$\frac{60}{60}$ PV

INDIAN INSTITUTE OF TECHNOLOGY BOMBAY

PHYSICS DEPT.

NO. 23B0994 CLASS BATCH P15/8

NAME V. CHIDVILAS REDDY

EXPT. No. 1 LABORATORY

DATE

DIFFRACTION OF LIGHT:

AIM:

To observe the intensity patterns generated by the diffraction of a laser beam when passed through a ~~single slit~~ double slit and to measure the sizes of these diffracting elements, upto micro-meter scale (i.e micron) accuracy.

Apparatus:

1) Optical Rail
2) Diode Laser (wavelength 650nm)
3) Kinematic laser mount
4) Power supply for laser
5) Pinhole detector
6) Cell mount with diffraction cell
7) Output measurement unit
8) Linear translation stage
9) Slit box

Theory:

When light rays are partially obstructed, they tend to show amount of bending around the obstacle which results in a pattern of illuminated and dark spots on a screen. This known as diffraction. This bending of light can be explai by Huygen's prenciple which states that every point on the w that arrives at the aperture acts as a source of spherical and these secondary waves interfere on the screen to gen the diffraction pattern.

① Diffraction of light by double slit :

$$I(\theta) = I_0 \cos^2\left(\frac{\pi d \sin\theta}{\lambda}\right)\left(\frac{\sin(\beta)}{\beta}\right)^2$$

where $\beta = \frac{\pi a \sin\theta}{\lambda}$,

where a = width of each slit

d = separation b/w slits

Conditions for maxima : $d\sin\theta = m\lambda$

Conditions for minima : $d\sin\theta = \left(\frac{2m+1}{2}\right)\lambda$,

where $m = \pm1, \pm2, \pm3 \ldots$

In this experiment $d > a$,

From the positions of maxima,

we can find slit separation, $d = \frac{m\lambda}{\sin(\theta_m)}$, $\theta_m = \tan^{-1}\left(\frac{y_m}{D}\right.$

INDIAN INSTITUTE
OF
TECHNOLOGY BOMBAY

PHYSICS DEPT.

NO. 23B0994 CLASS

BATCH P15/8

NAME V. Chidvilas Reddy

EXPT. No. 1

LABORATORY

DATE

Observations:

① Diffraction by double slit:

S.No	Main scale reading (mm)	Circular scale reading (mm)	Total reading (mm)	Intensity (μA)
1.	11	45 × 0.01 = 0.45	11.45	42.0
2.	11.5	25 × 0.01 = 0.25	11.75	31.5
3.	11.5	45 × 0.01 = 0.45	11.95	14.3
4.	12	32 × 0.01 = 0.32	12.32	2.6
5.	12.5	10 × 0.01 = 0.10	12.60	10.7
6.	12.5	30 × 0.01 = 0.30	12.80	23.6
7.	13	18 × 0.01 = 0.18	13.18	39.2
8.	13	43 × 0.01 = 0.43	13.43	32.3
9.	13.5	12 × 0.01 = 0.12	13.62	20.5
10.	14	7 × 0.01 = 0.07	14.07	2.3
11.	14.5	18 × 0.01 = 0.18	14.68	26.6
12.	14.5	42 × 0.01 = 0.42	14.92	31.8
13.	15	40 × 0.01 = 0.40	15.40	14

INDIAN INSTITUTE OF TECHNOLOGY

PHYSICS DEPT.

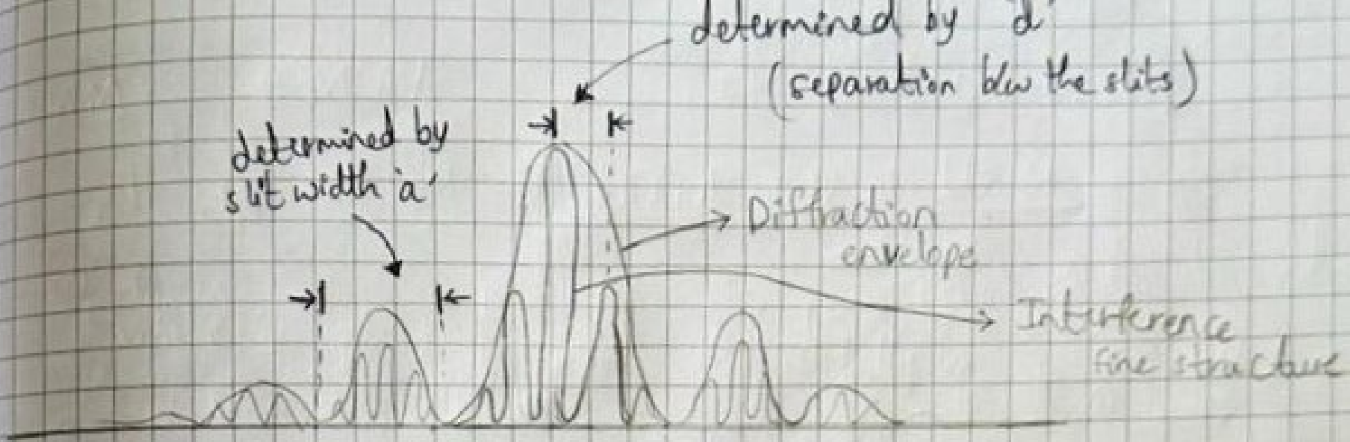
NO. NAME EXPT. No. DATE

CLASS

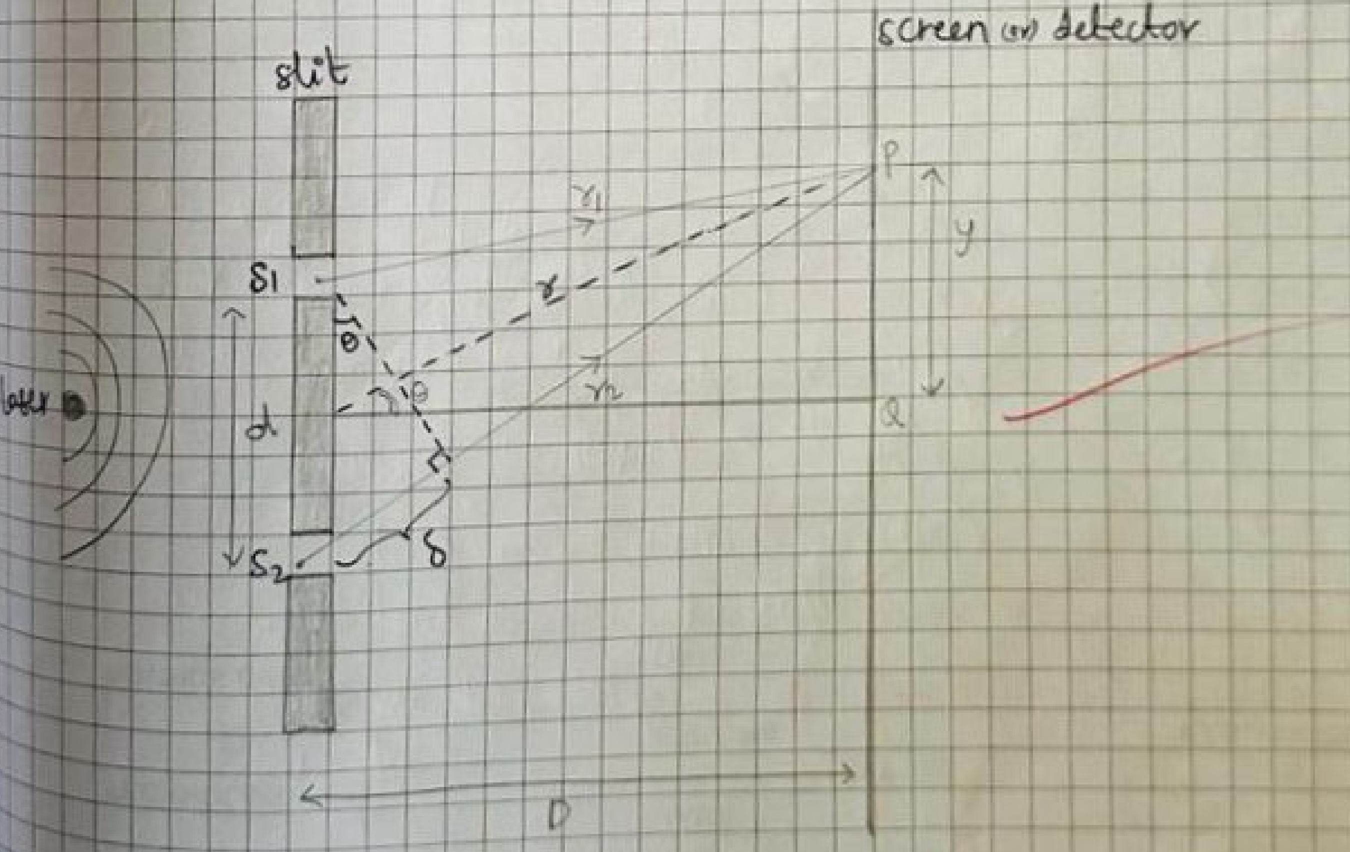
BATCH

LABORATORY

S.No	Main scale reading (mm)	Circular scale reading (mm)	Total reading (mm)	Intensity (μA)
14.	15.5	30×0.01 = 0.30	15.80	1.9
15.	16	40×0.01 = 0.40	16.40	18.5
16.	16.5	12×0.01 = 0.12	16.62	22.6
17.	10.5	40×0.01 = 0.40	10.90	13.3
18.	10.5	10×0.01 = ~~10.6~~ 0.10	10.60	2.6
19.	10	20×0.01 = 0.20	10.20	17.7
20.	10	0×0.01 = 0.00	10.00	30.9
21.	9.5	21×0.01 = 0.21	9.71	39.2
22.	9	30×0.01 = 0.30	9.30	20.4
23.	8.5	35×0.01 = 0.35	8.85	2.3
24.	8	40×0.01 = 0.40	8.40	19
25.	8	25×0.01 = ~~8.25~~ 0.25	8.25	26.7
26.	8	0×0.01 = 0.00	8.00	32.6
27.	7.5	0×0.01 = 0.00	7.50	13.5
28.	7	10×0.01 = 0.10	7.10	1.9
29.	6.5	40×0.01 = 0.40	6.90	5.3
30.	6	30×0.01 = 0.30	6.30	24.7



Diffraction pattern for double slit .



Diagram

INDIAN INSTITUTE OF TECHNOLOGY

PHYSICS DEPT.

NO. CLASS BATCH

NAME

EXPT. No. LABORATORY

DATE

So $\theta_m = \tan^{-1}\left(\frac{y_m}{D}\right)$.

y_m = distance of m^{th} maxima from central maxima

$$\theta_1 = \tan^{-1}\left(\frac{13.18 - 11.45}{1070}\right) = 0.092^\circ$$

$$\theta_1' = \tan^{-1}\left(\frac{11.45 - 9.71}{1070}\right) = 0.093^\circ$$

$$\theta_2 = \tan^{-1}\left(\frac{11.45 - 8.00}{1070}\right) = 0.184^\circ$$

$$\theta_2' = \tan^{-1}\left(\frac{14.92 - 11.45}{1070}\right) = 0.185^\circ$$

$$d\sin(\theta_m) = m\lambda \quad , \quad d = \frac{m\lambda}{\sin(\theta_m)}$$

$$\Rightarrow d_1 = \frac{1 \times 650 \times 10^{-9}}{\sin(0.092^\circ)} = 0.404 \text{ mm}$$

$$d_1' = 0.403 \text{ mm}$$

$$d_2 = 0.404 \text{ mm}$$

$$d_2' = 0.402 \text{ mm}$$

$$d_{avg} = \frac{\sum_{i=1}^{4} d_i}{4} = \frac{0.404 + 0.403 + 0.404 + 0.402}{4} = 0.403 \text{ mm}$$

(slit separation)

Precautions :

1) Do not touch the inner surface of diffraction
2) Avoid backlash error while moving the micromet scale on the detector.
3) Take care while handling all the equipment.
4) Avoid looking directly into the laser beam

Calculations :

① Double slit :-

$y_{\text{central max.}} = 11.45$ mm

$y_{\text{first maxima}}$:- $y_1 = 13.18$

$y_1' = 9.71$

second maxima :- $y_2 = 8.00$ mm

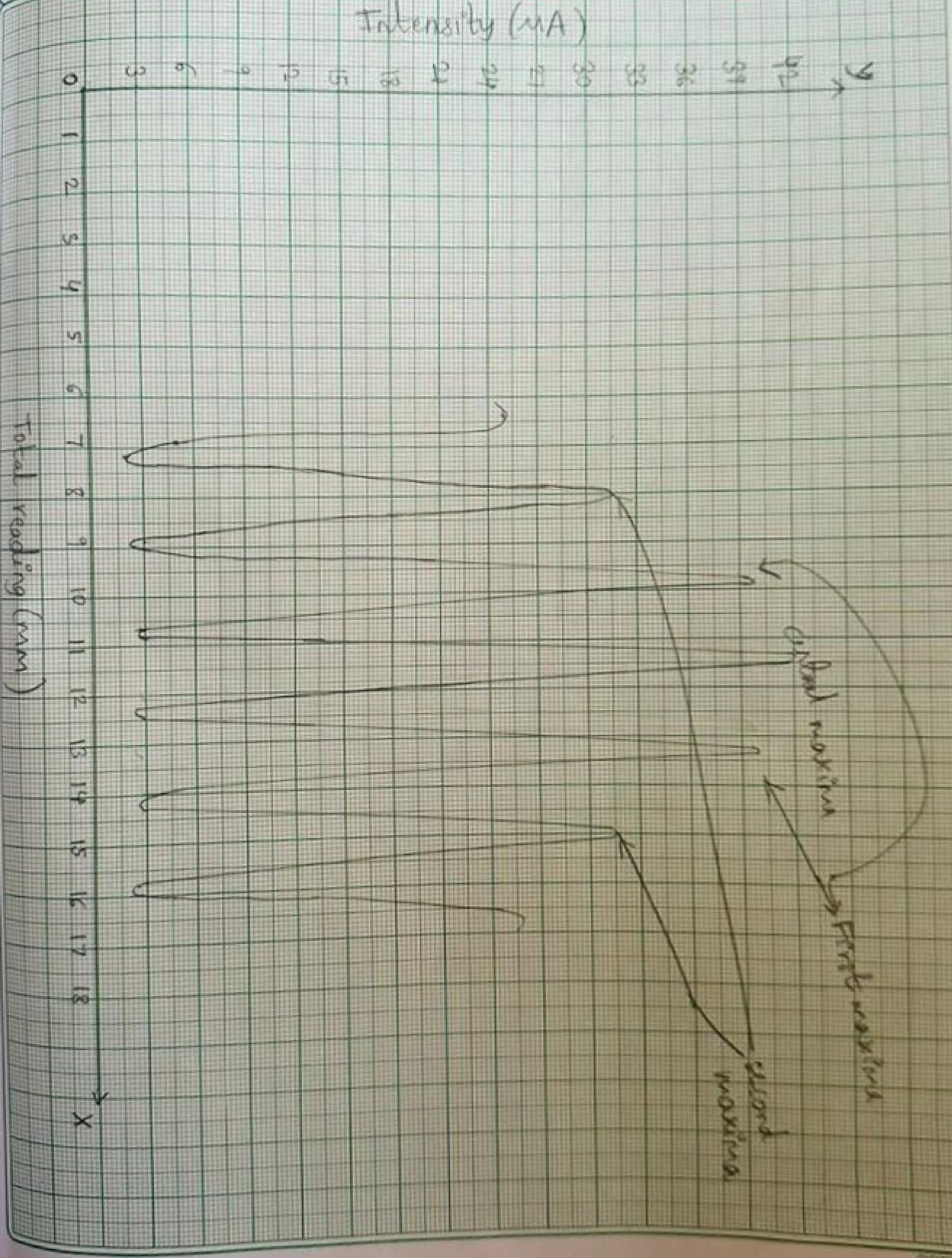
$y_2' =$ 14.92 mm

'D' = 1070 mm

Diffraction pattern

Intensity (μA) vs total reading (mm)

SCALE :- 1 cm along y-axis = 3 μA
1 cm in x-axis = 1 mm



$$\delta d = \sqrt{\frac{\sum_{i=1}^{4}(d_i - d_{avg})^2}{4}} = 1.22 \times 10^{-3}\ mm$$

$$= 0.0012\ mm$$

Ratio of slit width to slit separation $= \frac{a}{d} = \frac{1}{7}$

$$\boxed{\text{i.e } \frac{d}{a} = 7}$$

(since i got around 14 to 15 maxima in one diffr[illegible] en[illegible]

<u>Result:</u>

→ slit separation = 0.403 mm ± 0.0012 mm

→ $\frac{d}{a} = 7$