EXPERIMENT NO.-1

Object: To study the variation of T with l for a compound pendulum (bar pendulum) and then to determine:

(i) the value of the acceleration due to gravity (g) in the laboratory,
(ii) the position of centre of gravity of the bar,
(iii) the radius of gyration K of the bar about an axis passing through C.G. and perpendicular to its length.

Apparatus used: Bar pendulum, stop watch, knife edges fixed to a rigid support and metre scale.

Formula used:

The value of g can be calculated with the help of the following formula:

$$T = 2\pi\sqrt{\left(\frac{L}{g}\right)}$$

Or

$$g = \frac{4\pi^2 L}{T^2}\,\mathrm{m/sec^2}.$$

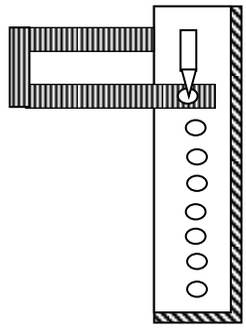
L = distance between centers of oscillation and suspension.

$=\left(\frac{k^2}{l}+l\right)$ i.e., the equivalent length of simple pendulum (It can be obtained from graph).

T = periodic time.

Description of Apparatus:

A bar pendulum consists of a uniform rectangular bar about a meter long with holes drilled along its length at equal distances from each other. The centre lies on the straight line passing through the centre of gravity of the pendulum. A sharp knife edge is attached to some heavy frame provided with leveling screws to make the knife edge horizontal. The bar can be suspended from any hole with the help of knife edge as shown in fig. (1).



Bar Pendulum

Principle: The principle is based on the interchangeability of the centres of suspension and oscillation. We know that for a point of suspension, there is another point on the other side of centre of gravity, known as centre of oscillation about which the time period is the same; there are also two other such points. The distances between centre of suspension and centre of oscillation is known as the length of equivalent simple pendulum $= \left(L = \frac{k^2}{l} + l \right)$ knowing this distance 'g' can be calculated.

Procedure:

(i) The bar pendulum is hung vertically by means of a knife edge.

(ii) Allow the bar to oscillate through a small angle with knife edge passing through hole no. (1) and note the time for 20 oscillations with the help of a stop watch. Find the time period of one oscillation. Remember that the knife edge at the lower end should be in hole no. (1).

(iii) Insert the knife edge in the next holes and find the time periods till the centre of gravity is approximately reached. The knife edge at the lower end should be changed accordingly.

(iv) Turn the bar pendulum and repeat the same procedure.

(v) A graph is plotted between T (time period) and the distance of knife edge x taking origin in the centre of the graph.

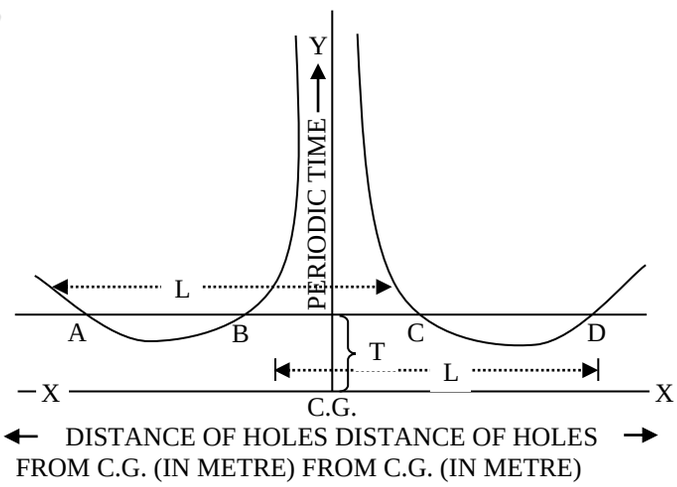
Observations :

Table for measurement of *l* and *T*.

No. of hole	Distanced of the hole from C.G. meter	No. of oscillations	Time taken			Periodic Time *T*secs.
			Min.	Secs.	Total secs.	
1	0.45	20	…	…	…	…
2	0.40	20	…	…	…	…
:	:	:	:	:	:	:
:	:	:	:	:	:	:
8	0.10	:	…	…	…	…
9	0.05	:	…	…	…	…
Position of centre of gravity (Turn the bar pendulum)						
10	0.05	20	…	…	…	…
11	0.10	20	…	…	…	…
:	:	:	:		:	:
:	:	:	:		:	:
:	:	:	:	…	:	:
17	0.40	:	…	…	…	…
18	0.45	:	…	…	…	…

Calculations: Plot a graph between period of oscillation *T*, against the distance of the hole from the centre of gravity, taking origin at the centre of the graph so that distances on one side of C.G. be taken positive, while on the other side as negative. The graph is one of the shape as shown in fig. (2).

Draw a line *AD* on the graph which cuts the graph at four points about which the time periods are the same. If the point *A* is centre of suspension then *C* is the centre of oscillation and the distance between the two is the length of the equivalent simple pendulum (*L*). Corresponding to these points, time periods may be obtained from period axis.



Now 'g' can be calculated by applying the following formula:

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

From graph

$$L = \frac{AC + BD}{2} = \ldots\ldots \text{meter}$$

and $T = \ldots\ldots \text{sec}$

$$\therefore g = \frac{4\pi^2 L}{T^2} \ldots\ldots \text{ m/sec}^2 .$$

Result: The value of acceleration due to gravity at … (Name of city) = … m/sec^2
Standard result: The value of g at … = 9.8 m/sec^2
Percentage error: = … %

Sources of error and Precautions:

(i) Before starting the experiment, the knife edge is made horizontal.
(ii) The amplitude of oscillations should be kept small.
(iii) The time of oscillations should be counted at least for 40 oscillations.
(iv) The pendulum should vibrate only in a vertical plane.
(v) Curves on the graph should be drawn smoothly.

EXPERIMENT NO.-2

Aim: To obtain "Brewster's angle", $\emptyset_0$, and verify Malus law.

Theory:

Polarization by Reflection

When unpolarized light shines on a dielectric such as glass or plastic, the reflected light will be partially polarized. For light striking the surface of a dielectric at some special angle of incidence, called "Brewster's angle", $\emptyset_0$, the reflected light will be completely polarized. The electric field vector for light incident on a surface can be resolved into two parts, one part lying in the plane of incidence (the plane which is perpendicular to the surface of the dielectric and which contains the direction in which the light wave is propagating and one perpendicular to the plane of incidence. Brewster discovered that at the angle $\emptyset_0$, the reflected wave is polarized perpendicular to the plane of incidence He also found that $\emptyset_0$ depends on the index of refraction, n, of the dielectric according to the simple law:

$$\emptyset_0 = \tan^{-1}(n)$$ (as shown in Figure 1)

The plane of the paper is the plane of incidence. The heavy dots in Figure 1,represent the component of the electric field vector pointing perpendicular to the plane of incidence, of the light incident at Brewster's angle on a dielectric (with index of refraction n >1. 5). The short lines represent the component of the electric field parallel to the plane of incidence (i.e., lying in the plane of the paper). The incident light is unpolarized and the reflected light is 100% polarized perpendicular to the plane of incidence.

Brewster's Phenomenon in daily life

Some common instances where reflected light is partially polarized are reflection of water and the glare of the hood of a car. Polaroid sunglasses operate on the principle that this reflected light will be at least partially polarized perpendicular to the plane of incidence. By orienting the lenses so that their transmission axes are vertical, this polarized reflected light (glare) is mostly absorbed by the sunglasses.

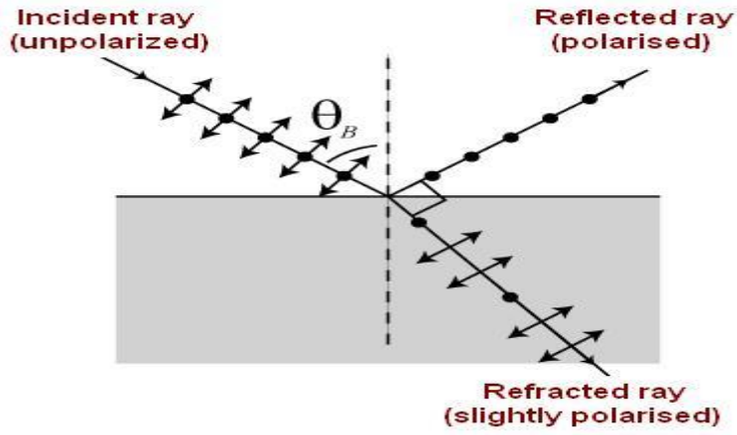


Figure 1.

From the Figure 1 , Brewster's angle i_p,

$$\mu = \tan i_p$$

where

$i_p + r = 90^\circ$

Malus Law

According to Malus, when completely plane polarized light is incident on the analyzer, the intensity I of the light transmitted by the analyzer is directly proportional to the square of the cosine of angle between the transmission axes of the analyzer and the polarizer.

i.e $I \propto \cos^2\theta$

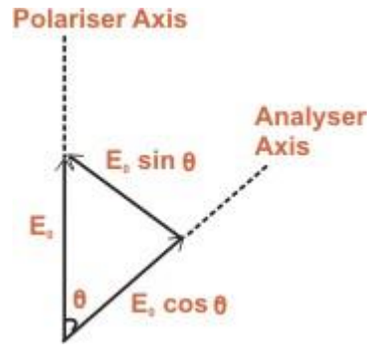


Figure 2

Suppose the angle between the transmission axes of the analyzer and the polarizer is θ. When the completely plane polarized light form the polarizer is incident on the analyzer. If E_0 is the amplitude of the electric vector transmitted by the polarizer, then intensity I_0 of the light incident on the analyzer is $I \propto E_0^2$

The electric field vector E_0 can be resolved into two rectangular components i.e $E_0\cos\theta$ and $E_0\sin\theta$. The analyzer will transmit only the component (i.e $E_0\cos\theta$) which is parallel to its transmission axis. However, the component $E_0\sin\theta$ will be absorbed by the analyzer. Therefore, the intensity I of light transmitted by the analyzer is,

$$I \propto (E_0\cos\theta)^2$$

$$I/I_0 = (E_0\cos\theta)^2/E_0^2 = \cos^2\theta$$

$$I = I_0\cos^2\theta$$

Therefore, $I \propto \cos^2\theta$. This proves law of Malus.

When θ = 0° (or 180°), $I = I_0\cos^2 0^\circ = I_0$. That is the intensity of light transmitted by the analyzer is maximum when the transmission axes of the analyzer and the polarizer are parallel.

When θ = 90°, $I = I_0\cos^2 90^\circ = 0$. That is the intensity of light transmitted by the analyzer is minimum when the transmission axis of the analyzer and polarizer are perpendicular to each other.

Procedure:

1.Set the pointer on the circular scale attached to the light source at some angle say 30º, adjust glass plate by rotating it and also the angle of the analyzer so

that maximum intensity is observed on the photometer.

$\emptyset$ = Position of pointer on the circular scale attached to the light source - pointer on the circular scale attached to the Analyzer.

2.Set the pointer on the circular scale attached to the light source at some angle 40°.Adjust glass plate by rotating it (the angle of the analyzer will remain same) so that maximum intensity is observed on the photometer .

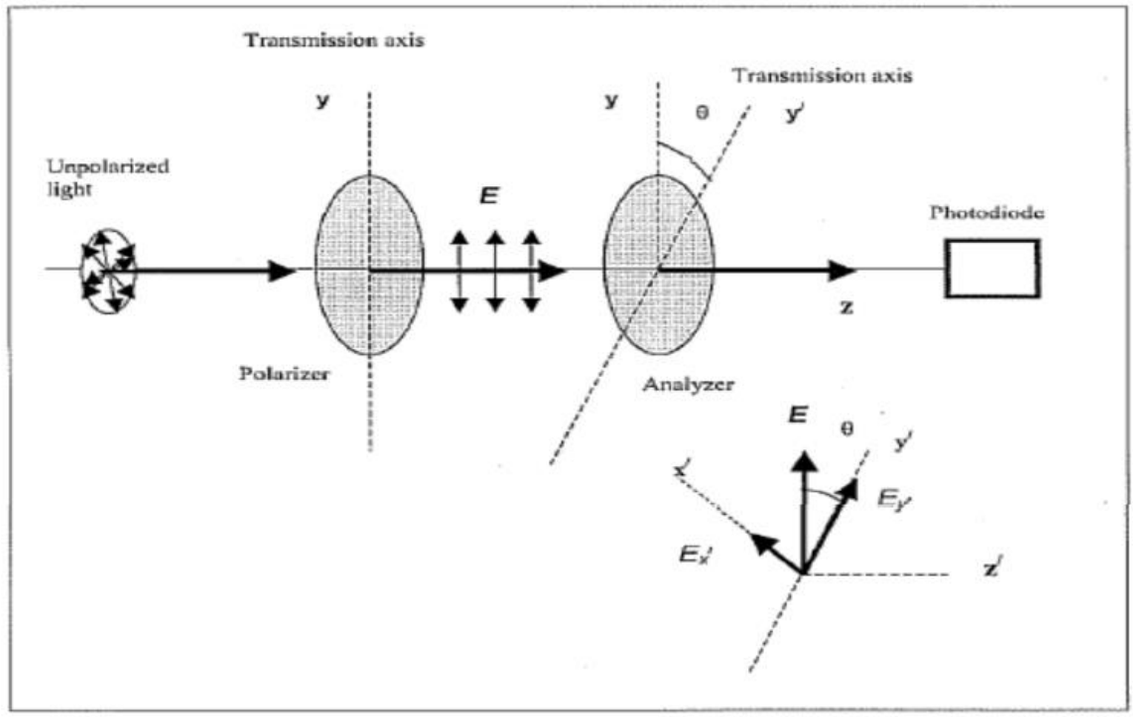
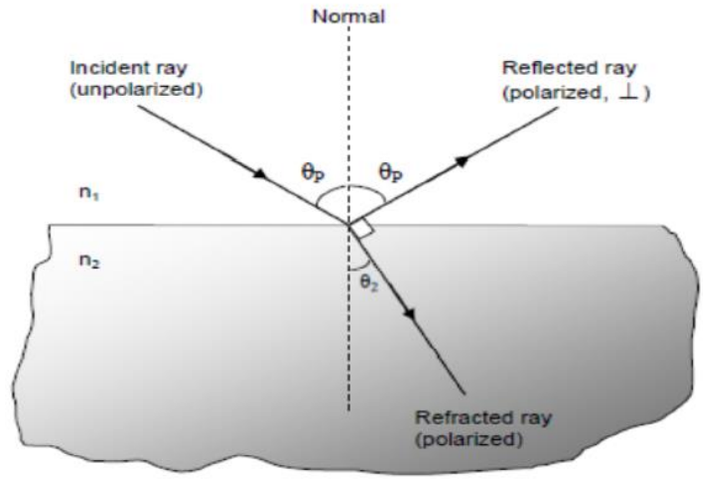


Figure-3



Unpolarized light incident at the polarizing angle and get polarized by reflection: BREWSTER'S LAW

Figure-4

Repeat the observations at various angles and plot the graph between angle and intensity the angle corresponding to the maximum intensity will correspond to "Brewster's angle", $\emptyset_0$.

Observations:

(I) To find Brewster's angle.

Table:I Θ = Angle between incident & Reflected light.

S. No.	Θ(deg.)	I_{max}(photodiv.)	I_{min} (photodiv.)	$\left[\frac{I_{max}-I_{min}}{I_{max}+I_{min}}\right]$
1.	50			
2.	60			
3.	.			
4.	.			
5.	.			
6.	.			
7.	.			
8.	150			

The angle at which the ratio $\left[\frac{I_{max}-I_{min}}{I_{max}+I_{min}}\right]$ is Maximum is the Brewster's angle.

$$P = \left[\frac{I_{max}-I_{min}}{I_{max}+I_{min}}\right]\times 100$$

P = % of Polarization

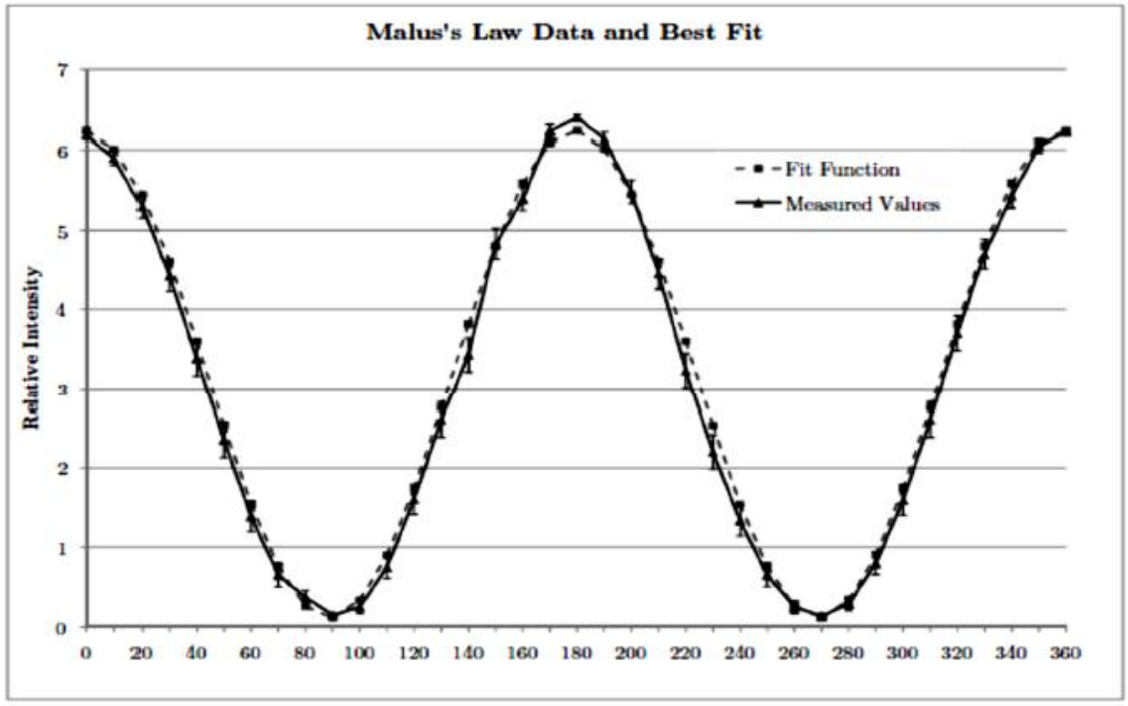
(II) To verify the Malus law

In order to verify Malus law set the pointer on the circular scale attached to the light source at $2\varphi_B$ adjust glass plate by rotating it and also the angle of the analyzer so that maximum intensity is observed on the photometer (reference fig. 2). Rotate pointer on the circular scale attached to the Analyzer and note the intensity of the photometer for every 10^o. Plot the graph between intensity and angle α up to 180^0 starting from Max. intensity taking this position as 0^0.

Table: II

S. No.	Angle through which analyzer is rotated (from-Max pos.found) Ø	Ø (deg.)	Photometer deflection Ø (photodiv.)	Cos Ø	Cos ^{2}Ø
1.		0^0			
2.		10^0			
3.		20^0			
4.		30^0			
5.		40^0			
6.		50^0			
7.		60^0			
8.		70^0			
9.		80			
10.		.			
11.		.			
12.		180^0			

1. Plot a graph between intensity and $\cos^2\emptyset$ showing a straight line and verify Malus law.



Expected variation between intensity and polarizing angle (best fit data)

Figure-4

Result:

The Brewester Angle for the given air glass interface =……

The Malus Law has been verified as shown in the graph.

Precautions and Sources of Error:

1.Analyzer and Polarizer should be at same horizontal level.

2. Analyzer must be rotated by small angles (5^o- 10^o). Changing values abruptly may cause errors.

3. Experiment should be performed in dark room.

EXPERIMENT NO.-3

Aim : To find the coefficient of thermal conductivity of a bad conductor by Lee's method.

Apparatus : Lee's disc apparatus consist of a metallic disc resting on a deep hollow cylinder (steam chamber) of same diameter, circular disc of the specimen of a bad conductor (ebonite or card-board), stop watch, two thermometer, boiler, heater, screw gauge and vernier caliper.

Theory : Thermal conductivity (k), is the property of a material that indicates its ability to conduct heat. Conduction will take place only if there exists a temperature gradient in a solid (or stationary fluid) medium. Heat moves along a temperature gradient, from an area of high temperature and high molecular energy to an area with a lower temperature and lower molecular energy. Conductive heat flow occurs in direction of the decreasing temperature because higher temperature is associated with higher molecular energy. This transfer will continue until thermal equilibrium is reached. The rate at which the heat is transferred is dependent upon the magnitude of the temperature gradient, and the specific thermal characteristics of the material. Thermal conductivity is quantified in the units of *W/mK*, and is the reciprocal of thermal resistivity, which measures an objects ability to resist heat transfer.

Lee's method is used to measure the thermal conductivity of a poorly conducting material, such as glass, wood, or polymer. This was one of the earliest methods used to measure thermal conductivity that gave reliable results and is a steady state method.

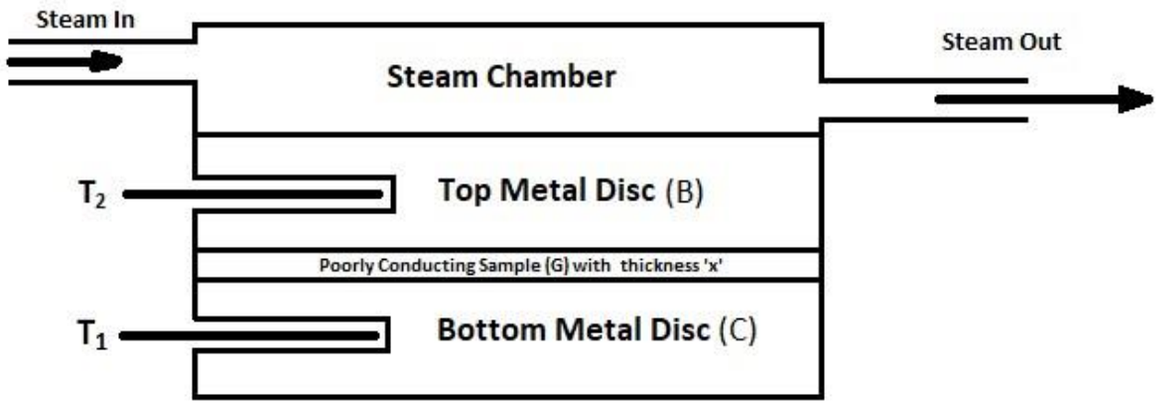
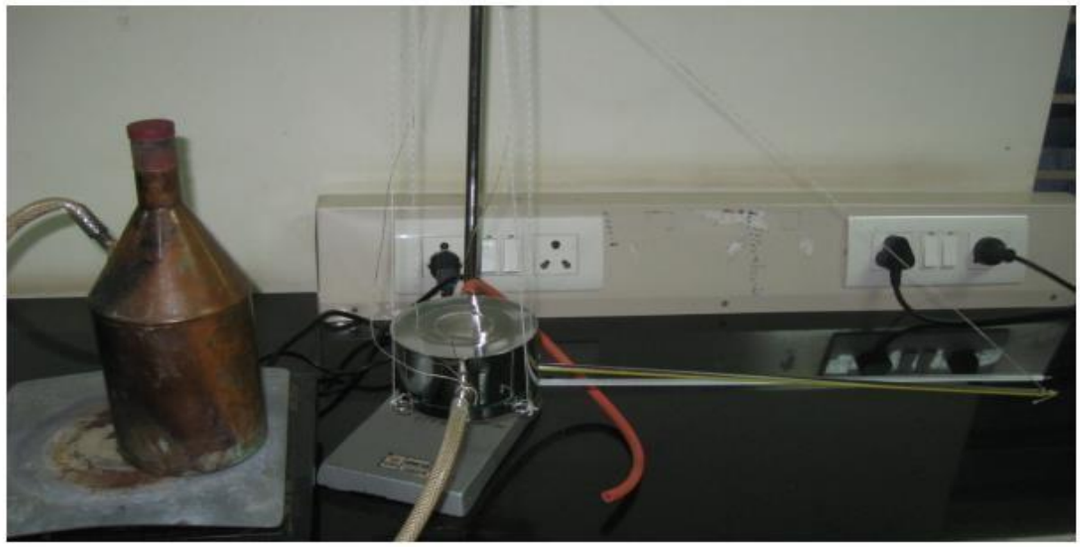


Figure 1 Experimental setup for Lee's Disc steady state thermal conductivity measurements.

The apparatus shown in Fig. 1 consists of two parts. The lower part C is circular metal disc. The experimental specimen G, usually rubber, glass or ebonite (here it is glass) is placed on it. The diameter of G is equal to that of C and thickness is uniform throughout. A steam chamber is placed on C. The lower part of the steam chamber, B is made of a thick metal plate of the same diameter as of C. The upper part is a hollow chamber in which two side tubes are provided for inflow and outflow of steam. Two thermometers T_1 and T_2 are inserted into two holes in C and B respectively. The complete setup is suspended from a clamp stand by attaching threads to these hooks. Two good conductivity metal discs (of the same metal) and allow the setup to come to equilibrium, so that the heat lost by the lower disc to convection is the same as the heat flow through the poorly conducting disc.



Photograph of thermal conductivity measurement setup

At the steady state, rate of heat transfer (*H*) by conduction, which is expressed by Fourier's Law is given as;

$$H = k\,A\,\frac{(T_2 - T_1)}{x} \qquad (1.)$$

where *k* is the thermal conductivity of the sample, *A* is the cross sectional area and ($T_2 - T_1$) is the temperature difference across the sample thickness '*x*' (see Fig. 1), assuming that the heat loss from the sides of the sample is negligible.

When steam flows for some time, the temperatures recorded (T_1 and T_2) gradually remain steady. This is the steady state. Let at the steady state,
Temperature of C = T_1 Temperature of B =

T_2

Surface area of G = $A\ (= \pi r^2)$
Conductivity of G = k
Thickness of G = x

Hence amount of heat flowing through G per second, H is given by Eq. (1). When the apparatus is in steady state (temperatures T_1 and T_2 constant), the rate of heat conduction into the brass disc C is equal to the rate of heat loss from the bottom of it. The rate of heat loss can be determined by measuring how fast the disc C cools at the previous (steady state) temperature T_1 (with the top of the brass disk covered with insulation). If the mass and specific heat of the lower disc are m and s, respectively and the rate of cooling at T_1 is dT/dt, then the amount of heat radiated per second is,

$$H = M\,s\frac{dT}{dt} \qquad (2.)$$

At steady state, heat conducted through the bad conductor per second will be equal to heat radiated per second from the exposed portion of the metallic disc. Therefore, equating Eqs. (1) and (2), we get the coefficient of the thermal conductivity of the sample as

$$k = \frac{M\,s\frac{dT}{dt}x}{(T_2 - T_1)} \qquad (3.)$$

Procedure :

1. Fill the boiler with water to nearly half and heat it to produce steam.
2. Put the specimen, steam chamber etc. in position and suspend it from the clamp stand. Insert the thermometers T_1 and T_2 in position.
3. Pass steam from the inlet of the cylindrical vessel and wait till the steady state is reached. This will take 30-40 minutes to reach the steady state.
4. Temperatures recorded in the thermometers will show a rise and finally will be steady at T_1 and T_2. Then, wait for 10 minutes after reaching the steady state to confirm that actual steady state is reached or not. Note the steady temperatures indicated by the thermometers T_1 and T_2. Interchange the thermometers T_1 and T_2 and again note down the temperature readings.
5. Remove the steam chamber and the specimen G. C is still suspended. Heat C directly by the steam chamber till its temperature is about $T_1 + 10°$.
6. Remove the steam chamber and wait for 30-60 seconds so that heat is uniformly distributed over the disc C.
7. Place the insulating material on C. Start recording the temperature at intervals of 30 seconds. Continue till the temperature falls by $10°C$ below T_1.
8. Plot a graph between temperature and time.
9. Take weight of C by a weighing balance. Measure the diameter of the specimen by using vernier calipers. Calculate the surface area, $A = \pi r^2$.
10. Measure the thickness of the specimen by screw gauge. Take observations at 3 or 4 spots and take the mean value.

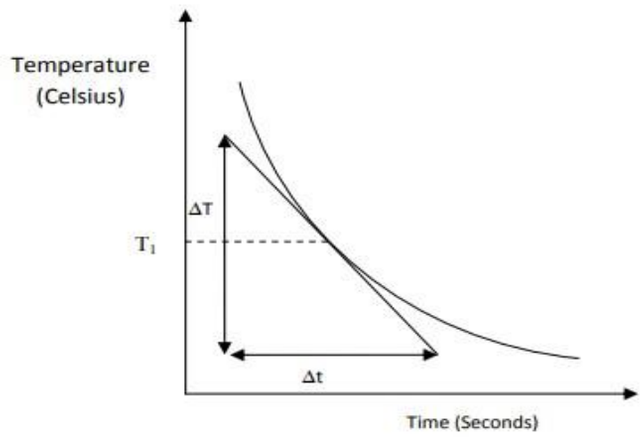


Fig. 3

Observations :

Mass of the metallic disc, M = _____ *gm*
Specific heat of metal, s = 0.0959 *kilo-cal/kg*
Diameter of the disc (using vernier calipers) :

S. No.	**Diameter (in *cm*)**
1.	
2.	
3.	

Mean diameter, D = _____
Radius of the disc, r =_____
Thickness of disc (using screw gauge) : Pitch = _____, Least Count = _____

S. No.	Initial reading I (in *cm*)	Final reading F (in *cm*)	Difference (I-F) (in *cm*)	Mean (in *cm*)
1.				
2.				
3.				

Mean thickness, x = _____*cm*
Steady state of thermometers :

1.) T_1 = i._____ ii. _____
2.) T_2 = i._____ ii. _____

Mean temperatures T_1 = _____ $°C$ and T_2 = _____ $°C$

Observations for cooling curve :

No. of observations	**1**	**2**	**3**	**4**	**5**	**6**	**…**	**…**	***… till temperature falls 10°C below T_1***
Time (in *seconds*)									
Temperature of disc T_1 (in °*C*)									

$\frac{dT}{dt}$

Corresponding to T_1, rate of cooling is _____ $°C/sec$ (from the graph)

Coefficient of thermal conductivity :

$$k = \frac{M\, s \frac{dT}{dt} x}{(T_2 - T_1)}$$

Precautions and Sources of Error:

1.) The diameter of the insulating disc should be equal to that of the cylindrical vessel and the metallic disc.
2.) The thermometer should be placed close to the face of the disc of the specimen.

3.) There should be a good thermal contact between the disc of material and the lower surface of the cylindrical surface and the upper surface of the circular metallic disc.

4.) The steady state temperature should be recorded only when the readings T_1 and T_2 remain constant after an interval of about 10 minutes.

5.)

Standard values of coefficient of thermal conductivity of bad materials :

Type of bad material	**Coefficient of thermal conductivity (*W/mK*)**
Polystyrene Foam	0.026
Wood - Pine	0.113
Natural Rubber	0.138
Teflon	0.251
Packed Snow	0.469
Pyrex Glass	1.13
Wet Soil	1.506
Manganese	6.694
Stainless Steel	13.389
Lead	34.3

EXPERIMENT NO.-4

Object: To determine the refractive index & dispersive Power of the material of the prism for the given colours (wavelengths) of white/mercury light with the help of a spectrometer.

Apparatus required: Spectrometer, given prism, mercury source and reading lens.

Formula used:
The refractive index of the material of the prism is given by the following formula

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

Where
A = Angle of the prism,
δ_m = Angle of minimum deviation.

Description of the apparatus:

The dispersive power, ω, of the material of the prism is given by the formula

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

where μ_v = refractive index of the material of the prism for violet colour,

$\mu_y = \mu$ = refractive index of the material of the prism for yellow colour.

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

Procedure:

(A) Measurement of the angle of the prism.

(i) Determine the least count of the spectrometer.

(ii) Place the prism on the prism table with its refracting angle A towards the collimator and with its refracting edge A at the centre as shown in the Fig. (3). In this case some of the light falling on each face will be reflected and can be received with the help of the telescope.

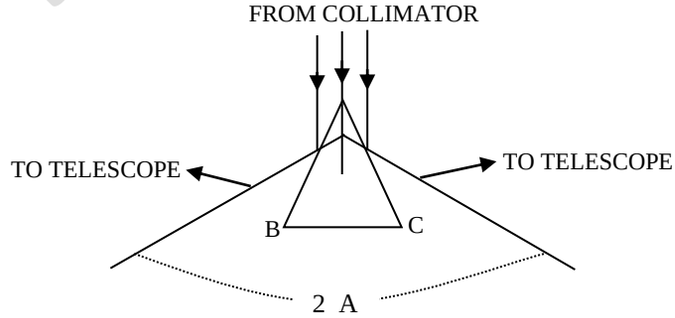
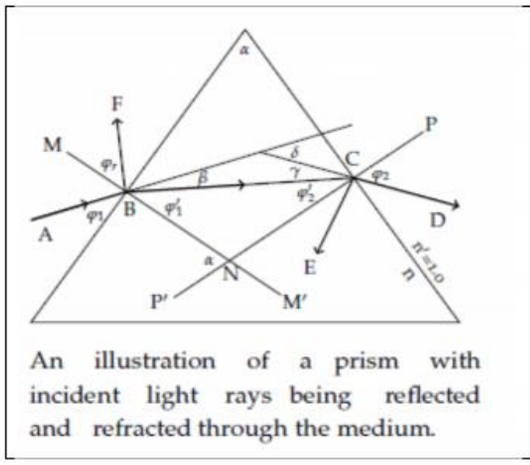
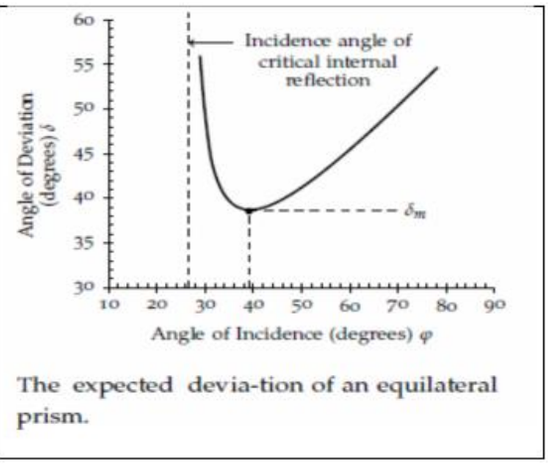


Fig. (1)



An illustration of a prism with incident light rays being reflected and refracted through the medium.



The expected devia-tion of an equilateral prism.

Figure-2

(iii) The telescope is moved to one side to receive the light reflected from the face *AB* and the cross-wires are focused on the image of the slit. The reading of the two verniers are taken.

(iv) The telescope is moved in other side to receive the light reflected from the face *AC* and again the cross-wires are focused on the image of the slit. The readings of two verniers are noted.

(v) The angle through which the telescope is moved or the difference in the two positions gives twice the refracting angle *A* of the prism. Therefore, half of this angle gives the refracting angle of the prism.

(B) Measurement of the angle of minimum deviation:

(i) Place the prism so that its centre coincides with the centre of the prism table and light falls on one of the polished faces and emerges out of the other polished face, after refraction. In this position be spectrum of light is obtained.

(ii) The spectrum is seen through the telescope and the telescope is adjusted for minimum deviation position for a particular colour (wavelength) in the following way:

Set up telescope at a particular colour and rotate the prism table in one direction, of course the telescope should be moved in such way to keep the spectral line in view. By doing so *a position will come where the spectral line move in the opposite direction although the rotation of the table is continued in the same direction.* The particular position where the spectral line begins to recede in opposite direction is the minimum deviation position for that colour. Note the readings of two verniers.

(iii) Remove the prism table and bring the telescope in the line of the collimator. See the slit directly through telescope and coincide the image of slit with vertical crosswire. Note the readings of two verniers.

(iv) The difference in minimum deviation position and direct position gives the angle of minimum deviation for that colour.

(v) The same procedure is repeated to obtain the angles of minimum deviation for other colours.

Observations :

(**Evaluation of least count - as an example)

(i) Value of the one division of the main scale = 0.5 degree

Total number of vernier divisions = 30

Least count of the vernier = 0.5/30 = 1 minute

(ii) Table for the angle (A) of the prism.

S. No.	Vernier	Telescope reading for reflection from first face		Telescope reading for reflection from second face			Difference a – b = 2A		Mean value of 2A	A	Mean A Degree	
		M.S. reading	V.S. reading	Total (a) Degree	M.S. reading		V.S. reading	Total (b) Degree				
1.	V_1	…	…	…	…	…	…	…	…	…		…
	V_2	…	…	…	…	…	…	…				
2.	V_1	…	…	…	…	…	…	…	…	…		…
	V_2	…	…	…	…	…	…	…				
3.	V_1	…	…	…	…	…	…	…	…	…		…
	V_2											

(iii) Table for angle of minimum deviation (δ_m).

S. No.	Colour	Vernier	Dispersed Image, Telescope in minimum deviation position			Telescope reading for Direct Image			Difference a – b	Mean deviation δ_m
			M.S. reading	V.S. reading	Total (a) D	M.S. reading	V.S. reading	Total (b) D		

			g	g	egree	g	g	egree		degree
1.	Violet	v_1 v_2	… …	… …	… …	… …	… …	… …	… …	…
2.	Red	v_1 v_2	… …	…	… …	… …	… …	… …	… …	…
3.	Yellow	v_1 v_2	… …	… …	… …	… …	… …	… …	… …	…

Calculations :

Angle of minimum deviation for violet = …

$$\mu \text{ for violet} = \frac{\sin\left(\frac{A+\delta_{m_1}}{2}\right)}{\sin(A/2)}$$

= ……

Angle of minimum deviation for Red = ……..

$$\mu \text{ for } red = \frac{\sin\left(\frac{A+\delta_{m_2}}{2}\right)}{\sin(A/2)}$$

Similarly find the value of μ for yellow.

Result : Refractive index for the material of the prism :

S.No.	Colour	Calculate d μ	Standar d μ	% Error
1.	Violet	…	…	…
2.	Red	…	…	…
3.	Yellow	…	…	…

Precautions and Sources of Error :

(i) The telescope and collimator should be individually set for parallel rays.
(ii) Slit should be as narrow as possible.
(iii) While taking observations, the telescope and prism table should be clamped with the help of clamping screws.
(iv) Both verniers should be read.

EXPERIMENT NO.5

Aim: To determine the wavelength of mercury green light using a plane diffraction grating.

Apparatus: A spectrometer, a spirit level, a mercury lamp, a diffraction grating with clamping arrangement, reading lens.

Theory: When a parallel beam of monochromatic light is incident normally on a grating, the transmitted light gives rise to primary maxima in certain directions given by the relation

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

Where a is the width of a transparency, b that of an opacity, θ_n the angle of diffraction for the nth order maximum and λ the wavelength of light.

Procedure:

1. Setting: Adjust the position of the eye-piece of the telescope so that the cross-wires are clearly visible. Focus the telescope on a distant object and set it for parallel rays. Level the spectrometer by the leveling screws and then 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 its ruled surface towards the telescope.

3. **Optical leveling of the grating table.** Rotate the table so that the plane of the grating is approximately inclined at an angle of 45° to the axis of the collimator. 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 perpendicular to the axis of the collimator. Look for the first order spectrum on one side of the direct image of 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 by symmetrical with respect to the horizontal cross-wire in all positions.

4. **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 in Fig.

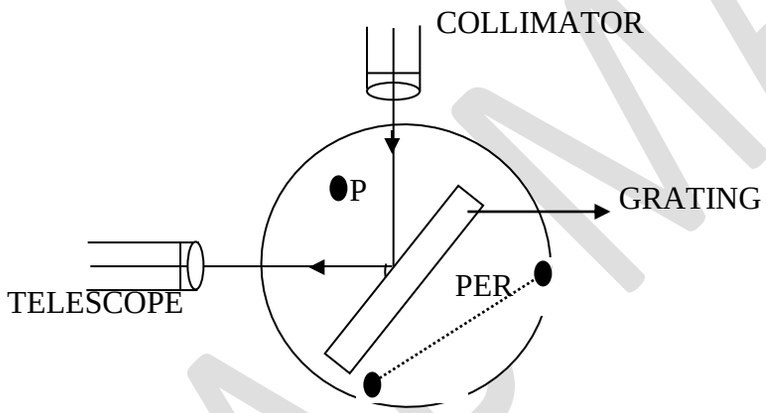


Fig.1. Setting of grating normal to incident light.

In this position the plane of the grating is inclined at an angle of 45° to the incident light. Note the reading. Turn the table through 45° 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 rules surface away from the collimator. Clamp the table in this position.

5. 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 source of the light is white then the VIBGYOR spectrum is observed as one moves from the central position of the principal maximum which is white. Turn the tangent screw of the telescope till the vertical cross-wire coincides with the centre of the image of the spectral line whose diffraction angle has to be ascertained. Note the reading of the scale on both the verniers.

6. Similarly note the reading of the verniers by setting the telescope on the second order diffracted image on either side of the direct light.
7. Repeat the above observations three times.
8. Note the number of lines per inch as marked on the grating and replace it carefully in the box with ruled surface upwards.

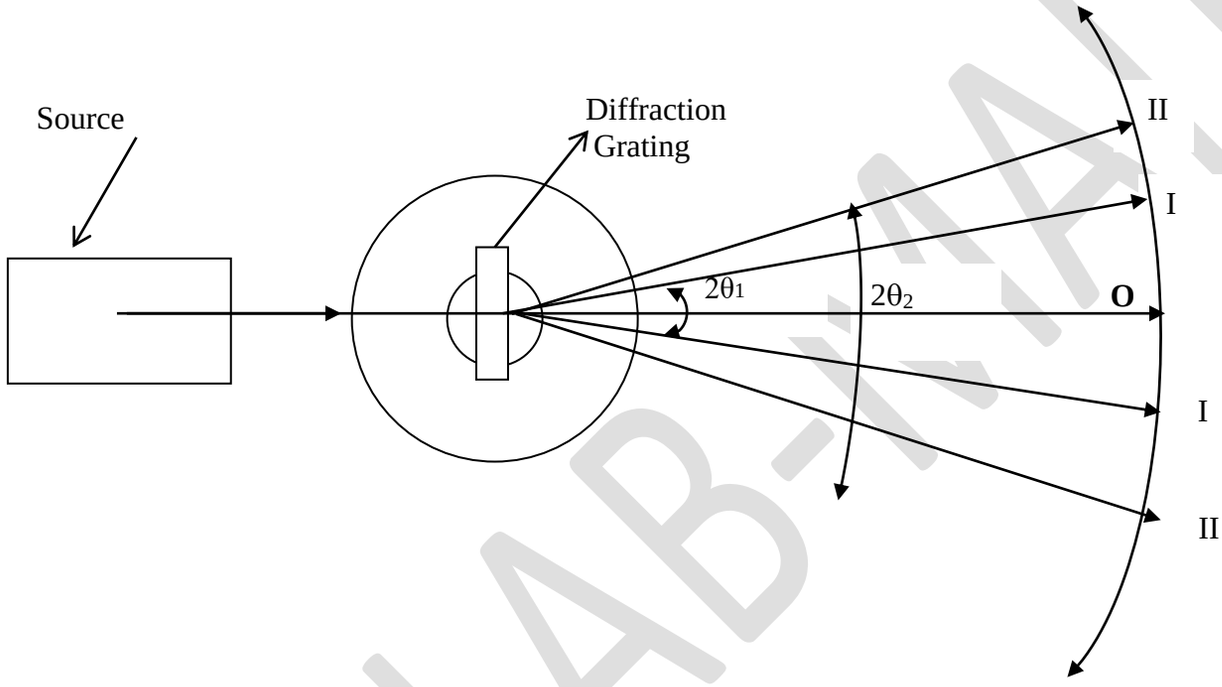


Fig2. Spectral distribution of incident light by grating.

Observations:

Vernier constant =... …

Number of lines per inch on the grating N =

∴ Grating element $(a+b) = \frac{2.54}{N}$ cm

Direct reading of telescope =

S. No.	Order of	Vernier	Telescope reading			Angle of diffraction		
			Left (L	Direct	Right (	L - R (2	(θ)	Mean

	spectrum		)		R)	θ)		
1	1st order	v_1 … v_2	… …	… …	… …	… …	… …	
2	2nd order	v_1 … v_2	… …	… …	… …	… …	… …	

Calculations:

Wavelength of mercury (green/blue) light as calculated from

1st order spectrum (for green light) $\lambda = (a+b)\sin\theta_1$ cm

2nd order spectrum (for green light) $\lambda = \frac{(a+b)\ \sin\theta_2}{2}$ cm

Mean wavelength λ = ……A^o

Result: Wavelength of Mercury(green) light , λ = ……A^o

Standard Result: Wavelength of mercury(green) light λ = 5461A^o

Percentage Error:

$$\frac{\text{Standard value} - \text{observed value}}{\text{Standard Value}} \times 100 = \ldots\ldots\%$$

SOURCES OF ERROR AND PRECAUTIONS:

1. The adjustment is incorrect if the angles of diffraction on the left and the right of the direct are not equal.

2. In the second order spectrum with a good grating the VIBGYOR is better resolved.
3. The ruled surface should face away from the collimator.
4. The light should fall on the whole of the grating surface.
5. In handling do not touch the faces of grating, hold it between thumb & finger by the edges.

EXPERIMENT NO.-6

Object: To determine the wavelength of sodium light by Newton's ring.

Apparatus : A plano-convex lens of large radius of curvature, optical arrangement for Newton's rings, plane glass plate, sodium lamp and traveling microscope.

Formula used:
The wavelength λ of light is given by the formula

$$\lambda = \frac{D_{n+p}^2 - D_n^2}{4\,p\,R}$$

Where

D_{n+p} = diameter of $(n+p)^{th}$ ring,

D_n = diameter of nth ring,

p = an integer number (of the rings),

R = radius of curvature of the curved face of the plano-convex lens.

Description of apparatus:

The optical arrangement for Newton's ring is shown in Fig. (1). Light from a monochromatic source (sodium lamp) is allowed to fall on a convex lens through a broad slit which renders it into a nearly parallel beam. Now it falls on a glass plate inclined at an angle 45° to the vertical, thus the parallel beam is reflected from the lower surface. Due to the air film formed by a glass plate and a plano convex lens of

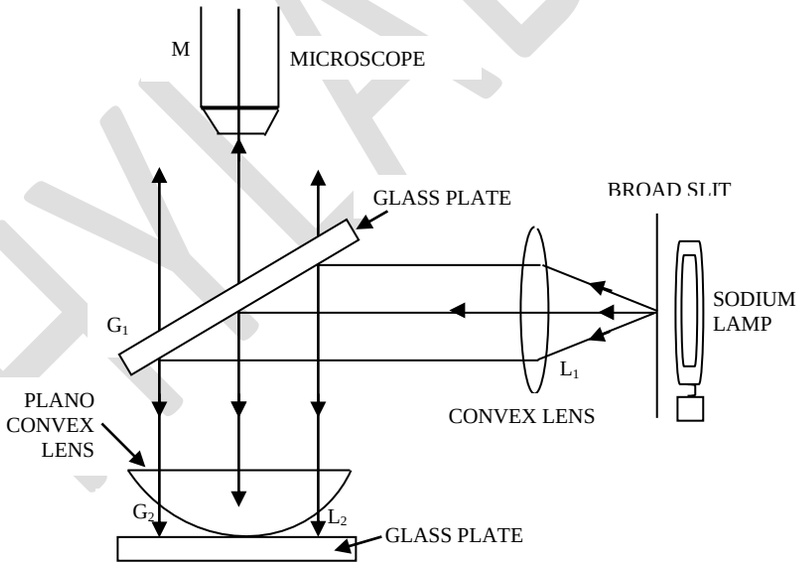


Figure-1

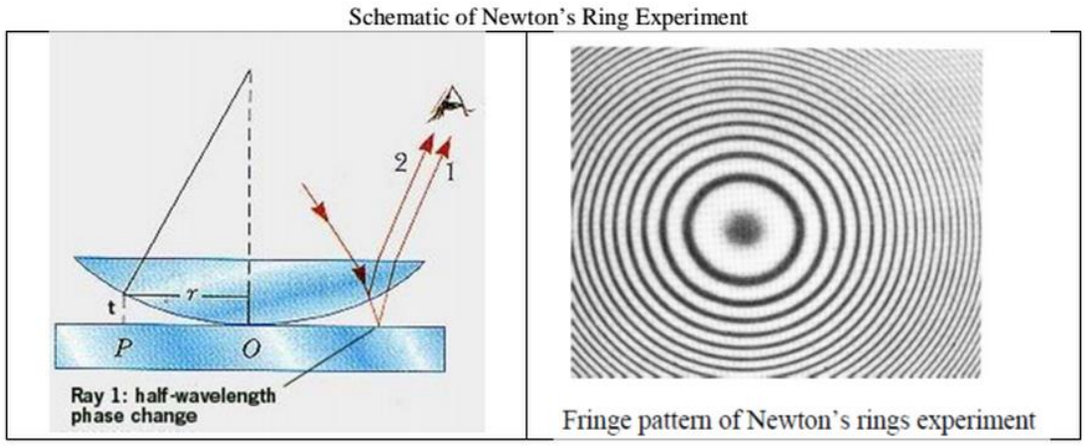


Figure-2

large radius of curvature, interference fringes are formed which are observed directly through a traveling microscope. The rings are concentric circles.

Procedure :

(i) If a point source is used only then we require a convex lens otherwise using an extended source, the convex lens L_1 is not required.

(ii) Before starting the experiment, the glass plates G_1 and G_2 and the plano convex lens should be thoroughly cleaned.

(iii) The centre of lens L_2 is well illuminated by adjusting the inclination of glass plate G_1 at 45°.

(iv) Focus the eyepiece on the cross-wire and move the microscope in the vertical plane by means of rack and pinion arrangement till the rings are quite distinct. Clamp the microscope in the vertical side.

(v) According to the theory, the centre of the interference fringes should be dark but sometimes the centre appears white. This is due to the presence of dust particles between glass plate G_2 and plano-convex lens L_2. In this case the lens should be again cleaned.

(vi) Move the microscope in a horizontal direction to one side of the fringes. Fix up the crosswire tangential is the ring and note this reading. Again the microscope is moved in the horizontal plane and the cross wire is fixed tangentially to the successive bright fringes noting the vernier readings till the other side is reached.

Observations :

Value of one division of the main scale = … mm.

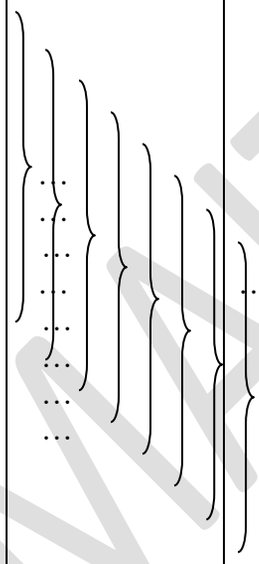
No. of divisions on the vernier scale = …

Least count of the microscope = …

R = …..

Table for the determination of $\left(D_{n+p}^2 - D_n^2\right)$

No. of the ring	Micrometer reading		Diameter D (a-b) c	D^2 (a-b)^2 c	$\left(D_{n+p}^2 - D_n^2\right)$ cm^2	Mean cm^2	p
	Left	Right					

e r i n g s	d *a* c m	n d *b* c m	m.	m			
2 0 1 9 1 8 1 7 1 6 1 5 1 4 1 3 1 2 1 1 1 0 9 8 7 6 5	… … … … … … … … … … … … … … … …	… … … … … … … … … … … … … … … …	… … … … … … … … … … … … … … … …	… … … … … … … … … … … … … … … …		…	8

For wavelength of sodium light, the following formula is used:

$$\lambda = \frac{D_{n+p}^2 - D_n^2}{4\ p\ R}$$

The value of $\left(D_{n+p}^2 - D_n^2\right)$ can also be obtained using a graph as shown in Fig. (5). The graph is plotted between the square of diameter of the ring along *Y*-axis and corresponding number of ring along *X*-axis.

Result: The mean wavelength λ of sodium light = … Angstrom

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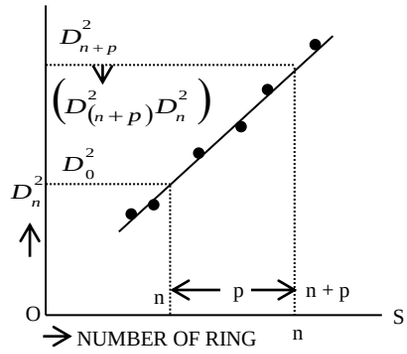


Fig. 5

Standard mean wavelength of sodium : λ = 5896 Angstrom

Percentage error =…%.

Sources of Error and Precautions :

(i) Glass plates and lens should be cleaned thoroughly.

(ii) The lens used should be of large radius of curvature.

(iii) The source of light used should be an extended one.

(iv) Before measuring the diameter of rings, the range of the microscope should be properly adjusted.

(v) Crosswire should be focused on a bright ring tangentially.

(vi) Radius of curvature should be measured accurately.

EXPERIMENT NO.-7

Object: To determine the specific rotation of cane sugar solution with the help of polarimeter.

Apparatus used : Polarimeter, a weighing balance, measuring cylinder, beaker and source of light.

If the polarimeter is employing a half shade device, a monochromatic source should be used and biquartz device is used then white light can be used.

Formula used :
The specific rotation of the plane of polarisation of sugar dissolved in water can be determined by the following formula,

$$S = \frac{\theta}{l \times c} = \frac{\theta \times V}{l \times m}$$

Where θ = rotation produced in degrees.

l= length of the tube in decimeter,

m = mass of sugar in gms, dissolved in water,

V = volume of sugar solution.

Description of apparatus :

The polarimeter is shown in fig. (1).

S is a source of light placed at the focus of convex lens. Thus the beam becomes parallel after passing through lens and then passes through the polarizer. The polarized light passes through the half shade and travels the length of the polarimeter tube made of glass. The light is analyzed with the help of the analyzer which can be rotated about a horizontal axis and its position can be ready by a vernier moving over a fixed graduated scale. The light is now viewed with the help of telescope. The analyzer and telescope are placed in the same tube. A filter is also used after the source to allow only a particular wavelength to pass through the polarimeter.

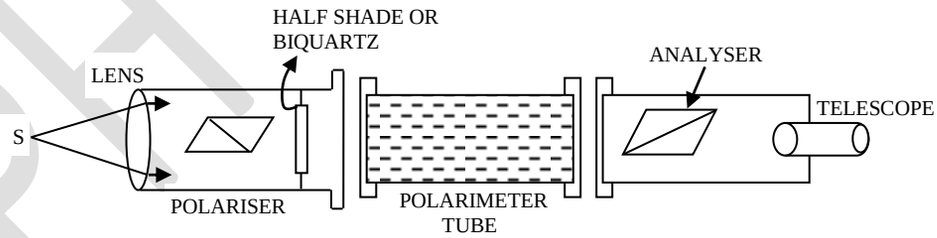
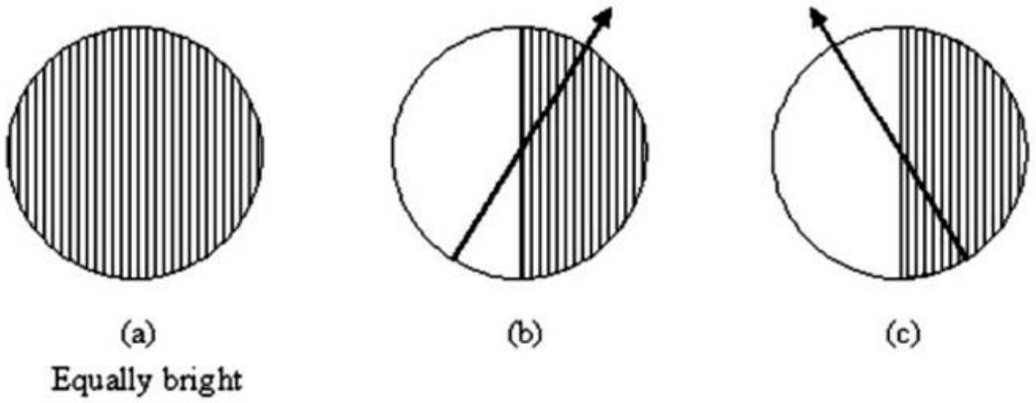
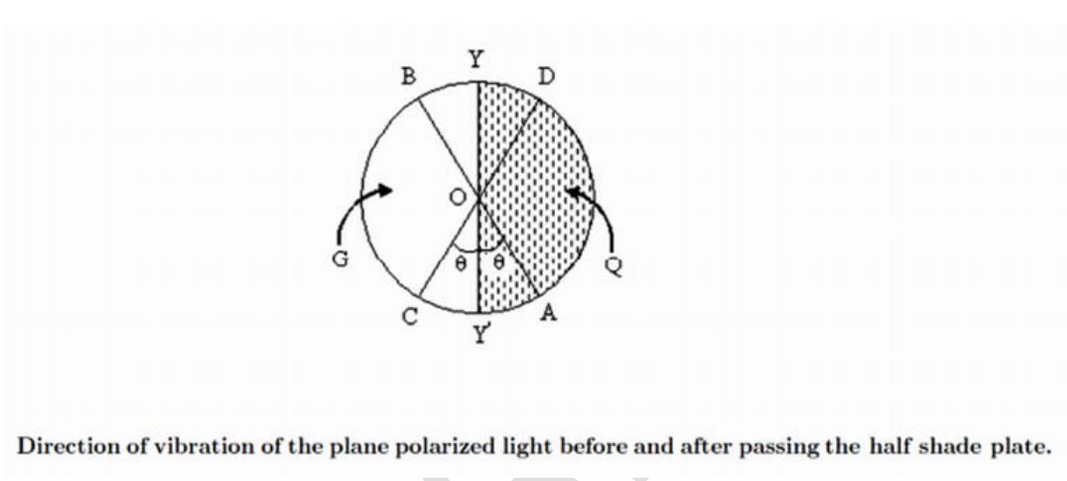


Figure-1



Brightness of the field of view.



Direction of vibration of the plane polarized light before and after passing the half shade plate.

Figure-2

Procedure :

(i) If the polarimeter is employing a half shade device, a monochromatic source should be used and if biquartz device is used then white light can be used.

(ii) Take the polarimeter tube and clean well both the sides such that it is free from dust. Now fill the tube with pure water and see that no air bubble is enclosed in it. Place the tube in its position inside the polarimeter.

(iii) Switch on the source of light and look through the eyepiece. Two halves of unequal intensity are observed. Rotate the analyzer until two halves of the field appear equally bright. Take the reading of main scale as well as vernier scale and find out the total reading. This can be done in different quadrants of the circular scale of the polarimeter.

(iv) Prepare a sugar solution of known strength. The procedure for preparing it can be seen under the heading observations.

(v) Take the polarimeter tube and remove the pure water. Fill it with the prepared sugar solution and again place it in the polarimeter.

(vi) Rotate the analyzer to obtain the equal intensity position. This can be done in the different quadrants of the circular scale of the polarimeter.

[When the tube containing sugar solution is placed in the path of the polarized light, the plane of polarization is rotated which disturbs the previous position observed with distilled water (equal illumination)].

Note down the position of the analyzer on the main and vernier scales in the case of both the distilled water and cane-sugar solution. The difference between the reading observed for the distilled water and that for cane sugar solution gives the angle of rotation for that given substance (in this case cane sugar)

**This is valid for a half-shade polarimeter with a monochromatic source of light. The precision is better if one observes the equally dark shades as the observation point .

**For a Bi-quartz polarimeter with a white light source of light, the passage of tint is the sensitive point of observation

(vii) Repeat the experiment with sugar solutions of different concentrations.

(viii) Measure the length of the tube in centimeters and change it in decimeters.

Observations :

(A) Preparation of sugar solution :

Mass of sugar taken m = … gm

Volume of the solution V = … c.c

Concentration of the solution m/V = … gm/c.c. =

Length of the polarimeter tube l = 2 decimeter

Room temperature = … degree centigrade

(B) Table for the specific rotation :

Value of one division of main scale = …

No. of division of vernier scale = …

Least count of vernier = …

Observation-Table:

Analyser reading with pure water		Concentration	Analyser reading with sugar solution		$a - a` \theta_1$	$b - b` \theta_2$	$\theta = \theta_1 + \theta_2 / 2$
Clock wise	Anti-clock wise		Clockwise	Anti-clock wise			

						n of solution (gm/c.c)								in degree
M.S.(deg.)	V.S.	Total (*deg.*) *a*	M.S.	V.S.	Total (*deg.*) *b*		M.S(deg.)	V.S	Total *deg.* *a`*		M.S.	V.S	Total (*deg.*) *b`*			
…	…	…	…	…	…	5 10 15	… … …	… … …	… … …	.. .. ..	… … …		… … …	… … …		…

Calculation: Draw a graph between θ and concentrations. The graph is shown in Fig. (2). From graph find out the value of θ for a particular concentration. Then,

$$S = \frac{\theta.V}{l.m}$$

$$= \ldots^{\circ}/dm./g./cm.^3$$

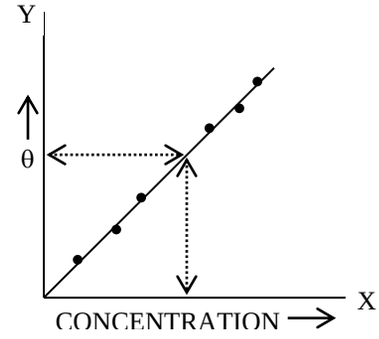
Result : The specific rotation for cane sugar at a temperature … °C and λ …… λ ……..

Standard value : …% dm./g./cm^3.

Percentage error : …%

Sources of error and Precautions :

(i) The polarimeter tube should be well cleaned.



(ii) Water used should be dust free

(iii) Whenever a solution is changed, rinse the tube with the new solution under examination.

(iv) There should be no air bubble inside the tube.

(v) The position of analyzer should be set accurately.

(vi) The temperature and wave-length of light used should be stated.

(vii) Reading should be taken when halves of the field of view become equally illuminated.

EXPERIMENT NO.8

Aim: To determine the wave length of He-Ne laser using transmission diffraction grating.

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

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

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

Where, $(a+b)$ is grating constant which is equal to

$$(a+b) = \frac{1}{N} \quad \text{(N = No. of lines per mm)}$$

$$\lambda = \frac{\sin\theta_n}{n.N}$$

$$\lambda = \frac{\sin\theta_n}{n.N}$$

Laser light is incident on the diffraction grating and diffraction pattern is obtained on the screen usually a graph paper, as shown in Fig. From the figure, we have

$$\sin\theta_n = \frac{y_n}{\sqrt{x^2 + {y_n}^2}}$$

$$\lambda = \frac{y_n}{\sqrt{x^2 + {y_n}^2}} \frac{1}{nN} \ldots \text{mm} \qquad \ldots (1)$$

wavelength of the laser light is calculated.

Procedure:

1.Place a diffraction grating in front of the laser beam so that a diffraction pattern is obtained on a graph paper which serves as screen placed at a distance of around 3m from the grating.

2. At point O, Ist, IInd, IIIrd, and so on are the zero order principal, Ist order principal, IInd order principal maxima and so on respectively.

3. Find the distance between the grating and the screen (x) and I, II, order diffraction spot from the central spot (y_1, y_2). Calculate λ by using equation 1.

4. Perform this process for each grating (100, 300, 600 lines per mm)

5. Calculate λ for each grating and then find the average value of λ .

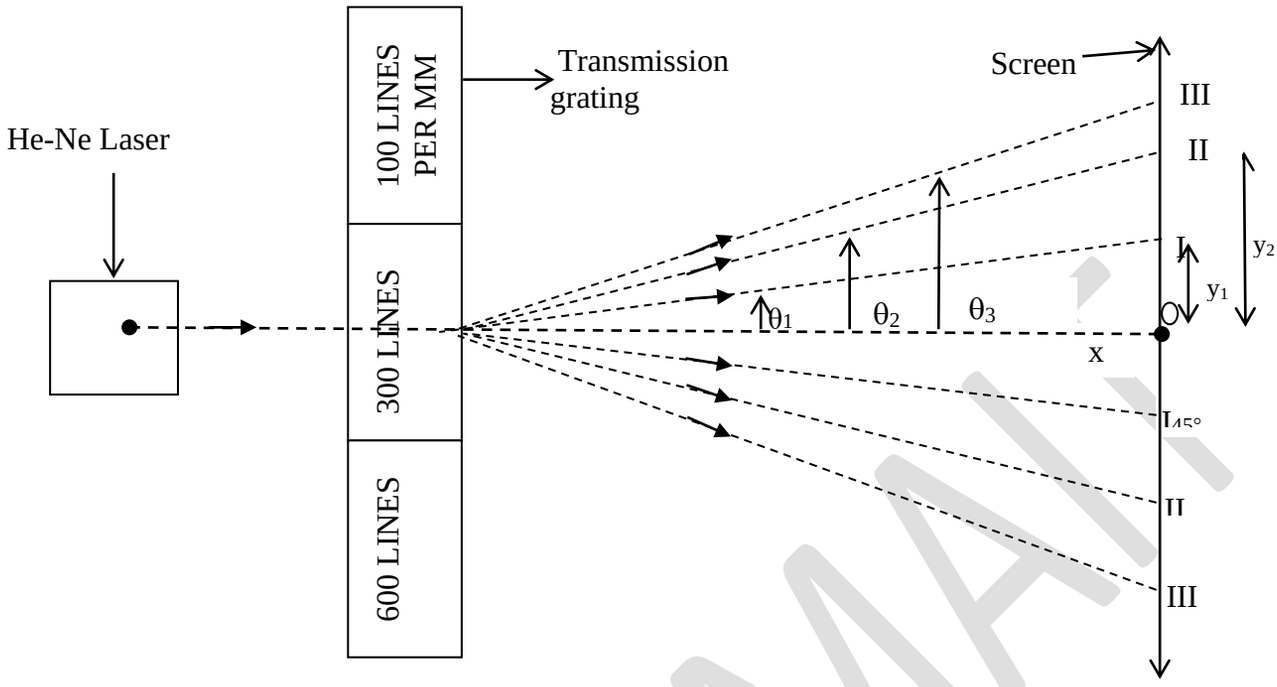


Fig1. Diffraction pattern of laser beam using transmission grating**.**

Observations: For N = 100 lines per mm

S.No.	Order of	Position	Distance	λ
1	…	…	…	…
2	…	…	…	…

Repeat the table For N = 300 lines per mm and for N = 600 lines per mm.

Calculations: $\lambda = \frac{y_n}{\sqrt{x^2 + y_n^{\,2}}} \frac{1}{nN}$ …mm = …. m=…… A°

Average value of λ =

Result: Wavelength of He-Ne laser light = …. A°

Standard Result: Wavelength of He-Ne laser light = 6328 A°

Percentage Error: $\frac{\text{Standard value} - \text{observed value}}{\text{Standard Value}} \times 100 = \ldots\ldots\%$

Sources of Error and Precautions:

1. The graph used as screen should not have foldings. If present it may introduce error.
2. The laser should neither be too close nor too far from the screen. Keep a distance of a few meters.
3. The spread should be obtained on a wide screen.
4. Do not stare laser source directly, it may damage your eye.

EXPERIMENT NO.9

Object: To determine the wavelength of sodium light with the help of Fresnel's bi-prism.

Apparatus: Optical bench with uprights, Sodium vapour lamp, Bi-prism, Slit and Micrometer eyepiece.

Formula Used: This wavelength 'λ' of the sodium light is given by the formula in the case of bi-prism experiment.

$$\lambda = \beta \frac{2d}{D}$$

where β = fringe width,
2d = distance between the two virtual sources,
D = distance between the slit and screen (Eyepiece upright)

And

$$2d = 2a(\mu - 1)\alpha$$

where α = refracting angle of bi-prism = 0.5^o = 0.00873 radians
a = distance between the slit and bi-prism
μ = refractive index of the material of the bi-prism

Description of the Apparatus:

Bi-Prism: A bi-prism is essentially two prisms, each of very small refracting angles α placed base to base. In reality the bi-prism is constructed from a single plate of glass by suitable grinding and polishing it; the obtuse angle of prism is only slightly less than 180^o (i.e. 179^o) and other angles are of 0.5^o are equal.

Optical Bench and Uprights: The optical bench used in the experiment consists of a heavy cast iron base supported on four leveling screws. There is a graduated scale along its one arm. The bench is provided with four uprights, which can be, clamped anywhere and the position can be read by means of vernier attached to it. Each of the uprights is subjected to the following motions:

1. motion along bench,
2. transverse motion (motion right angle to bench),
3. rotation about the axis of the upright,
4. with the help of tangent screw, the slit and bi-prism can be rotated in their own vertical planes.

TABLE DIAGRAM OF THE OPTICAL BENCH

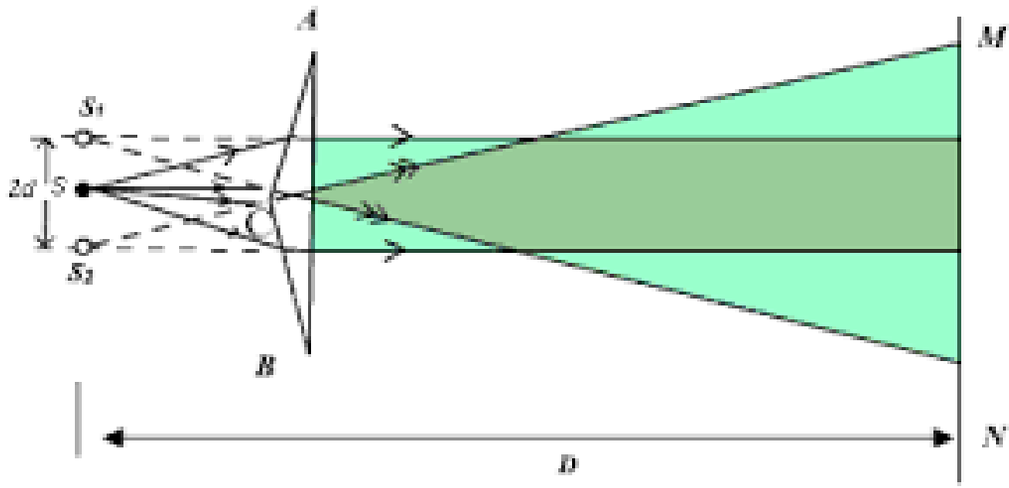


Fig: Fresnel's biprism experiment

Action of the biprism:

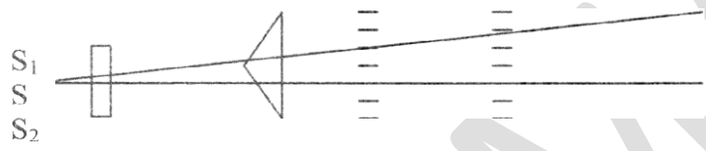
Monochromatic light from a source 'S' falls on two points of the prism and is bent towards the base. Due to the division of wavefront, the refracted light appears to come from Sl and S2. The waves from two sources superimpose to give an interference pattern. The fringes are hyperbolic but due to high eccentricity they appear to be straight lines in the focal plane of eyepiece.

Procedure:

1. The optical bench is leveled with the help of spirit level and leveling screws.
2. The slit, bi-prism and eyepiece are adjusted at the same height. The slit and the cross wire of eyepiece are made vertical.
3. The micrometer eyepiece is focused on crosswire.
4. An opening is provided to the cover of the monochromatic source, such that the light is allowed to be incident on the slit. The bench is so adjusted that light comes straight along its lengths. This adjustment is made to avoid the loss of light intensity for the interference pattern.
5. The bi-prism is placed upright near the slit and the eyepiece is moved sideway. The two images of the slit are seen through the bi-prism. If the images of the slit are not seen, then move the upright of bi-prism at right

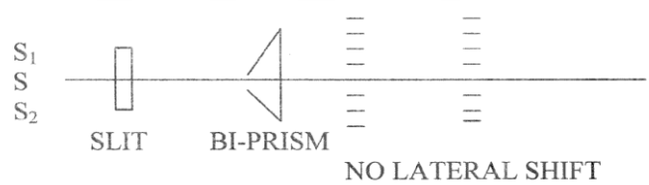
angles to the bench till they are obtained. The two images of the slit are made parallel by rotating bi-prism in its own plane.
6. The eyepiece is brought near to the bi-prism and given a rotation at right angle of the bench to obtain a patch of light. The interference fringes are obtained in this patch provided that the edge of the prism is parallel to the slit.
7. The edge of the bi-prism is made parallel to the slit, by rotating the bi-prism with the help of tangent screw till a clear interference pattern is obtained. These fringes can be easily seen even with the naked eye.
8. The line joining the center of the slit and the edge of the bi-prism should be parallel to the axis of the bench. If this is not so, there will be a lateral shift and its removal is most important. This is shown in figure:

**NOTE: The placement of the slit and the Fresnel's Biprism for no lateral shift



Slit bi-prism

LATERAL SHIFT



9. In order to adjust the system for no lateral shift, the eyepiece is moved away from bi-prism. In this case, the fringes will move to the right or left but with the help of base screw provided with bi-prism, it is moved at right angle to the bench in a direction to bring the fringes back to their original position.
10. Now move the eyepiece towards the bi-prism and the same adjustment is made with the help of eyepiece.
11. Now using the process again and again, the lateral shift is removed.

Procedure:

I. Measurement of fringe width (β):

1. The least count of the micrometer screw is ascertained.
2. The micrometer screw is placed at such a distance where fringes are distinct, bright and widely spaced (say 120 cms).
3. The cross wire is moved on one side of the fringes to avoid backlash error.
4. Now the cross wire is fixed at the center of a bright fringe and its reading is noted on the main scale as well as on micrometer screw.
5. The crosswire is now moved and fixed at the center of every second bright fringe.
6. The micrometer readings are noted. From these observations 'β' can be calculated.

II. Measurement of D:

1.The distance between slit and eyepiece uprights is noted. This distance gives 'D'.

The value of 'D' is corrected for the bench error.

III. Measurement of 2d:

$$2d = 2a(\mu - 1)\alpha$$

Observations:

Least count of micrometer screw

Pitch of the screw= ……cm

Number of divisions on the micrometer screw

Minimum Main Scale reading on the micrometer

I. Table for Fringe Width β

No. of fringes	Micrometer reading (a)			No. of fringes	Micrometer reading (b)			Difference for 20 fringes	Mean for 20 fringe	Fringe width
	M.S. read-mg ems	V.S. read-mg ems	Total ems		M.S. reading ems	V.S. read-ing ems	Total ems	a-b		Mean 13= ------ 20 ems
1				21						
3				23						
5				25						
7				27						
9				29						
11				31						
13				33						
15				35						
17				37						
19				39						

II. Measurement of 'D'

Position of upright carrying slit (a)

Position of upright carrying the eyepiece (b)

Observed value of D = b-a

III. Measurement of 2d:

$$2d = 2a(\mu - 1)\alpha$$

Calculations:

2d =……

D =……

λ=……..Å

Result:

Precautions and Sources Of Error:

1.The slit should be narrow and vertical as possible.
2. All uprights should be at the same height.
3. The micrometer screw should be rotated in one direction to avoid backlash error.
4. The distance between slit and eyepiece must be greater than four times the focal length of the convex lens (D > 4f) while measuring
5. The position of the slit and biprism should not be changed through the experiment.
6. Slit and biprism should be as close as possible to make β large. Also D should be large.

EXPERIMENT No. 10

Object: To find compressibility of given liquid by acoustic grating using Ultrasonic waves.

Apparatus: Sodium lamp, spectrometer, square box (ultrasonic cell) container for liquid, given liquid, ultrasonic transducer (Piezoelectric crystal), R.F. oscillator.

Theory: When ultrasonic waves pass through any medium presently in a liquid in our case. There is a pressure variation in liquid (in our case), due to compression and rarefaction produced by the ultrasonic waves. If these progressive waves get reflected by the wall opposite to the vibrating crystal of the container of the liquid, the standing waves are produced forming the nodes and antinodes in the form of regions of high pressure and low pressure. If light is passed through the liquid perpendicular to the direction of wave propagation, the regions of high pressure and low pressure act as a number of parallel slits, i.e., diffraction grating for the light waves then a well defined and sustained diffraction pattern will be obtained at the natural frequency of the crystal. Measuring the angle of diffraction as in the case of optical grating, we can use the following equation for the required measurement

$$(a+b)\sin\theta = n\lambda_{Na}$$

[The grating element $a+b=\lambda_{\upsilon}/2$ in this case, as shown in the diagram]

$$\frac{\lambda_{\upsilon}\sin\theta}{2} = n\lambda_{Na}$$

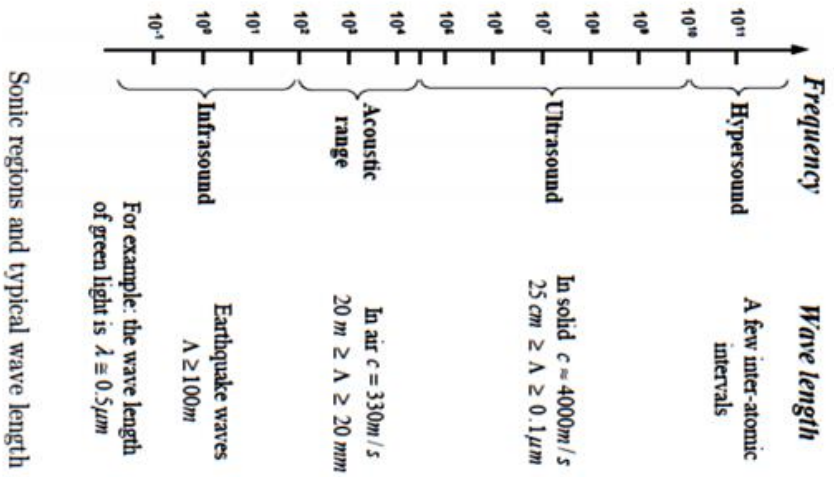
Where
θ = angle of diffraction
n = order of diffraction pattern
λ = wavelength of light used
λ_{υ}= wavelength of ultrasonic waves (*will be calculated*)

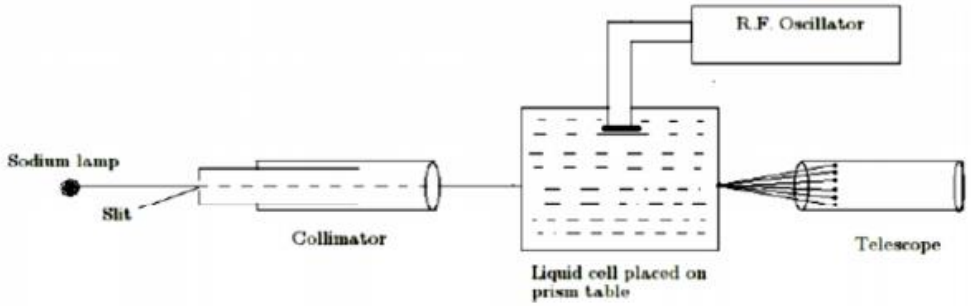
And using $v=\nu\lambda_{\upsilon}$ (ν is the natural frequency of crystal), v the velocity of ultrasonic waves.
Now using $v^2 = B/\rho$,

Where B: bulk modulus of the liquid
ρ: density of liquid used

The Compressibility
K = 1/B can be calculated

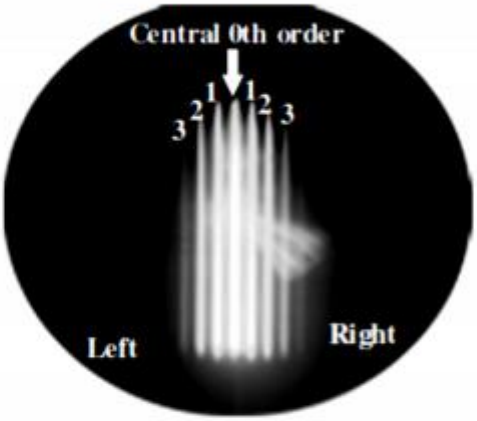
DIAGRAM:





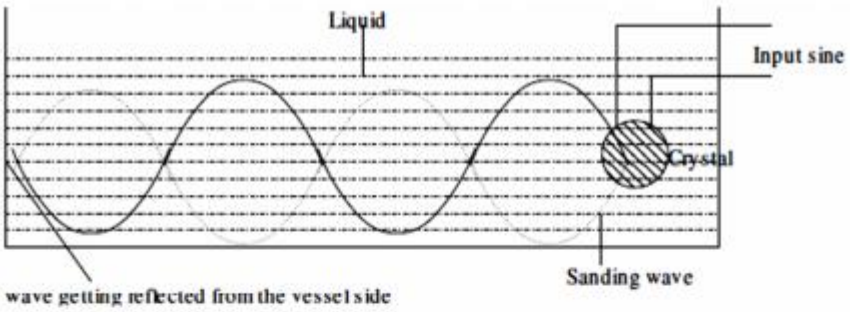
The schematic of the ultrasonic diffraction experiment

FIGURE-1

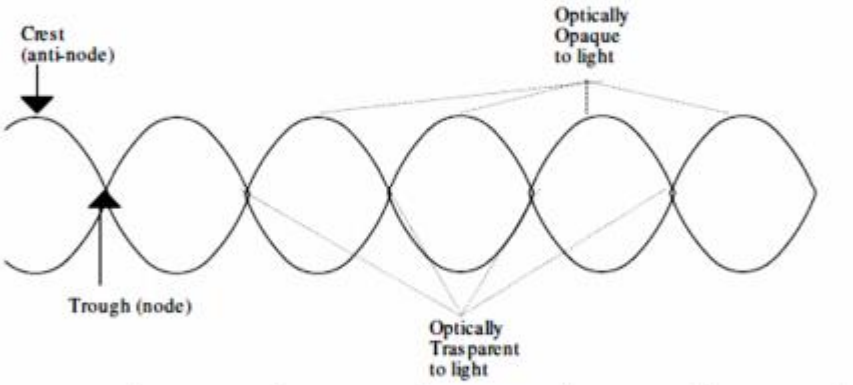


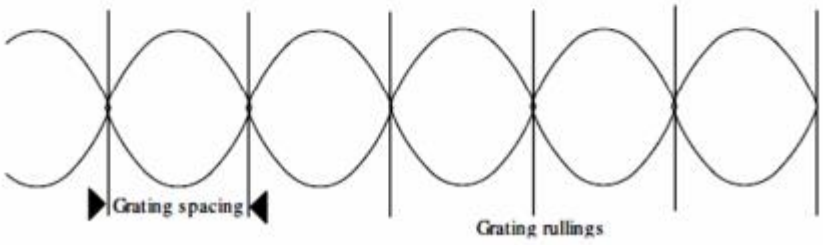
Spectral lines observed in liquid by acousting grating

Figure-2



Generation of ultra sound and its propagation forming standing wave.





$$d = \frac{\lambda'}{2}$$

The transparent and opaque regions of the standing wave

Figure-3

Standing wave acting like grating

Figure-4

Procedure:

1. Switch on the sodium lamp.
2. Fill the given liquid up to 3/4 of the square container box.
3. With the help of the stand, keep the crystal across the liquid dipped on one side.
4. Take the lead of the crystal and connect it to the oscillator.
5. Keep the ultrasonic cell unit on the prism table of the spectrometer at the center.
6. Set the telescope for the parallel rays accordingly set the collimator when the sodium light is fully illuminated and intense.
7. Switch on the oscillator and gradually move the knob of the oscillator and set it to resonant frequency of the piezoelectric crystal to get the maximum amplitude of the ultrasonic waves generated by the crystal. Two or more fine diffraction lines will appear adjacent to the initial central line, when the frequency is appropriate. (Crystal vibrates with the oscillator frequency, producing ultrasonic waves.)
8. Measure the angle of diffraction for the first order or second order diffraction pattern i.e., angle between the central line and adjacent lines on both sides.
9. Using the equations given in the theory, the compressibility can be calculated.

Observations:

Least Count of the spectrometer =... …

Direct reading of telescope =

S.No.	Order of spectrum	Vernier	Telescope reading			Angle of diffr
			Left	Direct	Right	Left
1	1st order	v_1 v_2	… …	… …	… …	… …
2	2nd order	v_1 v_2	… …	… …	… …	… …

Calculations:

In this case the grating element is taken to be

$$(a+b) = \lambda_{\upsilon} / 2 \text{ (in this case),}$$

depending on the location of the crystal ,as placed in the glass beaker

$$\frac{\lambda_{\upsilon} \sin\theta}{2} = n\lambda_{Na} \qquad (1)$$

where

θ = angle of diffraction

(as measured for the diffracted pattern as seen from the telescope for a given liquid)

n = order of diffraction pattern

λ_{Na} = wavelength of light used

λ_{υ}= wavelength of ultrasonic waves (*will be calculated*)

Now using the equation

$$v = \nu\lambda_{\upsilon}$$

ν is the natural frequency of crystal (*to be asked while issuing the crystal*), (usually between 4.5 MHz to 7.5MHz)

λ_u is the wavelength of the crystal as calculated from equation (1).

v is the velocity of ultrasonic waves as calculated using the above inputs of natural frequency of the crystal and its wavelength.

Now using the equation, the Bulk Modulus of the given liquid can be calculated

$$v^2 = B/\rho,$$

where v is the velocity of the ultrasonic wave as calculated, ρ is the density of the given liquid, B the Bulk Modulus of the given liquid can be calculated.

The inverse of Bulk Modulus gives us the compressibility of the given liquids.

***Take due care of units.*

Result:

Wavelength of Ultrasonic Wave,λ = ……m

Velocity of the Ultrasonic Wave , v = …….m/s

Bulk Modulus of the given liquid = ……kg/ms^2(or Pa or N/m^2)

Compressibility of the given liquid= …….m$s^2/kg(or\ Pa^{-1}\ or\ m^2/N)$

Sources Of Error and Precautions:

1. The adjustment is incorrect if the angles of diffraction on the left and the right of the direct are not equal.

2. In the second order spectrum with a good grating the two D-line generally appear to be separated. In such a case the angle of diffraction should be found separately for the two lines and wavelengths calculated corresponding to each.

3.The ruled surface should face away from the collimator.

4.The light should fall on the whole of the grating surface.

5.In handling do not touch the faces of grating, hold it between thumb & finger by the edges.