REFRACTIVE INDEX OF A PRISM

Aim:

To determine the refractive index of a given prism by using a Na Light.

Apparatus Required:

Spectrometer, prism, mercury vapour lamp, spirit level and reading lens.

Formula Used:

The refractive index μ 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, δm = angle of minimum deviation.

Procedure:

The following initial adjustments of the spectrometer are made first.

• The spectrometer and the prism table are arranged in horizontal position by using the levelling screws.
• The telescope is turned towards a distant object to receive a clear and sharp image.
• The slit is illuminated by a mercury vapour lamp and the slit and the collimator are suitably adjusted to receive a narrow, vertical image of the slit.
• The telescope is turned to receive the direct ray, so that the vertical slit coincides with the vertical crosswire.

(A) Measurement of the angle of the prism:

• Determine the least count
• Place the prism on the prism table with its refracting angle A towards the collimator and with its refracting edge A at the centre. In this case some of the light falling on each face will be reflected and can be received with the help of the telescope.
• 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 readings of the two verniers are taken.
• 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 the two verniers are taken.
• The angle through which the telescope is moved; or the difference in the two positions gives twice of 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 deviations:

• 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 the spectrum of light is obtained.
• 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 a way to keep the spectral line in view. By doing so a position will come where a spectral line recede in 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.
.• 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 the two verniers.
• The difference in minimum deviation position and direct position gives the angle of minimum deviation for that colour.
• The same procedure is repeated to obtain the angles of minimum deviation for the other Colours.

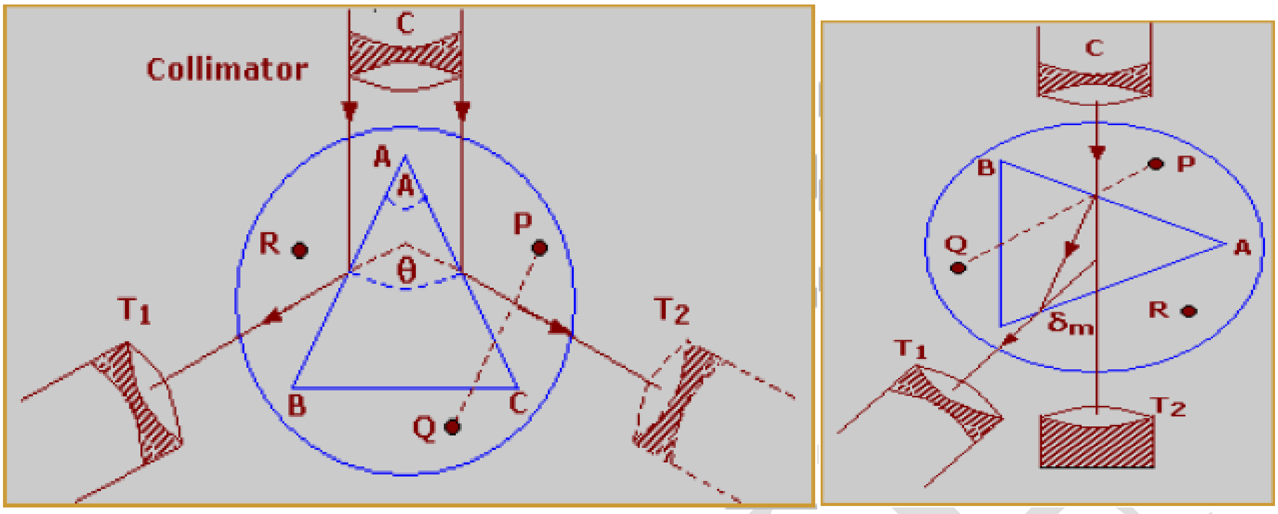


Figure: Left: Arrangement to determine the angle of prim.
Right: Arrangement to determine the angle of minimum deviation.

Observations:

(i) Value of the one division of the main scale = ……… degrees
Total number of vernier divisions = ……….
Least count of the vernier = ………. degrees = ……… second

(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 θ = a – b = 2A	Mean value of 2A	A	Mean A degrees
		MSR	VSR	TR (a)	MSR	VSR	TR (b)				
1	V_1								}		
	V_2										
2	V_1								}		
	V_2										
3	V_1								}		
	V_2										

MSR = Main Scale Reading, VSR = Vernier Scale Reading, TR = MSR+VSR = Total Reading.

(iii) Table for the angle of minimum deviation (δm).

S.No	Colour	Vernier	Telescope reading for minimum deviation			Telescope reading for direct image			Difference δ_m = a – b	Mean value of δ_m
			MSR	VSR	TR (a)	MSR	VSR	TR (b)		
1	Violet	V_1								}
		V_2								
2	Yellow	V_1								}
		V_2								
3	Red	V_1								}
		V_2								

MSR = Main Scale Reading, VSR = Vernier Scale Reading, TR = MSR+VSR = Total Reading.

Calculations:

Refractive index for yellow = …………

Angle of minimum deviation for red = ………..
Refractive index for red = …………..
Result: Refractive index for the material of the prism ______

DISPERSIVE POWER OF A PRISM

Aim:
To determine the dispersive power of a prism using Hg light

Apparatus:
A spectrometer, a glass prism, mercury lamp, reading lamp and a magnifying lens.

Formula used: The dispersive power of the medium of the prism is given by

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

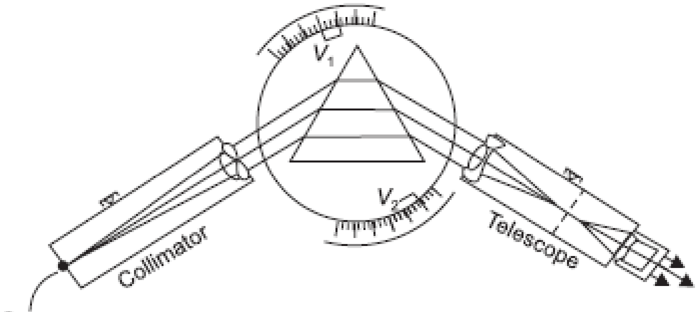
Where μb and μr are the refractive indices of the medium for blue and red lines respectively and μy refers to the refractive index for the *D* yellow line of sodium and may be written as:

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

The refractive indices μb and μr can be determined by using the formulae

$$\mu_r = \frac{\sin(A+\delta_r)/2}{\sin A/2}, \quad \mu_b = \frac{\sin(A+\delta_b)/2}{\sin A/2}$$

Where *A* is the angle of the prism and *δ*b and *δ*r are the angles of minimum deviation for the blue and red respectively.



Schematic diagram of the spectrometer

Manipulations:
1. Determine the vernier constant of the spectrometer.
2. Turn the telescope towards some brightly illuminated white background and move the eyepiece in or out till the cross-wire is sharply focused.
3. Switch on the neon lamp.
4. Bring the telescope and collimator in the same straight line and move the lamp right and left and up and down and fix its position when the illumination of the slit is maximum.
5. If the image of the slit is not bisected by the horizontal cross-wire in the telescope, adjust the leveling screws of the telescope or collimator till the slit is bisected.
6. Place the prism in the centre of the small prism table in such a way that one of its refracting face is at right angle to the line joining two of the levelling screws on the small prism table.

Optical Leveling:

7. Turn the table till the edge of the prism is opposite to the middle of the collimator lens. The image of slit will now be reflected from each of the two faces.
8. First get the image of the slit from that face of the prism, which has been kept at right angles to the line joining the two leveling screws on the prism table. If it is not bisected by the horizontal cross-wire it should be made to do so by adjusting either of the two screws. This is done to ensure that the faces of the prism are vertical.
9. Now view the slit through the telescope, as it is reflected from the other face of the prism. If it is not bisected, adjust the third screw. This operation makes the edge of the prism vertical and parallel to the slit.
10. The prism table is thus leveled and the two faces of the prism are made vertical.
11. Turn the prism table till the beam of parallel light from the collimator enters the prism at one face and emerges from the other. Now the refractive image of the slit will be seen. The prism table is moved in a direction to increase the angle of incidence. As we increase the angle of incidence, the refractive ray will move in a particular direction. At one particular angle of incidence, the refractive ray will cease to move. This gives the position of minimum deviation for the prism. If the prism is moved still further, the refractive ray will begin to move in opposite direction. Turn the telescope a little to one side of the image and fix it. It is evident that there are now two positions of the prism, one on each side of that of minimum deviation, which will bring the image of the line again into view in the center of the field of the telescope.
12. The prism is first turned to the position where the angle of incidence is greater than that corresponding to minimum deviation. The telescope is now focused while looking at the spectrum through the telescope.
13. Now rotate the prism table in the opposite direction till the image is again visible through the telescope.
14. Focus the collimator.
15. Turn the prism table again so as to increase the angle of incidence till the refracted rays after going out of the field of view are again visible.
16. Focus the telescope.
17. Again rotate the prism table so as to decrease the angle of incidence and when the image reappears focus the collimator.
18. If all the above operations have been performed correctly, you will find that the refracted image will always be in sharp focus, no matter in which direction the prism is turned. This is known as Schuster’s method of focusing the telescope and collimator.
19. Find the angle of the prism.
20. Find the angle of minimum deviation for bright red and greenish blue line of the mercury spectrum.

Observations:

1. Vernier constant of the spectrometer =
2. Readings for the angle of the prism ‘A

Sl No.	Readings for the Image Reflected				2A	A
	From Right Face		From Left Face		c – a d – b	
	Venier A a	Venier B b	Venier A c	Venier B d		
1.						
2.						
3.						

Mean A =

3. Readings for the angle of minimum deviation

Sl. no.	Colour of Light	Direct Reading		Reading for the Position of Minimum Deviation		δ_m
		A	B	A	B	
1.	Red					
2.	Red					
3.	Red					
1.	Blue					
2.	Blue					
3.	Blue					

Mean: δ_m (red) = δ_r =, δ_m (Blue) = δ_b =

Calculations :

$$\mu_r = \frac{\sin(A+\delta_r)/2}{\sin A/2} =$$

$$\mu_b = \frac{\sin(A+\delta_b)/2}{\sin A/2}$$

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

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

Result:

The dispersive power of a prism =

RESOLVING POWER OF PRISM

Aim :

To determine the resolving power of a prism.

Apparatus Required:

Spectrometer, prism, prism clamp, mercury lamp, lens.

Principle:

If a spectrograph can just resolve two lines near wavelength with a separation of, the resolving power is defined as $\lambda/\Delta\lambda$.

Resolving power for yellow and blue is given by

$$\omega = \frac{nb-ny}{n-1}$$

Where n_b and n_y are the refractive index of blue and yellow, and $n = \frac{nb+ny}{2}$

Procedure:

Preliminary adjustments:

1. Focus Telescope on distant object.

2. When focus is correct, start button is activated. Then click Start button.
3. Switch on the light by clicking Switch On Light button.
4. Focus the slit using Slit focus slider.
5. Adjust the slit width using Slit width slider.
6. Coincide the slit with cross wire in the telescope.

Performing Real Lab:

1. Turn the telescope towards the white wall or screen and looking through eye-piece, adjust its position till the cross wires are clearly seen.
2. Turn the telescope towards window, focus the telescope to a long distant object.
3. Place the telescope parallel to collimator.
4. Place the collimator directed towards sodium vapour lamb. Switch on the lamp.
5. Focus collimator slit using collimator focusing adjustment.
6. Adjust the collimator slit width.
7. Place prism table, note that the surface of the table is just below the level of telescope and collimator.
8. Place spirit level on prism table. Adjust the base leveling screw till the bubble come at the centre of spirit level.
9. Clamp the prism holder.
10. Clamp the prism in which the sharp edge is facing towards the collimator, and base of the prism is at the clamp.

Least Count of Spectrometer:

One main scale division (N) =................minute
Number of divisions on vernier (v) = ...
L.C $= \frac{v}{c}$ = ...minute

To determine the Angle of minimum deviation:

Direct method :

Performing simulator:

1. Rotate prism table so as to get the refracted light through the prism.
2. Make the slit coincide with telescope cross wire.
3. Slowly rotate the vernier table by using vernier fine adjusting slider.
4. Note the position where the slit is stationary for some moment.
5. Using telescope fine adjusting slider, make coincide the slit with cross wire.

Performing Real Lab:

1. Rotate the prism table so that the light from the collimator falling on one of the face of the prism and emerges through the other face.
2. The telescope is turned to view the refracted image of the slit on the other face.
3. The vernier table is slowly turned in such a direction that the image of slit is move directed towards the directed ray; ie., in the direction of decreasing angle of deviation.
4. It will be found that at a certain position, the image is stationary for some moment. Vernier table is fixed at the position where the image remains stationary.
5. Note the readings on main scale and vernier scale.
6. Carefully remove the prism from the prism table.
7. Turn the telescope parallel to collimator, and note the direct ray readings.

8. Find the difference between the direct ray readings and deviated readings. This angle is called angle of minimum deviation (D).

To determine the Resolving power of prism :

1. Rotate the vernier table so as to fall the light from the collimator to one face of the prism and emerged through another face. (refer the given figure).
2. The emerged ray has different colors.
3. Turn the telescope to each color, and note the readings for different colors.
4. Remove the prism, hence note direct ray reading.
5. Find the angle of minimum deviation for different color.(Say ,violet, blue, green, yellow).
6. Find the refractive index for these colors. Using equation (3).
7. Resolving power for yellow and blue

$$\omega = \frac{nb-ny}{n-1}$$

Where n_b and n_y are the refractive index of blue and yellow, and $n = \frac{nb+ny}{2}$

Line	Vernier	Refracted ray readings	Direct readings	Difference (Minimum Deviation)	Mean D	n
	V_1					
	V_2					
	V_1					
	V_2					
	V_1					
	V_2					
	V_1					
	V_2					

Refractive index for the line ________ n1 =
Refractive index for the line ________ n2 =
Average refractive index $n = \frac{n1+n2}{2}$
Resolving power for ______ and ______ line = $\omega = \frac{n2-n1}{n-1}$

Result:

Angle of the Prism =……………………………….Degrees
Angle of minimum deviation of the prism =……………………………….Degrees
Refractive index of the material of the prism =……………………………….
Dispersive power of the prism =……………………………….

SPECTROMETER – DETERMINATION OF CAUCHY'S CONSTANT

Aim:

To determine the value of Cauchy constants of a material of a prism

Apparatus Required:

Spectrometer, Prism, Mercury vapour lamp.

Formula

The refractive index n of the material of the prism for a wavelength λ is given by.

$$n = A + \frac{B}{\lambda^2}$$

Where A and B are called Cauchy's constants for the prism.
If the refractive indices n1 and n2 for any two known wavelength λ1 and λ2 are determined by a spectrometer, the Cauchy's constants A and B can be calculated from the above equation.

Procedure:

Preliminary adjustments:

1. Focus Telescope on distant object.
2. When focus is correct, start button is activated. Then click Start button.
3. Switch on the light by clicking Switch On Light button.
4. Focus the slit using Slit focus slider.
5. Adjust the slit width using Slit width slider.
6. Coincide the slit with cross wire in the telescope.

Performing Real Lab:

1. Turn the telescope towards the white wall or screen and looking through eye-piece, adjust its position till the cross wires are clearly seen.
2. Turn the telescope towards window, focus the telescope to a long distant object.
3. Place the telescope parallel to collimator.
4. Place the collimator directed towards sodium vapor lamb. Switch on the lamp.
5. Focus collimator slit using collimator focusing adjustment.
6. Adjust the collimator slit width.
7. Place prism table, note that the surface of the table is just below the level of telescope and collimator.
8. Place spirit level on prism table. Adjust the base leveling screw till the bubble come at the centre of spirit level.
9. Clamp the prism holder.
10. Clamp the prism in which the sharp edge is facing towards the collimator, and base of the prism is at the clamp.

Least Count of Spectrometer :

One main scale division (N) =................minute

Number of divisions on vernier (v) = ...

L.C $= \frac{N}{V} =$ ....minute

To determine the angle of the Prism:

1. Prism table is rotated in which the sharp edge of the prism is facing towards the collimator.

2. Rotate the telescope in one direction up to which the reflected ray is shown through the telescope.
3. Note corresponding main scale and vernier scale reading in both vernier (vernier I and vernier II).
4. Rotate the telescope in opposite direction to view the reflected image of the collimator from the second face of prism.
5. Note corresponding main scale and vernier scale reading in both vernier(vernier I and vernier II).
6. Find the difference between two readings, i.e.θ
7. Angle of prism, A=θ/2

Reading of reflected ray from	Vernier 1			Vernier 2		
	MSR	VSR	Total	MSR	VSR	Total
face 1 (say a)						
face 2 (say b)						
Difference between a & b						

Mean θ =.................Degrees

Angle of prism =.................Degrees

To determine the Cauchy's constants for the prism:

<u>Performing Real Lab</u>

The angle of the prism A and the angle of minimum deviation D for different wave length are determined. From this the refractive index n for these colours are calculated. Taking the value of λ from the mathematical table, the Cauchy's constants A and B are calculated for different pairs of spectral colours using the equation.

The Cauchy's constants can also be determined graphically. A graph is drawn with n along the y-axis and 1/λ2 along x-axis with zero as the origin for both axes. The graph is a straight line. The Y intercept gives A and the slope gives B.

<u>Performing simulator :</u>

1. Rotate the vernier table so as to fall the light from the collimator to one face of the prism and emerged through another face. (refer the given figure).
2. The emerged ray has different colors.
3. Turn the telescope to each color, and note the readings for different colors.
4. Remove the prism, hence note direct ray reading.
5. Find the angle of minimum deviation for different color.(Say ,violet, blue, green, yellow).
6. Find the refractive index for these colors. Using equation (3).
7. Draw the graph with n along the y-axis and 1/λ2 along x-axis with zero as the origin for both axes.

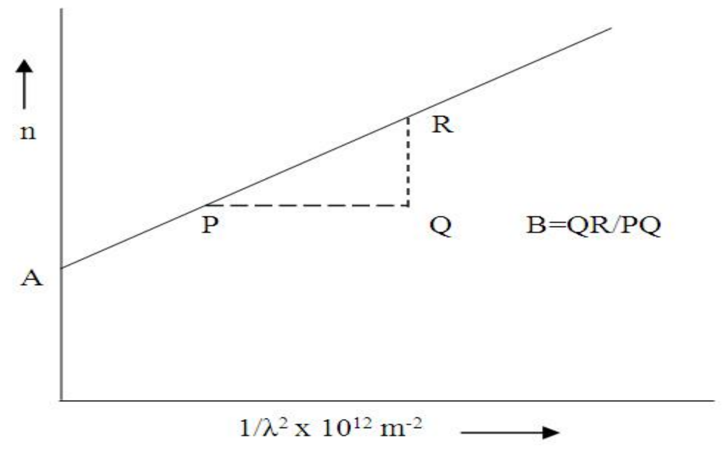
Table (1): To calculate A and B.

Pair of Colors	λ_1 x 10^{-9} m	λ_2 x 10^{-9} m	n_1	n_2	A	B
Yellow1 & Blue						
Green & Violet						

Table (2): To find A and B graphicaly.

Colour	λ x 10^{-9} m	$(1/\lambda^2)$ x 10^{12} m^{-2}	n
Yellow	579.1	2.988	
Green	546.1	3.353	
Blue	435.8	5.265	
Violet 2	404.7	6.103	

Graph:



Result:

Cauchy's constants

A =……………………………

B =…………………………… m2

WAVELENGTH OF LASER USING DIFFRACTION GRATING

Aim:

TO find a wavelength of laser source using diffraction grating.

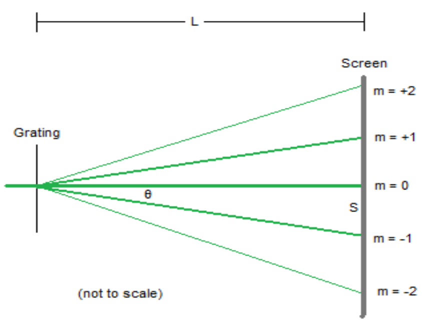
Apparatus required:

Diffraction grating, Laser source, Large screen, Stand with grating mount, metre scale

Formula

$$\text{Sin } \theta_n = Nn\lambda$$

$$\text{Sin } \theta_n = x_n / \sqrt{Xn2 + d2}$$



Procedure:

Laser, grating and a screen are arranged in a line as shown in a figure. Switch on the laser and pass through the grating so that the diffraction pattern can be seen on screen. The pattern consists of bright diffraction bands of orders n = 1,2…etc. On either side of the central spot. For normal incidence, the grating is aligned such that the separation between the central spot to the first order spot on both sides are equal. Adjust the spacing between the grating and the screen d to 0.23 m. Find the distance to the n th order (n=1,2) diffracted spot from the central spot on both sides of it on the screen as x_n. From the mean value of x_n, calculate $\sin\theta_n = x_n / \sqrt{Xn2 + d2}$ for each order. The number of lines per metre of the grating N is also noted. Then the wavelength given by $\lambda = \sin\theta_n / Nn$ is calculated. The experiment is repeated for various distances d= 0.5,0.75 and 1 m and the mean value of wave length is calculated.

Table :

Number of lines per metre on the grating N = ______ lines / m

s.no	Order n	Distance to the diffracted spot from the central spot x_n (m)			$\sin\theta_n = x_n/\sqrt{Xn2 + d2}$	Mean sin θ_n	$\lambda = \sin\theta_n / Nn$ (m)
		Left	Right	Mean			
1 2 3	I						
1 2 3	II						

Result :

Wavelength of the laser light =

MELDE'S APPARATUS

FREQUENCY OF VIBRATOR(TUNING FORK)

Aim:

To determine the frequency of vibrator or tuning fork of Melde's Apparatus by measuring the frequency of 1)transverse vibrations 2)longitudinal vibrations of a string.

Apparatus:

Melde's apparatus of electrically maintained vibrator or tuning fork with a long uniform string, scale pan,weight box etc.

1) TRANSVERSE MODE OF VIBRATIONS

Procedure:

In Melde's apparatus, a long string is attached to one of the prongs of the tuning fork(or vibrator). The other end of the string carrying scale pan is passed over a smooth pulley. The pulley is rigidly fixed to the edge of the table. The electrically maintained tuning fork is placed so that its prong is along the length of the string as shown in Fig28.1 below.

When the circuit is closed, the fork is set into vibration, at right angles to the length of the string. A mass of, say, 5g is placed on the pan. The transverse stationary waves are produced in the string due to the superposition of the traveling wave and reflected wave at the pulley. The length of the string is adjusted to get well defined loop of standing waves. Leaving the loops formed at the ends of the string, total number of loops is counted and total length of the loop is measured using meter scale. The length l of then is calculated. The experiment is repeated by adding the mass into the pan in step of 5g. The mass of entry pan m_p is determined and is added to the mass placed in it. The readings are tabulated as given in table 28.1. The linear density m of string that is, mass per unit length of the string is calculated by knowing the mass of the specimen string 10m in length.

Table 28.1: To determine (M`/ L^2)

Load in scale pan: M g	Total mass M`=(M+m_p)g	Number of loop N	Total length of loops m	Length of one loop l m	(M`/ l^2) kg.m^{-2}

Mean (M`/ l^2) = Kg m^{-2}

Mean $(M`/ l^2)^{1/2}$= Kg m^{-1}

A graph can be drawn connecting M` and $L^2$ as shown in fig 28.2 and the slope (M`/ l^2) can be determined.

M` kg	L^2 m^2

Formula:

In transverse mode of vibration of the string of the loop length L under the tension T, its frequency of vibration is equal to that of vibrating tuning fork. Therefore frequency of the fork

$$n = 1/2l\,[T/m]^{1/2} = 1/2\,[(g/m)(M`/l^2)]^{1/2}$$

where T is the tension in the string = (M+m_p)g =M`g. Here M` is the load including the mass of the pan m_p and g is the acceleration due to gravity.

Observation:

Mass of the scale pan m_p = kg
Mass of 10m of string = kg
Mass per meter of string m = kg m^{-1}
Mean $(M`/l^2)^{1/2}$ 1) by calculation = $kg^{1/2}m^{-1}$

2)by graph = $kg^{1/2}m^{-1}$

Frequency of the fork $n = 1/2[(g/m)(M`/l^2)]^{1/2}$ Hz

Result:

Frequency of tuning fork in transverse mode of vibration of string

1) By calculation = Hz
2) By graph = Hz

2)**LONGITUDINAL MODE OF VIBRATIONS:**

Procedure:

In the longitudinal mode, the fork vibrates in a direction parallel to the length of the string. The experiment is performed as in the case of transverse mode of vibrations. Observations are tabulated for various tensions. The table is identical to the table 28.1 which is already given. Here it should be noted that for same tension, the length of one loop is twice as that for transverse mode. Experiment is also repeated to find the relative density of the given solid and liquid.

Table 28.2: To determine ($M`/ L^2$)

Load in scale pan: M g	Total mass $M`=(M+m_p)$g	Number of loop N	Total length of loops m	Length of one loop l m	($M`/ l^2$) $kg.m^{-2}$

Formula:

In longitudinal mode, each and every point of the string makes one complete oscillation during which of fork completes two oscillations.Therefore,

Frequency of the fork $n = [(g/m)(M`/l^2)]^{1/2}$

As in the case of transverse mode, using the same formulae, the relative densities of solid and liquid are determined.

Observation:

Mass of the scale pan m_p = kg
Mass of 10m of string = kg
Mass per meter of string m = $kg\ m^{-1}$
Mean $(M`/l^2)^{1/2}$ 1) by calculation = $kg^{1/2}m^{-1}$
2)by graph = $kg^{1/2}m^{-1}$

Frequency of the fork $n = [(g/m)(M`/l^2)]^{1/2}$ Hz

Result:

Frequency of tuning fork in longitudinal mode of vibration of string

1) By calculation = Hz
2) By graph = Hz

LISSAJOUS FIGURES

Aim:

To use Lissajous figures to take phase measurements.

Apparatus:

General purpose oscilloscope (10MHz) , Function generators (1 Hz to 1 MHz) ,Digital multimeter.

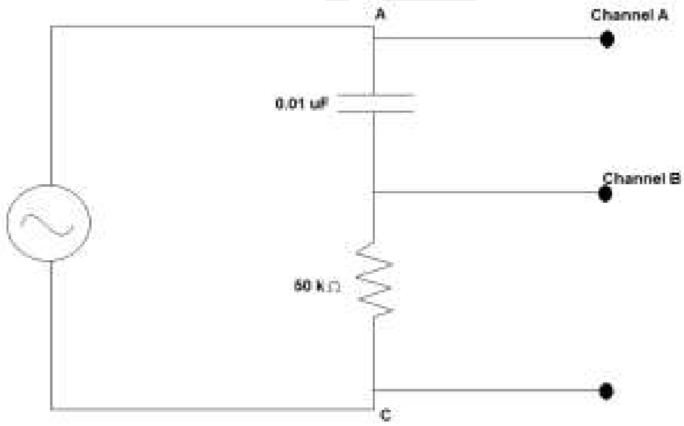
Theory:

A lissajous figure is produced by taking two sine waves and displaying them at right angles to each other. This easily done on an oscilloscope in XY mode. If the oscilloscope has the x-versus-y capability, one can apply one signal to the vertical deflection plates while applying a second signal to the horizontal deflection plates. The horizontal sweep section is automatically disengaged at this time. The resulting waveform is called Lissajous figure. This mode can be used to measure phase or frequency relationships between two signals.

Procedure:

1. The circuit was connected as in Figure 3.8.

2. The frequency of Ein was set at 1 kHz. R was set at 0 Ω. The signal voltage was set at 4 V peak-to-peak. The display was centered. R was changed to 10 kΩ and the pattern in was recorded in Table 3.3. The measured and calculated values was recorded in Table 3.3, for different values of R.



Observation:

S NO	X	Y	Ø= $\sin^{-1}(Y/X)$

Result:

The phase difference of lissajoue's figure =

REFRACTIVE INDEX OF A PRISM

Aim:

To determine the refractive index of a given prism by using a Na Light.

Apparatus Required:

Spectrometer, prism, mercury vapour lamp, spirit level and reading lens.

Formula Used:

The refractive index μ 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, δm = angle of minimum deviation.

Procedure:

The following initial adjustments of the spectrometer are made first.

• The spectrometer and the prism table are arranged in horizontal position by using the levelling screws.
• The telescope is turned towards a distant object to receive a clear and sharp image.
• The slit is illuminated by a mercury vapour lamp and the slit and the collimator are suitably adjusted to receive a narrow, vertical image of the slit.
• The telescope is turned to receive the direct ray, so that the vertical slit coincides with the vertical crosswire.

(A) Measurement of the angle of the prism:

• Determine the least count
• Place the prism on the prism table with its refracting angle A towards the collimator and with its refracting edge A at the centre. In this case some of the light falling on each face will be reflected and can be received with the help of the telescope.
• 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 readings of the two verniers are taken.
• 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 the two verniers are taken.
• The angle through which the telescope is moved; or the difference in the two positions gives twice of 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 deviations:

• 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 the spectrum of light is obtained.
• 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 a way to keep the spectral line in view. By doing so a position will come where a spectral line recede in 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.
.• 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 the two verniers.
• The difference in minimum deviation position and direct position gives the angle of minimum deviation for that colour.
• The same procedure is repeated to obtain the angles of minimum deviation for the other Colours.

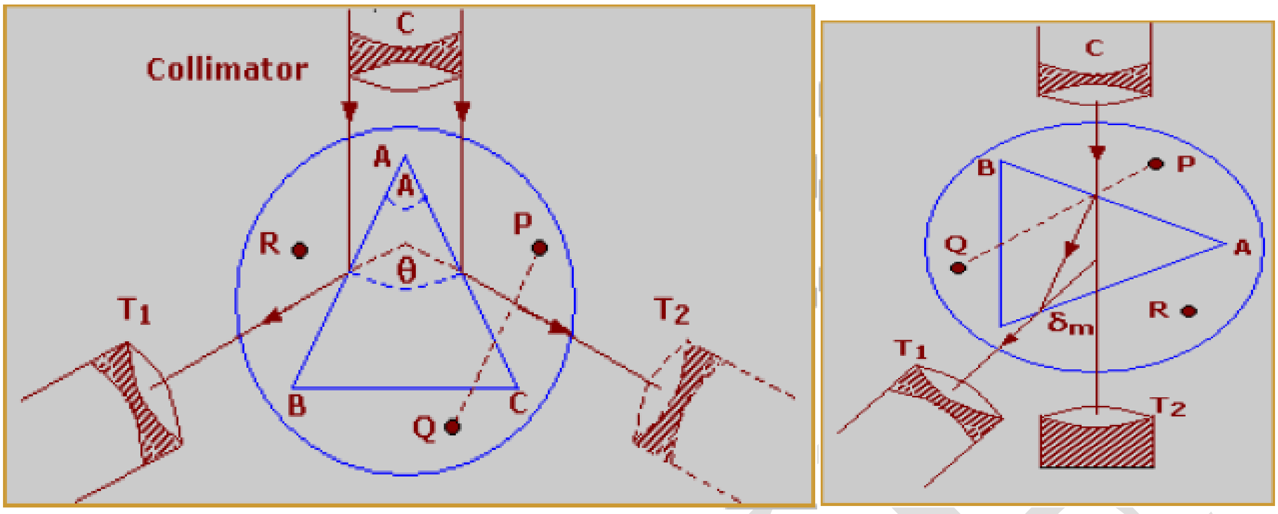


Figure: Left: Arrangement to determine the angle of prim.
Right: Arrangement to determine the angle of minimum deviation.

Observations:

(i) Value of the one division of the main scale = ……… degrees
Total number of vernier divisions = ……….
Least count of the vernier = ………. degrees = ……… second

(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 θ = a – b = 2A	Mean value of 2A	A	Mean A degrees
		MSR	VSR	TR (a)	MSR	VSR	TR (b)				
1	V_1								}		
	V_2										
2	V_1								}		
	V_2										
3	V_1								}		
	V_2										

MSR = Main Scale Reading, VSR = Vernier Scale Reading, TR = MSR+VSR = Total Reading.

(iii) Table for the angle of minimum deviation (δm).

S.No	Colour	Vernier	Telescope reading for minimum deviation			Telescope reading for direct image			Difference $\delta_m = a - b$	Mean value of δ_m
			MSR	VSR	TR (a)	MSR	VSR	TR (b)		
1	Violet	V_1								}
		V_2								
2	Yellow	V_1								}
		V_2								
3	Red	V_1								}
		V_2								

MSR = Main Scale Reading, VSR = Vernier Scale Reading, TR = MSR+VSR = Total Reading.

Calculations:

Refractive index for yellow = …………

Angle of minimum deviation for red = ………..
Refractive index for red = …………..
Result: Refractive index for the material of the prism ______

DISPERSIVE POWER OF A PRISM

Aim:
To determine the dispersive power of a prism using Hg light

Apparatus:
A spectrometer, a glass prism, mercury lamp, reading lamp and a magnifying lens.

Formula used: The dispersive power of the medium of the prism is given by

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

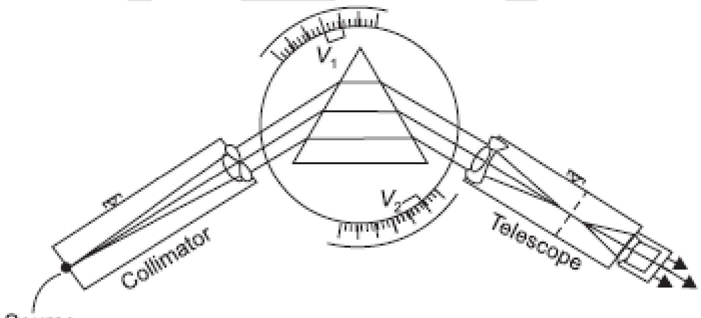
Where μb and μr are the refractive indices of the medium for blue and red lines respectively and μy refers to the refractive index for the *D* yellow line of sodium and may be written as:

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

The refractive indices μb and μr can be determined by using the formulae

$$\mu_r = \frac{\sin(A+\delta_r)/2}{\sin A/2}, \quad \mu_b = \frac{\sin(A+\delta_b)/2}{\sin A/2}$$

Where *A* is the angle of the prism and *δ*b and *δ*r are the angles of minimum deviation for the blue and red respectively.



Schematic diagram of the spectrometer

Manipulations:
1. Determine the vernier constant of the spectrometer.
2. Turn the telescope towards some brightly illuminated white background and move the eyepiece in or out till the cross-wire is sharply focused.
3. Switch on the neon lamp.
4. Bring the telescope and collimator in the same straight line and move the lamp right and left and up and down and fix its position when the illumination of the slit is maximum.
5. If the image of the slit is not bisected by the horizontal cross-wire in the telescope, adjust the leveling screws of the telescope or collimator till the slit is bisected.
6. Place the prism in the centre of the small prism table in such a way that one of its refracting face is at right angle to the line joining two of the levelling screws on the small prism table.

Optical Leveling:

7. Turn the table till the edge of the prism is opposite to the middle of the collimator lens. The image of slit will now be reflected from each of the two faces.
8. First get the image of the slit from that face of the prism, which has been kept at right angles to the line joining the two leveling screws on the prism table. If it is not bisected by the horizontal cross-wire it should be made to do so by adjusting either of the two screws. This is done to ensure that the faces of the prism are vertical.
9. Now view the slit through the telescope, as it is reflected from the other face of the prism. If it is not bisected, adjust the third screw. This operation makes the edge of the prism vertical and parallel to the slit.
10. The prism table is thus leveled and the two faces of the prism are made vertical.
11. Turn the prism table till the beam of parallel light from the collimator enters the prism at one face and emerges from the other. Now the refractive image of the slit will be seen. The prism table is moved in a direction to increase the angle of incidence. As we increase the angle of incidence, the refractive ray will move in a particular direction. At one particular angle of incidence, the refractive ray will cease to move. This gives the position of minimum deviation for the prism. If the prism is moved still further, the refractive ray will begin to move in opposite direction. Turn the telescope a little to one side of the image and fix it. It is evident that there are now two positions of the prism, one on each side of that of minimum deviation, which will bring the image of the line again into view in the center of the field of the telescope.
12. The prism is first turned to the position where the angle of incidence is greater than that corresponding to minimum deviation. The telescope is now focused while looking at the spectrum through the telescope.
13. Now rotate the prism table in the opposite direction till the image is again visible through the telescope.
14. Focus the collimator.
15. Turn the prism table again so as to increase the angle of incidence till the refracted rays after going out of the field of view are again visible.
16. Focus the telescope.
17. Again rotate the prism table so as to decrease the angle of incidence and when the image reappears focus the collimator.
18. If all the above operations have been performed correctly, you will find that the refracted image will always be in sharp focus, no matter in which direction the prism is turned. This is known as Schuster's method of focusing the telescope and collimator.
19. Find the angle of the prism.
20. Find the angle of minimum deviation for bright red and greenish blue line of the mercury spectrum.

Observations:

1. Vernier constant of the spectrometer =
2. Readings for the angle of the prism 'A

Sl No.	Readings for the Image Reflected				2A	A
	From Right Face		From Left Face		c – a d – b	
	Venier A a	Venier B b	Venier A c	Venier B d		
1.						
2.						
3.						

Mean A =

3. Readings for the angle of minimum deviation

Sl. no.	Colour of Light	Direct Reading		Reading for the Position of Minimum Deviation		δ_m
		A	B	A	B	
1.	Red					
2.	Red					
3.	Red					
1.	Blue					
2.	Blue					
3.	Blue					

Mean: δ_m (red) = δ_r =, δ_m (Blue) = δ_b =

Calculations :

$$\mu_r = \frac{\sin(A+\delta_r)/2}{\sin A/2} =$$

$$\mu_b = \frac{\sin(A+\delta_b)/2}{\sin A/2}$$

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

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

Result:

The dispersive power of a prism =

RESOLVING POWER OF PRISM

Aim :

To determine the resolving power of a prism.

Apparatus Required:

Spectrometer, prism, prism clamp, mercury lamp, lens.

Principle:

If a spectrograph can just resolve two lines near wavelength with a separation of, the resolving power is defined as $\lambda/\Delta\lambda$.

Resolving power for yellow and blue is given by

$$\omega = \frac{nb-ny}{n-1}$$

Where n_b and n_y are the refractive index of blue and yellow, and $n = \frac{nb+ny}{2}$

Procedure:

Preliminary adjustments:

1. Focus Telescope on distant object.

2. When focus is correct, start button is activated. Then click Start button.
3. Switch on the light by clicking Switch On Light button.
4. Focus the slit using Slit focus slider.
5. Adjust the slit width using Slit width slider.
6. Coincide the slit with cross wire in the telescope.

Performing Real Lab:

1. Turn the telescope towards the white wall or screen and looking through eye-piece, adjust its position till the cross wires are clearly seen.
2. Turn the telescope towards window, focus the telescope to a long distant object.
3. Place the telescope parallel to collimator.
4. Place the collimator directed towards sodium vapour lamb. Switch on the lamp.
5. Focus collimator slit using collimator focusing adjustment.
6. Adjust the collimator slit width.
7. Place prism table, note that the surface of the table is just below the level of telescope and collimator.
8. Place spirit level on prism table. Adjust the base leveling screw till the bubble come at the centre of spirit level.
9. Clamp the prism holder.
10. Clamp the prism in which the sharp edge is facing towards the collimator, and base of the prism is at the clamp.

Least Count of Spectrometer:

One main scale division (N) =................minute
Number of divisions on vernier (v) = ...
L.C $= \frac{v}{c} =$ ....minute

To determine the Angle of minimum deviation:

Direct method :

Performing simulator:

1. Rotate prism table so as to get the refracted light through the prism.
2. Make the slit coincide with telescope cross wire.
3. Slowly rotate the vernier table by using vernier fine adjusting slider.
4. Note the position where the slit is stationary for some moment.
5. Using telescope fine adjusting slider, make coincide the slit with cross wire.

Performing Real Lab:

1. Rotate the prism table so that the light from the collimator falling on one of the face of the prism and emerges through the other face.
2. The telescope is turned to view the refracted image of the slit on the other face.
3. The vernier table is slowly turned in such a direction that the image of slit is move directed towards the directed ray; ie., in the direction of decreasing angle of deviation.
4. It will be found that at a certain position, the image is stationary for some moment. Vernier table is fixed at the position where the image remains stationary.
5. Note the readings on main scale and vernier scale.
6. Carefully remove the prism from the prism table.
7. Turn the telescope parallel to collimator, and note the direct ray readings.

8. Find the difference between the direct ray readings and deviated readings. This angle is called angle of minimum deviation (D).

To determine the Resolving power of prism :

1. Rotate the vernier table so as to fall the light from the collimator to one face of the prism and emerged through another face. (refer the given figure).
2. The emerged ray has different colors.
3. Turn the telescope to each color, and note the readings for different colors.
4. Remove the prism, hence note direct ray reading.
5. Find the angle of minimum deviation for different color.(Say ,violet, blue, green, yellow).
6. Find the refractive index for these colors. Using equation (3).
7. Resolving power for yellow and blue

$$\omega = \frac{nb - ny}{n-1}$$

Where n_b and n_y are the refractive index of blue and yellow, and $n = \frac{nb+ny}{2}$

Line	Vernier	Refracted ray readings	Direct readings	Difference (Minimum Deviation)	Mean D	n
	V_1					
	V_2					
	V_1					
	V_2					
	V_1					
	V_2					
	V_1					
	V_2					

Refractive index for the line ________ n1 =
Refractive index for the line ________ n2 =
Average refractive index $n = \frac{n1+n2}{2}$
Resolving power for ______ and ______ line = $\omega = \frac{n2-n1}{n-1}$

Result:
Angle of the Prism =……………………………….Degrees
Angle of minimum deviation of the prism =……………………………….Degrees
Refractive index of the material of the prism =……………………………….
Dispersive power of the prism =……………………………….

SPECTROMETER – DETERMINATION OF CAUCHY'S CONSTANT

Aim:

To determine the value of Cauchy constants of a material of a prism

Apparatus Required:

Spectrometer, Prism, Mercury vapour lamp.

Formula

The refractive index n of the material of the prism for a wavelength λ is given by.

$$n = A + \frac{B}{\lambda^2}$$

Where A and B are called Cauchy's constants for the prism.
If the refractive indices n1 and n2 for any two known wavelength λ1 and λ2 are determined by a spectrometer, the Cauchy's constants A and B can be calculated from the above equation.

Procedure:

Preliminary adjustments:

1. Focus Telescope on distant object.
2. When focus is correct, start button is activated. Then click Start button.
3. Switch on the light by clicking Switch On Light button.
4. Focus the slit using Slit focus slider.
5. Adjust the slit width using Slit width slider.
6. Coincide the slit with cross wire in the telescope.

<u>Performing Real Lab:</u>

1. Turn the telescope towards the white wall or screen and looking through eye-piece, adjust its position till the cross wires are clearly seen.
2. Turn the telescope towards window, focus the telescope to a long distant object.
3. Place the telescope parallel to collimator.
4. Place the collimator directed towards sodium vapor lamb. Switch on the lamp.
5. Focus collimator slit using collimator focusing adjustment.
6. Adjust the collimator slit width.
7. Place prism table, note that the surface of the table is just below the level of telescope and collimator.
8. Place spirit level on prism table. Adjust the base leveling screw till the bubble come at the centre of spirit level.
9. Clamp the prism holder.
10. Clamp the prism in which the sharp edge is facing towards the collimator, and base of the prism is at the clamp.

<u>Least Count of Spectrometer :</u>

One main scale division (N) =................minute

Number of divisions on vernier (v) = ...

L.C $= \frac{N}{V} =$ ....minute

To determine the angle of the Prism:

1. Prism table is rotated in which the sharp edge of the prism is facing towards the collimator.

2. Rotate the telescope in one direction up to which the reflected ray is shown through the telescope.
3. Note corresponding main scale and vernier scale reading in both vernier (vernier I and vernier II).
4. Rotate the telescope in opposite direction to view the reflected image of the collimator from the second face of prism.
5. Note corresponding main scale and vernier scale reading in both vernier(vernier I and vernier II).
6. Find the difference between two readings, i.e.θ
7. Angle of prism, A=θ/2

Reading of reflected ray from	Vernier 1			Vernier 2		
	MSR	VSR	Total	MSR	VSR	Total
face 1 (say a)						
face 2 (say b)						
Difference between a & b						

Mean θ =..................Degrees

Angle of prism =..................Degrees

To determine the Cauchy's constants for the prism:

Performing Real Lab

The angle of the prism A and the angle of minimum deviation D for different wave length are determined. From this the refractive index n for these colours are calculated. Taking the value of λ from the mathematical table, the Cauchy's constants A and B are calculated for different pairs of spectral colours using the equation.

The Cauchy's constants can also be determined graphically. A graph is drawn with n along the y-axis and 1/λ2 along x-axis with zero as the origin for both axes. The graph is a straight line. The Y intercept gives A and the slope gives B.

Performing simulator :

1. Rotate the vernier table so as to fall the light from the collimator to one face of the prism and emerged through another face. (refer the given figure).
2. The emerged ray has different colors.
3. Turn the telescope to each color, and note the readings for different colors.
4. Remove the prism, hence note direct ray reading.
5. Find the angle of minimum deviation for different color.(Say ,violet, blue, green, yellow).
6. Find the refractive index for these colors. Using equation (3).
7. Draw the graph with n along the y-axis and 1/λ2 along x-axis with zero as the origin for both axes.

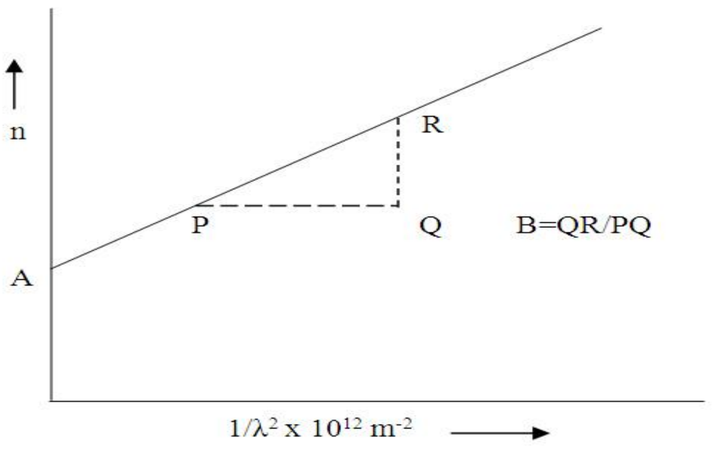
Table (1): To calculate A and B.

Pair of Colors	λ_1 x 10^{-9} m	λ_2 x 10^{-9} m	n_1	n_2	A	B
Yellow1 & Blue						
Green & Violet						

Table (2): To find A and B graphicaly.

Colour	λ x 10^{-9} m	$(1/\lambda^2)$ x 10^{12} m^{-2}	n
Yellow	579.1	2.988	
Green	546.1	3.353	
Blue	435.8	5.265	
Violet 2	404.7	6.103	

Graph:



Result:

Cauchy's constants

A =……………………………

B =…………………………… m2

WAVELENGTH OF LASER USING DIFFRACTION GRATING

Aim:

TO find a wavelength of laser source using diffraction grating.

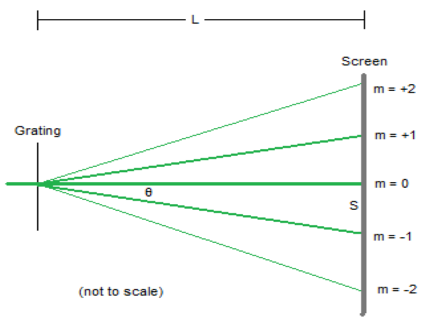
Apparatus required:

Diffraction grating, Laser source, Large screen, Stand with grating mount, metre scale

Formula

$$\text{Sin } \theta_n = Nn\lambda$$

$$\text{Sin } \theta_n = x_n / \sqrt{Xn2 + d2}$$



Procedure:

Laser, grating and a screen are arranged in a line as shown in a figure. Switch on the laser and pass through the grating so that the diffraction pattern can be seen on screen. The pattern consists of bright diffraction bands of orders n = 1,2…etc. On either side of the central spot. For normal incidence, the grating is aligned such that the separation between the central spot to the first order spot on both sides are equal. Adjust the spacing between the grating and the screen d to 0.23 m. Find the distance to the n th order (n=1,2) diffracted spot from the central spot on both sides of it on the screen as x_n. From the mean value of x_n, calculate $\sin\theta_n = x_n / \sqrt{Xn2 + d2}$ for each order. The number of lines per metre of the grating N is also noted. Then the wavelength given by $\lambda = \sin\theta_n / Nn$ is calculated. The experiment is repeated for various distances d= 0.5,0.75 and 1 m and the mean value of wave length is calculated.

Table :

Number of lines per metre on the grating N = ______ lines / m

s.no	Order n	Distance to the diffracted spot from the central spot x_n (m)			$\sin\theta_n = x_n/\sqrt{Xn2 + d2}$	Mean sin θ_n	$\lambda = \sin\theta_n / Nn$ (m)
		Left	Right	Mean			
1 2 3	I						
1 2 3	II						

Result :

Wavelength of the laser light =

MELDE'S APPARATUS

FREQUENCY OF VIBRATOR(TUNING FORK)

Aim:

To determine the frequency of vibrator or tuning fork of Melde's Apparatus by measuring the frequency of 1)transverse vibrations 2)longitudinal vibrations of a string.

Apparatus:

Melde's apparatus of electrically maintained vibrator or tuning fork with a long uniform string, scale pan,weight box etc.

1) TRANSVERSE MODE OF VIBRATIONS

Procedure:

In Melde's apparatus, a long string is attached to one of the prongs of the tuning fork(or vibrator). The other end of the string carrying scale pan is passed over a smooth pulley. The pulley is rigidly fixed to the edge of the table. The electrically maintained tuning fork is placed so that its prong is along the length of the string as shown in Fig28.1 below.

When the circuit is closed, the fork is set into vibration, at right angles to the length of the string. A mass of, say, 5g is placed on the pan. The transverse stationary waves are produced in the string due to the superposition of the traveling wave and reflected wave at the pulley. The length of the string is adjusted to get well defined loop of standing waves. Leaving the loops formed at the ends of the string, total number of loops is counted and total length of the loop is measured using meter scale. The length l of then is calculated. The experiment is repeated by adding the mass into the pan in step of 5g. The mass of entry pan m_p is determined and is added to the mass placed in it. The readings are tabulated as given in table 28.1. The linear density m of string that is, mass per unit length of the string is calculated by knowing the mass of the specimen string 10m in length.

Table 28.1: To determine (M`/ L^2)

Load in scale pan: M g	Total mass M`=(M+m_p)g	Number of loop N	Total length of loops m	Length of one loop l m	(M`/ l^2) kg.m^{-2}

Mean (M`/ l^2) = Kg m^{-2}

Mean $(M`/ l^2)^{1/2}$= Kg m^{-1}

A graph can be drawn connecting M` and $L^2$ as shown in fig 28.2 and the slope (M`/ l^2) can be determined.

M` kg	L^2 m^2

Formula:

In transverse mode of vibration of the string of the loop length L under the tension T, its frequency of vibration is equal to that of vibrating tuning fork. Therefore frequency of the fork

$$n = 1/2l\,[T/m]^{1/2} = 1/2\,[(g/m)(M`/l^2)]^{1/2}$$

where T is the tension in the string = (M+m_p)g =M`g. Here M` is the load including the mass of the pan m_p and g is the acceleration due to gravity.

Observation:

Mass of the scale pan m_p = kg
Mass of 10m of string = kg
Mass per meter of string m = kg m^{-1}
Mean $(M`/l^2)^{1/2}$ 1) by calculation = $kg^{1/2}m^{-1}$

2)by graph = $kg^{1/2}m^{-1}$

Frequency of the fork $n = 1/2[(g/m)(M`/l^2)]^{1/2}$ Hz

Result:

Frequency of tuning fork in transverse mode of vibration of string

1) By calculation = Hz
2) By graph = Hz

2)**LONGITUDINAL MODE OF VIBRATIONS:**

Procedure:

In the longitudinal mode, the fork vibrates in a direction parallel to the length of the string. The experiment is performed as in the case of transverse mode of vibrations. Observations are tabulated for various tensions. The table is identical to the table 28.1 which is already given. Here it should be noted that for same tension, the length of one loop is twice as that for transverse mode. Experiment is also repeated to find the relative density of the given solid and liquid.

Table 28.2: To determine $(M`/ L^2)$

Load in scale pan: M g	Total mass $M`=(M+m_p)g$	Number of loop N	Total length of loops m	Length of one loop l m	$(M`/ l^2)$ $kg.m^{-2}$

Formula:

In longitudinal mode, each and every point of the string makes one complete oscillation during which of fork completes two oscillations.Therefore,

Frequency of the fork $n = [(g/m)(M`/l^2)]^{1/2}$

As in the case of transverse mode, using the same formulae, the relative densities of solid and liquid are determined.

Observation:

Mass of the scale pan m_p = kg
Mass of 10m of string = kg
Mass per meter of string m = $kg\ m^{-1}$
Mean $(M`/l^2)^{1/2}$ 1) by calculation = $kg^{1/2}m^{-1}$
2)by graph = $kg^{1/2}m^{-1}$

Frequency of the fork $n = [(g/m)(M`/l^2)]^{1/2}$ Hz

Result:

Frequency of tuning fork in longitudinal mode of vibration of string

1) By calculation = Hz
2) By graph = Hz

LISSAJOUS FIGURES

Aim:

To use Lissajous figures to take phase measurements.

Apparatus:

General purpose oscilloscope (10MHz) , Function generators (1 Hz to 1 MHz) ,Digital multimeter.

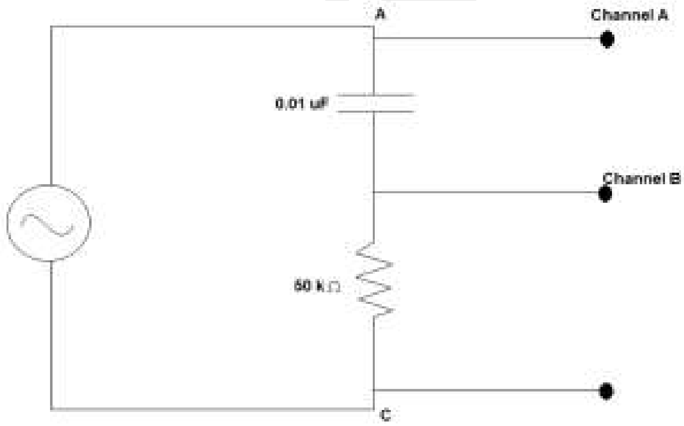
Theory:

A lissajous figure is produced by taking two sine waves and displaying them at right angles to each other. This easily done on an oscilloscope in XY mode. If the oscilloscope has the x-versus-y capability, one can apply one signal to the vertical deflection plates while applying a second signal to the horizontal deflection plates. The horizontal sweep section is automatically disengaged at this time. The resulting waveform is called Lissajous figure. This mode can be used to measure phase or frequency relationships between two signals.

Procedure:

1. The circuit was connected as in Figure 3.8.

2. The frequency of Ein was set at 1 kHz. R was set at 0 Ω. The signal voltage was set at 4 V peak-to-peak. The display was centered. R was changed to 10 kΩ and the pattern in was recorded in Table 3.3. The measured and calculated values was recorded in Table 3.3, for different values of R.



Observation:

S NO	X	Y	$\emptyset = \sin^{-1}(Y/X)$

Result:

The phase difference of lissajoue's figure =