05496$	$= 2624.0$ lines/inch
	50	5.4	2.7	0.054	3.091	0.0539		
2	30	6.6	3.3	0.11	6.277	0.109	$= \frac{0.537}{5}$	$\frac{100939.8}{39.37}$
	35	7.6	3.8	0.109	6.221	0.108		
	40	8.6	4.3	0.108	6.164	0.1087		
	45	9.7	4.85	0.108	6.164	0.107	$= 0.1074$	$= 2563.87$
	50	10.7	5.35	0.107	6.107	0.106		
3	30	10	5	0.1667	9.464	0.164	$= \frac{0.806}{5}$	$\frac{101002.5}{39.37}$
	35	11.5	5.75	0.164	9.314	0.162		
	40	13.1	6.55	0.1637	9.297	0.162		
	45	14.6	7.3	0.162	9.202	0.160	$= 0.1612$	$= 2565.46$
	50	16	8	0.16	9.09	0.158		
4	30	13.5	6.75	0.225	12.68	0.220	$= \frac{1.08}{5}$	$\frac{101503.7}{39.37}$
	35	15.3	7.65	0.219	12.353	0.214		
	40	17.8	8.9	0.223	12.571	0.217		
	45	20	10	0.222	12.517	0.216	$= 0.216$	$= 2578.2$
	50	21.8	10.9	0.218	12.298	0.213		
5	30	17	8.5	0.283	15.802	0.272	$= \frac{1.346}{5}$	$\frac{101203.0}{39.37}$
	35	19.7	9.85	0.281	15.695	0.271		
	40	22.5	11.25	0.281	15.695	0.271		
	45	25.5	12.75	0.283	15.802	0.272	$= 0.2692$	$= 2570.58$
	50	27	13.5	0.27	15.110	0.260		

Mean $N = 101591.4$ l/m

$= 2580.42$ lines/inch

Calculation :-

$n = 1$

$D = 30$ cm

$2L = 3.3$ cm

$L = \frac{3.3}{2} = 1.65$ cm

$L/D = \frac{1.65}{30} = 0.055 = \tan\theta$

$\theta = \tan^{-}(0.055) = 3.148^{\circ}$

$\sin\theta = \sin(3.148^{\circ}) = 0.0549$

$D = 35$ cm

$2L = 3.9$ cm

$L = \frac{3.9}{2} = 1.95$ cm

$\tan\theta = \frac{L}{D} = \frac{1.95}{35} = 0.0557$

$\theta = \tan^{-1}(0.0557) = 3.188^{\circ}$

$\sin\theta = \sin(3.188^{\circ}) = 0.0556$

$D = 40 \text{ cm}$

$2L = 4.4 \text{ cm}$

$L = 2.2 \text{ cm}$

$\tan\theta = \frac{2.2}{40} = 0.055$

$\theta = \tan^{-1}(0.055) = 3.148^\circ$

$\sin\theta = \sin(3.148^\circ) = 0.549$

$D = 45 \text{ cm}$

$2L = 5 \text{cm}$

$2L = 2.5 \text{cm}$

$\tan\theta = \frac{2.5}{45} = 0.0556$

$\theta = \tan^{-1}(0.0556) = 3.182^\circ$

$\sin\theta = \sin(3.182^\circ) = 0.0555$

$D = 50 \text{cm}$

$2L = 5.4 \text{cm}$

$L = 2.7 \text{cm}$

$\tan\theta = \frac{2.7}{50} = 0.054$

$\theta = \tan^{-1}(0.054) = 3.091^\circ$

$\sin\theta = \sin(3.091^\circ) = 0.0539$

Mean $\sin\theta = \frac{0.0549 + 0.0556 + 0.0549 + 0.0555 + 0.0539}{5}$

$= \frac{0.2748}{5} = 0.05496$

$N = \frac{\sin\theta}{n\lambda} = \frac{0.05496}{1 \times 10^{-9} \times 532} = 103,308$ lines/m

$= \frac{103308}{39.37} = 2624.0$ lines/inch

Mean $N = \frac{103,308 + 100939 + 101002 + 101503 + 101203}{5}$

$= \frac{507957}{5} = 101591$ lines/metre

$= 2580.42$ lines/inch

Observations

For $n=1$ Mean $\sin\theta = 0.05496$

$n=2$ Mean $\sin\theta = 0.1074$

$n=3$ Mean $\sin\theta = 0.1612$

$n=4$ Mean $\sin\theta = 0.216$

$n=5$ Mean $\sin\theta = 0.2692$

Result:

The density of lines in the given grating was determined to be $N = 101591$ lines/metre $= 2580.42$ lines/inch