Newton's Ring

OBJECT: To find the wavelength of sodium light by measuring the diameters of Newton's rings.

Apparatus : A traveling microscope, Sodium lamp, plano-convex lens and magnifying glass.

Formula :

$$\lambda = \frac{D_m^2 - D_n^2}{4(m-n)R}$$

where 'λ' is the wavelength of Sodium light, D_m is the diameter of m^{th} ring , D_n is the n^{th} ring , R is the Radius of curvature of plano-convex lens = 100 cm.

OBSERVATION:

Vernier constant = ... mm

PROCEDURE:

1. Level the microscope table and set the microscope tube in a vertical position. Find the vernier constant of the horizontal scale.
2. Glass plate and lens's surface should be clean. Place them in position as shown in figures. Place the arrangement in front of a sodium lamp so that the height of the lamp of the glass plate G is the same as that of the centre of the sodium lamp. Place a screen in between having a hole of about one inch square in it at the same height. Place the convex lens in between and adjust its position so that a parallel beam of light is made to fall on the glass plate G inclined at an angle of 45^0
3. Adjust the position of the microscope so that it lies vertically above the centre of the lens N. focus the microscope, so that alternate dark and bright rings are clearly visible.
4. Adjust the position of the microscope till the point of inter-section of the cross wire coincides with the centre of the ring system and one of the corss-wire is perpendicular to the horizontal scale.
5. Slide the microscope to the left till the cross-wire lies tangentially at the centre of the 2^{nd} dark ring. Note the reading on the vernier scale of the microscope. Slide the microscope backward with the help of the slow motion screw and note the reading when the cross-wire lies tangentially at the centre of the 4^{th} , 6^{th} , 8^{th} , 10^{th} dark rings respectively.

6. Keep on sliding the microscope to the right side and note the reading when the cross-wire again lies tangentially at the centre of the 2^{nd}, 4^{th}, 6^{th}, 8^{th}, 10^{th} dark rings respectively.

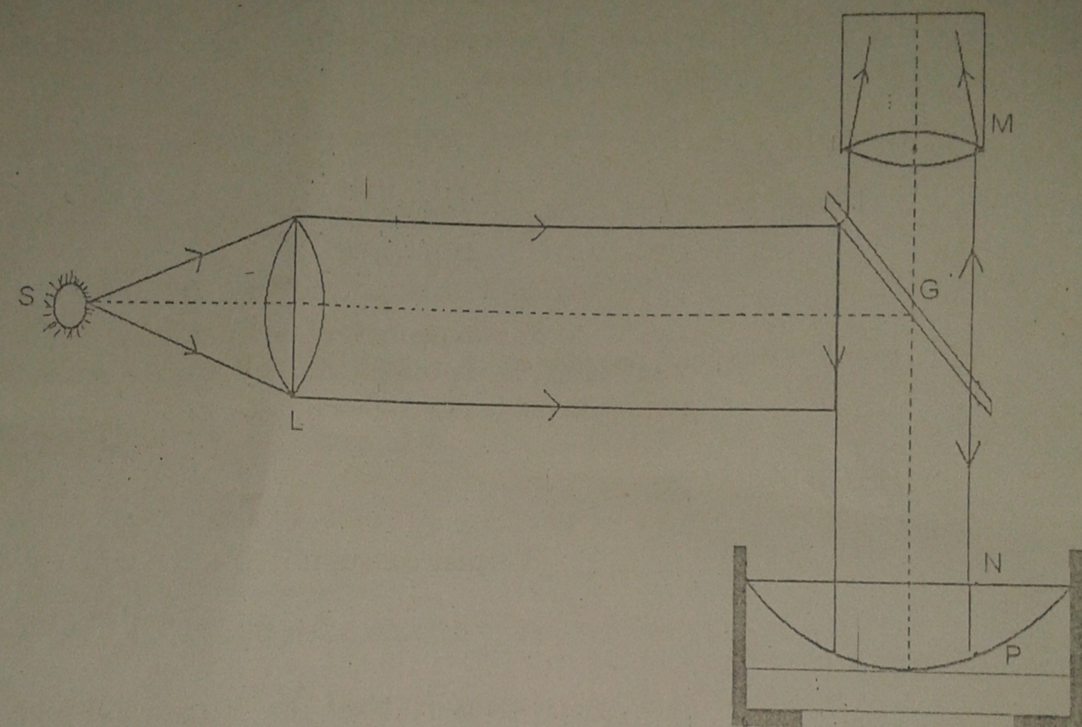


Table for diameter of rings:

No. of Rings	Reading on Left (L)			Reading on Right (R)			Diameter (L – R)
	Main Scale Reading (M.S.R.)	Vernier Scale Reading (V.S.R.)	Total	Main Scale Reading (M.S.R.)	Vernier Scale Reading (V.S.R.)	Total	
2							
4							
6							
8							
-							
-							
-							
-							
-							

CALCULATION:

Choose at least four different sets of m, n. Calculate λ for each such pair and then take the average to find the resultant λ.

S.No.	m	n	m-n	D_m	D_n	D_m-D_n	λ
1.	4	2	2				
2.	6	2	4				
3.	8	4	4				
4.	---	---	---				

Average λ							

Result: The wavelength of sodium light is ______________ A^0

Percentage Error:

Precautions:

1. The lens and glass plate should be cleaned properly.
2. While taking readings one should move the telescope in one direction only. One should avoid going back and forth to coincide the crosswire with the diameter.
3. Lens of a large focal length should be used.
4. The point of intersection of the cross wires should coincide tangentially with a particular ring.
5. The amount of light for the source should be adjusted for maximum visibility of the rings and there should be good contrast between dark and bright rings.

Diffraction Grating

Object: To determine the wave length of different components of white light using a diffraction grating.

Apparatus: Spectrometer, Mercury lamp, grating holder, diffraction grating, magnifying lens and sprit level.

Formula:

In the diffraction grating the condition for the first maxima is

$$(a+b)\sin\theta = n\lambda \quad (n=1)$$

where 'λ' is the wave length of light, 'θ' = angle of diffraction and $(a+b)$ is the grating element. The grating has 15,000 lines per inch so the grating element $(a+b)$ is 2.54/15,000 cm.

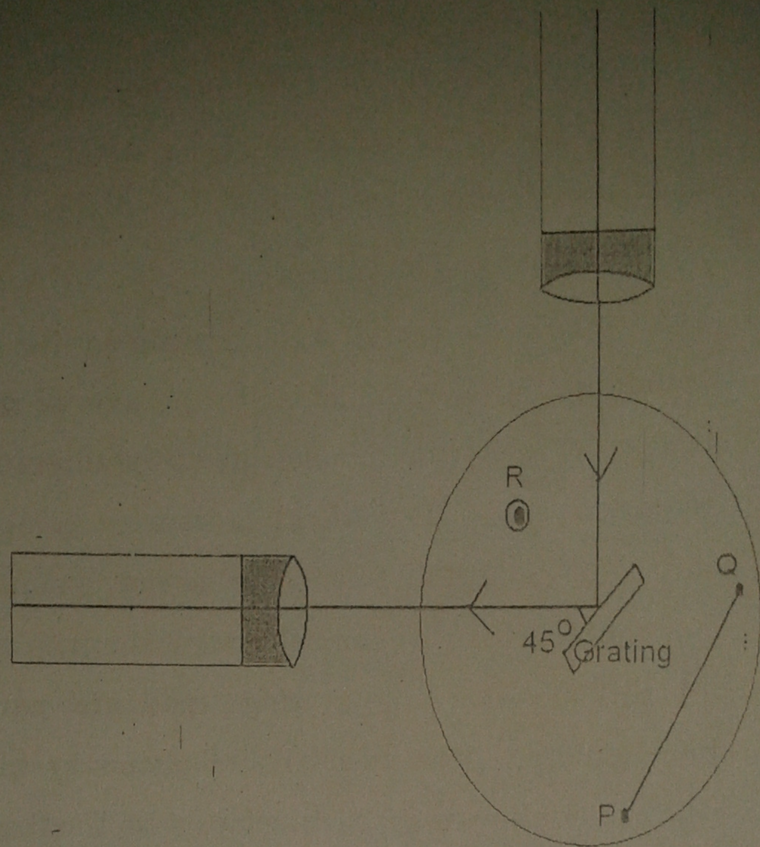
The white light has seven different colour (wavelength) light: Violet, Blue, Indigo, Yellow, Orange, Green, Red. Find wavelengths of any two colours.

PROCEDURE:

1. **Setting:** Adjust the position of the eye-piece of the telescope so that the cross-wire are clearly visible. Focus the telescope on a distant object and set it for parallel rays. Level the spectrometer by the leveling screw and them the prism table with the help of a spirit level.
2. Fix the grating stand on the circular table with two screws in the holes drilled on one of the lines parallel to the line joining two of the screws meant for the purpose, say P and Q. The face of the stand to which the clamps are attached should be at the centre of the table. Take out the grating carefully from the box, holding it from the edge and without touching its surface, fix it very carefully to the frame with us ruled surface towards the telescope.

3. Rotate the table so that the plane of the grating is approximately inclined at an angle of 45^0 to the axis of the collimeter. Rotate the telescope to receive the reflected light from the grating surface. If the image of the slit is not symmetrical with respect to the horizontal cross-wire, adjust with the help of the third screw R. In this position the plane of the grating will be vertical.
4. Rotate the table carrying the grating so that the plane of the grating is approximately perpendicular to the axis of the collimator. Look for the first order spectrum on one side of the direct image or the slit. Turn the telescope so that vertical cross-wire coincides with the first order diffracted image. If this image is not symmetrical with respect to the horizontal cross-wire, adjust it with the help of one of the screws P or Q. In this position the grating lines are parallel to the axis of the spectrometer. Now turn the telescope to the other side so that the vertical cross-wire again coincides with the first order diffracted image. If the adjustments are carefully done then the diffracted images of the slit will be symmetrical with respect to the horizontal cross-wire in all positions.
5. setting the grating normal to the incident light. Place the telescope in line with the collimator so that the vertical cross-wire falls exactly in the centre of the image of the slit. Note the scale reading. Add 90 to the reading and place the telescope at this reading to set it perpendicular to the axis of the collimator. Clamp it in this position.

Rotate the grating table till the plane face of the grating is facing both the collimator and the telescope. Look through the telescope and turn the table very slowly till the centre of the slit falls exactly on the vertical cross-wire as shown figure



In this position the plane of the grating is inclined at an angle of 45o to the incident light. Note the reading. Turn the table through 45o from this position so that the plane of the grating is normal to the incident light with its plane face towards the collimator. The grating is now set normal to the incident light with its ruled surface away from the collimator. Clamp the table in this position.

6. Place the eye in front of the collimator and move it gradually towards the telescope till the first order diffracted image is visible. Bring the telescope in this position and observe the image through it. Clamp the telescope in this position. If the resolving power of the grating is sufficiently high two distinct narrow lines corresponding to the wavelength 5890 Ao and 5896 Ao will lie side by side in the field of view. Ordinarily the two line will appear as one in first order spectrum. Turn the tangent screw of the telescope till the vertical cross-wire coincides with the centre of the image of the slit. Note the reading of the scale on the both verniers. Similarly observe the first order spectrum on the other side of the direct image and note the reading on both the verniers.

7. Similarly note the above observations three times.
8. Note the number of the line per inch as marked on the grating and replace it carefully in the box with ruled surface upwards.

OBSERVATION:

Vernier constant $= \dfrac{\text{Value of one main scale division}}{\text{Total no. of division on Vernier}} = \dfrac{30'}{30} = 1' = \dfrac{1}{60}$ degrees.

Observation Table

For angle of diffraction for ____________ light

Vernier position	Left position			Right Position			2θ	θ
	Main Scale Reading (M.S.R.)	Vernier Scale Reading (V.S.R.)	Total	Main Scale Reading (M.S.R.)	Vernier Scale Reading (V.S.R.)	Total		
V_1								
V_2								

Similarly record observations for another colour (wavelength).

CALCULATION:

$$2\,\theta_1 = [360 - V_1\,(\text{left})] + V_1\,(\text{right})]$$

$$2\,\theta_2 = V_2\ (\text{right}) - V_2\,(\text{left})$$

$$2\,\theta = \frac{2\,\theta_1 + 2\,\theta_2}{2}$$

$$\lambda = \frac{2.54}{15000} \times \sin\theta$$

RESULT:

PRECAUTIONS:

a). The ruled surface of the grating must face the telescope.
b). The slit should be made very fine and bright.
c). The grating surface should not be touched.
d). While setting the grating, two images are seen, the telescope should be focused on the brighter one.
e). When observations are to be made the prism table should be clamped.

Refractive Index of Prism

OBJECT: To determine the refractive index of the material of the prism by using spectrometer.

APPARATUS: Spectrometer, mercury lamp, a prism, spirit level, reading lamp and magnifying glass.

FORMULA:

$$\mu = \frac{\sin[(A+D_m)/2]}{\sin(A/2)}$$

where 'μ' is the refractive index of material of the prism, A = angle of prism, D_m = angle of minimum deviation.

OBSERVATION:

$$\text{Vernier constant} = \frac{\text{Value of one main scale division}}{\text{Total no. of division on Vernier}} = \frac{30'}{30} = 1' = \frac{1}{60}\text{degrees.}$$

PROCEDURE:

a). Cross wires of the telescope are adjusted properly and then the telescope is focused on a distant object. A clear and sharp image is got in telescope with the proper adjustment of the telescope screws. This will make the telescope, set for parallel rays.

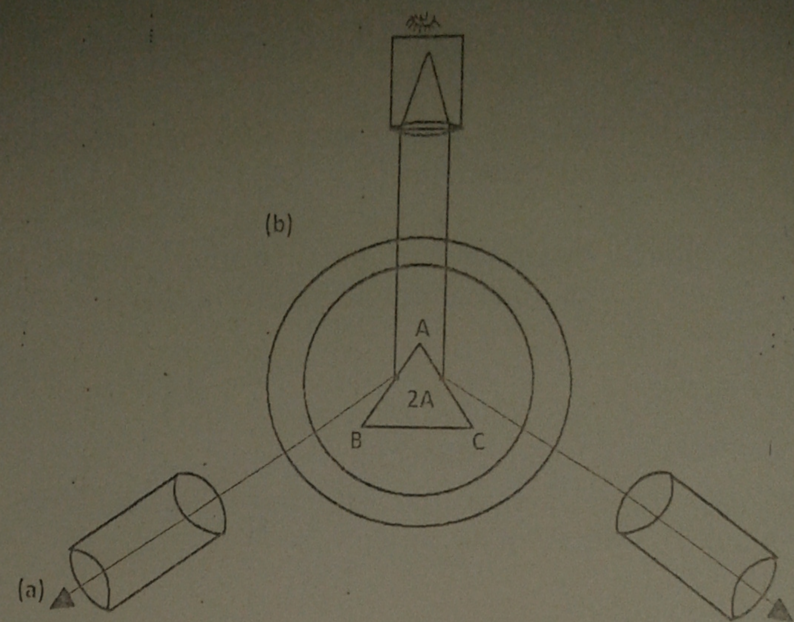
b). The telescope is now turned to a position where the axis of telescope and collimator are in the same line. The slit of collimator is adjustment so that a fine and sharp image of the sodium lamp that illuminates the slit is obtained in the telescope. Now slit is at focus of telescope wire and is adjusted for parallel rays.

c). Determination of angle of prism. To find the angle of prism, the prism is paced at centre of prism table with its base perpendicular to the axis of collimator and the edge towards collimator. Parallel rays from collimator will be incident on refracting surface AB and AC are reflected by reach face.

The telescope is now turned to receive the light reflected from face AB an its position is so adjusted that the image of slit is at the centre of vertical cross wires of telescope. The position of both venires of telescope is recorded.

The telescope is then turned and its receives the light reflected from face AC. Then it is adjusted till the image of both slit of collimator coincides with the centre of the vertical cross wires of telescope. The position of both the venires is again recorded.

The mean difference of these two reading gives the angle 2A, and half of this angle of prism A.



d). Determination of D_m. The prism is placed on the centre of prism table; and the height of the table is adjusted. On one of the refracting faces of prism the parallel rays of monochromatic light from collimator are incident with oblique angle.

e). The image is seen through opposite refracting face through the prism. The prism table is turned in a particular direction till the image of slit becomes stationary and on further turning of prism table, it moves back. The position of the prism table where the image stops moving is position of minimum deviation. If the prism table is turned in any direction from position of minimum deviation the image of the moving slit moves back. The position of telescope is ready by two venires to minimize the errors.

Prism is removed and telescope is brought in line with collimator. The image of slit is focused at the centre of cross wire.

And the position of telescope is also read on two venires.

The difference between the corresponding reading for two position of telescope given the angle minimum deviation D_m.

The experiment is repeated 3 to 4 times to minimize the error.

Observation table of Angle of Prism:

S.No.	Vernier	Telescope reading for reflected image at first face			Telescope reading for reflected image at second face		
		Main Scale Reading (M.S.R.)	Vernier Scale Reading (V.S.R.)	Total	Main Scale Reading (M.S.R.)	Vernier Scale Reading (V.S.R.)	Total
1.	V_1						
2.	V_2						

Calculation for angle of prism (A):

$$2\,A_1 = [360 - V_1\,(\text{left})] + V_1\,(\text{right})]$$

$$2A_2 = V_2\ (\text{right}) - V_2\,(\text{left})$$

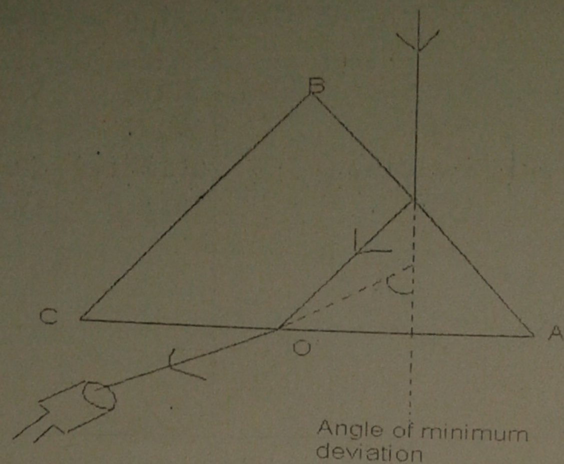
$$2A = \frac{2\,A_1 + 2\,A_2}{2}$$

Angle of prism (A) = ...

Observation table for angle of minimum deviation D_m for Yellow light

Vernier V_1			Vernier V_1		
Telescope Reading		Difference D_m	Telescope Reading		Difference D_m
Min. Dev.	Direct		Min. Dev.	Direct	

Angle of minimum deviation D_m = --------------------



RESULT:

Refractive index of material of the prism =

PRECAUTIONS:

a). Proper leveling of the various parts should be done with spirit level.
b).The slit should be adjusted so that a narrow and fine image is obtained in the telescope.
c). The centre of the prism table, centre of the collimator and centre of the telescope should be adjusted in the same line.
d). Tangents screw provided at the base of the spectrometer should be used for fine adjustment.

SOURCES OF ERROR:

a). Prism may not be placed in the exact minimum deviation position.
b). There may be some error in taking the readings of the cross wires if the telescope is not adjusted in vertical position.

Dispersive Power of Prism

OBJECT: To determine the dispersive power for the material of a prism.

APPARATUS: Spectrometer, mercury lamp, a prism, spirit level, reading lamp and magnifying glass.

FORMULA:

$$\mu = \frac{\sin[(A+D_m)/2]}{\sin(A/2)}$$

where 'μ' is the refractive index of material of the.prism, A = angle of prism, D_m = angle of minimum deviation.

Dispersive power (ω) is given by the expression:

$$\omega = \frac{\mu_V - \mu_R}{\mu_Y - 1}$$

Where μ_R , μ_Y , μ_V are the refractive indexes for Red light, Yellow light and Violet light respectively.

OBSERVATION:

$$\text{Vernier constant} = \frac{\text{Value of one main scale division}}{\text{Total no. of division on Vernier}} = \frac{30'}{30} = 1' = \frac{1}{60}\text{ degrees.}$$

PROCEDURE:

a). Cross wires of the telescope are adjusted properly and then the telescope is focused on a distant object. A clear and sharp image is got in telescope with the proper adjustment of the telescope screws. This will make the telescope, set for parallel rays.

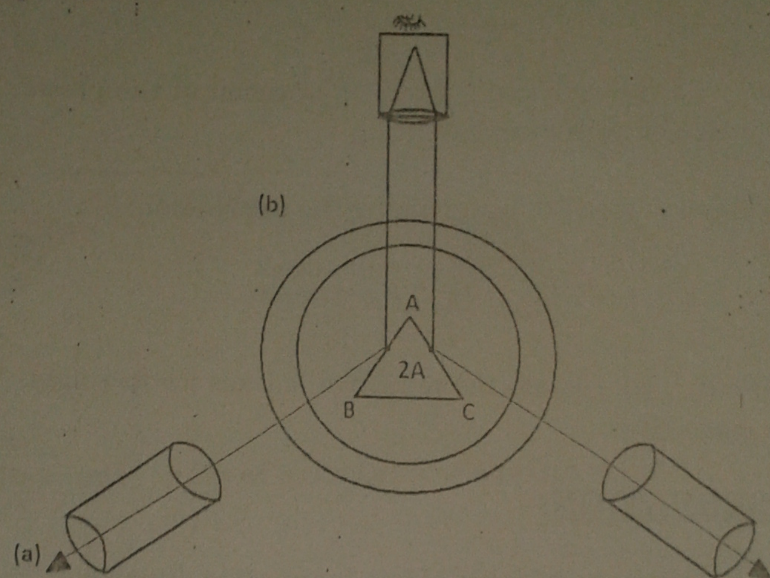
b). The telescope is now turned to a position where the axis of telescope and collimator are in the same line. The slit of collimator is adjustment so that a fine and sharp image of the sodium lamp that illuminates the slit is obtained in the telescope. Now slit is at focus of telescope wire and is adjusted for parallel rays.

c). Determination of angle of prism. To find the angle of prism, the prism is paced at centre of prism table with its base perpendicular to the axis of collimator and the edge towards collimator. Parallel rays from collimator will be incident on refracting surface.AB and AC are reflected by reach face.

The telescope is now turned to receive the light reflected from face AB an its position is so adjusted that the image of slit is at the centre of vertical cross wires of telescope. The position of both venires of telescope is recorded.

The telescope is then turned and its receives the light reflected from face AC. Then it is adjusted till the image of both slit of collimator coincides with the centre of the vertical cross wires of telescope. The position of both the venires is again recorded.

The mean difference of these two reading gives the angle 2A, and half of this angle of prism A.



d). Determination of D_m. The prism is placed on the centre of prism table; and the height of the table is adjusted. On one of the refracting faces of prism the parallel rays of monochromatic light from collimator are incident with oblique angle.

e). The image is seen through opposite refracting face through the prism. The prism table is turned in a particular direction till the image of slit becomes stationary and on further turning of prism table, it moves back. The position of the prism table where the image stops moving is position of minimum deviation. If the prism table is turned in any direction from position of minimum deviation the image of the moving slit moves back. The position of telescope is ready by two venires to minimize the errors.

Prism is removed and telescope is brought in line with collimator. The image of slit is focused at the centre of cross wire.

And the position of telescope is also read on two venires.

The difference between the corresponding reading for two position of telescope given the angle minimum deviation D_m.

The experiment is repeated 3 to 4 times to minimize the error.

Observation table of Angle of Prism:

S.No.	Vernier	Telescope reading for reflected image at first face			Telescope reading for reflected image at second face		
		Main Scale Reading (M.S.R.)	Vernier Scale Reading (V.S.R.)	Total	Main Scale Reading (M.S.R.)	Vernier Scale Reading (V.S.R.)	Total
1.	V_1						
2.	V_2						

Calculation for angle of prism (A):

$$2A_1 = [360 - V_1(\text{left})] + V_1(\text{right})]$$

$$2A_2 = V_2(\text{right}) - V_2(\text{left})$$

$$2A = \frac{2A_1 + 2A_2}{2}$$

Angle of prism (A) = ...

Observation table for angle of minimum deviation D_m

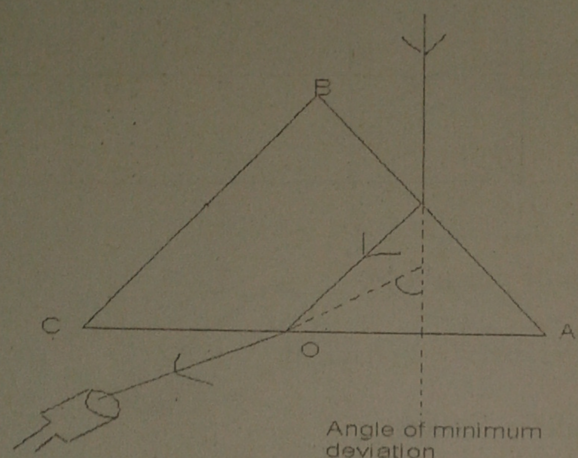
Color	Vernier V_1			Vernier V_2		
	Telescope Reading		Difference D_m	Telescope Reading		Difference D_m
	Min. Dev.	Direct		Min. Dev.	Direct	
Red						
Yellow						
Violet						

We know

$$\mu = \frac{\sin[(A+D_m)/2]}{\sin(A/2)}$$

Using above formula calculate 'μ' for Red, Yellow and Violet colours. Knowing the refractive index for three colours calculate the dispersive power of prism using the following equation.

$$\omega = \frac{\mu_V - \mu_R}{\mu_Y - 1}$$



RESULT:

Dispersive power for the material of the prism =

PRECAUTIONS:

a). Proper leveling of the various parts should be done with spirit level.

b).The slit should be adjusted so that a narrow and fine image is obtained in the telescope.

c). The centre of the prism table, centre of the collimator and centre of the telescope should be adjusted in the same line.

d).Tangents screw provided at the base of the spectrometer should be used for fine adjustment.

SOURCES OF ERROR:

a). Prism may not be placed in the exact minimum deviation position.

b). There may be some error in taking the readings of the cross wires if the telescope is not adjusted in vertical position.

BAR PENDULUM

OBJECT: To plot a graph between the distance of the knife edges from thecentre of gravity and the time period of bar pendulum. From the graph, find

a). Acceleration due to gravity(g).

b). Radius of gyration(k) of the bar pendulum.

APPARATUS: Bar pendulum, Stop watch, Meter rod.

FORMULA:

The general formula of the time period for bar pendulum is given by following equation

$$T = 2\pi\sqrt{\frac{\frac{k^2}{l} + l}{g}}$$

Where k = radius of gyration

l = distance b/w centre of gravity and suspension point

g = Acceleration due to gravity

t = Time period

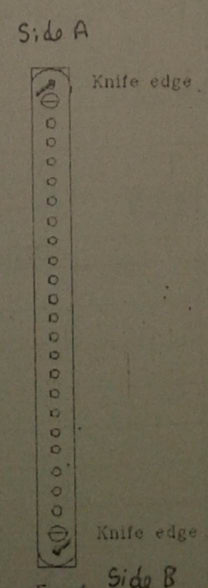


fig. 1

A graph is plotted between the distance of knife edge from the C.G. taken along the x- axis and the corresponding time 't' taken along y axis for the bar pendulum and the nature of the graph is shown in fig. 2. Now a horizontal line ABCDE parallel to x – axis is drawn. It cuts the graph in points A,B, D,E about which the time period is same.

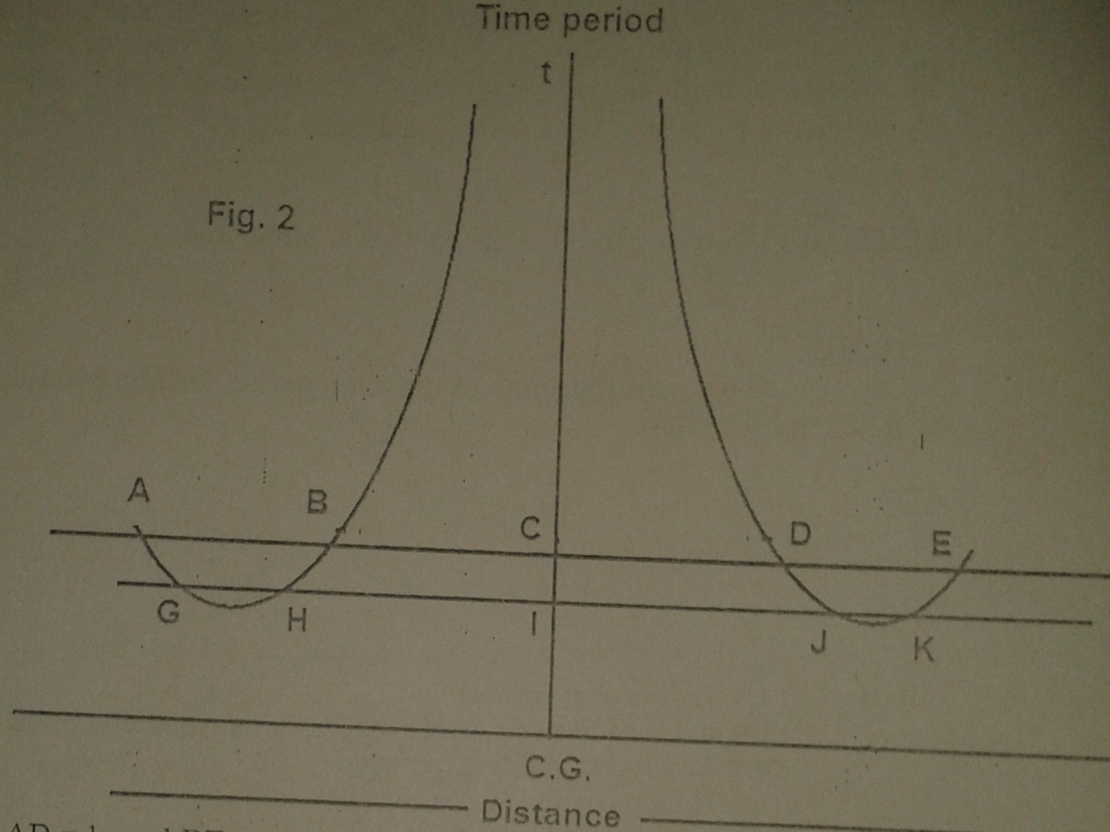


Fig. 2

AD = l_1 and BE = l_2

Similarly drawn line G H I J K . Now G J = l_3 and H K = l_4

OBSERVATION TABLE:

No. of Hole	Side A			Side B		
	Total time (t) for 20 vibrations	T = t/20	Distance from C.G. (cm)	Total time (t) for 20 vibrations	T = t/20	Distance from C.G. (cm)
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						

PROCEDURE:

a). Place the knife-edges in the first hole on both sides of the bar.
b). Suspend the pendulum from the knife-edge in the side of the end of bar.
c). Set the pendulum into oscillations with small amplitude (3^0- 5^0).
d). Note the time taken for 20 oscillations and measure the distance of the hole from the centre of gravity of the bar.
e). Repeat the observations with knife-edges in the 2nd 3rd 4th 5th 6th 7th 8th holes.
f). Now suspend the bar from the knife-edges on the other sides.

CALCULATION:

For the line ABCDE

T_1 =.................... secs

l_1 =.................... cm (AD)

l_2 =.................... cm (BE)

For the line GHIJK

T_2 = ... secs

l_3= .... cm (GJ)

l_4= .... cm (HK)

Now

$$L_1 = \frac{l_1 + l_2}{2} \qquad L_2 = \frac{l_3 + l_4}{2}$$

Now find the value of acceleration due to gravity by using the formula given below,

$$g_1 = \frac{4\pi^2 L_1}{T_1^2} \quad \text{and} \quad g_2 = \frac{4\pi^2 L_2}{T_2^2}$$

The acceleration due to gravity is the average of the two 'g' values found.

Radius of gyration (k):

$$k_1 = \sqrt{(AC)(CD)} \quad \text{and} \quad k_2 = \sqrt{(GJ)(HK)}$$

$$k = \frac{k_1 + k_2}{2} \text{ cm}$$

RESULT: Acceleration due to gravity

(g) = ...m/sec^2

Radius of gyration (k) = ...cm

PERCENTAGE ERROR:

PRECAUTIONS:

a). The knife edges should be horizontal and the bar pendulum parallel to the wall.
b). Amplitude should be small.
c). The time period should be noted after the pendulum has made a few vibrations and the vibrations have become regular.
d). The two knife edges should always lie symmetrically with respect to the C.G.
e). The distance should be measured from the knife edges.
f). The graph drawn should be a free hand curve.

SOURCES OF ERROR:-

a). Slight error is introduced due to resistance of air.
b).Slight error is introduced due to curvature of the knife – edges, because they are not sharp.
c). The support may be yielding slightly.
d). The amplitude of oscillation cannot be very small as desirable.

Viva – Voce

Q1. What is compound pendulum?
Q2. What do you mean by centre of suspension and centre of oscillation?
Q3. What is the distance of point having minimum time period from the centre of gravity?
Q4. What is the time period of a compound pendulum at its centre of gravity?
Q5. About how many points the time period of a compound pendulum is same?
Q6. What is the radius of gyration and what are its units?
Q7. Why is a compound pendulum superior to simple pendulum?
Q8. How does the period vary with distance of knife edge from centre of gravity of the pendulum?

LASER EXPERIMENT

OBJECT: To determine the wave length of He – Ne laser by using a transmission grating.

APPRATUS: He – Ne laser , transmission grating (three in one) , measuring tape , screen ,grating mount.

THEORY: The wavelength of laser light can be measured easily by use of a transmission diffraction grating. A transmission grating is an optical component which produces spectrum of light due to diffraction. It has large number of lines grooved on it. Now a day replica grating is used for experimental purpose.

If 'd' is the spacing between the lines, then according to diffraction.

FORMULA:

$$d \sin\theta = n\lambda \quad (\lambda = 632.8 \text{ nm})$$

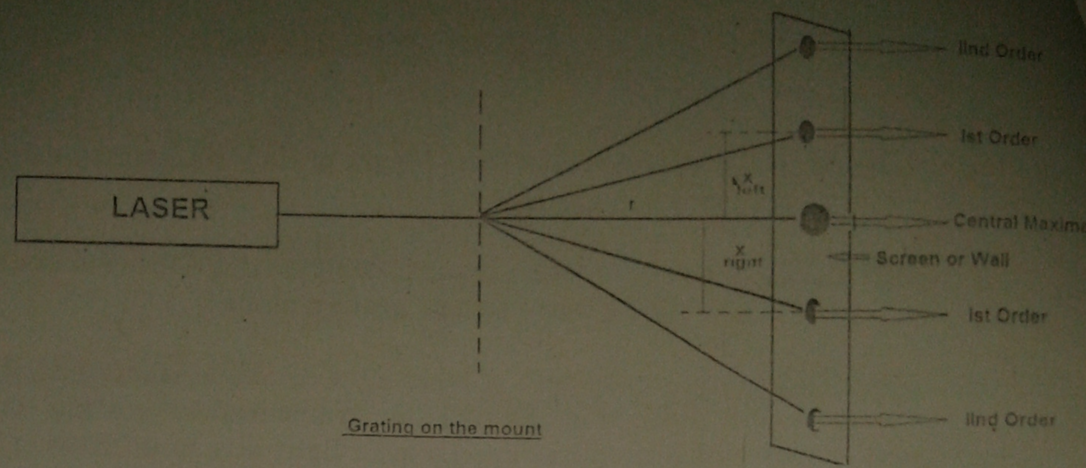
where 'θ' is the angle between the direct beam and diffracted beam , 'n' is the order of spectrum , 'λ' is the wave length of laser light .

For first order spectrum, n=1, then

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

By knowing d (1/number of lines per cm.) and measuring the angle 'θ' subtended between the direct beam and first spot we can determine the wavelength of laser light.

DIAGRAM:



PROCEDURE:

1. Mount the grating strip on the grating holder. There are three different gratings in the grating strip

2. Illuminate the grating at the centre by placing it about 20-30 cm away from the laser. The laser should be mounted in such a way, so that its beam falls almost horizontally in the centre of the grating.

3. The beam on passing through the grating produces several spots due to diffraction. The separation between the spots is large, if you are using the grating with larger number of lines. The separation is small when you use the grating having smaller number of lines.

4. Let us denote the distance between wall and grating by 'r'. For all measurements keep r fixed. Keep 'r' between 70-100 cm.

5. In the spectrum there is one bright spot called central maxima . On both sides of central maxima there are several spots of diminishing intensity. First spot adjacent to central maxima is due to 1^{st} order spectrum, second spot from central maxima is due to second order spectrum and so on and so forth. Mark the spots with a pencil.
6. Now measure the separation between the central maxima and first spot for both left and right spectrum. So we get x_1(left) and x_1(right). Now calculate sin θ for right and left using the formula given below.

$$\text{Sin}\,\theta = x/(x^2+r^2)^{1/2}$$

Now using Eq.1, find 'λ' for left and right positions for n= 1 (first spot) . Then take average of the two.

7. Similarly calculate ' λ' for second and third order spectrum.

8. Now move the grating holder so that the laser beam falls on a different grating (change d).

9. Again calculate the wavelength using steps 2 to 7.

OBSERVATIONS:

r = __________ cm
Number of lines/cm = __________
d = 1/numbers of lines per cm = __________ cm

Table for wavelength measurement –

n	Left spectrum			Right spectrum			λ
	x (cm.)	Sin θ	λ (cm)	x (cm.)	Sin θ	λ (cm)	average (cm)
1							
2							
3							

Make two such tables for any of the two gratings.
Mean wavelength =
% ERROR = (λ calculated –λ/λ)×100

PRECATIONS:

a). Do not touch the grating surface.
b). LASER should not be on continuously for more than five minutes.
c). Switch the laser off using the switch given at the back of the laser.

Questions:-

a). What are coherent sources?
b). Is sodium lamp, LASER a coherent source?
c). What is simulated and spontaneous emission?
d). Why are the readings of left and right spectrum different?

OPTICAL FIBRE EXPERIMENT

OBJECT: To determine the Numerical aperture of an optical fibre using He-Ne Laser source.

APPARATUS: He-Ne Laser source, Optical fibre, microscope objective, two fibre optics chucks and screen with a graph paper pasted on it.

FORMULA: The numerical aperture (NA) of an optical fibre is given by

$$N.A. = \sin\theta_0 = \sqrt{(\mu_1^2 - \mu_2^2)}$$

Where

θ_0 = Maximum acceptance angle

μ_1 = Refractive index of core

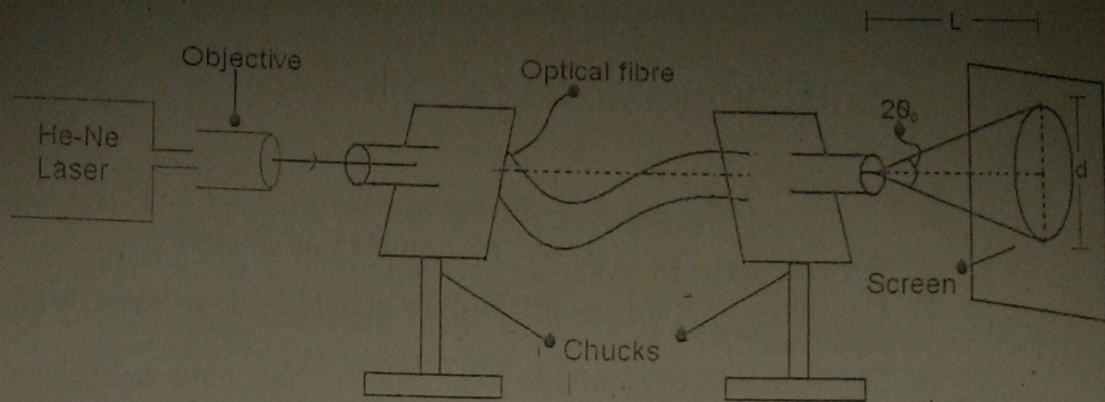
μ_2 = Refractive index of cladding

In a short length of optical fibre, ideally a ray entering at an angle Θ_i at the input end comes out at the same angle Θ_i from the output end. Therefore the emerging rays from the output end of the fibre will also appear as a cone of semi angle Θ_i. It is then simpler to make measurements on this end of the fibre to determine the numerical aperture of the fibre.

If the emerging rays from the output end of the optical fibre make a spot of diameter 'd' on a screen kept at a distance 'L' from the output end of the fibre, then as it is obvious from the figure.

$$\sin\theta_0 = \frac{d/2}{\sqrt{(d/2)^2 + L^2}} = \frac{d}{\sqrt{(d^2 + 4L^2}}$$

DIAGRAM:



PROCEDURE:

1. Arrange the laser source, the microscopic objective, the input and output end of the optical fibre at the same horizontal level with the help of stands.
2. Switch ON the laser or make the light passing through the objective and optical fibre fall on the screen.
3. Place the screen at some distance from the output end of the fibre. A circular spot is formed on the screen.
4. Measure the distance 'L' between the output end of the optical fibre and screen. Also put marks for the diameter 'd' of the spot on the screen and measure it.
5. Repeat the above procedure for different values of 'L' and measure the corresponding diameter of the spot formed.
6. Calculate the numerical aperture for each value of 'L'and take the mean.

OBSERVATIONS:

S. No.	Distance 'L' in cm.	Diameter 'd' in cm.	N.A. = $\frac{d}{\sqrt{(d^2+4L^2}}$
1.			
2.			
3.			
4.			

RESULT: The numerical aperture for the given optical fibre is.........

PRECAUTIONS:

1. The end of the fibre should be clean.
2. The input end of the optical fibre should be kept close to the microscopic objective.
3. The laser source should be kept close to the microscopic objective.
4. The screen should be held vertically.
5. The optical fibre must be connected through optic fibre checks to avoid any leakage.

VIVA-VOCE:

1. Why must the refractive index of cladding always be lower than that of the core?
2. Define fibre optic system.
3. What are the advantages of using fibre optic communication system?
4. Distinguish between acceptance angle and numerical aperture?
5. What is the purpose of cladding in optical fibre?
6. How does the light propagate in an optical fibre?
7. Enumerate few advantages of optical fibre over conventional copper cables?

SPECIFIC ROTATION EXPERIMENT

OBJECT: To determine the specific rotation of cane sugar solution with the help of half shade polarimeter.

APPARATUS: Laurent's half shade polarimeter, sodium lamp, sugar, beakers, water etc.

FORMULA: If 'θ' is the optical rotation produced by 'l' decimeters of a solution and 'c' the concentration in gram per c.c., then specific rotation 'S' at given temperature (t) and corresponding to a wavelength (λ) is given by

$$[S]_{\lambda}^{t} = \frac{\theta}{lc} = \frac{Rotation \cdot in \cdot degrees}{Length \cdot in \cdot decimeters \times concntration \cdot in \cdot gm / c.c.}$$

PROCEDURE:

1. Preparation of 20% solution. Taken a clean dry beaker. Add about 20 gm. of sugar in it and weight. Calculate the volume of solution to have a 20% strength as follows:

$$Volume \cdot required = \frac{m \times 100}{20} c.c.$$

where 'm' is the mass of sugar in the beaker.

Add nearly half this volume of water in the beaker and stir well till the whole of sugar is dissolved. Add more water, if necessary taking care the volume the solution is less than the calculated value of the volume.

Transfer the solution into a graduated cylinder. Rinse the beaker with a small quantity of water and add to the cylinder. Make the required volume by adding more water little by little with a pipette.

2. Setting: Find the vernier constant of the circular scale. Place the polarimeter so that the aperture is in front of the sodium lamp. Look through the telescope and adjust the position of the eye-piece so that the two halves of the half shade device are clearly in focus.

3. Remove the brass caps of the polarimeter tube. Clean the tube as well as the glass windows. Now replace on of the caps in position taking care that no strain is exerted on the glass window. Hold the tube in vertical position and fill it with water. Slip the second glass window gently on the tube taking care that no air bubbles are left underneath it. Screw the cap gently taking care that no strain is exerted on the glass window.
4. Place the tube in position in the polarimeter and cover it. Rotate the analyzing nicol by rotating the circular scale till the two halves of the half shade device are in equally dark position. In this position there will be an abrupt change in the intensity of the halves when slight rotation on either side is given. Note the reading on the scale.
   Turn through 180^0, set the analyzer again for equally dark position and note the reading on the scale.
   Note: if the instrument is properly set, there is no strain on the glass windows, and water is free from optically active impurities, the scale reading will be 0 to 180 in the two positions respectively.
5. Now fill the tube with 20% sugar solution prepared as explained above. Place it in position and note the scale readings when the two halves are in equally dark position. Repeat by turning through 1800.
6. Take 30 c.c. of the 20% sugar solution and make the volume to 60 c.c. so as to reduce the strength to one half (10%). Fill the tube with this 10% solution and take the reading as explained above.

OBSERVATION:

Room temperature = ...^{0}C
Length of the tube(l) = ...dm
Mass of the sugar dissolved (m) = ...gm
Volume of the solution = ...cc
Least count of the vernier = ... cm

S. No.	Reading on analyzer for equal illumination in degree					Rotation in degree		
	With water		With sugar solution			$\theta_1(A \sim C)$	$\theta_2(B \sim D)$	$(\theta_1 + \theta_2)/2$
	1^{st} position (A)	2^{nd} position at 180^0 (B)	Strength of solution	1^{st} position (C)	2^{nd} position at 180^0 (D)			
1.								
2.								
3.								

CALCULATIONS:

The specific rotation of cane sugar is given by:

$$[S]_{\lambda}^{t} = \frac{\theta}{lc}$$

RESULT: The specific rotation of cane sugar is ....degree/conc./dm.

PRECAUTIONS:

1. The tube and the glass windows should be clean.
2. There should be no air bubble in the glass tube when the tube is filled with the solution.
3. The caps should be screwed in such a manner that there is no leakage. These should not be made very tight so as strain the glass windows.
4. The reading should be taken in the equally dark position and not in the equally bright position.
5. Before filling the tube with a solution the tube should be rinsed with the same solution.
6. Sugar must be dust free.
7. Water used should pure.

VIVA-VOCE:

1. What do you mean by polarized light ?
2. What do you mean half shade device or Laurent plate ?
3. Is light from sodium lamp polarized ?
4. What is phenomenon of double refraction ?
5. What are uniaxial and biaxial crystals ?
6. Why light waves can be polarized, while sound waves cann't be polarized ?

PLANCK CONSTANT EXPERIMENT

OBJECT: To determine the Planck's Constant.

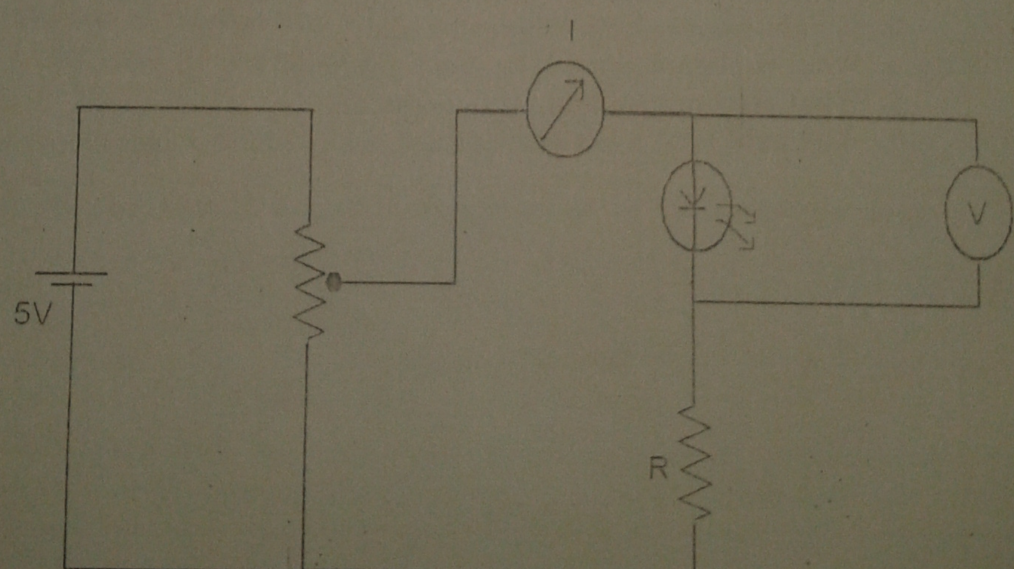
APPARATUS: Planck constant kit, Different colours LEDs.

FORMULA:

$$h = \frac{eV\lambda}{c}$$

Where 'e' is the charge of electron (1.6×10^{-19} C)
'c' is the speed of light (3×10^{8} m/sec.)
'λ' is the wavelength of respective LED colour
'V' is the voltage corresponding to respective LED.

CIRCUIT DIAGRAM: -



As shown above the electric circuit consists of 5V supply, ten turn potentiometer to vary voltage across the LED from 0V to 5V and voltmeter to measure current and voltage respectively through the LED. In addition to the diode(LED) there was a 33 K-ohm resistor connected in series with the diode. This served a two-fold purpose. First, it provided a known resistance in the circuit and second, it prevented the overloading of the diode.

PROCEDURE:

1. Digital Voltmeter to measure the voltage across the LEDs.
2. Micro ammeter to determine the current through LEDs.
3. Ten turn linear potentiometer with calibrated dial to vary the voltage across the LEDs.
4. Jack J to connect the LEDs.
5. Connect the LED to the jack provided on the front panel and switch ON the unit.
6. Take the different voltage and current measurement of LED (as tabulated below) for V-I characteristic of LED.

Table for V-I characteristics of LEDs:

S. No.	Current (μA)	Green (Volts)	Blue (Volts)	Red (Volts)	Yellow (Volts)
1.	0				
2.	1				
3.	2				
4.	3				
5.	5				
6.	10				
7.	20				
8.	30				
9.	40				
10.	50				
11.	60				
12.	70				
13.	80				

Now plot the V-I characteristics of all the LEDs on a graph paper and take the voltages corresponding to a constant current (V).

<u>LEDs colours and their wavelengths (λ):</u>

Green	= 481 nm
Yellow	= 583 nm
Blue	= 430 nm
Red	= 660 nm

Now calculate the value of Planck's constant given by the formula:

$$h = \frac{eV\lambda}{c}$$

corresponding to each LED & take the average.

RESULT: The value of the Planck's constant (h) =

% Error:

PRECAUTIONS:

Vernier Constant

Reading = Main Scale + (Vernier Scale Reading x least Count)

Least Count = $\dfrac{\text{Smallest division on the M.S.}}{\text{Total No. of divisions on the V.S.}}$

V.S. reading = Reading of the V.S. which coincide with the M.S.

Newton's ring:
Least M.S. reading = .05 cm. Total no. of division on V.S. = 50
Least count = $\dfrac{.05\text{ cm.}}{50}$ = .001 cm. = .01 mm.

Spectrometer:
M.S. least reading = $.5^0$ Total division of V.S. = 30
Least count = $\dfrac{.5^0}{30}$ = 1/60 degree

Vernier Caliper:
M.S. least reading = 1 mm. Total no. of division of V.S. = 50
Least Count = $\dfrac{1\text{mm.}}{50}$ = .02 mm.

<u>Example of vernier caliper</u>:

M.S. (mm)	V.S.	T.R. (mm.)
21	25	(21 + 25 x .02) = 21.5mm
22	8	(22 + 8 x .02) = 22.16 mm