Department of Applied Physics

APPLIED PHYSICS LAB B.Tech 1st Semester

Paper Code: AP-101
Paper Title: Applied Physics Lab-I

OBJECTIVE: To impart experimental skills which are useful in various branches of Engineering and Technology. The practical course is based on experiments designed to illustrate various phenomena in different areas of physics and hence provides thorough understanding of the subject. This course is also aimed at enhancing the analytical capability of the engineering students.

List of Experiments

1. To determine the compressibility of a given liquid by Ultrasonic Diffraction Method.
2. To determine the specific rotation of sugar solution using Laurent's half shade polarimeter.
3. To verify the equation of focal length of combination of lenses using Nodal Slide Assembly.
4. To determine the wavelength of yellow line of mercury light using Plane diffraction Grating.
5. To determine the dispersive power of the material of a prism using Spectrometer.
6. To determine the wavelength of sodium light by Newton's rings.
7. To determine the resolving power of Telescope.
8. To find the Numerical aperture of a given optical fiber.
9. To study the mechanical forced oscillator and to determine the resonance frequency.
10. To compare the wavelength of a laser source measured by diffraction pattern from a single slit and a plane diffraction grating.

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EXPERIMENT NO. -1

AIM: To determine the compressibility of a given liquid by Ultrasonic Diffraction Method.

APPARATUS: Radio frequency oscillator, glass cell filled with liquid (Kerosene oil), a piezoelectric crystal slab, spectrometer, sodium lamp, liquid (kerosene oil)

THEORY: The sound waves of frequency more than 20,000 Hz are called ultrasonic waves or ultrasonics. A radio frequency oscillator input is connected to the A.C. mains and the output to the piezoelectric crystal slab. The piezoelectric crystal slab fixed on a side in the glass cell in order to dip the crystal in the liquid. When the frequency of the oscillator is equal to the natural frequency of the piezoelectric crystal, resonance occurs and ultrasonic waves of the same frequency produced in the liquid. When ultrasonic waves are produced in a liquid the pressure varies with the distance from the ultrasonic source being higher at a compression and lower at rarefaction. The density of the medium and the refractive index also show a periodic variation with distance from the source along the direction of propagation of the wave. Under such a condition, if light from a slit is passed through the liquid in a direction at right angles to the wave propagation, the liquid behaves as a diffraction grating with grating element (width of opacity + width of transparency) equal to the wavelength of ultrasonic wave λ_u. Such a grating is known as *acoustic grating*. The light which suffers diffraction at this grating show a number of diffraction images of the slit, when observed through a telescope.

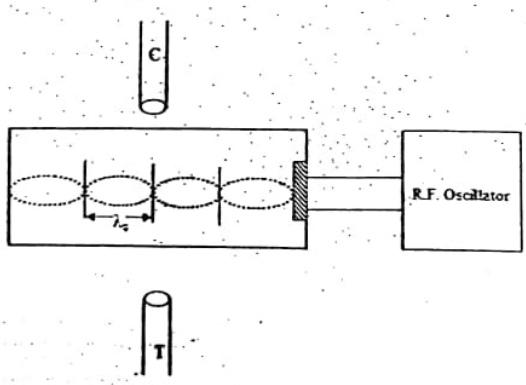

Fig. 1

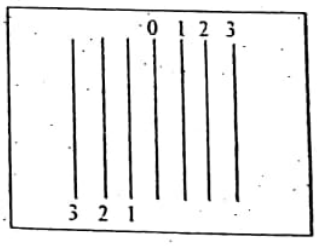

Fig. 2

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The ultrasonic wave passing through liquid behaves as an elastic wave in which the compressions and refractions travel one behind the other spaced equally apart as shown in Fig. 1. The successive distance between the two compressions or rarefaction is equal to the wavelength of ultrasonic wave λ_u. If λ is the wavelength of incident light in air and θ is the angle of diffraction for the nth order maxima, then

$$\lambda_u \sin\theta_n = n\lambda \qquad \text{(where (a+b) is equal to } \lambda_u\text{)}$$

$$\therefore \text{Wavelength of the ultrasonic waves } (\lambda_u) = n\lambda/\sin\theta_n \qquad \ldots\ldots (1)$$

If ν is the frequency of ultrasonic waves, the velocity (V) of the ultrasonic wave in the liquid is given by $V = \nu\,\lambda_u$ ..... (2)

The relation between the velocity of sound wave in a liquid and its bulk elasticity (E) is given by

$$V = \sqrt{\frac{E}{\rho}} \Rightarrow E = \rho V^2 \qquad \ldots\ldots (3)$$

Where ρ is the density of liquid, V is the velocity of sound wave obtained by Eq. (2) and E is the bulk elasticity of the liquid. The reciprocal of this bulk elasticity is known as the compressibility of the liquid.

$$K = \frac{1}{E} \qquad \ldots (4)$$

Thus, the compressibility of the liquid can be determined by ultrasonic diffraction method.

PROCEDURE:

1. Adjust the spectrometer in order to obtain a well collimated beam
2. Place the glass cell on the prism table and fill it by given liquid upto its ¾ of the height.
3. Turn the prism table till the front & back faces of the cell are exactly normal to the incident light. Also make sure that the ultrasonic waves produced by the crystal travel in the liquid in a direction perpendicular to the direction of incident light.
4. Switch on the radio frequency oscillator. Adjust the frequency of the oscillator so that it becomes equal to the natural frequency of the crystal slab. At this stage resonance takes place and diffraction pattern will be seen in the telescope. An enlarged view of diffraction pattern is shown in Fig. 2.

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5. Note down the frequency of R.F oscillator at which diffraction pattern is obtained. This is also the frequency of the ultrasonic wave in the liquid. Keep this as constant at this value through out the experiment.
6. Measure the angle $2\theta_1$ between the first order spectral lines, similarly measure $2\theta_2$, $2\theta_3$, etc.

OBSERVATIONS:

Wavelength of the sodium light (λ) = 5893×10^{-10} m

Frequency of the oscillator used (f) = ……..Hz.

Least count of spectrometer =

Density of liquid (ρ) = 810 kg/m^3

Measurements of the angle of diffraction (θ) for the *n*th order diffraction maxima

Order of diffraction maxima (n)	Vernier	Telescope on Right			Telescope on left			2θ		Mean $2\theta_n$	Mean θ_n (deg.)
		M.S x (deg.)	V.S.* y	Total= a(=x+y) deg.	M.S. x (deg.)	V.S.* y	Total= b(=x+y)deg.	V_1 (|a-b|)	V_2 (|a-b|)		
2	V_1										
	V_2										
1	V_1										
	V_2										

*V.S. reading(y) = No. of divisions on vernier scale in front of main scale x Least count of the spectrometer.

CALCULATIONS:

Wavelength of the ultrasonic waves (λ_u) = $n\lambda/\sin\theta_n$

For first order

n=1

Mean θ_1= …

$\lambda u = \lambda/\sin\theta_1$ = …m

For second order

n=2

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Mean θ_2= …

$\lambda u = 2\lambda / \sin\theta_2$ = …m

Velocity of ultrasonic wave in liquid (V) = $f\lambda_u$ = …… *m/sec*

Bulk elasticity (E) = ρV^2 = …… N/m^2 *(Pa)*

Compressibility (K) = (1/E) = …… $N^{-1}m^2$

Standard value of K (kerosene) = 5.2×10^{-10} m^2/N (0.52×10^{-9} m^2/N)

RESULTS:

The velocity of ultrasonic wave in liquid (Kerosene) is found to be…… *m/sec* and its compressibility is …… $N^{-1}m^2$

PRECAUTIONS:

(1) The crystal slab should be immersed completely in the liquid.

(2) The crystal slab should be set in such a way that the ultrasonic waves produced by it travel at right angles to the incident light.

(3) The diffraction pattern should be sharp and narrow.

(4) As the angles measured are extremely small, angles should be observed carefully.

(5) The frequency of the R.F. oscillator should be properly adjusted for resonance and should not be disturbed during the experiment.

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EXPERIMENT NO. 2

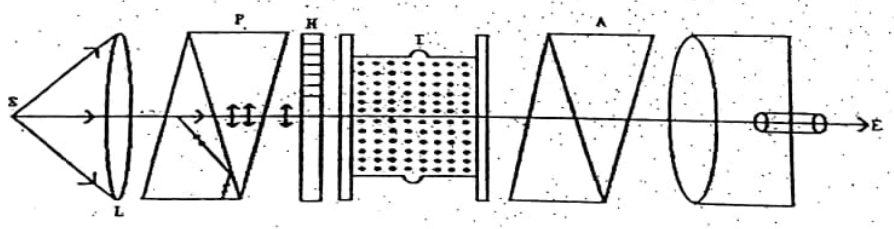
- **AIM:** To determine the specific rotation of sugar solution using Laurent's half shade polarimeter.

APPARATUS: Laurent's Half Shade Polarimeter, spirit level, Sodium Lamp, Polarimeter tube, Reading Lamp, weight box, balance, sugar cubes, beakers, graduated jar.

THEORY:

Polarimeter is an instrument which is used to measure the optical rotation produced by an optically active substance. It consists of two Nicol prisms capable of rotating about a common axis. It is also provided with hollow tube for filling the solution of optically active substance.

The experimental arrangement is shown if figure, S is source of monochromatic light placed at the focus of convex lens L. The beam, rendered parallel by lens L, falls on called polarizer P. After passing through polarizer P the light become plane polarized. The polarized light beam passes through a half-shale device H (called Laurent plate) and then through a tube T containing optically active solution. The transmitted light passes through another Nicol 'A' which can be rotated about the direction of propagation of light as axis and its rotation can be read on a circular scale graduated in degree, with the help of a Vernier.



Liquid containing an optically active substance e.g. sugar solution, camphor in alcohol etc. rotate the plane of the linearly polarized light. The angle through which the plane polarized light is rotated depends on (1) the thickness of the medium (2) concentration of the solution (3) Wavelength of light (4) temperature.

Working Formula:

Specific rotation is defined as the rotation produced by a decimeter (10 cm) long column of the liquid containing 1 gm of the active substance in one cc of the solution. Therefore

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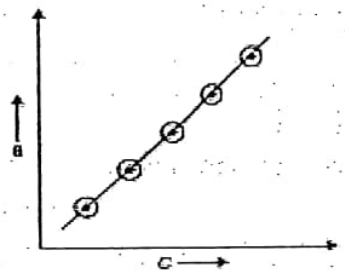
$$S = 100 / (l\,c)$$

Where S represents the specific rotation at temperature t °C for a wavelength λ, θ is the angle of rotation, l is the length of the solution in cm. through which the plane polarized light passes and c is the concentration of the active substance in gm/cc in the solution.

The angle through which the plane of polarization is rotated by the optically active substance is determined with the help of a Polarimeter, when this instrument is used to determine the quantity of sugar in a solution, it is known as a saccharimeter.

The graph between c (x-axis) and θ (y-axis) is a straight line.



PROCEDURE:

1. Weigh in a watch glass 20 gm of sugar and carefully dissolve it in water to make up 100 cc of solution. This gives 20% solution of sugar.
2. The Vernier constant of circular scale is found. The Polarimeter is placed so that the aperture is in front of sodium lamp. After looking through the telescope the position of the eyepiece is adjusted so that the two halves of half shade device are clearly in focus.
3. Clean the Polarimeter tube and fill it with distilled water. See that there is no air bubble in the tube when the end caps have been screwed. Place the tube in its position inside the Polarimeter.
4. Rotate the analyzer A till the field of view is completely and uniformly dark i.e. both halves are equally dark. In this position there will be an abrupt change in intensity of two halves with slight rotation on either side. Read the position of analyzer on the circular scale, provided for the purpose. A further rotation through 180° will again produce extinction (i.e. equally dark position). Record this position of analyzer also on the circular scale for further use.

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5. Remove the tube, empty it, rinse it with solution and then fill it completely with solution, removing all air bubbles. Clean the ends and put the tube in position. The two halves of the field will appear unequal dark. Rotate the analyzer till the two halves are equally dark and note the reading. The difference in readings gives rotation θ.
6. Rotate the analyzer through 180° to produce extinction again and read the scale. This difference gives the rotation produced. Get a second position of extinction by a further rotation of 180° and take mean for the rotations θ produced.
7. Now, to 50 cc of solution add 50 cc of water and mix thoroughly. This gives a 10% solution. Take readings with it and then mix 50 cc of this solution with 50 cc of water. This gives a 5% solution. Take readings with this also. Repeat with 2.5% and 1.25% solution.

OBSERVATIONS:

Least Count of Analyzer LC = ...degree

Room Temperature t = ... °C

Length of the Polarimeter Tube 'l' = ... cm

Wavelength of Sodium Light 'λ' = 5893 Å

Table A: To find Angle of Rotation

Concentration of Sugar Solution 'c'		Polarimeter Reading					
		Clockwise 'a'			Anticlockwise 'b'		
		CSR (in degrees)	VSR	TSR = CSR + VSR* LC (in degrees)	CSR (in degrees)	VSR	TSR = CSR + VSR* LC (in degrees)
0%	0						
20%	0.20						
10%	0.10						
5%	0.05						
2.5%	0.025						

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Calculations: Determination of θ from Table A

Conc. Of Sugar Solution 'c' (gm/cc)	Clockwise Final 'a' (in degrees)	Anticlockwise Final 'b' (in degrees)	Mean (a + b)/2 (in degrees)	Rotation θ (in degrees)	θ_i/c (i= 1,2,3,4) (degree/gm.cc^{-1})
0			say c_0		
0.20			say c_1	$\theta_1 = c_1 - c_0$	
0.10			say c_2	$\theta_2 = c_2 - c_0$	
0.05			say c_3	$\theta_3 = c_3 - c_0$	
0.025			say c_4	$\theta_4 = c_4 - c_0$	

Mean θ = ... degree; Mean θ/c =..... degree/gm.cc^{-1}.

Numerical Calculations

Now $S = 10\,\theta / (l\,c)$

Where; l is length of polarimeter tube in cm

Take mean value of θ/c

Calculate S for the observations made.

Graphical Calculations

From the graph between c and θ which is a straight line,

Take slope = θ / c

Now $S = 10\,\theta / (l\,c) = 10 * \text{slope} / l$

Where, l is length of Polarimeter tube in cm.

Calculate S graphically for the observations made.

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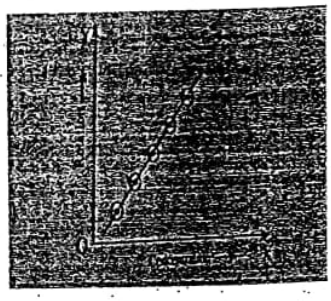

Result: The specific rotation of sugar solution is _____ at _____°C (Room Temperature) and λ = _____Å graphically.

The specific rotation of sugar solution is _____ at _____°C (Room Temperature) and λ = _____Å numerically.

PRECAUTIONS:

1. The Polarimeter tube and glass windows should be well cleaned.
2. Care should be taken in weighing sugar and measuring the quantity of water.
3. The sugar solution should be well mixed so as to have uniform concentration.
4. Care should be taken that there is no air bubble when the tube is filled with liquid.
5. Note the temperature of the room and also the wavelength of the light used.
6. Start with a concentrated solution and then go on diluting by adding water to it.

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EXPERIMENT NO. - 3

AIM: To verify the equation of focal length of combination of lenses using Nodal Slide Assembly.

$$\frac{1}{F}=\frac{1}{f_1}+\frac{1}{f_2}-\frac{d}{f_1 f_2}$$

where F, represents the focal length of the combination of two convex lenses of focal lengths f_1 and f_2 when the two are separated by a distance d.

APPARATUS: Nodal slide arrangement (optical bench, plane mirror, cross-slit and a lamp) and two convex lenses of nearly same focal lengths.

DESCRIPTION OF APPARATUS:

The nodal slide assembly consists of an optical bench which is provided with four uprights (Fig. 1). On one upright, placed at one extreme end of the bench, is mounted a lamp housing which has a circular opening for light from the frosted lamp to pass out and illuminate the cross-slits in a metal plate mounted on the adjacent upright. The third upright carries the nodal slide. Nodal slide is essentially a horizontal metal support capable of rotation about the vertical axis; and lens or lenses can be mounted upon the support. The metallic support can be fixed or it can be moved back and forth by means of a screw so that the relative position of the two lenses can vary with respect to this upright. The support can be rotated in a horizontal plane. The fourth upright carries the plane mirror which can be rotated about the horizontal axis perpendicular to the bed of the bench.

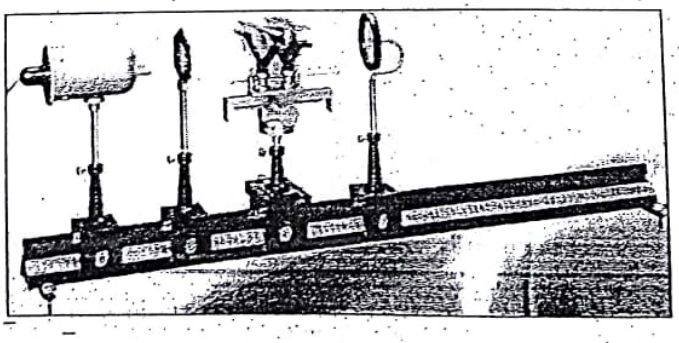

Figure 1. Experimental set-up.

THEORY:

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The principle is based on the property of nodal points, i.e., when a ray of light passes through one of them, its conjugate ray passes through other and is always parallel to the incident ray. If the system is now rotated slightly about the vertical axis, the image will not be shifted from its position. The distance of the screen from the axis of rotation gives the principal focal length of the lens system.

The focal length of a lens system is the distance between its principal point and the corresponding focal point. The principal points coincide with the corresponding nodal points when the media are the same on both the sides of the system (here, air). Thus the focal length of the system can be determined by locating a nodal point and the corresponding focal point.

The second nodal point can be located by using the fact that in case of parallel beam of light incident on a convergent lens system, thus forming an image on a screen in its second focal plane, the image does not shift laterally when the system is rotated about a vertical axis passing through its second nodal point.

The distance between the uprights carrying the screen (or –cross- slit) and the nodal slide (which gives the position of the axis of rotation) will, therefore, give the focal length of the lens system.

PROCEDURE:

(1) First the focal length f_1 and f_2 of the two given lenses are determined. For this, one of the lenses is mounted on the nodal – slide such that its optical center lies on the axis of rotation of nodal slide. The source of light, screen having the cross slit and plane- mirror are mounted on the proper uprights and the heights of uprights are adjusted in such a manner that the line joining the center of each part is parallel to the bed of the bench.

(2) The cross- slit is illuminated and the plane of the mirror is adjusted till the image of the cross slit is formed close to the cross slit itself. If the image is blurred and not well defined then the upright carrying the nodal slides moved towards or away from the slit till the image becomes sharp and well defined. (In this position light diverging from the cross-slit emerges as a parallel beam of light after passing through the lens. This parallel beam of light is reflected as parallel beam from the plane-mirror and brought to focus on the plane of the cross-slit by the lens. In other words, the screen having the cross -slit serves as the second focal plane for the parallel beam of light coming from the plane

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mirror).

(3) The slide is rotated slightly about the vertical axis and lateral shift of the image is observed. If there is any shift, the position of the axis of rotation with respect to the lens is slightly changed by moving the nodal slide on the upright by means of the screw provided for this purpose. The sharpness of the image is disturbed. The image is refocused by moving the upright (carrying the nodal slide) on the optical bench. Lateral shift of the image is again observed. The same process is repeated till the image of the slit is in sharp focus and does not show any lateral shift when the nodal slide is slightly rotated about its vertical axis. The distance between the plane of the ~~cross~~ slit and the axis of rotation now gives the focal length of the lens.

(4) The lens is rotated through 180^0 and the whole process is repeated. The mean of the two distances, thus obtained, will give the exact focal length "f_1" of the lens.

(5) The first lens is removed and the second lens is mounted on the nodal- side. Its focal length "f_2" is determined in the same manner as described.

(6) To determine the focal length of the combination, the two lenses are mounted on the nodal slide at some distance apart (the lenses are being placed equidistance and on opposite sides of the axis of rotation). By adjusting the inclination of the plane mirror and the position of the nodal slide the image of the cross slit is made to lie on the side of the slit itself. The shift in the image due to a slight rotation of the nodal slide is observed. If there is any lateral shift, with the simultaneous focusing of image a suitable position of the nodal slide is determined for which no lateral shift of the image occurs due to a slight rotation of the nodal slide. The distance between the plane of the screen and the axis of the rotation of the nodal slide now gives the focal length of the combination.

(7) Different sets of reading are to be taken by turning the faces of the lens through 180^0 and inter-changing the position of the component lenses.

(8) The experiment is repeated for different values of distance (d) between the lenses (say 4,6,8 cm).

(9) The focal length of the combination is also obtained theoretically for each value of 'd' by using the formula

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$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$

$$F = \frac{f_1 f_2}{f_1 + f_2 - d}$$

(10) It will be found that the experimental and theoretically values of the focal length of the combination for given separation agree fairy well thus verifying the truth of the formula.

OBSERVATIONS:

Table 1: Observation for the focal length of the first lens:

S.No	Light Incident On	Position of The Cross- Slit (a) (cm)	Position of the lens (b) (cm)	Focal Length (f_1= b-a) (cm)	Mean f_1 (cm)
1	One Face				
	Other Face				
				Mean f_1	

Table 2: Observation for the focal length of the Second lens:

S.No	Light Incident On	Position of The Cross- Slit (a) (cm)	Position of the lens (b) (cm)	Focal Length (f_2= b-a) (cm)	Mean f_2 (cm)
1	One Face				
	Other Face				
				Mean f_2	

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Table 3: Observations for the focal length of the combination of two lenses:

S.No.	Distance Between lenses x (cm).	Light Incident On	Position of Cross Slit (a) (cm)	Position of The Nodal Slide (b) (cm)	Experimental Focal Length F_e (b-a) (cm)	Experimental mean Focal length (F_e) (cm)	Theoretical focal length (F_{th})
1.		One face					
		Other face					
2.		One face					
		Other face					
3.		One face					
		Other face					
					Mean F_e =		Mean F_{th} =

CALCULATION:

Calculate the theoretical combined focal length with the help of the formula

$$(1/F_{th}) = (1/f_1) + (1/f_2) - (d/f_1f_2)$$

RESULT:

The theoretically calculated F_{th} and experimentally observed F_e values of the focal length of the combination are very nearly equal (F_{th} - F_e= ....) and hence the formula is verified.

$$(1/F) = (1/f_1) + (1/f_2) - (d/f_1f_2)$$

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PRECAUTIONS:

1. False images formed by partial reflection from the faces of the lenses should not be confused with the true image of the cross-slit.
2. While determining the focal length of a single lens, its optical centre must lie on the axis of rotation of the nodal slide. (for easy and quick setting)
3. Bench-error should also be taken into account.
4. The nodal slide should be rotated slightly about the axis of rotation.
5. In order to get a bright image of the slit the plane mirror should be placed as close to the combination as possible.

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EXPERIMENT NO. - 4

AIM: To determine the wavelength of yellow line of mercury light using Plane diffraction Grating.

APPARATUS: Spectrometer, Plane transmission grating, mercury vapour lamp

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

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

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

Where, $(a+b)$ = grating element ,

θ = angle of diffraction for a particular spectral line of wavelength λ

n = order of spectrum

PROCEDURE:

1. Setting

Take a spectrometer and set it so that the following conditions are satisfied.

a) The telescope should be focused in order to receive parallel rays.

b) The collimator is to be adjusted in order to send parallel rays.

c) The grating should be normal to the incident light beam.

d) The slit should be parallel to the line of grating.

To ensure the normal incidence condition (c), turn the telescope in order to receive the direct image of slit and coincide it with the cross wire. Note the reading of both the verniers. Let the reading of a vernier be ϕ. Rotate the telescope through 90^0. Under this condition the vernier will read ϕ+90 and the axis of telescope and collimator are perpendicular. Rotate the prism table (now grating table) about the main axis of the instrument in order to obtain the reflected image of the slit in the field of view of telescope. Coincide the image of slit with the cross wire. Note this reading. Under this condition the plane of grating will be at an angle of 45^0 with the incident beam. Now turn the grating through an angle of 45^0 in order to put it perpendicular to the incident beam.

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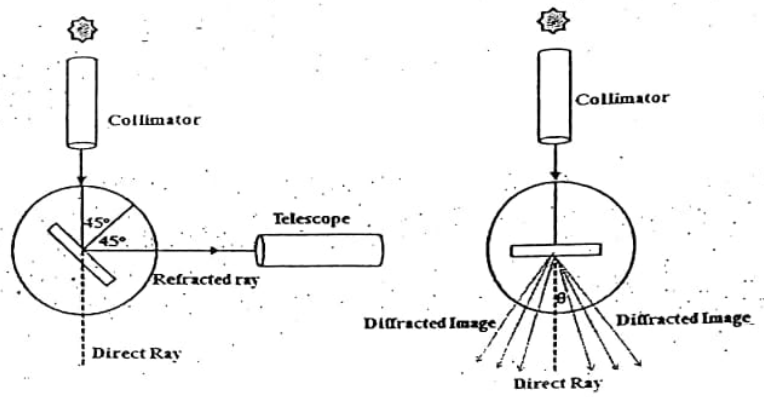

Fig.1 Setting diffraction grating normal to the incident light

2. Measurement of angle of diffraction for different spectral lines

1. On rotating the telescope on either side of the direct image, spectrum will be observed in different order as shown in Fig. 2. It can be seen that violet color spectral line will have smaller angle of diffraction as compared to red.

2. Turn the telescope to one side say left of the direct image coincide the crosswire with the green line of the mercury appearing at the extreme left in second order. Note the readings of the both verniers.

3. Rotate the telescope in the same direction and coincide it with the violet line of the

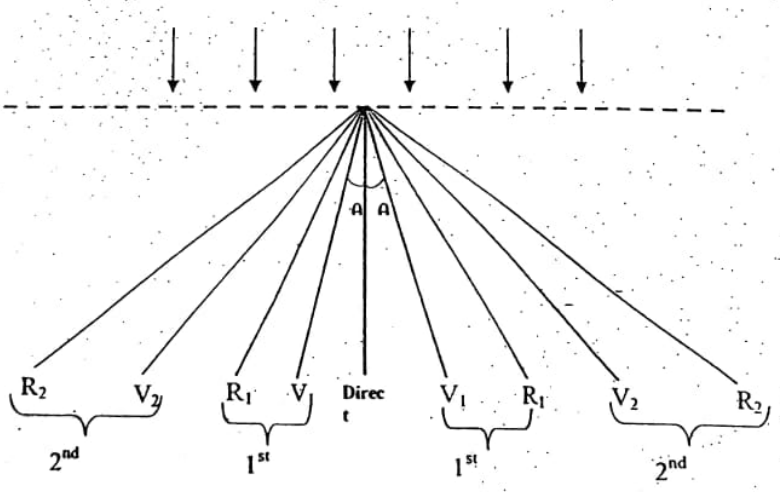

Fig.2 Grating diffraction

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Table 1: Measurement of angle of diffraction (θ)

Order of Spectrum	Colour	Vernier Scale	Reading of spectrum on						Angle of Diffraction	θ
			Left Side of Direct image			Right Side of Direct Image				
			MS (deg.)	VS	Total Reading x = MS + (VS x L.C) (deg.)	MS (deg.)	VS	Total Reading y = MS + (VS x L.C) (deg.)	$2\theta = x - y$ (degree)	(deg.)
First n =1	Green	V_1	.....							
		V_2	.....							
	Violet	V_1	.....							
		V_2	.....							
Second $n = 2$	Green	V_1	.....							
		V_2	.....							
	Violet	V_1	.....							
		V_2	.....							

MS= Main Scale Reading, VS= Vernier scale reading, L.C. = least count of spectrometer

CALCULATIONS:

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

$$\text{Grating element, } (a+b) = \frac{2.54}{N} cm^{-1}$$

Where, N is the number of ruling per inch on the grating.

For first order n =1, wavelength of spectral lines can be calculated by:

$$\lambda = \frac{(a+b)\sin\theta}{1} = (a+b)\sin\theta$$

λ for green = ... Å

λ for violet = ... Å

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For second order n =2, wavelength of spectral lines is given by:

$$\lambda = \frac{(a+b)\sin\theta}{2}$$

λ for green = ...Å

λ for violet = ...Å

Average value of λ for green and violet color can be calculated by taking average of λ for both the orders.

RESULT:

The wavelengths of the various spectral lines of mercury spectrum calculated by the grating are given below

Colour of the spectral line	Observed wavelength (Å)	Standard wavelength (Å)	Percentage error
Violet		4358	
Green		4916	
Yellow		5770	
Red		6234	

PRECAUTIONS AND SOURCES OF ERRORS:

1. All adjustments of the spectrometer must be correctly made.
2. Slit should be as narrow as possible.
3. Grating should be set normal to the incident light.
4. Ruled surface of the grating should face the telescope.
5. Both the verniers should be read.

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EXPERIMENT NO. - 5

AIM: To determine the dispersive power of the material of a prism using Spectrometer.

APPARATUS: Spectrometer, prism, spirit level, magnifying lens, reading lamp and source of light (Mercury Lamp).

FORMULA USED:

The dispersive power of the material of prism is given by

$$\omega = \frac{\mu_v - \mu_r}{\mu_y - 1}$$

where,

μ_v : Refractive index of the material of the prism for the violet colour.

μ_r : Refractive index of the material of the prism for the red colour.

μ_y : Refractive index of the material of the prism for the yellow colour.

$$\mu_y = \frac{\mu_v + \mu_r}{2}$$

Also, the refractive index is given by

$$\mu = \frac{\text{Sin}\left(\frac{A+\delta_m}{2}\right)}{\text{Sin}\left(\frac{A}{2}\right)}$$

where,

A : Angle of prism

δ_m : Angle of minimum deviation

Knowing the values of δ_m for violet, red and yellow colours μ_v, μ_r, and μ_y can be determined, respectively.

PROCEDURE:

A. ADJUSTMENT OF THE SPECTROMETER

Follow the following procedure:

1. Level the spectrometer table and set the collimator and telescope for the parallel rays and follow general instructions for adjustment of spectrometer.

   Some are as follows:

a. The slit should be thin and vertical.

b. It should be symmetrical for both sides.

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c. Note least count of the Vernier scale.

d. Adjust the height of the prism table.

2. Place the prism on the prism table such that one of its refracting faces AB(say) in figure 1 lies perpendicular to line joining two screws.

3. Unscrew the prism table screw such that two windows on the top of the table are perpendicular to collimator. Both the scales can be read easily now.

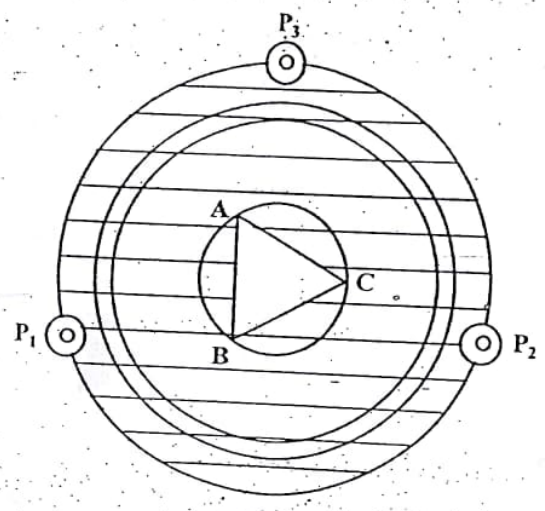

FIGURE I

B. DETERMINATION OF THE ANGLE OF PRISM (*A*)

Follow the following procedure:

1. Place the prism at the centre of the prism table with its base perpendicular to the axis of collimator and the edge A towards the collimator. Parallel rays from the collimator will be incident on refracting surfaces AB and AC and are reflected by each surface as shown in figure 2.

2. Now turn the telescope to receive the light reflected from the face AB and the position of the telescope is so adjusted that the image of the slit coincides with vertical cross wires of the telescope.

3. Note down the reading of both the verniers scales V_1 and V_2.

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4. Again move the telescope on other side such that it receives the light reflected from the face AC and adjust it till the image of the slit coincides with the with vertical cross wires of the telescope.
5. The reading of both the verniers scales V_1 and V_2 is recorded again.
6. Write the observations in the table 1 for the determination of angle of prism (A).

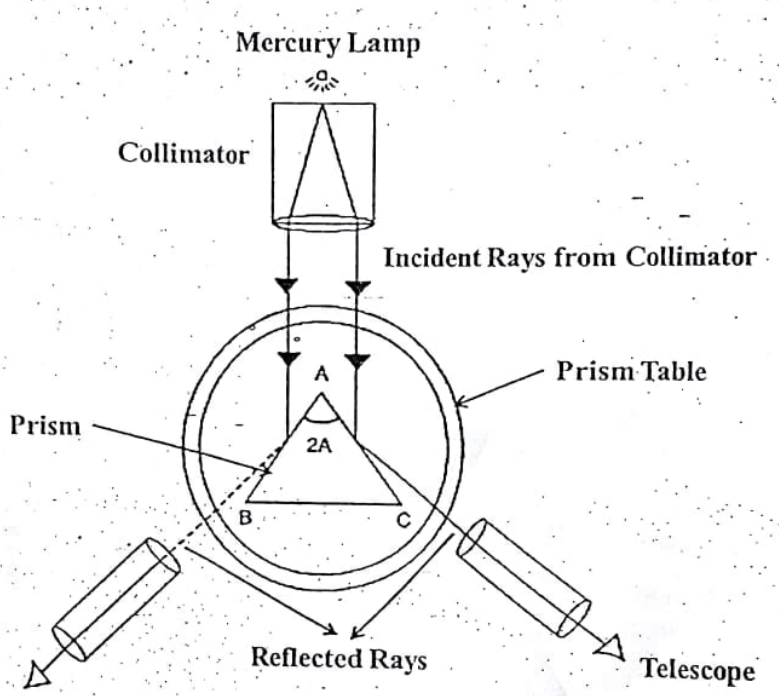

FIGURE 2

C. DETERMINATION OF ANGLE OF MINIMUM DEVIATION (δ_m)

Follow the following procedure:

1. The prism is placed on the prism table such that the light from the collimator is incident on one of the refracting faces of the prism. The incident light get deviated by the prism and dispersed through another refracting surface. Thus, a spectrum is obtained as shown in figure 3.
2. Focus the telescope on the violet line of the spectrum.
3. Now gradually rotate the prism table in the one direction, the spectrum will appear to move. The telescope is also moved along with the prism table so as to keep the image of

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the violet colour in the field of view. Keep on rotation of the prism table until a position is obtained from where the spectrum begins to move in the opposite direction even though the prism is continued to move in the same direction. This position for which the image of violet colour just retraces its path is the position of minimum deviation.

4. The telescope is focused such that the image of violet line coincides with the vertical cross wires. Fix the prism table as well as telescope in this very position and note down the readings of both the Vernier scales V_1 and V_2 in observation table 2.
5. At this position of minimum deviation, do the same for red and yellow line of the spectrum successively by setting the vertical crosswire on red and yellow line and note the readings of both the Vernier scales V_1 and V_2 in observation table 2.
6. Keep the table fixed and remove the prism from prism table gently and move the telescope towards the collimator axis and see the slit directly through it. Note the readings of both the Vernier scales V_1 and V_2 in observation table 2.

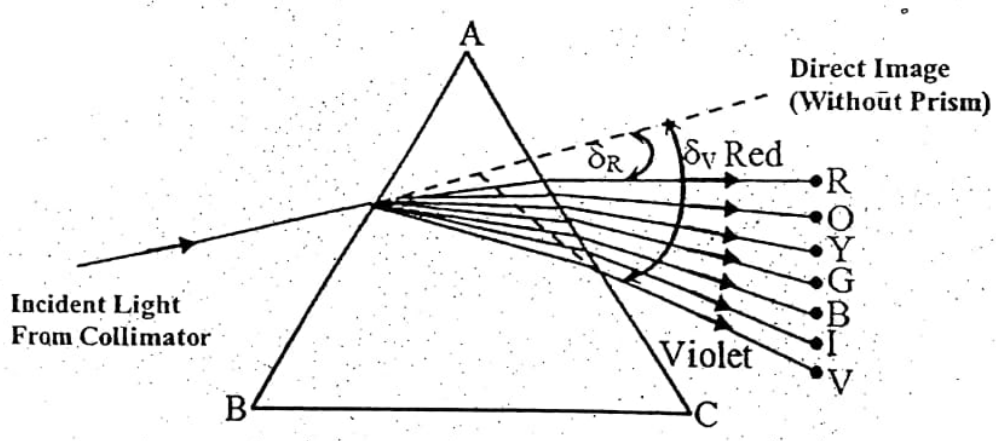

FIGURE 3

OBSERVATIONS:

(i) Value of one division of main (circular) scale = -------- (~ 0.5^0 say)

(ii) Total no. of divisions on the vernier scale = --------- (approx. 30, say)

(iii) Least count (L.C.) of the spectrometer vernier = --------- minute (~$0.5^0/30$ = 1 minute)

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Table 1: For the determination of angle of prism (A).

S.No	Vernier	Reflected from AB Face			Reflected from AC Face			$2A = F - F'$ (deg.)	Mean $2A$ (deg.)
		M.S.R M (deg.)	V.S.R V**	Total $F=M+V$ (deg.)	M.S.R M' (deg.)	V.S.R V'	Total $F'=M'+V'$ (deg.)		
1.	V_1								
2	V_2								

**V.S.R. (V) = Divison on vernier scale best coinciding with main scale division ×Least count of the spectrometer

M.S.R. : Main Scale Reading

V.S.R. : Vernier Scale Reading

Angle of prism A = ... Degree

Table 2 : For the determination of angle of minimum deviation (δ_m).

S.No.	Colour	Vernier	Reading in the minimum deviation position			Reading in the position of direct image			Angle of minimum deviation $\delta_m = f - f'$ (deg.)	Mean δ_m (deg.)
			M.S.R m (deg.)	V.S.R v**	Total $f=m+v$ (deg.)	M.S.R m' (deg.)	V.S.R v'	Total $f'=m'+v'$ (deg.)		
1.	Violet	V_1 V_2	... ...	....	... .	....	....	....	....	..... $= \delta_{mv}$
2.	Yellow	V_1 V_2	... ...	....	....	....	....	....	....	..... $= \delta_{my}$
3.	Red	V_1 V_2	... ...	....	....	....	....	....	....	..... $= \delta_{mr}$

CALCULATIONS:

(i) Angle of minimum deviation for violet colour, δ_{mv} = ...

The refractive index,

$$\mu_v = \frac{\sin\left(\frac{A+\delta_{mv}}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

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(ii) Angle of minimum deviation for yellow colour, δ_{my} = ...

The refractive index,

$$\mu_y = \frac{\sin\left(\frac{A+\delta_{my}}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

(iii) Angle of minimum deviation for red colour, δ_{mr} = ...

The refractive index,

$$\mu_r = \frac{\sin\left(\frac{A+\delta_{mr}}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

(iv) The dispersive power of the material of prism

$$\omega = \frac{\mu_v - \mu_r}{\mu_y - 1}$$

RESULT:

The dispersive power of the material of the given prism is ..... .

Standard Results: The standard value of the dispersive power of

(i) Dense flint glass prism = 0.027

(ii) Extra dense flint glass prism = 0.030

PRECAUTION AND SOURCES OF ERROR:

1. The telescope and collimator should be set individually for parallel rays.
2. Proper levelling of various parts should be done with spirit level.
3. The height of the prism table should be so adjusted that the maximum light must fall on the entire surface of the prism
4. Slit should always be vertical.
5. The slit should be adjusted so that a narrow and fine image can be obtained in the telescope.
6. While taking observations, the telescope and prism table should be clamped with the help of clamping screws.
7. Care should be taken in noting the readings of the vernier scales. The reading lens should be used for taking readings on both the verniers.
8. The prism table and the telescope should not be rotated simulatenously. To move the one, other should be clamped.

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EXPERIMENT NO. - 6

AIM: To observe Newton rings formed by the interface of produced by a thin air film and to determine the wavelength of sodium light.

APPARATUS: Plano convex lens, plane glass plate, sodium lamp, travelling microscope, spherometer, magnifying lens & optical arrangement for Newton's rings.

FORMULA USED: The wavelength of the light is given by

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

Where D_{n+m} = diameter of $(n+m)_{th}$ ring

D_n = diameter of n_{th} ring

R = radius of curvature of the spherical surface of the plano-convex lens

$$R = \frac{l^2}{6h} + \frac{h}{2}$$

l = distance between two legs of the spherometer

h = thickness of the lens at the centre

Formation of Newton Rings:

The term "Newton's rings" refers to a phenomenon that occurs when a curved piece of glass, typically a convex lens, is put in contact with a flat piece of glass. The curved glass sits on the flat glass, creating a film of air between them whose thickness is increasing larger along the length of the curve. When white light is directed into the curved glass, a series of concentric circles, like a bull's eye, appears.

Sir Isaac Newton was the first to observe the phenomenon, which is why the concentric rings are referred to as Newton's rings. The concentric circles produced by the Newton's rings phenomenon typically are dark alternating with bright, with the dark beginning in the center. The phenomenon occurs as a result of interference between the light reflected by the two surfaces. Another characteristic of the Newton's ring phenomenon is that the circles nearer the center are thicker than those on the periphery of the circle. This has to do with the curvature of the convex

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lens. As the lens becomes more distant from the flat glass beneath it, the rings become thinner and closer together.

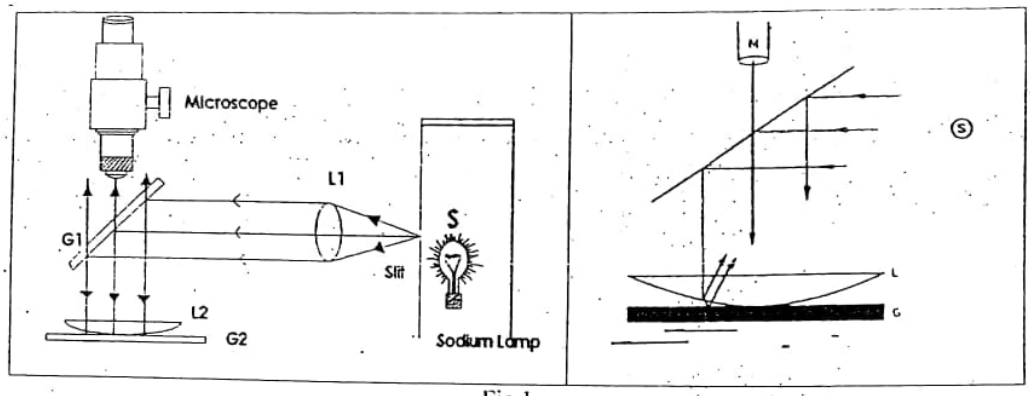

Fig.1

Formula Used:

The wavelength of monochromatic light which produces these rings is given by:

$$R = \frac{(D_{n+m}^2 - D_m^2)}{4m\lambda} \Rightarrow \lambda = \frac{(D_{n+m}^2 - D_m^2)}{4mR}$$

Where, R = Radius of curvature of the surface of convex lens in contact with glass plate

D_{n+m} = Diameter of $n+m^{th}$ bright ring

D_m = Diameter of mth bright ring

II. Setup and Procedure:

1. Clean the plate G and lens L thoroughly and put the lens over the plate with the curved surface below B making angle with G (see fig 1).
2. Switch in the monochromatic light source. This sends a parallel beam of light. This beam of light gets reflected by plate B falls on lens L.
3. Look down vertically from above the lens and see whether the center is well illuminated. On looking through the microscope, a spot with rings around it can be seen on properly focusing the microscope.

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4. Once good rings are in focus, rotate the eyepiece such that out of the two perpendicular cross wires, one has its length parallel to the direction of travel of the microscope. Let this cross wire also passes through the center of the ring system.
5. Now move the microscope to focus on a ring (say, the 20th order dark ring). On one side of the center. Set the crosswire tangential to one ring as shown in fig 2. Note down the microscope reading. fig 2

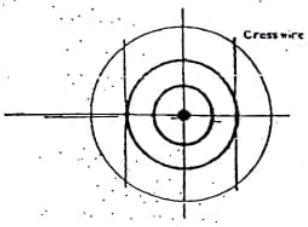

Figure 2

(Make sure that you correctly read the least count of the vernier in mm units)

6. Move the microscope to make the crosswire tangential to the next ring nearer to the center and note the reading. Continue with this purpose till you pass through the center. Take readings for an equal number of rings on the both sides of the center.
7. Remove the plano convex lens and find the radius of curvature of the convex surface in contact with the glass plate accurately using the spherometer. The formula for the calculation of Radius of curvature is

$$R = (l^2/6h) + (h/2)$$

where, l = distance between two legs of spherometer

h = height of convex surface of lens

OBSERVATIONS:

A) Determination of least count of the microscope

Value of one smallest division of the main scale = _____ cm

Number of divisions on the vernier scale = _____

Least count of the microscope = _____ cm

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B) Determination of D^2_n

Table 1

Measurements of the diameter of the ring

Ring No. (n+m)	Microscope readings (cm) on the						Diameter D_{n+m}= R_1-R_2 (cm)	D^2_{n+m} (cm^2)
	Left (R_1)			Right (R_2)				
	Main scale (M.S)cm	Vernier Scale (V.S)cm	Total [M.S.+(V.S. ×l.c.)] cm	Main scale (M.S) cm	Vernier Scale (V.S)cm	Total [M.S.+(V.S. × l.c.)] cm		
n+10								
n+9								
n+8								
n+7								
n+6								
n+5								
n+4								
n+3								
n+2								
n+1								

Table 2 Calculation of Radius of Curvature of given Planoconvex lens

Pitch of the screw =..... *cm*
Number of circular scale divisions = ...
Least count of the spherometer (*l.c.*) = ...cm

S. No.	Spherometer reading						h=b-a	Mean h cm	*l* cm	R=(l^2/6h) + h/2 cm
	Zero reading on plane surface (a)			Reading on lens (b)						
	M.S. cm	V.S. cm	Total [M.S.+(V.S. ×Lc.)] cm	M.S. cm	V.S. cm	Total [M.S.+(V.S. × l.c.)] cm				

CALCULATION:- Numerical Calculations

In the formula, $\lambda = (D_m^2 - D_n^2) / 4R(m-n)$

Take n= 10, m= 20 (say) we have

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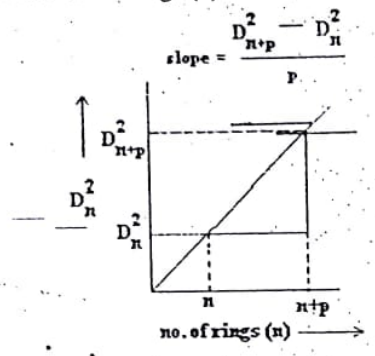
$$\lambda = (D_{20}^2 - D_{10}^2) / 4R(20-10)$$

$$\lambda = (D_{20}^2 - D_{10}^2) / 40R$$

Similarly calculate λ for different readings.

Graphical calculations

Plot the graph between D_n^2 & no. of the rings (n). Best-fit line is the drawn.



Measure the slope of that line which is

$$Slope = \frac{D_{n+m}^2 - D_n^2}{m}$$

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

$$\lambda = \frac{slope}{4R}$$

RESULT: - The Numerically Calculated value for λ is _____Å.

The Graphically Calculated value for λ is _____Å.

The actual value for λ for Sodium light is **5893** Å.

% Error is _____.

PRECAUTIONS:-

Notice that as you go away from the central dark spot the fringe width decreases. In order to minimize the errors in measurement of the diameter of the rings the following precautions should

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be taken:

1) The microscope should be parallel to the edge of the glass plate.
2) If you place the cross wire tangential to the outer side of a perpendicular ring on one side of the central spot then the cross wire should be placed tangential to the inner side of the same ring on the other side of the central spot.(See fig 3)
3) The traveling microscope should move only in one direction.
4) The Lens and the glass plate should be cleaned.
5) A lens of large radius of curvature should be used. The Radius of curvature of Plano convex lens should be measured accurately.
6) The point of intersection of cross wires should coincide with the center of ring system.
7) The micrometer screw should always be moved in the same direction.
8) The amount of light from the source should be adjusted for maximum visibility.

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EXPERIMENT NO. - 7

AIM: To determine the resolving power of telescope.

APPARATUS: A telescope fitted with a rectangular adjustable slit, source of light (Sodium light), black painted glass plate with two fine parallel slits about 2 or 3 mm apart, travelling microscope and a meter scale.

FORMULA USED:

The theoretical and practical resolving powers are given by:

$$\text{Theoretical resolving power} = \frac{\lambda}{d}$$

$$\text{Practical resolving power} = \frac{OO'}{D}$$

Where,

λ = Mean wavelength of light used.

d = Width of the rectangular aperture (slit) for just resolution of two objects.

OO' = Separation between the two objects which are to be resolved by the telescope (here the two objects are the double slits on glass slide)

D = Distance of the objects from the objective of the telescope.

Hence, for the Limiting angle of resolution (θ), we have

$$\frac{\lambda}{d} = \frac{OO'}{D}$$

THEORY: The resolving power of a telescope represents its ability to form separate and distinguishable images of two distant objects kept close to each other. It is measured by the angle subtended at the objective of the telescope by the two objects which are just resolved by it. The smaller the value of this angle, the higher is the resolving power of the telescope. This angle is a measure of the limit of resolution of the telescope which can be defined as the smallest angle subtended at the objective of the telescope by the two objects, which are just resolved by the telescope.

The limiting angle of resolution (θ) for a telescope fitted with a rectangular aperture is given by $\theta = \frac{\lambda}{d}$

λ = wavelength of sodium light

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d = width of the aperture (placed before the objective of the telescope)

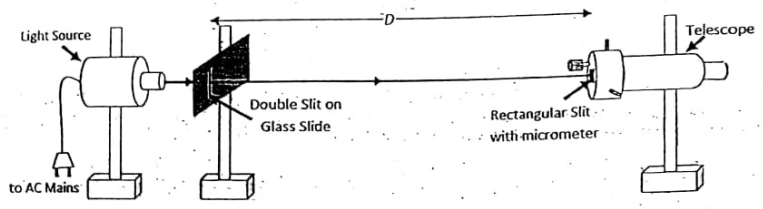

Fig. 1 Set up for resolving power of telescope

In the limit of small angular resolution ($\tan\theta \approx \theta$), the limit of resolution can approximated as:

$$\theta = \frac{OO'}{D}$$

OO' = distance between the two parallel lines

D = distance between the object and the objective of the telescope

Fig. 2 Well resolved images

Fig. 3 Just resolved images

PROCEDURE:

1. Using travelling microscope determine the distance between the two parallel lines (OO'). Mount the telescope on the stand and adjust the height of telescope such that two parallel line and eye piece of telescope are linear.
2. Move the telescope (away from the two parallel lines) and adjust at a position where you will get fine focussed image of two parallel lines.
3. Now place the cross wires in telescope at the image of (say) right slit; note down its position. Let this be R in cm or mm.
4. Next place the cross wires in telescope at the image of left slit; note down its position. Let this be L in cm or mm.
5. The difference between R and L will give the distance between the two parallel lines (OO' = R-L)

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6. Mount the rectangular adjustable slit near to the objective of the telescope in closed position and adjust the width of the rectangular adjustable slit to the minimum value for which the two images of the parallel lines (OO') just merge. Measure this width of rectangular adjustable slit.
7. Measure the distance between black painted glass plate (with two fine parallel slits) and objective of the telescope with meter scale. This gives value of D.
8. Repeat the experiment for three different values of D (i.e. at a gap of 10 cm).

OBSERVATION AND CALCULATIONS:

Wavelength of light used λ (Å) = _____

(a) Table 1: Determination of the distance between the parallel lines (OO') using travelling microscope:

Value of one division of main scale of travelling microscope (x) =

Total number of division on vernier scale of travelling microscope (y) =

Least count of travelling microscope (L.C.) = x/y = _____

S.No.	At left hand edge of parallel line 'L'			At Right hand edge of parallel line 'R'			Distance between two parallel lines (OO') in mm
	Main scale reading (M.S.)	Vernier scale division (V.S.)	Total = M.S. + (V.S.) x (L.C.)	Main scale reading (M.S.)	Vernier scale division (V.S.)	Total = M.S. + (V.S.) x (L.C.)	|R - L|
1.							
2.							
3.							

(b) Table 2: Determination of the slit width for rectangular adjustable 'd':

Value of one division of main scale on the micrometer (x) =

Total number of division on circular scale of micrometer (y) =

Least count of Micrometer (L.C.) = x/y = _____

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S.No	Distance between parallel lines on black painted glass and objective 'D'	Minimum width of slit for resolution 'd'		
		Main Scale Reading (M.S.)	Vernier Scale Reading (V.S.)	Total 'd' = M.S. + (V.S.) x (L.C.)
1. 2. 3.				

(c) Table 3: Determination of resolving power:

S.No	D	Minimum width of slit for resolution 'd'	Distance between two linear sources (OO')	Theoretical resolving power λ/d	Experimental resolving power OO'/D
1. 2. 3.					

RESULT:

The resolving power of the telescope obtained by two formulas is approximately equal.

PRECAUTIONS AND SOURCES OF ERRORS:

(1) The plane of the two parallel slits on the plate should be vertical and parallel with the rectangular aperture.

(2) The axis of the telescope should be horizontal.

(3) The width d of the rectangular aperture should be measured very carefully.

(4) The distance 'D' between the plates of object slits and rectangular aperture should be measured accurately.

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EXPERIMENT NO. - 8

AIM: To find the Numerical Aperture of a given Optical fiber.

APPARUTUS: He-Ne: Laser, Microscopic Objective, Optical Fiber and Multimeter.

THEORY: Optical fibers are fine transparent glass or plastic fibers which can propagate light. They work under the principle of total internal reflection from diametrically opposite walls. In this way light can be taken anywhere because fibers have enough flexibility. This property makes them suitable for data communication, design of fine endoscopes, micro sized microscopes etc. An optic fiber consists of a core that is surrounded by a cladding which is normally made of silica glass or plastic. The core transmits an optical signal while the cladding guides the light within the core. Since light is guided through the fiber it is sometimes called an optical wave guide. The basic construction of an optic fiber is shown in figure (1).

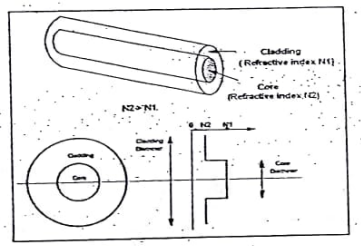

Figure 1: Basic construction of an optical Fiber.

In order to understand the propagation of light through an optical fibre, consider the figure (2). Consider a light ray (i) entering the core at a point A, travelling through the core until it reaches the core cladding boundary at point B. As long as the light ray intersects the core-cladding boundary at small angles, the ray will be reflected back in to the core to travel on to point C where the process of reflection is repeated .ie., total internal reflection takes place. Total internal reflection occurs only when the angle of incidence is greater than the critical angle. If a ray enters an optic fiber at a steep angle (ii), when this ray intersects the core-cladding boundary, the angle of intersection is too large. So, reflection back in to the core does not take place and the light ray is lost in the cladding. This means that to be guided through an optical fibre, a light ray must enter the core with an angle less than a particular angle called the acceptance angle of the fibre. A ray which enters the fiber with an angle greater than the acceptance angle will be lost in the cladding.

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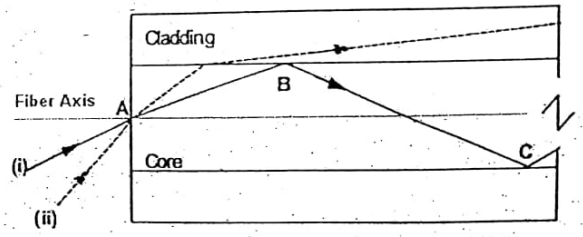

Figure 2 Propagation of light in an optical fibre

Numerical aperture is a basic characteristic of an optical fiber. It represents the size or degree of openness of the input acceptance cone. Mathematically it is defined as the sin of half angle of the acceptance cone.

Using Snell's law the maximum angle with which light will be accepted into and guided through fiber is.

$$NA = \sin(\theta_a) = (n_1^2 - n_2^2)^{1/2}$$

Where $\sin\theta_a$ is the numerical aperture and n_1 and n_2 are the refractive index of the core and the cladding, respectively.

If the incident angle $\theta < \theta_a$, the ray undergoes multiple internal reflections at core and cladding interface and it is called the guided ray. If $\theta > \theta_a$, the ray undergoes only partial reflection at core cladding interface.

In short, length of fiber, ideally a ray launched at angle θ at the input end should come out at the same angle θ from output end. Therefore the far field at the output end will also appear as a cone of semi angle θ_a emanating from the fiber end.

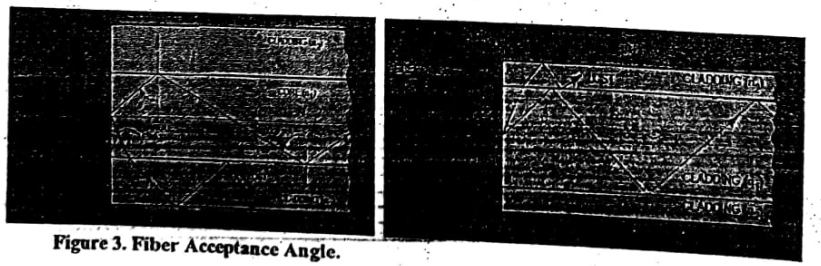

Figure 3. Fiber Acceptance Angle.

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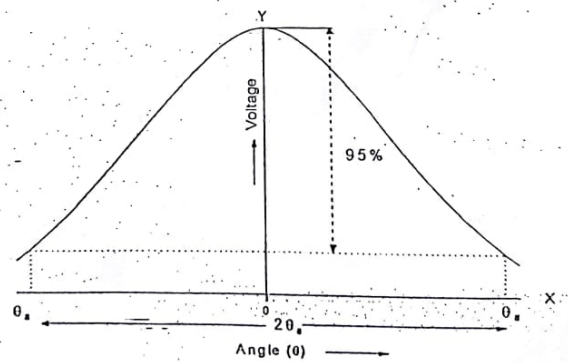
PROCEDURE:

1. Take the background reading in the multimeter.
2. Light from the laser is coupled into the given fiber by using microscope objective.
3. The output end of the fiber is placed in front of photo detector.
4. A pinhole detector is mounted on the rotational stage such that the pinhole is at same horizontal level, as the fiber end.
5. Without disturbing the input coupling, the fiber's spot is scanned in suitable steps at each angular position of the detector. The angular reading of the rotation stage and reading of multimeter (in milli volts) is recorded. At least 20 reading should be taken so that a proper graph can be drawn.
6. Background reading can be taken for all detector positions after switching off the light source. Subtract this background reading from the observed value to get the actual reading.
7. Plot a graph, showing actual reading in voltage along y-axis and angular position of the detector along x-axis. A typical graph will appear as shown in the figure below.
8. From the graph, find out the angle $2\theta_a$ corresponding to the 95% below from the maximum detector reading and hence obtain θ_a.
9. Find NA=Sin θ_a



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OBSERVATIONS:

Table for Numerical Aperture

S.No.	Angular Deflection (degrees)	Detector Reading (mV)	Actual reading (mV) (Detector Reading- Background Reading)
1			
2			
…			
…			
20			

RESULT: Numerical Aperture (NA) of a given optical fiber is …

PRECAUTIONS:

1. The optical fibre provided should be handled carefully so as to prevent cracks.
2. Mounting and coupling should be done carefully.
3. Optical source should be properly aligned with the cable.
4. Care should be taken so that laser light should not directly fall into the eye.

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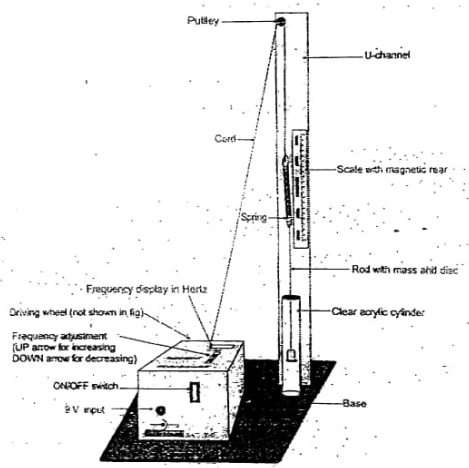
EXPERIMENT NO. -9

AIM: To study the mechanical forced oscillator and to determine the resonance frequency.

APPARATUS:

The apparatus consists of a mass attached to a spring, which is connected to a cord passing over a pulley and further connected to a drive wheel. The frequency of the drive wheel is displayed in "Hertz" on its panel. Mass on the spring can be made to oscillate free or damped in a tube of water. The system can be driven at various frequencies and the amplitude can be measured with a scale.



THEORY:

The resonance phenomenon occurs when a system is driven at its natural oscillation frequency. Resonance means that the system exhibits a maximum response to a driving force when it is driven at some particular frequency.

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Consider the motion of a mass 'm' hanging from a spring whose support is fixed. Let the displacement of the mass from its equilibrium position be 'x', then force F_1 on the mass due to the spring,

$F_1 = -kx$ (1)

where, k is the spring constant

Eqn. (1) can be written as

$F_1 = m\, d^2x/dt^2 = -kx$ (2)

$d^2x/dt^2 = -kx/m$ (3)

if at t=0, the mass is at x=0 and its velocity is v=0

then, solving (3)

$x = v_0/\omega_0 \sin \omega_0 t$ (4)

where, $\omega_0 = (k/m)^{1/2}$ is called the "Natural Oscillation Frequency".

$T = 2\pi/\omega_0 = 2\pi/(m/k)^{1/2}$ (5)

Now, consider the case when the support holding the spring moves up and down at some frequency ω which is not the natural oscillation frequency ω_0. The movement of the spring acts as the driving force. Let, the displacement of the support be $a = a_0 \cos \omega_0 t$, where a_0 is the amplitude of the motion of the support. In this case, the force on the mass due to spring

$F_s = -k(x-a)$ (6)

The amplitude of the oscillation gradually decreases to zero as a result of friction which arises from air resistance or internal forces. The magnitude of the frictional force F_f, is proportional to the velocity of the mass but has a direction opposite to it.

Therefore, $F_f = -b\, dx/dt$ (7)

where, b is a positive constant. Combining all, we obtain

$-k(x-a) - b\, dx/dt = m d^2x/dt^2$ (8)

The solution of this equation gives

$x(t) = x_0 \cos(\omega t - \theta)$ (9)

where x_0 is the amplitude of motion and θ is the difference in phase between the motion

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of the support and the mass.

The above equation shows that the mass oscillates at the same frequency as the support but with a phase shift θ.

PROCEDURE:

1. Attach the free end of the spring to the thread and pass the thread over the pulley.
2. Unscrew the disc attached to the rod and pass it through the lid of the clear acrylic cylinder. Attach the 150gm brass weight to the rod. Now, screw the disc to its position.
3. Fill the cylinder with clear water to a level just below the brim and close the lid of the cylinder.
4. Place the scale (with magnetic rear) just behind the cylinder and see the scale through the cylinder. The scale appears to be magnified. If needed, adjust the scale vertically or sideways so that the lower edge of the disc lies on the graduation of the scale.
5. Switch ON the Oscillator and set the frequency to 0.10 Hz by pressing the downward arrow switch.
6. Set the driving frequency to f=0.2 Hz by pressing the Upward Arrow Switch.
7. Carefully observe the total displacement 'y' of the disc along the scale. Divide this by 2 to get the Amplitude 'x'.
8. Increase the frequency in steps of 0.2 Hz upto a frequency just above the natural frequency of the mass spring system and each time find out the amplitude. (Note: after setting the frequency to some value, allow the Mass spring system to oscillate for few minutes and then note down the amplitude.)
9. Use spread sheet to plot the amplitude x versus $\omega=2\pi f$. Observe that at resonance, the amplitude becomes maximum.

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OBSERVATIONS AND CALCULATIONS:

S.No.	Applied frequency (f) Hz	$\omega=2\pi f$	Amplitude (x) cm
1.			
2.			
....			
....			
10.			

RESULTS:

Resonance frequency .... Hz. at amplitude of .... cm.

PRECAUTIONS AND SOURCES OF ERROR:

1. The axis of the spring should be vertical.
2. The scale should be vertical and should not touch the pointer.
3. The spring should not be stretched beyond the elastic limit.
4. The amplitude of vertical oscillations should be small.
5. The spring should oscillate vertically and any other motion should not be there.

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EXPERIMENT NO. -10

AIM: To compare the wavelength of a laser source measured by diffraction pattern from a single slit and a plane diffraction grating.

APPARATUS: He-Ne laser, diffraction grating, screen (graph paper), scale, slit.

THEORY:

Diffraction pattern for a single slit

When monochromatic radiation of wavelength λ is diffracted by a narrow rectangular slit, the nth order minima is formed at an angle θ_n given by

$$a \sin \theta_n = n\lambda \qquad (1)$$

where, a is the width of the slit and

$$\sin \theta_n = \frac{x_n}{D} \qquad (2)$$

x_n is the distance of the nth minima from the centre of the central maxima.

D is the distance of screen from the slit (see fig.1)

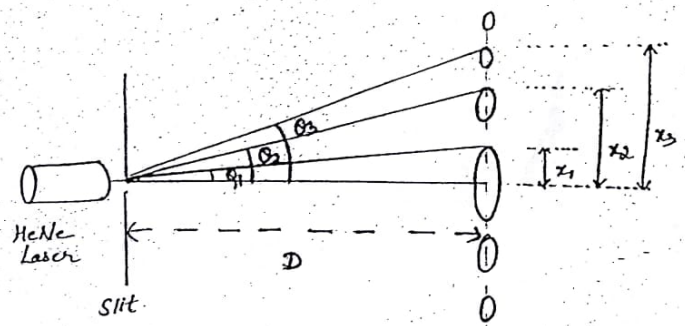

Figure 1

From equations (1) and (2) we get,

$$a\left(\frac{x_n}{D}\right) = n\lambda$$

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$$\lambda = \frac{ax_n}{nD} \qquad (3)$$

If the values of a, D and x_n (for n =1, 2, 3, -------), wavelength of the laser light can be calculated.

For rectangular adjustable slit

1. Place a rectangular adjustable slit (in closed position means zero slit width) in front of the laser beam.
2. Now open the slit (i.e. increase the slit width) by rotating the circular nob of the slit and simultaneously see the diffraction pattern formed on screen.
3. Adjust the slit width to get the sharp diffraction pattern on the screen.
4. Measure the distance of the first order diffraction minima from the centre of the central spot. This is the value of x_1. Also, measure the width of the slit (a) and the distance of screen from the slit (D). Substitute these values in equation (3), $\lambda = \frac{\sin\theta_n}{nN} \times 10^{-3}$, for n=1 and calculate λ_1.
5. Repeat the above process for second and third order diffraction minima and find x_2 and x_3 and then calculate the values of λ_2 and λ_3.
6. Take the mean of these λ values; this will be the value of the wavelength of the laser light.

OBSERVATION:

(i) **Width of the slit 'a'**

MSR	VSR	TSR = MSR+VSR*LC 'a'

Distance of the screen (Graph paper) from the slit (D)= ----------

S.No.	Order of minima (n)	Position of minima (x_n)	Wavelength (λ_n)
1.			
2.			
3.			

Mean λ = ----------Å

(2) Plane Diffraction Grating:-

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Theory:- When monochromatic radiation of wavelength λ is diffracted by a diffraction grating, the nth order principle maxima is formed at an angle θ_n given by.

$$(a+b)\sin\theta_n = n\lambda \qquad (4)$$

where (a + b) is grating element which is equal to

$$(a+b) = \frac{1}{N} \qquad (5)$$

where (N = Number of lines per mm)

Thus,

$$\lambda = \frac{\sin\theta_n}{nN}\times 10^{-3} \qquad (6)$$

If laser light is incident on the diffraction grating and diffraction pattern is obtained on the screen (usually a graph paper), as shown in the fig (2).

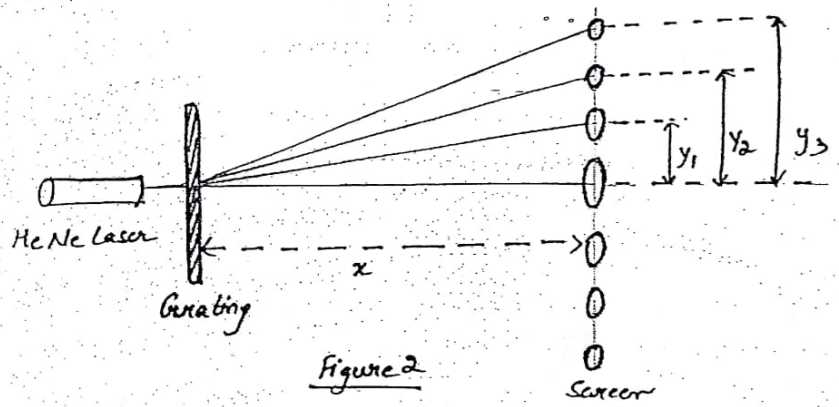

Figure 2

From the figure, we have

$$\sin\theta_n = \frac{y_n}{\sqrt{x^2+y_n^2}} \qquad (7)$$

Substituting in equation (6) we get

$$\lambda = \frac{y_n}{\sqrt{x^2+y_n^2}}\cdot\frac{1}{nN}\times 10^{-3} \text{ m}$$

If we know the value of N, x and y_n (for n = 1, 2, 3, 4------), the wavelength of laser can be calculated.

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15 5 5 5

PROCEDURE:-

For diffraction grating

1. Place a diffraction grating in front of the laser beams so that a diffraction pattern is obtained on a graph paper which serves as screen placed at a distance of around 2m from the grating.
2. The central maxima (brightest spot) is due to the undeviated rays. Measure the distance of first order (n =1) diffraction spot from the centre of the central spot (y_1). Also measure the distance from the grating to the screen (x).
3. Calculate $sin\theta_n = \frac{y_n}{\sqrt{x^2+y_1^2}}$
4. Put this value in equation (6) for n = 1 and calculate the value of λ_1.
5. Repeat the above process for second, third, fourth order diffraction spot and find sin θ_2 , sin θ_3 , sinθ_4 and then calculate λ_2, λ_3, λ_4.
6. Take the mean of these λ values. This will be the value of the wavelength of the laser light.

OBSERVATIONS:-

(i) Number of lines ruled per inch on the grating (N) = ____(say, 15000 lines /inch)
(ii) Grating element $(a + b)$ = 2.54 / N cm. = ... cm.
(iii) Distance from the grating to the screen (x) = ----------

S.No.	Order of Diffraction spot(n)	Position of the spot (y_n)	Wavelength (λ_n)

RESULT:

(1) The wavelength of He-Ne laser source measured by diffraction pattern from a single slit is ----------Å
(2) The wavelength of He-Ne laser source measured by diffraction pattern from a plane diffraction grating is ----------Å
(3) The wave length of the laser source measured by above two methods is approximately same.

THE - END

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