NAME : Raghav Dwivedi CLASS: CSE (Section-B)

ROLL NO. : 34 EXAM NO.

Experiment Number 01

Aim:

To measure the divergence of Helium Neon laser beam.

Apparatus Required:

He-Ne laser, stand, screen, measuring tape

Theory and Formula Used:

Divergence is defined as the spread of the laser beam i.e. how much angle is subtended by the laser spot at the point of origin. It is measured in radians.
The divergence of the laser beam is extremely small as compared to the conventional lights sources.
A laser beam after travelling the distance upto moon spreads only 2 Km across while this much spread takes place by torch light only when light travels a few kilometer distance. The typical divergence of He-Ne laser is of the order of 1 milli radian.
We set up 3 equations to obtain the values of divergen-ce angle. For this purpose, 'W' (spot size) is measured at some arbitrary planes distant z, z+D and z+2D from a reference plane.
We have

$$\theta = \frac{\sqrt{W_3^2 - 2W_2^2 + W_1^2}}{D\sqrt{2}}$$

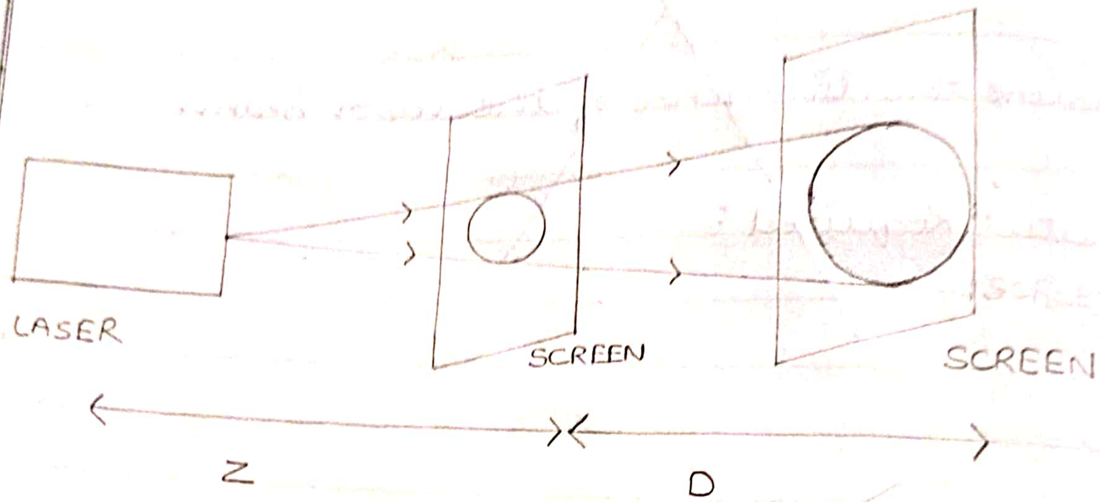


Fig.

Procedure :

The beam spot sizes are measured at 3 different planes at $z=z$, $z=z+D$, $z=z+2D$ respectively. The seperation D is measured with a meter scale or measuring tape. The divergence angle is then calculated using the formula. The procedure must be repeated by measuring spot size at additional planes and then averaging the values.

Calculation :

$$\Rightarrow \theta = \frac{\sqrt{W_3^2 - 2W_2^2 + W_1^2}}{D\sqrt{2}} = \frac{\sqrt{(0.4\,cm)^2 - 2(0.3\,cm)^2 + (0.2\,cm)^2}}{(50\,cm)\sqrt{2}}$$

$$\Rightarrow \theta = \frac{\left(\sqrt{0.16 - 0.18 + 0.04}\right) cm}{(50\sqrt{2}\,cm)} = \frac{\sqrt{0.20 - 0.18}}{50\sqrt{2}}$$

$$\Rightarrow \theta = \frac{\sqrt{0.02}}{50\sqrt{2}} = \frac{\cancel{\sqrt{2}} \times \sqrt{\frac{1}{100}}}{50\cancel{\sqrt{2}}} = \frac{1}{50 \times 10} = \frac{1}{500}\ rad$$

$$\Rightarrow \theta = 0.002\ rad = 2 \times 10^{-3}\ rad = 2\ milli\ rad$$

Result :

The divergence of the laser beam is one of its important parameter. The experimentally obtained divergence value is in a very good agreement with the theoretical value. The average divergence is found to

Observation Table:

S.No.	Distance (cm)	Spot Size (cm) 'W'	Divergence (radian) 'θ'
1.	100	0.2	2×10^{-3}
2.	150	0.3	2×10^{-3}
3.	200	0.4	2×10^{-3}

be 2 milli radians as expected.

Precautions :

1. Do not stare directly into the beam.
2. Measure the width of central maxima accurately.
3. laser beam from He-Ne laser must fall normally.
4. Avoid direct eye exposure to the laser radiation

Implications :

1. One can calculate the wavelength of light (source) trees used in this experiment.
2. One can study the diffraction pattern of LASER.
3. We can calculate value of N.A. by using LASER.
4. LASER can be very useful in measurement of atmospheric pollutants such as dust, smoke and flyash. Pulsed laser are used for this kind of work.
5. Semiconductor lasers are used for printing.

Viva Voce

1. He-Ne laser is which type of ~~laser~~ LASER ?

(A) He-Ne laser is a gas laser.

2. Which pumping method is used in He-Ne ~~laser~~ LASER ?

(A) Electrical excitation

Page. No. ______ Expt. No. ______ Date ______

3. At what wavelength does He-Ne ~~laser~~ LASER operate?

(A) 632 nm

4. What is the special property of He-Ne ~~LASER~~ LASER?

(A) It is highly coherent and monochromatic.

5. What is the difference in He-Ne and other ~~lasers~~ LASER?

A) It gives a continuous laser beam.

Harshi
14/11/

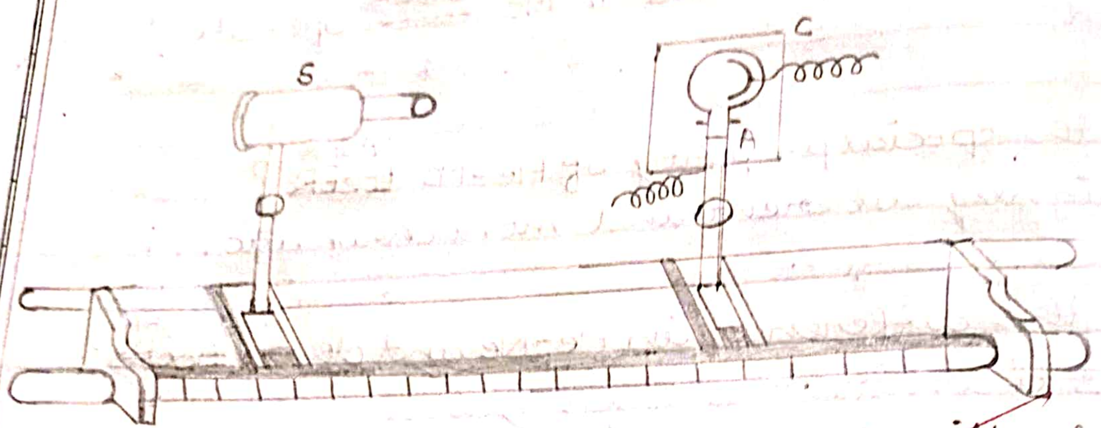
Experiment Number 2

Aim:
Verify the inverse square law.

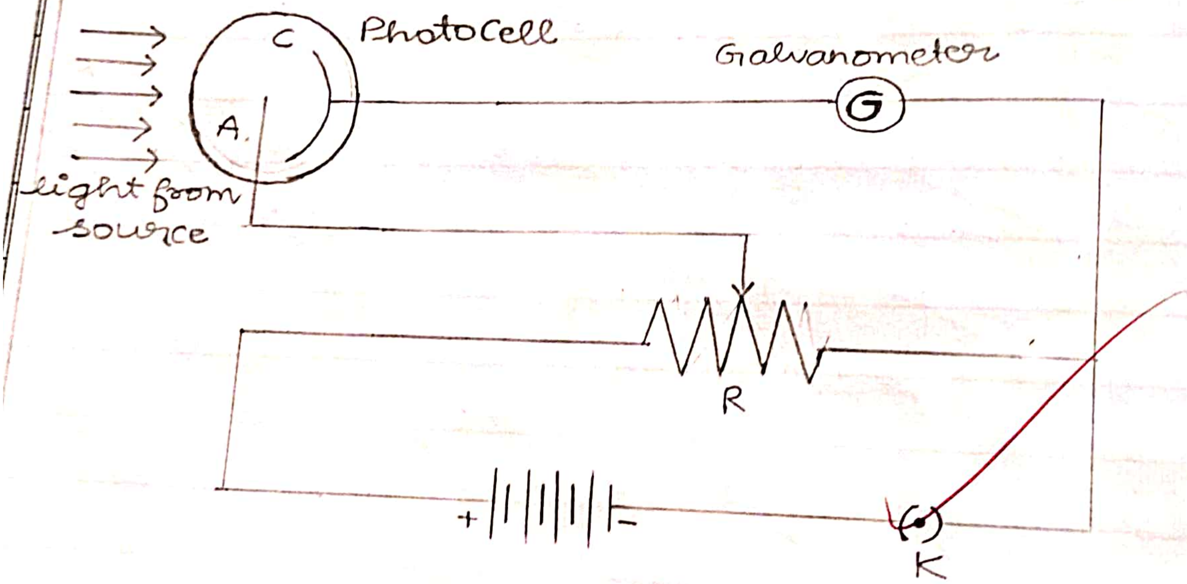
Apparatus Required:
One electric bulb, moving coil galvanometer, lamp and scale arrangement, photovoltaic cell, bench with two uprights.

Theory:
The photovoltaic cell is enclosed in a wooden box.
Inverse square law of light states that for a source of light having constant luminous intensity, the intensity of illumination (I) at a point on the surface in case of normal incidence is inversely proportional to the square of distance (r) at that point from the source i.e. $I \propto 1/r^2$.
Hence, a straight line graph between galvanometer deflection θ and $1/r^2$ will verify inverse square law of light.

Procedure:
1. Make connections and and adjust the lamp and scale arrangement,
2. Insert first bulb on upright and move bulb towards the photovoltaic cell in steps and note the corresponding



(a) optical bench with photovoltaic cell fitted with lamp and scale arrangement



(b) Electrical circuit with photovoltaic cell

Page. No. Expt. No. Date

deflections.

3. Plot the graph between deflection θ of spot of light and the distance of the source S1 from the surface of the S2 photovoltaic cell. Repeat observation

4. To verify the inverse square law. Plot a graph between θ and r^2. It is a straight line.

Result :

The obtained graph between $\frac{1}{\theta}$ and r^2 proves inverse square law.

Precautions:

1. While taking the readings of the meter, care should be taken to note accurate values.
2. The photovoltaic cell should be exposed to light for long time continuously.
3. The photovoltaic cell and bulb are mounted in such a way that light falls normally on the surface of the photocell.

Viva Voce :

1. What do you mean by inverse square law?

(A:) The inverse square law states that the intensity of illumination is inversely proportional to the square of the distance of the cell surface from the given

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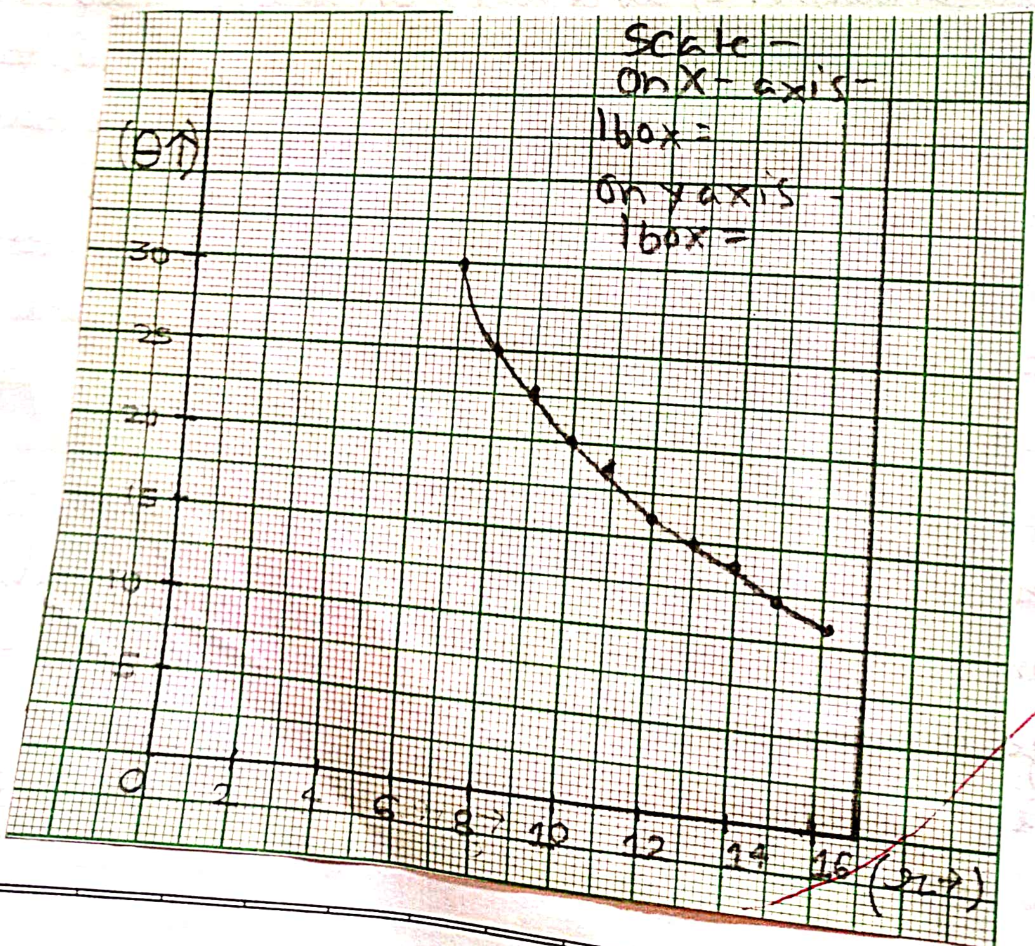
Observation Table:

S.No.	pos^n of uprights carrying Photovoltaic cell x_1 (cm)	Lamp x_2 (cm)	Galvanometer Deflection θ (mA)	Difference $r=(x_2-x_1)$ (cm)	r^2 (cm^2)	$\frac{1}{\theta}$ (mA^{-1})
1.	28	35	30	7	49	0.033
2.	27	35	25	8	64	0.040
3.	26	35	23	9	81	0.043
4.	25	35	20	10	100	0.050
5.	24	35	19	11	121	0.055
6.	23	35	16	12	144	0.062
7.	22	35	15	13	169	0.069
8.	21	35	14	14	196	0.076
9.	20	35	12	15	225	0.086
10.	19	35	11	16	256	0.093



Page. No.	Expt. No.	Date

source.

2. Define Intensity of illumination.

A. It is defined as the light falling per second on a unit area of the surface placed at a point under consideration.

3. What do you mean by photoconductivity?

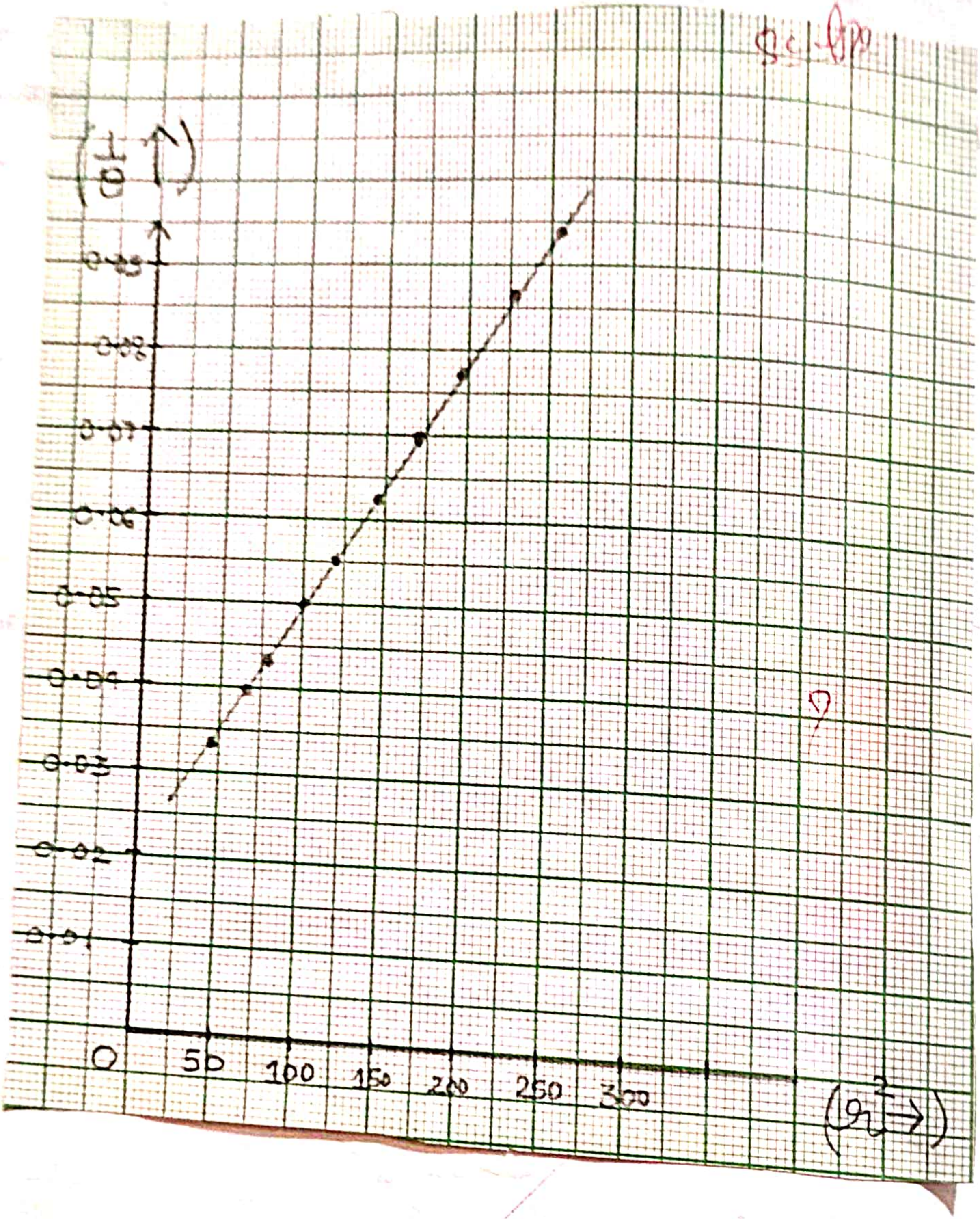
A. It is an optical and electrical phenomenon in which a material becomes conductive due to absorption of electromagnetic radiation such as visible light, ultraviolet light and infrared light or gamma radiation.

4. What is photovoltaics?

(A) It is the direct conversion of light into electricity at the atomic level. Some materials exhibit a property known as photoelectric effect that causes them to absorb photons of light and release electrons. When free electrons are captured, electric current results that can be used as electricity.

5. What is photoconductive cell?

(A) The photoconductive cell is a two terminal device whose terminal resistance will vary linearly with the intensity of light. For various reasons, it is known as photoresistive device.


0
50
100
150
200
250
300

Page. No. ________ Expt. No. ________ Date ________

Implications:

Inverse Square Law explains how radiations propogate in space. There are many applications on inverse square law in various fields. Some of them are :-

(i) Use of Emr for communication : A signal transmitted from the spacecraft is received on the earth after travelling distance of 94 AV.

(ii) In photography and stage lighting : It is used for proper focussing of light on the subject on the stage. Also, we need a proper flash or studio light while making movies, then the object at double the distance from source light receives only quarder amount of light. Hence, if a person moves 4m away, he will need four times of the light for the exposure.

(iii) In radiology and radiotherapy treatment : Using inverse square law, we can reduce the dose of radiation by reducing the distance. It explains how the dose gets reduced by increasing the distance. It can also be said that dose is inversely proportional to square of radius. Thus, by doubling the radius we can reduce the dose by a factor of 4.

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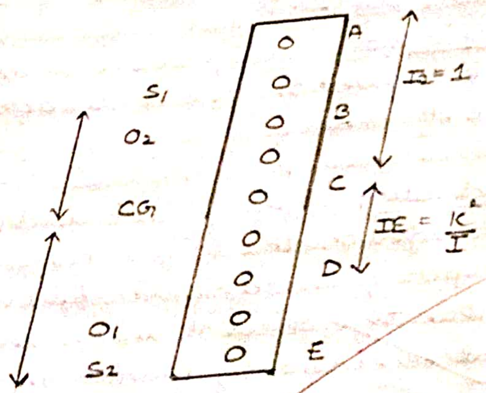
Harshika 1/11/22



Experiment No. 3

Aim:
To study the variation of T with L for a compound pendulum (Bar Pendulum) and then to determine the value of acceleration due to gravity (g) in the laboratory.

Apparatus Required:
Bar Pendulum, Stopwatch, Knife edges fixed to a rigid support, meter scale.

Theory and Formula Used:
The value of g can be calculated with the help of the following formula.

$$T = 2\pi\sqrt{\frac{L}{g}}$$

OR

$$g = \frac{4\pi^2 L}{T^2}$$

L = Distance between centres of oscillation and suspension (can be obtained from graph)
T = time period

The principle is based on interchangeability of centres of suspension and oscillation. We know that for a suspension, there is another point on the side of centre of gravity, called centre of oscillation about which the

Page. No. Expt. No. Date

time period is the same, there are also two other such points. The distances between centres of suspension and centre of oscillation is called length of equivalent simple pendulum. Knowing this distance, 'g' can be calculated.

Procedure :

1. The bar pendulum is hanged vertically with means of a knife edge.
2. Allow bar to oscillate through a small angle with knife edge passing via hole 1. Note the time for 10 oscillations with a stopwatch. Find time period of 1 oscillation. Remember that knife edge at lower edge should be in hole no. 1.
3. Insert knife edge in next holes and find time period till centre of gravity is approximately reached. The knife edge at lower end should be changed accordingly.
4. Turn the bar pendulum and repeat the same procedure.
5. Plot a graph between T(time period) and distance of knife edge x taking origin in centre of graph.

Result :

The value of acceleration due to gravity at New Delhi = 10.~~80~~ 43 m/sec^2

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Observation Table :

Sl No.	No. of hole	Distance of hole from C.G. (meter)	No of oscillations	Time Taken (seconds)	Periodic Time T (seconds)
1.	1	0·45	10	15·84	1·584
2.	2	0·40	10	15·66	1·566
3.	3	0·35	10	15·32	1·532
4.	4	0·30	10	15·22	1·522
5.	5	0·25	10	15·06	1·506
6.	6	0·20	10	15·50	1·550
7.	7	0·15	10	16·70	1·670
8.	8	0·10	10	19·53	1·953
9.	9	0·05	10	25·78	2·578

Sl No.	No. of hole	Distance of hole from C.G. (meter)	No of oscillations	Time Taken (seconds)	Periodic Time T (seconds)
1.	1.	0·45	10	15·72	1·572
2.	2.	0·40	10	15·50	1·550
3.	3.	0·35	10	15·18	1·518
4.	4.	0·30	10	15·16	1·516
5.	5.	0·25	10	15·12	1·512
6.	6.	0·20	10	15·65	1·565
7.	7.	0·15	10	16·63	1·663
8.	8.	0·10	10	19·76	1·976
9.	9.	0·05	10	25·87	2·587

Page. No. ________ Expt. No. ________ Date ________

Standard Result :

The value of g at New Delhi = 9.8 m/sec^2

Percentage error :

$\Rightarrow$ $\%\text{ error} = \left(\frac{\text{Result} - \text{Standard Result}}{\text{Standard Result}}\right) \times 100\% = \left(\frac{9.84 - 9.80}{9.80}\right) \times 100 = 0.41\%$

Sources of Errors and Precautions

1. The amplitude of oscillation should be kept small.
2. The pendulum should vibrate only in a vertical plane.
3. Curves on graph should be drawn smoothly.
4. The time of oscillation should be count atleast for 40 oscillations.
5. Before starting the experiment, knife edge is made horizontal.

Implications :

A. Bar pendulum can be used in many fields (real time) such as seisometers.

~~A. It is a rigid~~

$\rightarrow$ Seisometer : To measure seismic activity in the ground. It tells from which direction earthquake was coming. When they detect moment, such as shifting of plates due to earthquake, a pendulum with a pen attached to it graphs the magnitude of moment.

If the pendulum move/swings vigorously, scientests come to know that seismic waves are intense and potentially dangerous.

Calculations :

From graph, $L = \frac{AC+BD}{2} = \frac{0.60+0.60}{2} = 0.60\,m$

$T = 1.550$ sec

$g = \frac{4\pi^2 L}{T^2} = \left(\frac{4\times(\pi)^2\times 0.60}{1.550}\right) m/s^2 = 9.84\ m/s^2$

Page. No. ______ Expt. No. ______ Date ______

B: Moreover, this experiment will enable us to

(a) determine the length of equivalent simple pendulum.

(b) determine radius of gyration of bar pendulum.

by plotting a time period of oscillation against distance of of suspension of CG.

$$l_1 = \frac{1}{2}[AC+CE] = \frac{1}{2}AE$$

$$l_2 = \frac{1}{2}[BC+CA] = \frac{1}{2}BD$$

$$K = \sqrt{l_1 l_2}$$

(c) verify that there are two pivot points on other side of CG (centre of gravity) about which the time period is same.

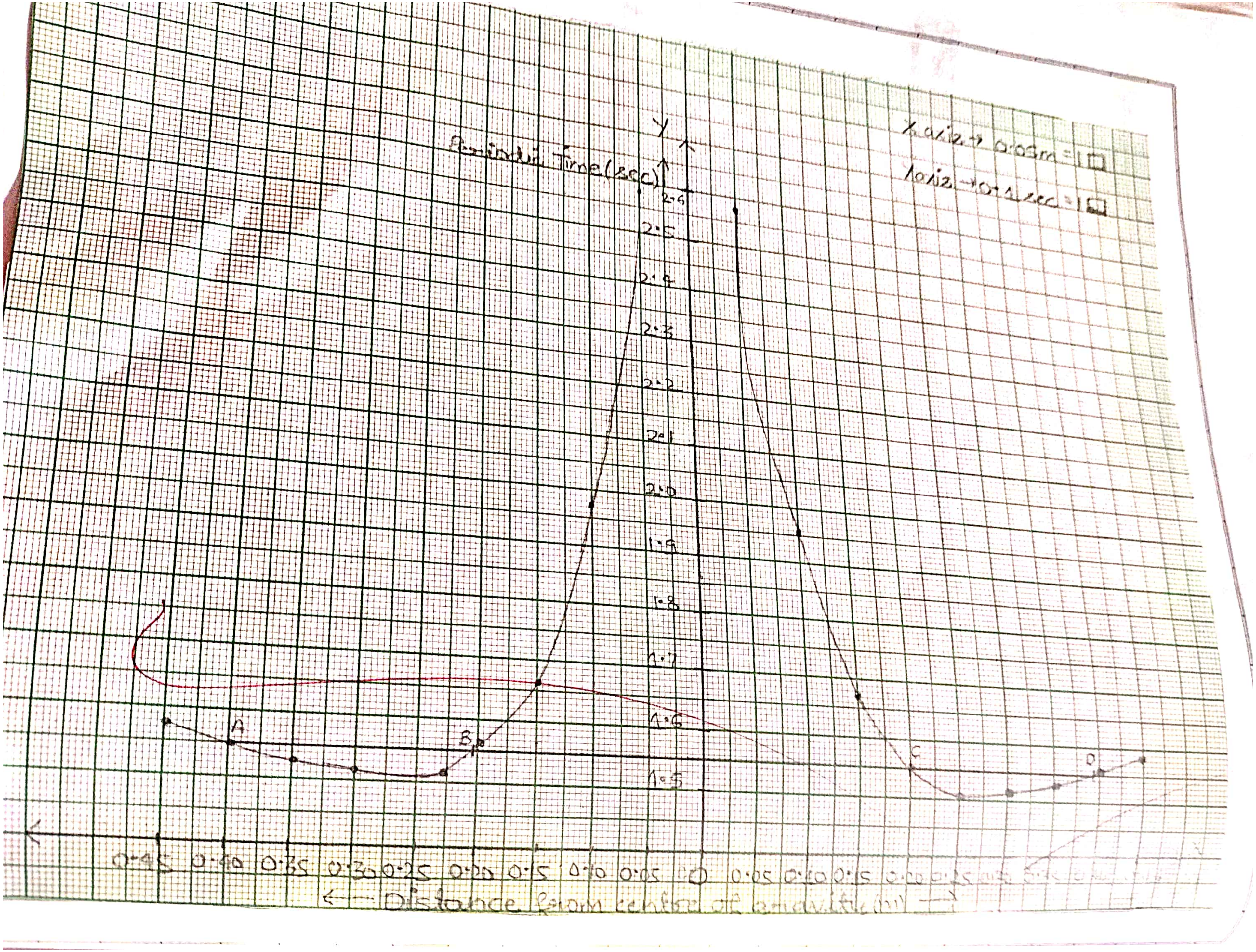
Viva-Voce

1. What is a compound pendulum?

A. It is a rigid body capable of oscillating freely about a horizontal axis passing through it.

2. What is time period of a compound pendulum at centre of gravit

A. Time period is infinity



X axis → 0.05m = 1□
Y axis → 0.1 sec = 1□
Periodic Time (sec)
Y
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
A
B
C
D
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0
0.05
0.10
0.15
Distance from centre of gravity (m)

Page. No. Expt. No. Date

3. About how many periods, points of oscillation is same?

A. About four points. They are two centres of oscillation points and two centres of suspension points, all lie in the same plane.

4. What is radius of gryation and its units.

A. It is distance of centre of gravity about which entire mass of the body seems to be concentrated. Its unit are meter or cm.

5. Why is compound pendulum superior to simple pendulum.

A. It is superior because-

(i) it is a solid bar so it can execute a lot of oscillations.

(ii) There is no lag between both the strings.

(iii) Sometimes, the bob rotates about its own axis also.

22/11/22

Experiment No: 4

Aim :

To determine the wavelength of sodium light by Newton's Ring.

Apparatus Required:

Newton's Ring Apparatus (A photoconvex lens, an optical glass plate placed on a pwooden state having a plane glass plate), a travelling microscope, sodium lamp, a convex lens

Theory :

Newton's Ring are formed as a result of interference between the waves reflected from the top and bottom of airfilm surface formed between the lower convex surface of the lens and the top surface of the plate (P).

$$\lambda = (D_{m+n}^2 - D_n^2)/4mR$$

where

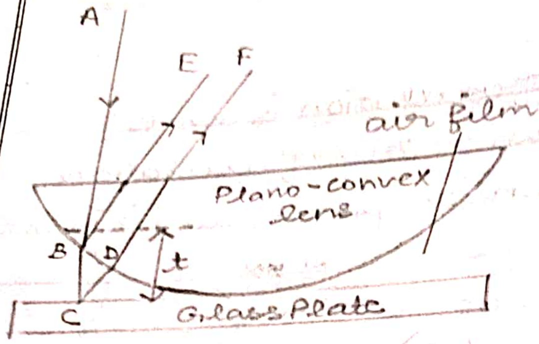
D_{m+n} is the diameter of $(n+m)^{th}$ bright ring.

D_n is the diameter of n^{th} bright ring.

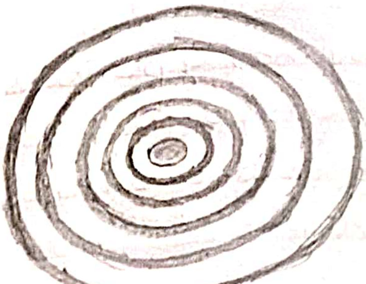
R is radius of curvature of the curved surface of lens

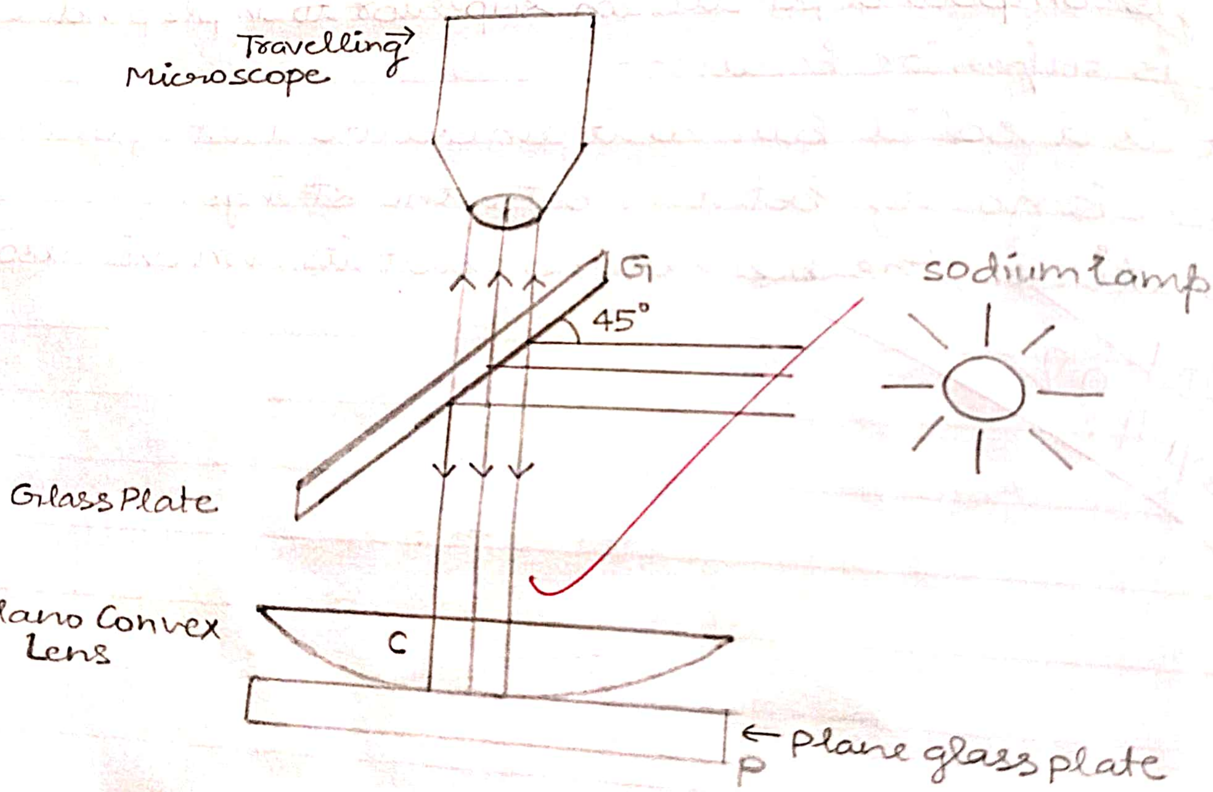
Procedure :

1. Clean the planoconvex lens and the two glass plates and f them.
2. Set the glass plate G at angle of 45°.
3. Switch on the sodium lamp and adjust the position.



A
E
F
air film
Plano-convex lens
B
D
t
C
Glass Plate





Travelling Microscope
G
45°
sodium lamp
Glass Plate
Plano Convex Lens
C
Plane glass plate
P

Page. No. Expt. No. Date

of convex lens L1, so that the parallel light falls on the inclined plate.

4. Placed the travelling microscope with its tube vertical, above the inclined plate G with its objective above the point of contact of plano convex ~~d~~lens L and the plate P.

5. Focus the eye piece on the cross wire and focus the microscope so that Newton's Ring are clearly ~~fo~~ visible.

6. Calculate least count of microscope scale.

7. Clamp the microscope and using its slow motion screw move the microscope horizontally, till the cross-wire lies beyond 20th or 24th bright ring on the right hand side of central dark ring.

8. Note microscope (cross wire) reading on 20th or 24th bright ring.

9. Now slowly move the microscope toward left and note atleast 8 to 10 readings, alternately on bright rings. eg. On 24th, 22nd, 20th, ... 2nd bright ring.

10. Now go on moving the microscope slowly towards left till it crosses the central dark point and again touches 2nd bright ring.

11. Again, note the reaging on 2nd, 4th, ..., 20th, 22nd, 24th bright ring.

12. Here, care must be taken to note, only those bright rings on left hand side, corresponding to which reading on right hand side were noted.

Page. No. ________ Expt. No. ________ Date ________

13. Calculate diameter D_n and D_n^2 of each n^{th} Bright ring.

14. Plot a graph between D_n^2 and n, which is straight line and then find its slope.

Result:

Wavelength of sodium light as obtained by Newton's Ring method is 6.175×10^{-8} cm

Actual value = 5893×10^{-8} cm

Percentage Error = 4.785%.

Source of Error and Precaution:

1. The sourfaces of planoconvex and glass plate should be optically spherical and plane respectively.
2. The sodium light should have an extended source.
3. Newton's ring should not be disturbed during whole set of observations.

Implications:

1. The interference technique of Newton's Rings is widely used for the quality control of optical surfaces because the precision obtained with this ~~of~~ method proves to be very satisfactory.
2. Wavelength of any light source can be determined.
3. Thickness of a thin can be determined.
4. Using this experiment, refractive index of a liquid can be calculated.

No. of Rings	Microscope Readings Left side a (mm)	Right side b (mm)	Diameter (D) a-b (mm)	D^2 (mm²)	$D^2_{n+m} - D^2_n$ (mm²)	Mean (mm²)
1.	46.62	45.26	1.36	1.85		
2.	46.87	44.55	2.32	5.38	19.03	
3.	47.16	44.21	2.95	8.70		
4.	47.46	44.07	3.39	11.49	19.32	
5.	47.72	43.15	4.57	20.88		19.76
6.	47.93	42.96	4.97	24.70	19.92	
7.	48.14	42.79	5.35	28.62		
8.	48.20	42.52	5.68	32.26	20.97	

Calculation

$$\lambda = D^2_{n+m} - D_n^2 / 4mR = \frac{19.76}{4 \times 4 \times 2} \times 10^{-6}$$

$$= 61.75 \times 10^{-8} m$$

$$= 6175 A^\circ$$

$$\% \text{ error} = \frac{6175 - 5893}{5893} \times 100 = 4.785\%$$

Page. No. ______ Expt. No. ______ Date ______

5. FRED model allows for simulation of physical optics phenomenon such as diffraction and interference with this capability, components such as gaussian laser beams and interference can be accurately modeled and incorporated into optical system.

Viva-Voce

(Q1) Where are the rings formed.
The rings are formed in the air film between glass plate and lens. These are called localised fringes.

(Q2) What will be change in diameter of rings if a drop of a transparent liquid is put between the lens and the plate?
(A) The fringes will contract because their diameter will become less, as given by formula

$$D_n^2 = \frac{(2n+1)\lambda R}{2\mu} \quad \text{for a bright ring.}$$

(Q3) Why is an extended source used here?
(A) So that whole surface of lens is illuminated, otherwise fringes will not be circular.

(Q4) Are rings equispaced?
(A) No, rings get closer with increase in diameter

Teacher's Signature : Hanshfks 26/12/22

Aim :

To determine the wavelength of sodium light by plane diffraction grating.

Apparatus Required :

A diffraction grating, spectrometer, sodium lamp, prism, reading lens.

Theory :

The wavelength λ of any spectral lines can be calculated by the formula

$$\lambda = \frac{(a+b)\sin\theta}{n}$$

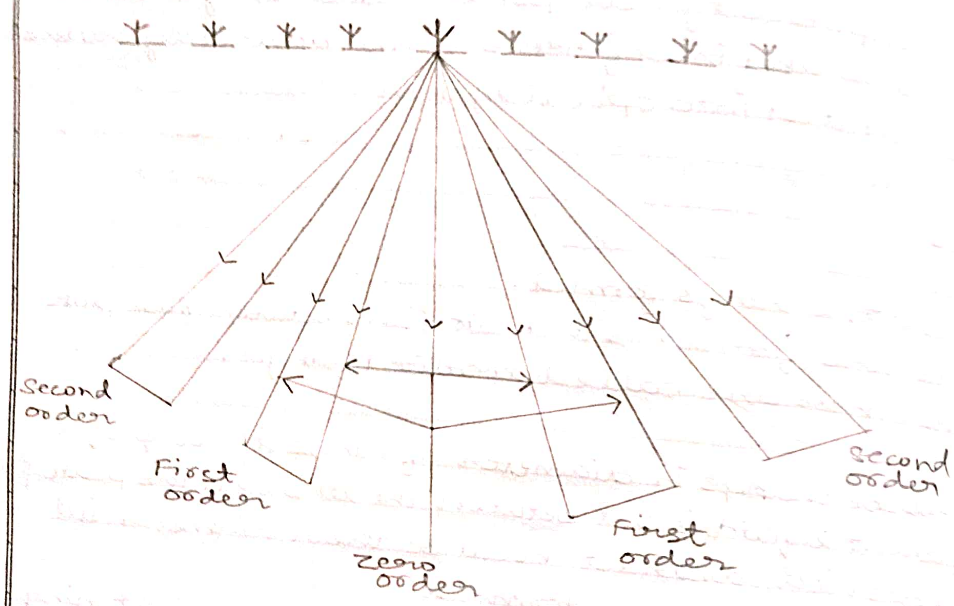
where $(a+b)$ = grating element

θ = angle of diffraction

n = order of the spectrum

Procedure :

1. The axis of telescope and that of collimator must intersect principal vertical axis of rotation of telescope. Collimator and telescope are arranged in a line and image on slit is focussed on the vertical cross wire.
2. Now the slit is rotated in its own plane till the spectral lines become sharp and bright.
3. Rotate telescope to left side of direct image and adjust line on the vertical cross wire for 1^{st} order. Note down reading of


Second order
First order
Zero order
First order
Second order

both the verniers in each reading.

4. Rotate telescope further to obtain second order spectrum and again the spectral lines on vertical cross wire and note the readings

5. Now rotate the telescope to the right of the direct image and repeat above procedure for first order as well as for second order.

6. find out difference of same kind of verniers (V_1 from V_1 and V_2 from V_2) for line in first order and then in second order. The angle is twice the angle of diffraction.

Result :

The wavelength of sodium light is found to be ? A.U.

Precautions and Source of Error :

1. Before performing experiment, spectrometer should be adjusted.
2. Grating should be set to normal to incident light.
3. Grating should not be touched by fingers.
4. While taking observations, telescope and prism table should be kept fixed.

Implications :

Diffraction gratings can be used to produce monochromatic light of required wavelength.

Observations :

No. of ruling per inch , N = 15000
least count of spectrometer = 1' = 0.16°

S.no.	Order of diffraction (n)	Scale	Image on left side: Main scale	Image on left side: Vernier scale	Image on left side: Total reading (a)	Image on right side: Main scale	Image on right side: Vernier scale	Image on right side: Total reading (b)
1	1	V_1	160	$10 \times \frac{1}{60}$	160.16	195	$5 \times \frac{1}{60}$	195.08
		V_2	340	$10 \times \frac{1}{60}$	340.16	375	$10 \times \frac{1}{60}$	375.16

Calculation :

For V_1 $\quad \theta = \left|\frac{a-b}{2}\right| = \left|\frac{160.16 - 195.08}{2}\right| = 17.46°$

For V_2 $\quad \theta = \left|\frac{a-b}{2}\right| = \left|\frac{340.16 - 375.16}{2}\right| = 17.50°$

Mean $\theta = \frac{17.46 + 17.50}{2} = 17.48°$

$(a+b) = \frac{2.54}{N} = \frac{2.54}{15000} = 0.0001693$ per cm

$\lambda = \frac{(a+b)\sin\theta}{n} = \frac{0.0001693}{1}(\sin 17.45°)$

$\lambda = 0.00005076 85$

$\lambda = 5076 8.5$ Å

Diffraction grating are often used in Monochromator, spectrometer, Laser, wavelength division, multiplexing, devices, optical pulse compressing devices and many other optical instruments.
Due to the sensitivity to refractive index of media, diffraction grating can be used as sensor of fluid properties.

Moreover, phenomenon of diffraction is used a lot in discovery of structures and atoms. It has been used a lot in discovering medicidines and drugs.

Diffraction is also fundamental in other applications such as X-Ray diffraction sudies of crystal and holography.

Viva Voce

1. What is diffraction grating?
A. An arrangement consisting of a large number of parallel slits of same width and seperated by equal opaque spaces is known as diffraction grating.

2. What are the requisites of a good grating?
A. The line should be exactly parallel, uniform, equidistant and of equal width.

4. What is grating element

(A) The distance between the centres of two successive slit is called grating element. This is donated by $(a+b)$ where a is width of transparent part and b is width of opaque part.

5. What type of grating is used in this experiment?

(A) Plane transmission grating

6. What are the uses of a diffraction grating?

(A) It helps to study diffraction spectra and measure wavelength.

Aim :

To determine the resolving power of grating.

Apparatus Required :

Plane diffraction grating, spectrometer, mercury lamp, reading lens.

Theory :

The resolving power $\lambda/\partial\lambda$ of a plane diffraction grating is given by -

$$RP = \lambda/\partial\lambda = N_0 n$$

where

$d\lambda$ = smallest wavelength difference b/w the two spectral lines which are just resolved by grating.

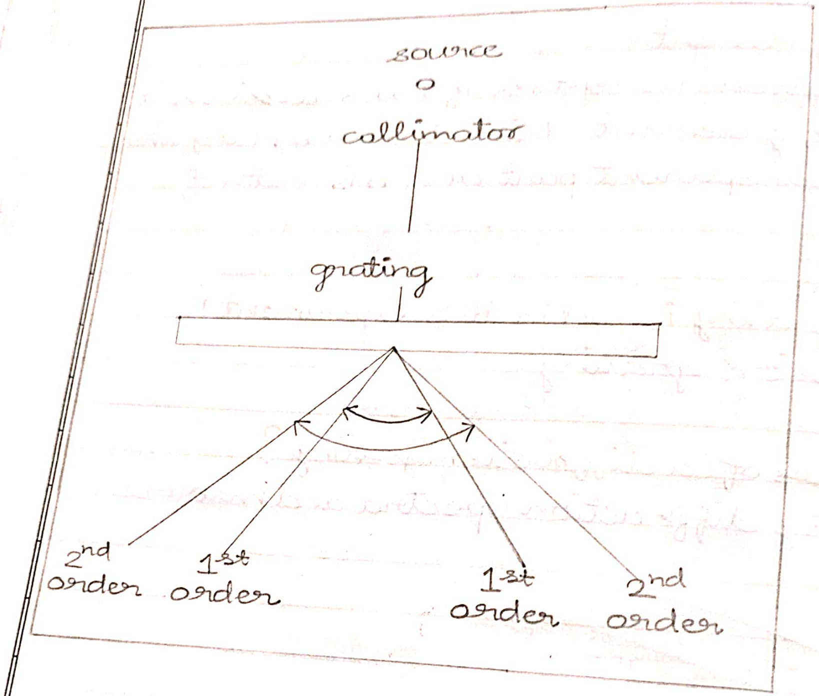
λ_0 = the mean wavelength of two spectral lines which are just resolved.

N_0 = total number of lines in the exposed width of the grating in just resolution position.

n = order of the spectrum

Procedure :

1. The spectrometers adjustments are made as described under the spectrometer head in the general section on refraction and dispersion of light.


source
collimator
grating
2nd order
1st order
1st order
2nd order

2. The slit should be adjusted parallel to the ruling of the grating.
3. Rotate the telescope to the left side of direct image and you will get the spectrum. Now ~~where you~~ there would be two lines of each colour.
4. Choose a colour (say yellow), adjust the 1^{st} line on the vertical cross wire for 1^{st} order. Note down the readings
5. of both the verniers. Now adjust the 2^{nd} line on the vertical cross wire and again note down the reading of both the verniers.
5. Rotate the telescope further to obtain the second order spectrum and again the spectral lines on the vertical cross wire and note the readings.
6. Now rotate the telescope to the direct image and note down the readings of both the verniers.
7. Repeat the experiment for different colors.

Result :

The resolving power of a given grating for yellow colour is found to be ?

Percentage Error :

$$\%\ error = \frac{(\text{Theoritical value} - \text{Observed value})}{\text{Theoritical value}} \times 100$$

?

Observations : No of lines per cm of grating $a+b = \frac{2.54}{15000} = 0.0001693$

No of ruling per inch, $N = 15000$

least count of spectrometer $= \frac{1^\circ}{50} = 0.01^\circ$

S.no.	order of diffraction (n)	colour	scale	Image on left side: main scale	vernier scale	Total reading (a)	θ_1
1.	1	Yellow	V_1	4	4	4.04	21.02
2.	1	Yellow	V_2	183	6	183.06	20.02
1.	2	Yellow	V_1	4.5	6	4.55	21.53
2.	2	Yellow	V_2	183.5	5	183.55	20.51

direct image : $V_1 = 343 + 2 \times 0.01 = 343.02$

$V_2 = 163 + 4(0.01) = 163.04$

Calculation :

$$(a+b) = 2.54/N = 0.0001693 \text{ per cm}$$

$$\lambda_2 = \frac{(a+b)\sin\theta_1}{n} = \frac{(0.0001693)(\sin 20.52^\circ)}{1} = 5934 \times 10^{-8} \text{ cm}$$

$$\lambda_2 = \frac{(a+b)\sin\theta_2}{n} = \frac{(0.0001693)(\sin 21.05^\circ)}{1} = 6008 \times 10^{-8} \text{ cm}$$

$$d\lambda = |\lambda_1 - \lambda_2| = 134 \times 10^{-8} \text{ cm}$$

$$\lambda = \frac{\lambda_1 + \lambda_2}{2} = 6001 \times 10^{-8} \text{ cm} \qquad \Rightarrow RP = \frac{\lambda}{d\lambda} = 24.78$$

Std Value : $\lambda_1 = 5770 \text{Å}$ $\lambda_2 = 5970 \text{Å}$

$$\lambda = \frac{\lambda_1 + \lambda_2}{2} = 5870 \text{Å} \qquad d\lambda = \lambda_2 - \lambda_1 = 200 \text{Å}$$

$$RP = \frac{\lambda}{d\lambda} = \frac{5870}{200} = 29.35$$

Page No. ______ Expt. No. ______ Date ______

Sources of Error and Precautions :

1. Before performing the experiment, the spectrometer should be adjusted.
2. Grating should be set normal to the incident light.
3. Grating should not be touched by fingers.
4. While taking observations, telescope and prism table should be kept fixed.

Applications :

1. Resolving power should separate images of very closely placed two objects.
2. Resolving power of different grating is defined as its ability to form separate diffraction maxima of two closely separated wave length.
3. It is used in field of astronomy to analyse the light of astronomical objects gathered by telescope. This analysis gives the compositional data of the objects seen by telescope.

Viva Voice

Q. Define Resolving Power.

A. The RP of a grating may be defined as its ability to form separate diffraction maxima of two wavelengths which are very close to each other. $RP = \lambda / d\lambda$ where $d\lambda$ is the difference between the two wavelength of spectral lines.

Page. No. ______ Expt. No. ______ Date ______

Q2. What is significance of Resolving Power equation ?

(A) R.P. is directly dependent on the diffraction order of an expression if the spectral lines are to be resolved. This distance between the two lines is a minimum when ~~then~~ peak of one line is at the minimum of second line and vice versa.

(Q3) What is grating element ?

(A) The distance between centres of two successive slits is called grating element. This is denoted by $(a+b)$ where a is width of transparent part and b is the width of opaque part.

Q4) What are uses of diffraction grating?

A) It helps to study diffraction spectra and measure wavelength.

5) Which diffraction occurs in diffraction grating exp and how?

A) Fraunhoffer's diffraction occurs since the spectrometer is focussed for parallel rays, so that source and images are effectively at infinite distance from the grating.

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Aim:

To find the wavelength of He-Ne laser using transmission diffraction grating.

Apparatus Required:

He-Ne laser, diffraction grating, optical bench with four stands, a screen with a graph paper on it, meter scale, travelling microscope

Theory:

When a monochromatic beam of wavelength λ is diffracted by a diffraction grating, the n^{th} order principal maxima is formed at an angle θ_n given by

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

where $(a+b)$ is grating constant and $\lambda = \frac{(a+b)\sin\theta_n}{n}$

where $(a+b)$ is the grating constant and $\lambda = \frac{(a+b)\sin\theta_n}{n}$

When laser light is incident on the screen formed by a graph paper, $\sin\theta_n$ can be obtained for different order maximas.

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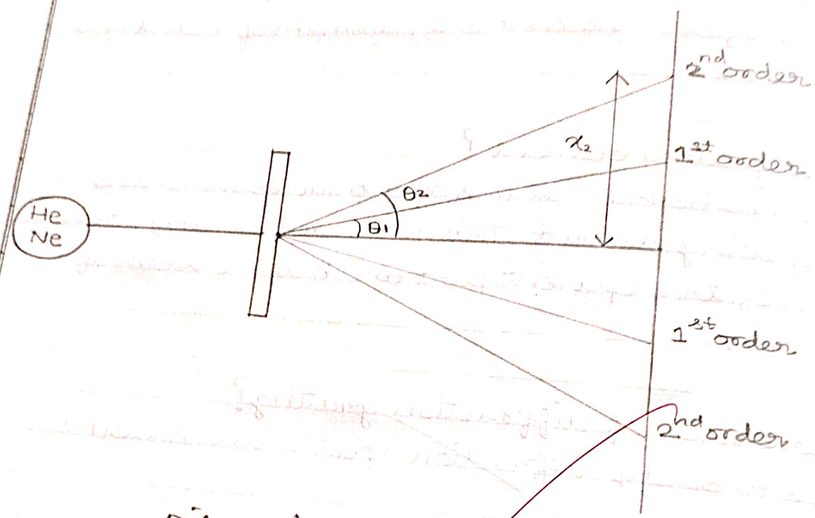


Diffraction Pattern

from the figure, we have $\sin\theta_n = \frac{x_n}{\sqrt{L^2+x_n^2}} = \frac{x_n}{L}$ (if $x_n << L$)

substituting $\sin\theta_n$ for different order in above equation, λ can be obtained.

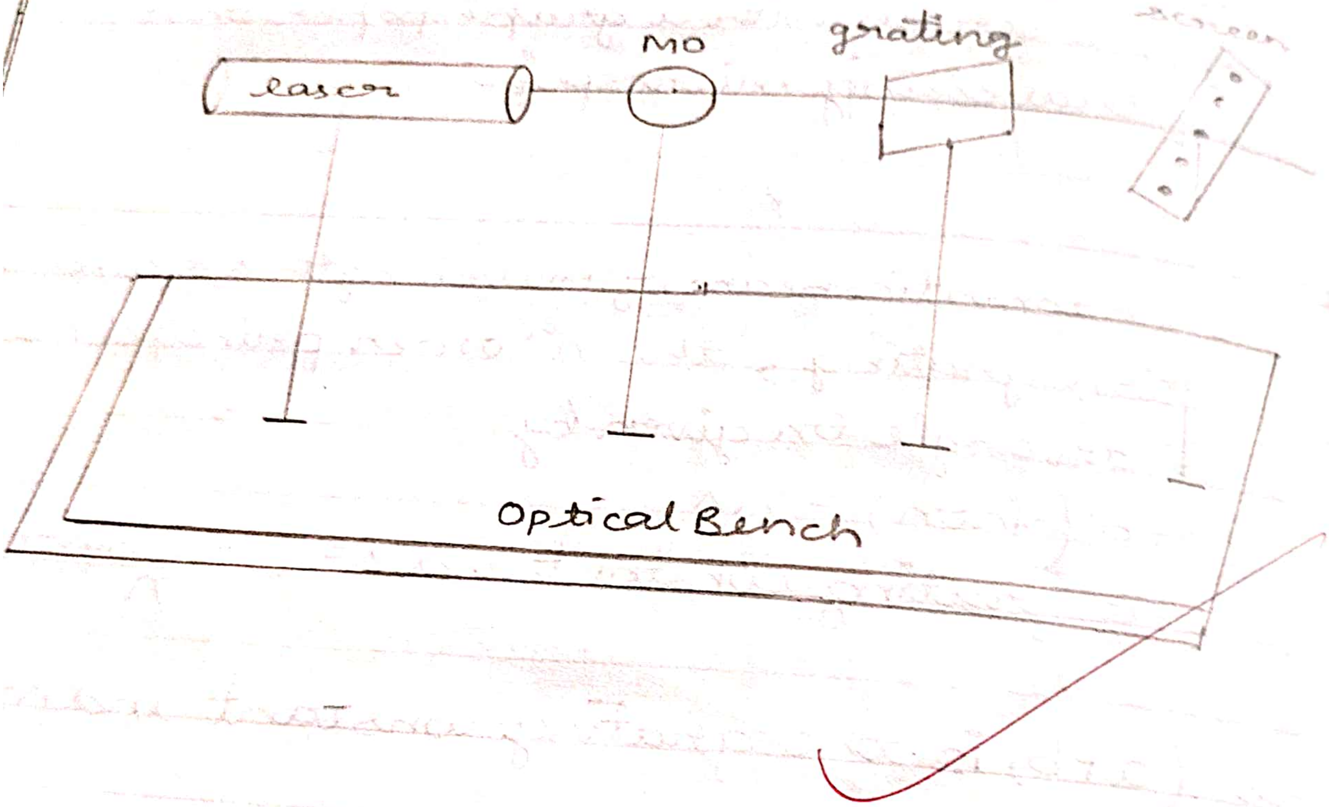
Procedure :

1. Mount a diff~~erent~~raction grating on a stand and illuminate it with a laser beam coming from the He-Ne laser source. Place a graph paper pasted on a screen S vertically at a distance of 1 to 2m from the grating. Adjust the distance of the screen the grating till a sharp diffraction pattern in the form of several bright spots of diminishing intensity is obtained mark the center of the spots (maxima) with a cancel.

2. Measure the distance L between the grating and the screen with a meter scale. Also measure the distance of maxima x_n from the central maxima with the help of the scale on the graph paper on a travelling microspore.

3. Remove the diffraction grating and measure the diameter d of the direct spot on the screen kept at a distance D from the laser source.

4. Repeat ~~st~~ step 3 for different distances of screen from the laser.



laser
MO
grating
screen
Optical Bench

5. Calculate angular spread $\theta = d/D$

Result :

Wavelength of He-Ne laser light λ = actual value

= 6328 Å

% error = 2.94%

Precaution and Source of Error :

1. Do not see at laser source directly as it may cause damage to the eye.
2. The graph used at the screen should be vertically straight.

Implications

He-Ne laser can be used -

→ In bar code scanners

→ In tool alignment

→ In blood analysis

→ In therapy and tissue healing and pain relief

→ In holography in producing 3D images of objects.

→ In particle counting and food sorting.

Diffraction grating can be used.

→ In monochromator spectrometer, multiplexing devices and many other optical instruments.

→ In sensor of ~~ma~~ fluid properties.

Observation Table:

(i)

(ii) Measurement of λ

Number of line per inch on the grating, N = 15000

grating constant $(a+b) = 2.54/N = 25/15000$ cm

distance of screen from grating, L = ____ cm

Sl No.	Order of diffraction N	Distance of maxima from central spot, x_n cm	$\sin\theta_n = \frac{x_n}{\sqrt{(x_n^2+L^2)}}$	$\lambda = \frac{(a+b)\sin\theta_n}{n}$ cm
1	1	295.5	0.3791	6.41×10^{-5}
2	2	830	0.7553	6.39×10^{-5}
3	1	31.2	0.3976	6.73×10^{-5}
4	2	95.5	0.7984	6.75×10^{-5}

mean $(\lambda) = 6.57\times10^{-5}$ cm

$= 6570$ Å

% age error $= \frac{6570 - 6382}{6382} = 2.94\%$

→ Diffraction ~~phe~~ phenomenon is used a lot in discovering medicines and drugs.

→ diffraction phenomenon is also fundamental in other applications such as X-ray diffraction studies of crystal and holography.

Viva Voce Questions

1. In He-Ne laser, lasing is through neon gas, what is the role of Helium?

(A) In He-Ne laser, helium serves as a buffer gas and helps in excitation of neon atoms. Since He atoms are much lighter than Ne atoms, electrons transfer energy more readily to He atoms. The excited He-atoms in turn transfer their energy to Ne atoms.

2. Why is the necessary to use a narrow tube in He-Ne laser?

(A) A narrow discharge tube is necessary for rapid de-excitation of atoms by collision with the walls, with a tube of large diameter, the probability of collisions of atoms with the walls decreases and less atoms are ~~favourable~~ available at ground level for further excitation. This can cease the laser action in due course.

Aim :

To determine the numerical aperture (NA) of an optical fibre

Apparatus :

Optical-fibre, two fibre optical chucks, He-Ne laser, a microscopic objective, screen with a graph paper pasted on it.

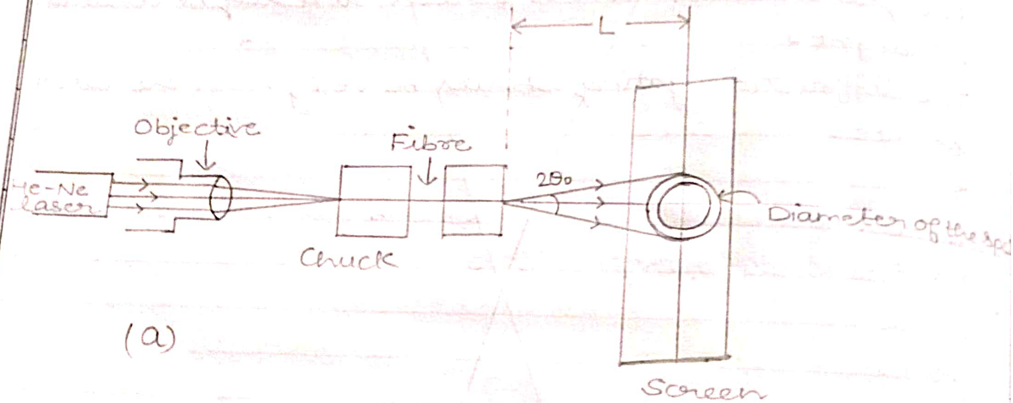
Theory :

Students are advised to go through chapter 5 on fibre optics. Numerical apperture (NA) of optical fibre ~~or~~ is a measure of light gathering ability of the fibre and is an important parameter which determines the angle of the "light accepting cone" (θ_0) at the ~~point of~~ input end of the fibre. The numerical apperture is defined as the sine of the acceptance cone. It is given as

$$NA = \sin\theta_0 = \sqrt{\mu_f^2 - \mu_c^2} \text{ where}$$

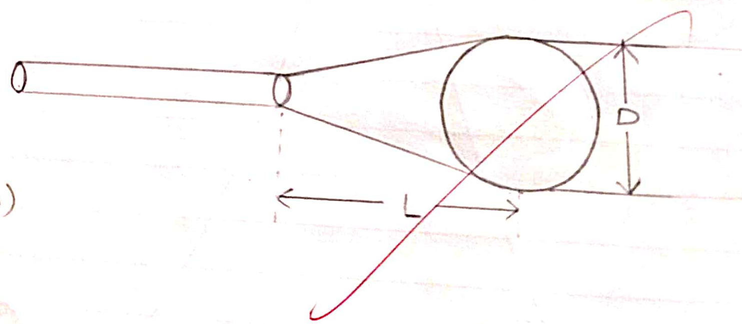
μ_f and μ_c are refractive indices of core and clading respectively. Thus, to determine the numerical aperture, acceptance angle θ_0 of the fibre should be known.

In a short length of optical fibre, ideally a ray of known entering at an angle i at the input end comes out at the same angle i from the output end. Therefore, the emerging rays from the output end of the fibre will also appear as a cone of semiangle i. It is thus easy to make measurements on this end of the ~~ene~~ fibre ~~said~~ to



He-Ne laser
Objective
Chuck
Fibre
$2\theta_0$
L
Screen
Diameter of the spot

(a)



L
D

(b)

also appear determine numerical apperture of fibre.
If emerging rays from output end of optical fibre make a spot of diameter D on a screen kept at a distance L from output end of fibre, then from figure

$$\sin\theta_a = \frac{D/2}{\sqrt{(D/2)^2 + L^2}} = \frac{D}{\sqrt{D^2+4L^2}}$$

$$NA = \frac{D}{\sqrt{D^2+4L^2}}$$

Procedure :

1. Insert the ends of the optical fibre in fibre optics chunks mounted in uprights on an optical bench.
2. Switch on He-Ne laser.
3. Adjust He-Ne laser so that laser beam is coupled ~~on~~ into one of the fibre ends ~~of~~ through a 20X microscopic objective mounted in an upright.
4. Fix a graph sheet on the screen mounted in an upright.
5. Place the screen at some distance at the other end of optical fibres (i.e output end) such that it is perpendicular to the axis of fibre.
6. Adjust position of screen by moving it towards or away from output end of the fibre, so that a bright circular spot is formed on the screen.
7. Measure the diameter of circular spot formed on the screen let it be D. Also, measure the distance between the output

Observations:

S.No.	Distance between output end of optical fibre and screen (L cm)	Diameter of circular spot D cm	$NA = \frac{D}{\sqrt{D^2+4L^2}}$
1	3	2.8	0.4
2	4	3.6	0.4
3	5	4.5	0.4

Mean value of Numerical Aperture = 0.4

end of optical fibre and screen. Let it be L.

5. Repeat above experiment to take at least four observations for different values of L and D.

Result :

Numerical Apperture = 0.4

Precautions :

1. Optical fibre should not bend when light is being propogated.
2. Light should be coupled properly into fibre so that a bright spot of light is observed.
3. Optical fibre axis should be parallel to optical bench.

Source of Errors :

1. There may be losses due to bending, radiation and leakage etc.
2. The ends of optical fibre might not be sharply cut and bright spot may not be exactly circular.
3. The intensity of light is reduced as distance between screen and ouput end of fibre is in erased.

Viva-Voce

Give a general idea of core and clading diameter.

Core diameter is about 5μm to 100μm and clading about 125 μm.

2. What material is used in communication grade fibres?
A. Silica (SiO_2)

3. What is a step index fibre?
A. If core of optical fibre has uniform refractive index.

4. Does high temperature damage the fibres?
A. Fibres are resistive to high temperature as silica has high melting point.

5. Is crosstalk possible in optical fibre?
A There is not possibility of crosstalk because optical fibre is made of cylindrical silica which is non conductive and non radiative.

Implications

1. Medical used as light guides, imaging tools and also as lasers for surgeons.
2. used hydrophones for seismic waves and SONAR as wiring in aircraft, submarines and also field networking.
3. Used for data transmission
4. Cable companies use it for HDTV and other applications.

Teacher's Signature : Harshika 6/2/23