ENGINEERING PHYSICS

PHYSICS LAB MANUAL

EN14103(P)

LIST OF EXPERIMENTS

SINI P P

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AP in Physics

EXPERIMENT No. - 1

GRATING - NORMAL INCIDENCE - SPECTROMETER

AIM

To standardise the grating using the green line of the mercury spectrum and hence to determine the wavelength of the other prominent lines of mercury spectrum by the normal incidence method.

APPARATUS

Spectrometer, the given grating, mercury vapour lamp, etc.

PRINCIPLE

At normal incidence,

$\sin\theta = N n \lambda$ Where,

θ = the angle of diffraction,

N = the number of lines per metre of the grating

n = the order of the spectrum

and λ = the wave length of light used in metre.

If λ of green line is known, N can be calculated, ie the grating can be standardised.

$$N = \frac{\sin\theta_1}{n\lambda}$$

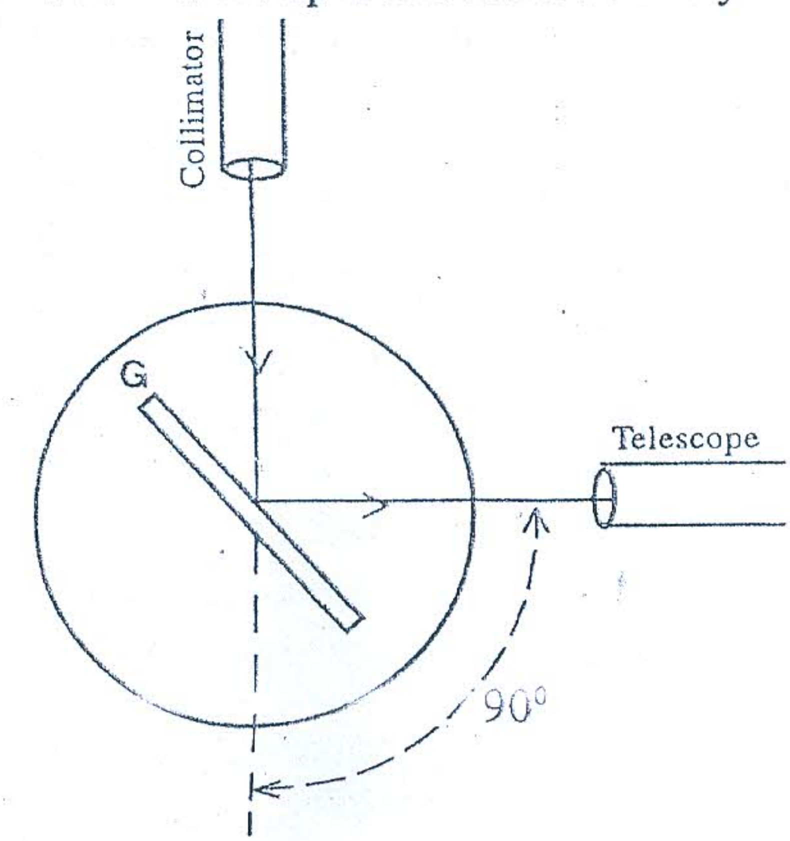
Having found the value of N, the wave lengths of the other prominent lines can be determined using the formula,

$$\lambda = \frac{\sin\theta}{Nn}$$

PROCEDURE

i) To arrange the grating for normal incidence

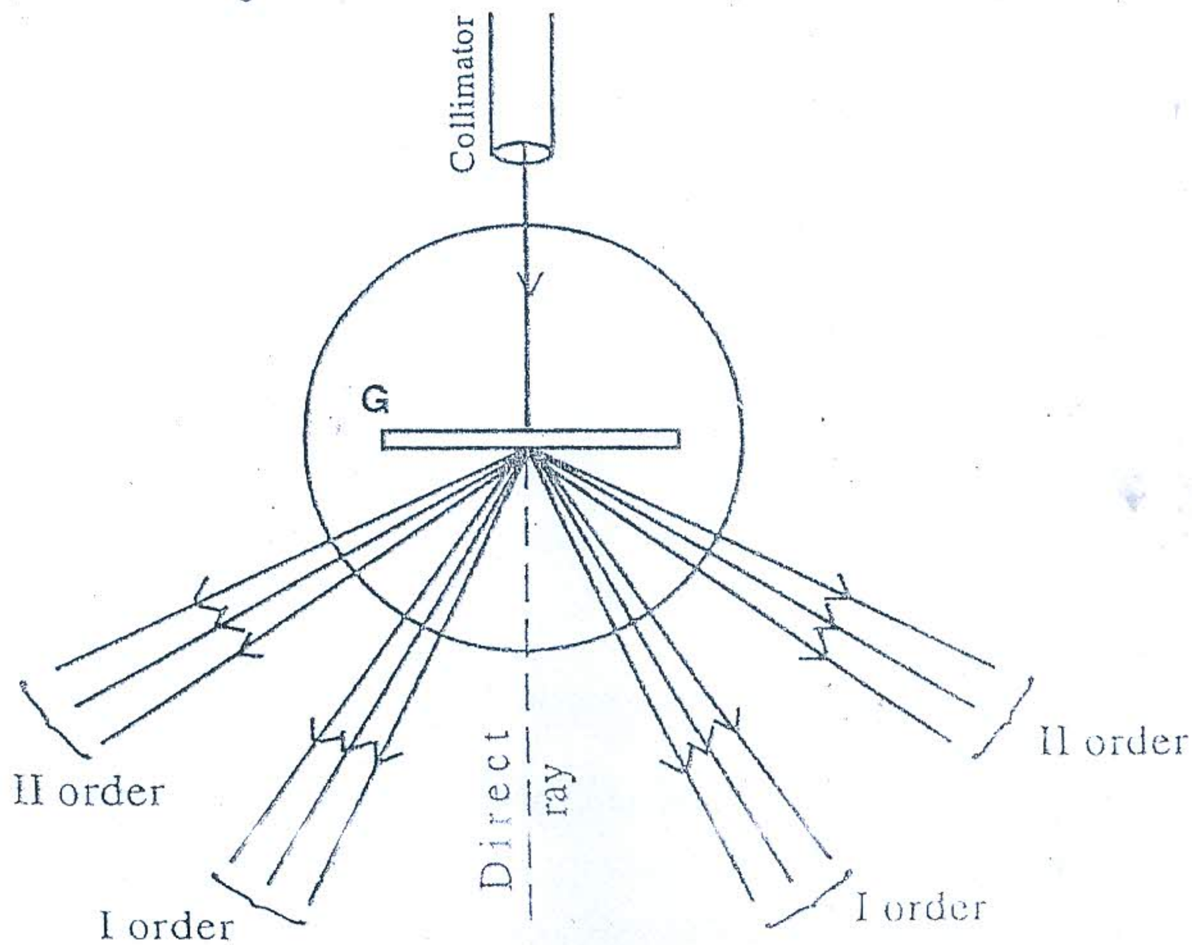
The preliminary adjustments of the spectrometer are made. The slit is made narrow. The telescope is brought in line with the collimator. The telescope is adjusted so that the point of intersection of the cross-wires coincides with the fixed edge of the image of the slit. The telescope is then clamped. The vernier table is unclamped and adjusted so that the reading of vernier I is 0^0 and the reading of vernier II is 180^0. The vernier table is then clamped. The telescope is then unclamped and rotated exactly through 90^0 and then clamped. The grating is then mounted on the grating table, with it's ruled surface facing the collimator. The grating table alone is rotated so that the reflected image of the slit coincides with the point of intersection of the cross-wires. The reflected image will be white in colour. (There may be two reflected images. The brighter one is chosen.) Now the angle of incidence is 45^0. The vernier table is now unclamped and rotated exactly through



45° in such a direction that the ruled surface of the grating faces the collimator. The vernier table is then clamped. The grating is now in the normal incidence position.

II) TO STANDARDISE THE GRATING

The telescope is unclamped and brought in line with the collimator. The direct image of the slit (white in colour) is observed. From this position, the telescope is slowly rotated towards left. The first order spectrum of mercury light is observed. The telescope is adjusted so that the cross-wire coincides with the green line. The readings of vernier I and vernier II are noted. The telescope is then rotated to the right of the direct image and adjusted so that the cross-wire coincides with the green line of the first order spectrum in the right. The readings of vernier I and vernier II are noted. The difference in readings of the corresponding verniers on the left and the right sides is determined. The average value of the difference gives 2θ. Then the angle of diffraction for the first order green line, θ_g is found. Assuming the wavelength of green line,



λ_g, the number of rulings per metre, N, of the grating is calculated using the formula, $N = \frac{\sin\theta_g}{n\lambda_g}$ where n=1 for first order image

This is repeated for the green line of the second order (n=2) and the mean value of N is calculated.

iii) To determine the wavelengths of the other lines

The angles of diffraction for the different lines in the first order spectrum are determined as before. Then, the corresponding wavelengths are calculated using the formula,

$$\lambda = \frac{\sin\theta}{Nn} \qquad \text{where n=1 for first order.}$$

The experiment is repeated for the second order spectrum (n=2) also. The mean wave lengths of different lines are found.

OBSERVATIONS

i) Adjustments for normal incidence

	Vernier I	Vernier II
Direct reading	-	-
Reading after the telescope is turned through 90^0	-	-
Reading after rotating the vernier table through 45^0	-	-

2) To standardise the grating To find N

Value of 1 msd = ... degree

= .... minutes

No. of divisions on the vernier n = ...

Least count (LC of the vernier) $= \frac{1\text{msd}}{n}$ = ...

= .... minutes

Total reading = Main Scale Reading + (Vernier Scale Reading x LC)

Wavelength of mercury green, $\lambda_g = 5461 \times 10^{-10}$ m

Order n	Vernier	Diffracted reading						Difference $2\theta_g$	Mean θ_g	$N = \frac{\sin\theta_g}{n\lambda}$
		Left			Right					
		MSR	VSR	Total	MSR	VSR	Total			
1	V_1									
	V_2									
2	V_1									
	V_2									

Mean N = ... /m

3) Determination of wavelengths

Order n	Line	Vernier	Diffracted reading						Difference 2θ	Mean θ	$\lambda = \frac{\sin\theta}{nN}$
			Left			Right					
			MSR	VSR	Total	MSR	VSR	Total			
1	violet	V_1									
		V_2									
	Blue	V_1									
		V_2									
	Blue-green	V_1									
		V_2									
	Yellow II	V_1									
		V_2									
	yellow I	V_1									
		V_2									

RESULT

The wavelengths of the prominent lines of the mercury spectrum are given in the tabular column.

NOTE

a) The wavelength in nanometer = wavelength in metre x 10^9 because $1m=10^9$ nm. The wave length of Hg. green,

$$\lambda_g = 5461 \times 10^{-10} \text{ m} = 546.1 \text{ nm}$$

b) The grating can be standardised, ie, the number of lines / metre, N can be found using sodium light also; For this, the grating is adjusted in the normal incidence position using sodium light. The angle of diffraction 'θ' for the first order (n=1) is determined. Then, assuming the wavelength of sodium light, λ, the value of N is calculated using the formula,

$$N = \frac{\sin\theta}{n\lambda}$$

$$n = 1$$

$$\lambda = 5893 \times 10^{-10} \text{ m}$$

The angle of diffraction for the second order (n=2) also is measured and N is calculated. Then mean value of N found.

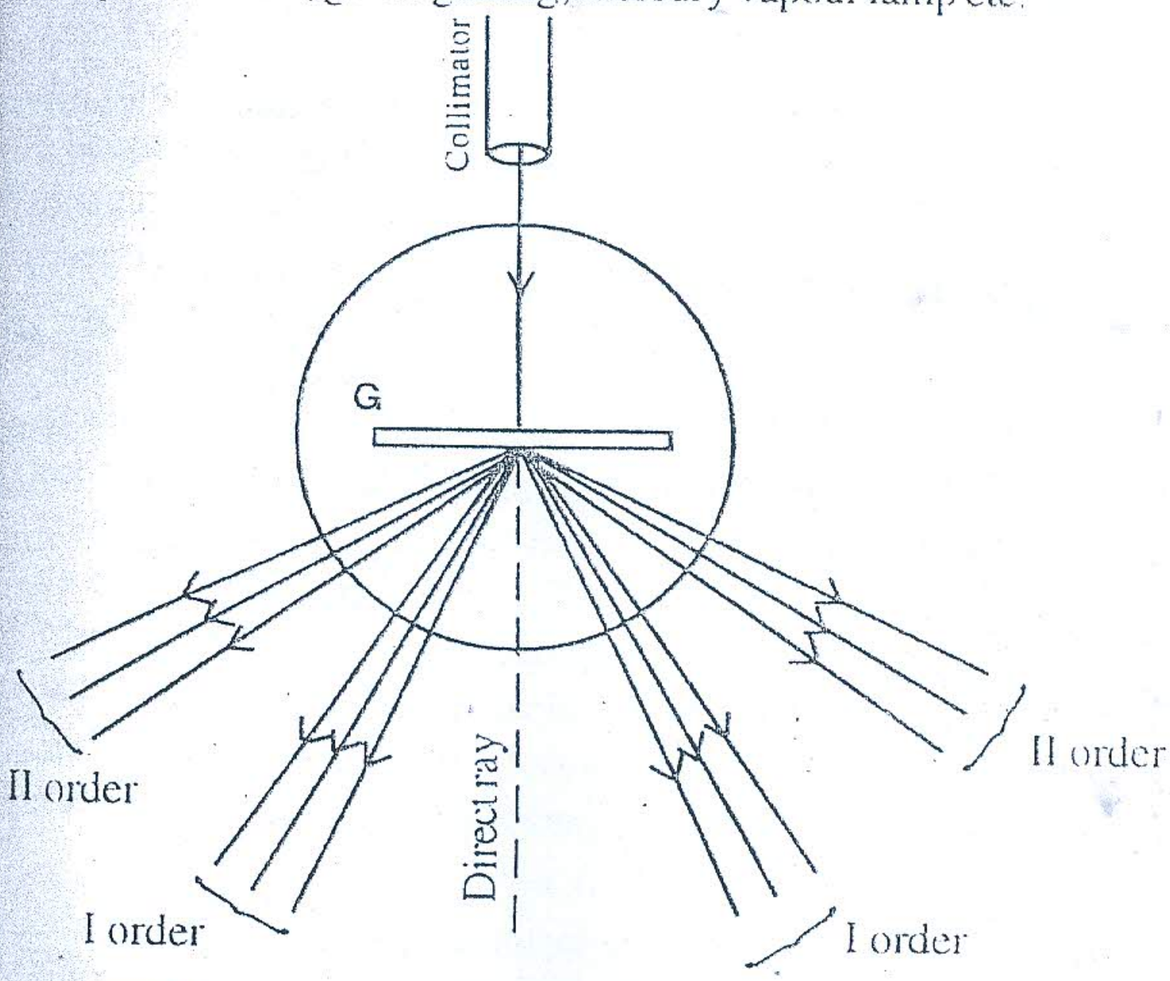
DISPERSIVE POWER OF GRATING - SPECTROMETER

AIM:

To determine the dispersive of a plane transmission grating arranged for normal incidence.

APPARATUS:

Spectrometer, given grating, mercury vapour lamp etc.



PRINCIPLE

The dispersive power of a grating is the ratio of change in angle of diffraction to the corresponding change in wavelength of any two neighbouring lines. Let 2 wavelengths λ and $\lambda + d\lambda$ be diffracted through θ and $\theta + d\theta$.

Dispersive power of grating $= \dfrac{d\theta}{d\lambda}$

For a grating, for normal incidence

$$\sin\theta = Nn\lambda \quad \text{..................(1)}$$

where θ *is the angle of diffraction, n is the order of spectrum, N is the number of lines per unit length and* λ *is the wavelength of light*

Differentiating $\cos\theta\, d\theta = Nn d\lambda$

$$\therefore \frac{d\theta}{d\lambda} = \frac{Nn}{\cos\theta} \quad \text{..................(2)}$$

PROCEDURE

The preliminary adjustments of the spectrometer ie eye-piece adjustment, telescope adjustment and collimator adjustment are done. The spectrometer is now set up for normal incidence of light from a mercury lamp. Telescope is brought in a line with the collimator to observe the direct image. Now it is turned to either side of the direct image to observe the diffracted spectrum in the first order. The vertical cross wire is adjusted to coincide with the lines, violet I, violet II, green, yellow I and yellow II successively on the left side. The readings for each line both in vernier I and vernier II are noted. Now the telescope is turned to the right side of the direct image and vertical cross wire is adjusted to coincide with the lines successively. The readings for each line in both the verniers are taken. The difference between the readings in corresponding verniers on the left and the right side gives 2θ. Mean angle of diffraction θ for each line is calculated. Grating is standardised as follows.

For a grating, $\sin\theta = Nn\lambda$.

For first order (n = 1), knowing wavelength of green line ($\lambda_g = 5460 \times 10^{-10}$m), the number of lines per metre of the grating (N) is calculated from $N = \dfrac{\sin\theta_g}{n\lambda_g}$ where θ_g is the angle of diffraction.

Wavelength for each line is calculated from the above equation Sin

$\theta = Nn\lambda$. Dispersive power $\frac{d\theta}{d\lambda}$ for violet region is calculated as follows θ_1 is the angle of diffraction for violet I whose wavelength is λ_1. Similarly θ_2 is the angle of diffraction for violet II whose wavelength is λ_2.

$$d\theta = \theta_1 \sim \theta_2 \text{ and } d\lambda = \lambda_1 \sim \lambda_2.$$

$\frac{d\theta}{d\lambda}$ is determined.

Mean angle of diffraction $\theta = \frac{\theta_1 + \theta_2}{2}$ is calculated. Dispersive power is also found using $\frac{Nn}{\text{Cos}\theta}$. The mean value is calculated. Similarly dispersive power is also found for the pair yellow I and yellow II lines, pair of Blue and green etc. The experiment is repeated for the second order spectrum also.

OBSERVATIONS

Adjustment for normal incidence

	Vernier I	Vernier II
Direct Reading	....	....
Reading when telescope is turned through 90^0	....	....
Reading when vernier table is turned through 45^0	....	....

To find the least count (*l*.c)

Value of 1 main scale division = ...minute

No: of vernier scale division n = ...

$$\text{Least Count (L.C)} = \frac{1\,msd}{n}$$

$$= \text{..................minute}$$

Total reading = Main Scale Reading + (Vernier Scale Reading x LC)

To determine wavelength of lines

Order n	Line	Vernier	Diffracted reading						Difference 2θ	Mean θ	$\lambda = \frac{\sin\theta}{nN}$
			Left			Right					
			MSR	VSR	Total	MSR	VSR	Total			
	Violet I	V_1									
		V_2									
	Violet II	V_1									
		V_2									
	Blue	V_1									
		V_2									
	Greenish Blue	V_1									
		V_2									
	Green	V_1									
		V_2									
	Yellow I	V_1									
		V_2									
	Yellow II	V_1									
		V_2									

To calibrate the grating

Wavelength of green $\lambda_g = 5460 \times 10^{-10}$ m

Angle of diffraction θ_g = ...

Order of the spectrum n = 1

$$\therefore \text{Number of lines / m, N} = \frac{\sin\theta_g}{n\lambda_g}$$

= ....

Dispersive power of grating for violet region

Number of lines/m, N = ...

Order of sepctrum, n = ...

For Violet I

Angle of diffraction θ_1 = ...

Wavelength λ_1 = ...

For Violet II

Angle of diffraction θ_2 = ...

Wavelength λ_2 = ...

$\therefore d\theta = \theta_1 \sim \theta_2 =$ ....

$d\lambda = \lambda_1 \sim \lambda_2 =$ ....

$$\therefore \text{Dispersive power } \frac{d\theta}{d\lambda} = \text{........................degree/m}$$

$$\text{Mean angle of diffraction } \theta = \frac{\theta_1 + \theta_2}{2}$$

= ....

$$\therefore \text{Dispersive power } \frac{Nn}{\cos\theta} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$\therefore \text{Mean Dispersive power} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

Dispersive power for yellow region

For Yellow I

Angle of diffraction θ_1 =.........................

Wavelength λ_1 =.........................

For Yellow II

Angle of diffraction θ_2 = ...

Wavelength λ_2= ....

$\therefore d\theta = \theta_1 \sim \theta_2 =$ ....

$d\lambda = \lambda_1 \sim \lambda_2 =$ ....

$$\therefore \text{Dispersive power } \frac{d\theta}{d\lambda} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{degree/m}$$

$$\text{Mean angle of diffraction } \theta = \frac{\theta_1 + \theta_2}{2}$$

$$= \ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$\therefore \text{Dispersive power } \frac{Nn}{\cos\theta} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{degree/m}$$

$$\therefore \text{Mean Dispersive power} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{degree/m}$$

Result

1. Mean dispersive power of grating in Violet region = ...degree/m
2. Mean dispersive power of grating in Yellow region ...degree/m

3

Experiment 3

RESOLVING POWER OF GRATING

AIM

To determine the resolving power of a plane transmission grating using spectrometer arranged for normal incidence.

APPARATUS

Spectrometer, given grating, mercury vapour lamp etc.

PRINCIPLE

Resolving power of a grating is its ability to show two neghbouring spectral lines in a spectrum as separate. *If λ and $\lambda+d\lambda$ are wavelengths of two neighbouring spectral lines, the resolving power of the grating is the ratio* $\frac{\lambda}{d\lambda}$.

By Rayleigh's criterion for resolution, when the two spectral lines are just resolved.

Resolving power of grating $\frac{\lambda}{d\lambda} = nN_1$ where n is the order of spectrum and N_1 is the total number of lines in the given grating.

If b is the mean width of an adjustable slit for the positions of just resolution and just unresolution,

then resolving power $\frac{\lambda}{d\lambda} = bnN$ where n is the order of spectrum and N is the number of lines per unit length of grating.

PROCEDURE

The preliminary adjustments of the spectrometer ie eye-piece adjustment, telescope adjustment and collimator adjustment are done. The spectrometer is now set up for normal incidence of light from a mercury lamp. Telescope is brought in a line with the collimator to observe the direct image. Now it is turned to either side of the direct image to observe the diffracted spectrum in the first order. The vertical cross wire is adjusted to coincide with the lines green, yellow I and yellow II successively on the left side. The readings for each line both in vernier I and vernier II are noted. Now the telescope is turned to the right side of the direct image and vertical cross wire is adjusted to coincide with the lines successively. The readings for each line in both the verniers are taken. The difference between the readings in corresponding verniers on the left and the right side gives 2θ . Mean angle of diffraction θ for each line is calculated. Grating is standardised as follows. For a grating, Sin θ = Nn λ . For first order (n = 1), knowing wavelength of green line ($\lambda_g = 5460 \times 10^{-10}$m), the number of lines per metre of the grating (N) is calculated from

$N = \frac{\sin \theta_g}{n\lambda_g}$ where θ_g is the angle of diffraction. Wavelength for

each line is calculated from the above equation. Sin θ = Nn λ .

Now a rectangular adjustable slit provided is placed vertically in between the lens and the screen using a stand. Telescope is rotated to the left side of the direct image to observe the diffracted Yellow I and Yellow II lines of the first order. Looking through the telescope, the width of the adjustable slit is slowly reduced by operating its adjustable screw until the two yellow lines come closer and closer and finally merge together as a single line. Now the two lines are just unresolved. The slit is taken and is focussed using a vernier microscope. Its width is measured correctly by making the vertical cross-wire of the microscope coinciding with its left and right edges.

The slit is again replaced in its position and looking through the telescope, the width is slowly increased until the two yellow lines get separated. This is the condition for just resolution. The slit is taken and its width at this resolution condition is again determined accurately as above. The mean width of the slit (b) is calculated. This is repeated for the lines on the right side also. Knowing this mean width, resolving power can be calculated. This is repeated for second order spectrum.

OBSERVATIONS

1. Adjustment for normal incidence

	Vernier I	Vernier II
Direct Reading	....	....
Reading when telescope is turned through 90^0	....	....
Reading when vernier table is turned through 45^0	....	....

2. To find the least count (*l*.c)

Value of 1 main scale division = ...minute

No: of vernier scale division n = ...

$$\text{Least Count (L.C)} = \frac{1\,\text{msd}}{n}$$

$$= \text{..................minute}$$

Total reading = Main Scale Reading + (Vernier Scale Reading x LC)

3. To calibrate the grating

Wavelength of green $\lambda_g = 5460 \times 10^{-10}$ m

Angle of diffraction θ_g = ...

Order of the spectrum n = 1

$$\therefore \text{Number of lines / m, } N = \frac{\sin \theta_g}{n\lambda_g}$$

$$= \text{.........................}$$

4. To determine wavelength of lines

Order n	Line	Vernier	Diffracted reading						Difference 2θ	Mean θ	$\lambda = \frac{\sin\theta}{nN}$
			Left			Right					
			MSR	VSR	Total	MSR	VSR	Total			
	Green	V_1									
		V_2									
	Yellow I	V_1									
		V_2									
	Yellow II	V_1									
		V_2									

5. To calculate resolving power of grating

Wavelength of yellow I, $\lambda_1 =$ .... Å

Wavelength of Yellow II, $\lambda_2 =$ .... Å

$\therefore$ Mean wavelength $\lambda = \dfrac{\lambda_1 + \lambda_2}{2} =$ .... Å

Change in wavelength $d\lambda = \lambda_2 \sim \lambda_1 =$ .... Å

$\therefore$ Resolving power $\dfrac{\lambda}{d\lambda} =$ ....

Number of lines / metre N = ...

Length of grating $l =$ ....m.

Total number of lines in grating $N_1 = n l =$ ....

Order of the spectrum $n =$ ....

$\therefore$ Resolving power $= nN_1 =$ ....

MICROSCOPE READING TO FIND WIDTH OF SLIT 'b'

Value of 1 main scale division = ...cms

Number of vernier scale division n = ...

$$\therefore \text{ Least count} = \frac{1\text{ msd}}{n} = \text{......................cms}$$

Position of telescope	Reading of microscope						Difference $R_2 \sim R_1$	Mean width b
	On left edge R_1			On right edge R_2				
	MSR	VSR	MSR VSRxLC	MSR	VSR	MSR VSRxLC		
unresolved position								
resolved position								

Resolving power = bnN= ....

RESULT

Resolving power of the given grating = ...

EXPERIMENT - 4

NEWTONS'S RINGS - RADIUS OF CURVATURE OF CONVEX LENS

AIM

To determine the radius of curvature of a convex lens by Newton's Rings method.

APPARATUS

Newtons' rings apparatus, sodium vapour lamp, vernier microscope, a convex lens of large focal length (about 1 m), etc.

PRINCIPLE

The diameter of the n^{th} dark ring is given by,

$$D_n^2 = 4nR\lambda \quad ......(1)$$

where R is the radius of curvature of the lower surface of the convex lens and λ is the wave length of light used.

The diameter of the $(n+k)^{th}$ dark ring is given by

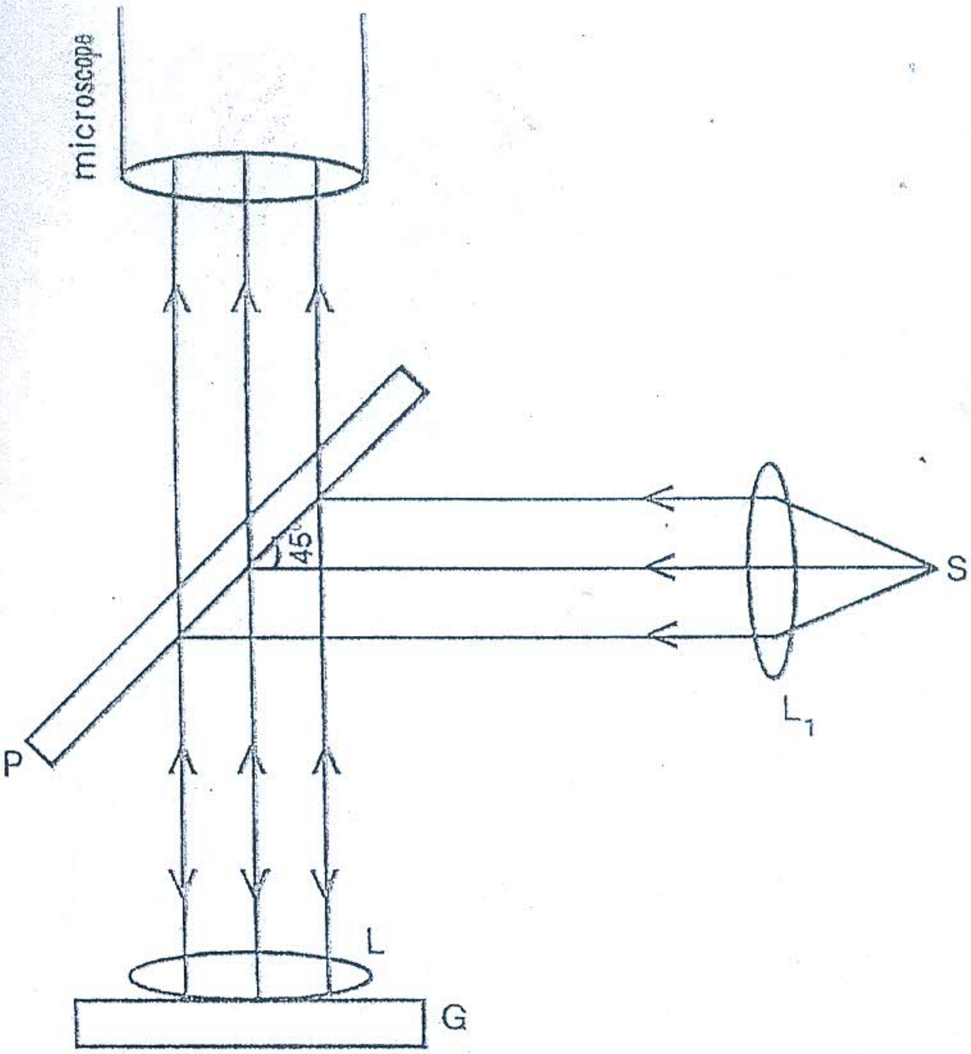
$$D_{n+k}^2 = 4\ (n+k)\ R\lambda \quad ....(2)$$

Then $$D_{n+k}^2 - D_n^2 = 4\ kR\lambda$$

or $$R = \frac{D_{n+k}^2 - D_n^2}{4k\lambda} \quad ....\ (3)$$

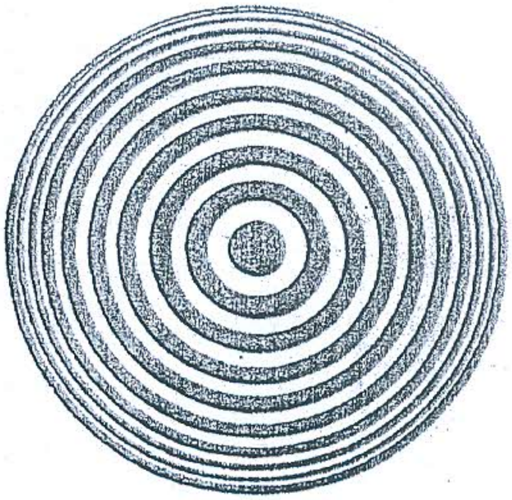
PROCEDURE

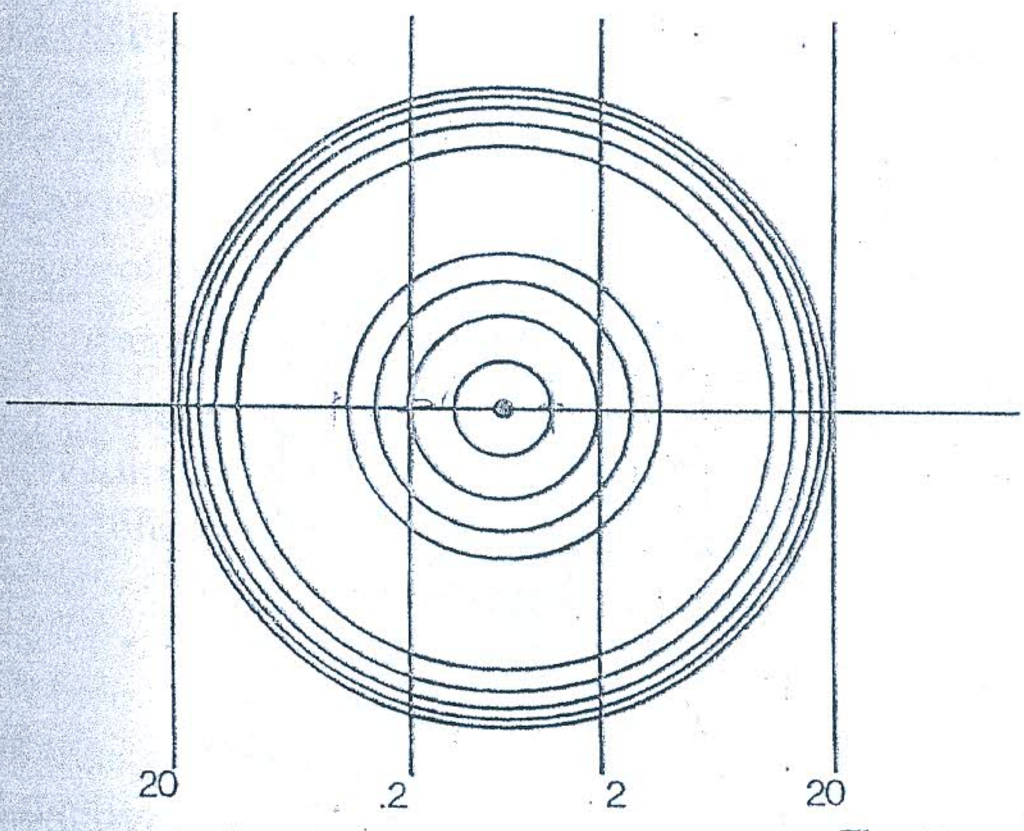
The Newton's rings apparatus consists of an optically plane glass plate 'G' on which a long-focus convex lens L is placed. Above the lens there is a glass plate 'P' inclined at 45° to the horizontal.



Light from a sodium lamp is rendered parallel by a short-focus convex lens L_1. These parallel rays fall on the glass-plate P and get reflected vertically downward and fall on the system of the lens L and the glass plate G. The light reflected from the lower surface of the lens L and the upper surface of the glass plate G interfere and a number of concentric dark and bright rings are formed. These rings are observed through a microscope arranged vertically above the glass-plate P. The microscope is focussed well so that the rings are clearly seen.

The centre of the ring system is dark. Then by working the tangential screw, the point of intersection of the cross-wires is kept at the central dark spot. Then the microscope is moved to the left and to the right in order to ensure that about 25 dark rings are clearly seen.





Newton's rings *Fig. 2*

Then again starting from the central dark spot, the microscope is moved to the left by working the tangential screw so that the cross-wire is tangential to the 22nd dark ring on the left. The tangential screw is then slowly adjusted so that the cross-wire is tangential to the 20th dark ring. The microscope reading on the horizontal scale is taken. Then by working the tangential screw the cross-wire is kept tangential to the 18th, 16th, 14th, etc., dark ring up to the second dark ring on the left and the reading corresponding to each ring is taken. Then, by working the tangential screw, the microscope is moved in the same direction until the cross-wire is tangential to the second dark ring on the right. The corresponding reading is taken. Similarly the cross-wire is kept tangential to the 4^{th}, 6^{th}, 8^{th}, etc. dark rings up to the 20^{th} dark ring on the right. The reading corresponding to each ring is taken. (The tangrential screw should be worked only in one direction from the position of the 20^{th} ring on the left to the position of the 20^{th} ring on the right. This is to avoid back lash error)

The difference in readings on the left and right of each ring gives its diameter D. The value of D^2 is calculated. The values of $D^2_{n+k} - D^2_n$ are calculated, for a value of k = 10. Then the mean value of $(D^2_{n+k} - D^2_n)$ is found.

If the wavelength of sodium light is λ, the radius of curvature of the convex lens for the marked surface can be determined using the equation

$$R = \frac{D^2_{n+k} - D^2_n}{4k\lambda}$$

where $k = 10$

OBSERVATIONS

a) Microscope readings

Value of 1 msd = ... cm

No. of divisions on the vernier n = ...

$$\text{Least count (LC)} = \frac{1\text{msd}}{n} = \ldots\ldots\ldots\ldots$$

= .... cm

Wavelength of monochromatic light λ = 5893 Å

Order of the ring	Microscope reading						Diameter D a ~ b m	D^2	$D^2_{n+k} - D^2_n$
	Left			Right					
	MSR (x) cms	VSR (y)	Total x+(yxLC) (a) cms	MSR cms	VSR	Total (b) cms			
20									
18									
16									
14									
12									
10									
8									
6									
4									
2									

Mean value of $D^2_{n+k} - D^2_n$ = ... m^2

Radius of curvature of the surface of the lens

$$R = \frac{D^2_{n+k} - D^2_n}{4k\lambda}$$

(here k = 10)

= .... m

RESULT

Radius of curvature of the convex lens

R = ... m

Experiment - 5

DIAMETER OF A WIRE BY AIR WEDGE

AIM

To determine the diameter of a thin wire by measuring the width of the interference bands formed by the air wedge arrangement and also the angle of wedge.

APPARATUS

Two optically plane rectangular glass plates, the given wire, sodium vapour lamp, travelling microscope etc.

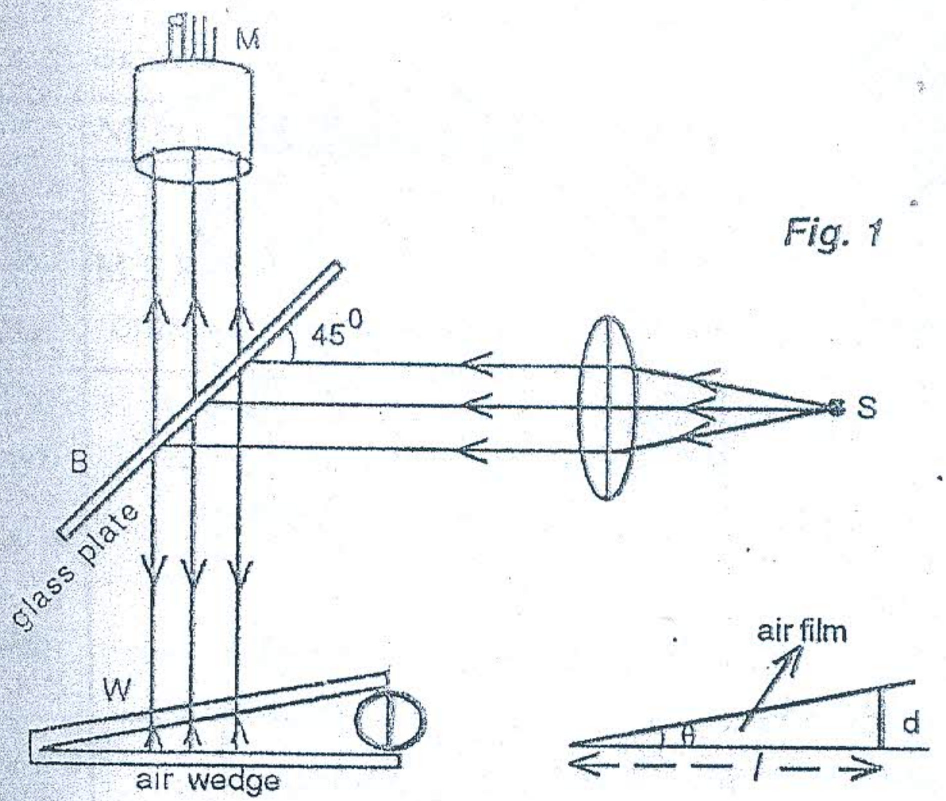
(Air wedge is formed by placing two optically plane glass plates one above the other and keep the wire in between the plates. One end of the plates is held tight by a rubber band so that it becomes the line of contact and put another rubber band loosely on the other end so that it forms the open edge).

THEORY

The diameter of the wire used to form the air wedge is given by $d = \frac{l\lambda}{2\beta}$ where l is the distance of the wire from the edge at which plates are in contact (tight end), λ the wave length of light used and β the band width.

PROCEDURE

Light from the sodium lamp is rendered parallel by a short focus convex lens (lamp should be placed at a large distance) and is allowed to fall on a glass plate inclined at 45^0 to the horizontal (fig 1). Place the air wedge such that light reflected from the glass plate B is incident normally on the air wedge.



Adjust the travelling microscope which is placed vertically above the glass plate B to view clearly the interference bands. (Bands are formed by the light reflected from the top and bottom surfaces of air film enclosed between the two glass plates of air wedge). Using the tangential screw, one of the cross wires is made to coincide with a dark band. Count the number of clear bands obtained (20 or above) so that tangential screw is free to move on either side. Make the cross wire to coincide with a dark band either on extreme right or extreme left and take the reading on the horizontal scale. (Reading = MSR + VSR x L.C). Move the cross wire to n + 2^{th}, n + 4^{th}, ..., n + 18^{th} band and note the microscope readings in each case. From these readings width of 10 bands is calculated (X) and mean band width β is also found $\left(\frac{X}{10}\right)$.

Distance 'l' between the wire and line of contact of the plates is measured. Knowing the wave length of sodium light (589.3 nm) diameter of the wire is calculated.

OBSERVATIONS

Value of 1 main scale division = ...cm

Number of divisions on the vernier n =

L.C. of microscope $= \frac{1 \text{ msd}}{n}$ = ...cms

Number of bands	Microscope readings M.S.R cms	V.S.R	Total = M.S.R + VSR x LC cms	Width of 10 bands X cms	Mean X cms	Band width $\beta = \frac{\text{mean X}}{10}$ cms
n			x_0			
n + 2			x_2			
n + 4			x_4			
n + 6			x_6			
n + 8			x_8			
n + 10			x_{10}	$x_{10} - x_0 =$		
n + 12			x_{12}	$x_{12} - x_2 =$		
n + 14			x_{14}	$x_{14} - x_4 =$		
n + 16			x_{16}	$x_{16} - x_6 =$		
n + 18			x_{18}	$x_{18} - x_8 =$		

Distance of wire from the line of contact of the plates } l = ...cms

Wave length of sodium light = 589.3 nm

Diameter of the wire d $= \frac{\lambda l}{2\beta}$ ....cms

= ....m

Angle of wedge θ $= \frac{\lambda}{2\beta}$ radians

RESULTS:

Diameter of the wire = ...m

Angle of wedge = ... radians

EXPERIMENT 6

ULTRASONICS DIFFRACTOMETER - VELOCITY AND WAVELENGTH OF ULTRASONIC WAVES

AIM

To determine velocity and wavelength of ultrasonics using ultrasonic diffractometer

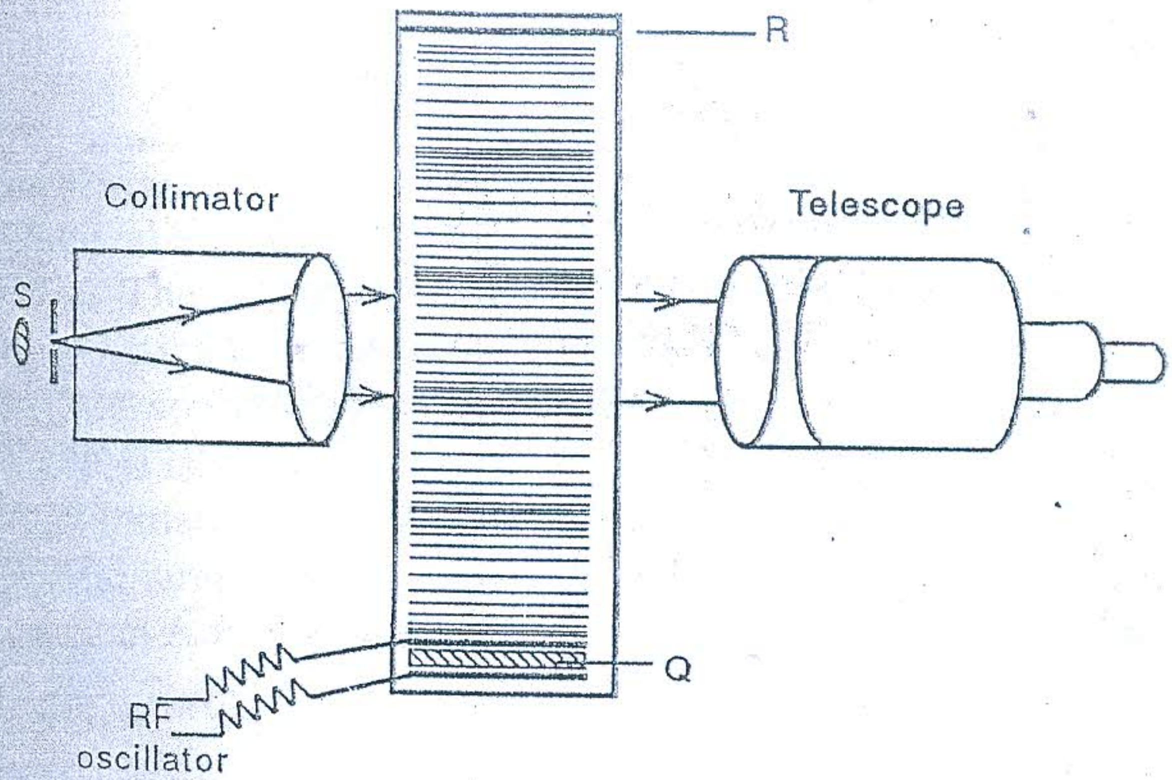
APPARATUS

Quartz crystal (2 to 5 Mega hertz) mounted in between a pair of metal plates, a rectangular optically plane glass vessel (cell), liquid like kerosene or C Cl_4, Spectrometer, A.F. Oscillator etc.

PRINCIPLE

When a quartz crystal Q placed between two metal plates in a liquid is set into vibrations using an A.F. oscillator, ultrasonics are produced. When these ultrasonics are reflected by a reflector, longitudinal stationary waves are produced in the liquid. As a result, alternate nodal planes and antinodal planes are formed. At nodal planes, the layers are crowded together (compressions or condensations) and density is maximum. At antinodal planes, layers are separated (rarefactions) and density is minimum. This set up of nodal planes and antinodal planes behave like slits and opaque spaces of a plane grating. Such an arrangement is called acoustinc grating. Using this acoustic grating, velocity 'V' and wavelength 'λ' of ultrasonics can be determined.

A parallel beam of monochromatic light from a sodium vapour lamp is collimated and is allowed to fall normally on



this acoustic grating. Diffraction takes place and the diffracted beam is observed through the telescope of a spectrometer. On either side of the central maximum various orders of principal maxima are obtained. If θ is the angle of diffraction for a principal maximum, then $d \sin\theta = n\lambda$ ....(1) where 'd' is the distance between two consecutive nodal planes or two consecutive antinodal planes, n is the order of spectrum and λ is the wavelength of monochromatic light. d can be calculated from this grating equation.

But, $d = \frac{\lambda_a}{2}$ .... *or*

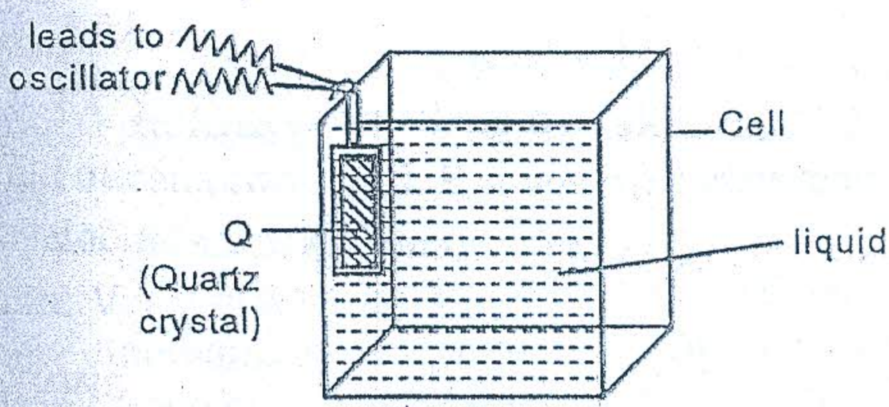
$\lambda_a = 2d$........................(2) where λ_a is the wavelength of ultrasonic wave in the liquid.

But $V = \upsilon\lambda_a$ ....(3) where υ is the frequency of oscillations of the crystal and V is the velocity of ultrasonic wave in the liquid.

DESCRIPTION

Ultrasonic diffractometer mainly consists of a quartz crystal Q placed between two metal plates provided with connecting leads. The quartz crystal set up is clamped inside on one face of an optically plane rectangular glass cell filled with kerosene or CCl_4 so that the crystal is immersed completely in liquid. The cell is placed on the prism table of a spectrometer and it is illuminated by a beam of monochromatic light from a sodium vapour lamp. The quartz crystal can be subjected to vibrations from an A.F. oscillator.

PROCEDURE



The initial adjustments of a spectrometer are made. The rectangular cell containing liquid is placed on the prism table perpendicular to the collimator. The quartz crystal Q together with metal plates and connection leads is clamped inside the liquid on another side of cell. A narrow beam of monochromatic light from collimator is allowed to fall normally on the cell. The direct image is observed through the telescope. Now the A.F. oscillator is switched on and the frequency of A.F. oscillator is varied from 2 to 5 Megahertz. The crystal is subjected to these oscillation and it begins to vibrate in resonance with the oscillator. As a result ultrasonic waves are produced in liquid. These waves get reflected from the opposite side of the cell producing longitudinal stationary waves in the form of compressions and rarefactions. This arrangement behaves like a grating and as a result ultrasonic waves are diffracted. On either side of the central maximum different orders of principal maxima are obtained. The telescope is turned so that the cross-wire coincides with the spectral line of the first order on one side of the central maximum. The main scale reading and vernier scale reading are noted. Now the telescope is turned to the other side so that the cross-wire coincides with the spectral line of first order. Main scale reading and vernier scale reading are noted. From these two sets of readings, 2θ for first order and hence θ are calculated. The distance 'd' between two consecutive nodes or antinodes is found out from the grating equation

$d \sin \theta = n\lambda$ where λ, the wavelength of sodium light is known (5893 $\mathring{A}$). λ_a, the wavelength of ultrasonics in liquid. can be found out from $\lambda_a = 2d$. Knowing the frequency υ of oscillator, velocity V of ultrasonics in liquid is calculated from the equation, $V = \upsilon \lambda_a$

OBSERVATIONS

Value of 1 m s d =...................

Number of Vernier Scale divisions } N =...................

Least count $= \dfrac{1 \text{ m s d}}{N}$

=...................

Frequency of oscillator υ =...................Hertz

Order of the spectrum n =...................

Wavelength of light λ =...................m

<table>
<tr><th rowspan="3">Vernier</th><th colspan="6">Reading of Diffracted Image</th><th rowspan="3">$2\theta = x_1 \sim x_2$</th><th rowspan="3">θ</th><th rowspan="3">$d = \frac{n\lambda}{\sin\theta}$</th></tr>
<tr><th colspan="3">Left</th><th colspan="3">Right</th></tr>
<tr><th>MSR</th><th>VSR</th><th>Total x_1</th><th>MSR</th><th>VSR</th><th>Total x_2</th></tr>
<tr><td>V_1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>V_2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Mean d = ...m

$\therefore$ Wavelength of Ultrasonics in liquid λ_a = 2d

= ....m

Velocity of Ultrasonics in liquid V = $\upsilon\lambda_a$

= ....m/s

RESULTS

1) Wavelength of ultrasonics in liquid λ_a = ...m

2) Velocity of ultrasonics in liquid V =..............m/sec

EXPERIMENT - 7

FREQUENCY OF FORK - MELDE'S STRING

AIM

To determine the frequency of a tuning fork by Melde's arrangement,

(a) using the transverse mode of vibration and

(b) using the longitudinal mode of vibration

APPARATUS

Electrically maintained tuning fork, fine thread, scale pan, weight box, balance etc.

The arrangement consists of an electrically maintained tuning fork. One end of a fine string is attached to one of the prongs of the fork. The other end of the string carrying a scale pan is passed over a pully.

PRINCIPLE

(a) Transverse mode of vibration

The frequency 'n' of the fork is calculated using the formula

$$n = \sqrt{\frac{g}{4m}\left(\frac{M}{l^2}\right)} \quad ....(1)$$

(b) Longitudinal mode of vibration

$$n = \sqrt{\frac{g}{m}\left(\frac{M}{l^2}\right)} \quad ....(2)$$

where

m = linear density of string

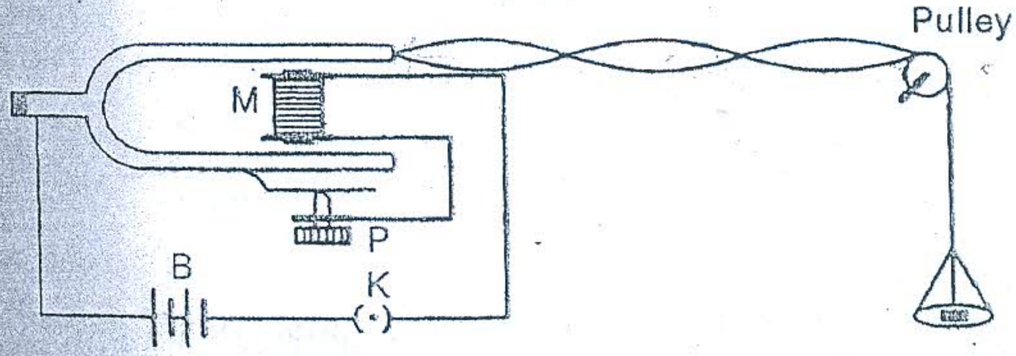
M = total mass at the end of the string

l = average length of one loop

g = acceleration due to gravity

PROCEDURE

(A) Transverse mode of vibration



The mass of the scale pan is determined correct to a milligram. 10 metres of the given string is weighed accurately. Hence its linear density (mass per unit length), 'm' is found.

The electrical connections are made as shown in the diagram. The string is arranged horizontally with its length parallel to the prong of the fork. Here, the fork vibrates in a direction perpendicular to the length of the string.

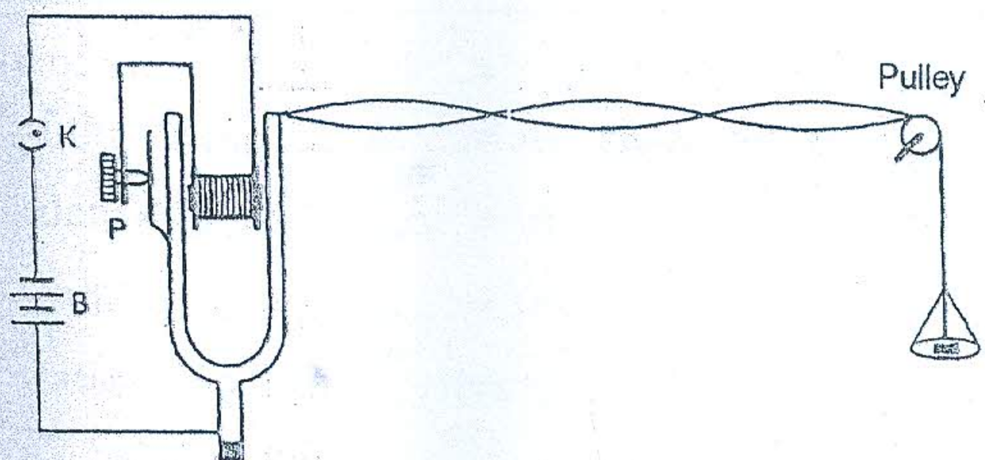
A mass of about 2 or 3 gms is placed in the scale pan. The circuit is closed. The fork vibrates. Transverse stationary waves are formed in the string. The length of the string between the prong and the pulley is carefully adjusted by moving the fork, so that a number of well defined loops are formed in the string. Leaving the loops at the two ends, the lengths of a definite number of loops are measured. Then the average length of a loop is found (l). The total mass M at the end of the string (mass of scale pan + mass placed in the pan) is noted. The value of $\frac{M}{l^2}$ is found.

The experiment is repeated for different masses in the scale pan and the mean value of $\frac{M}{l^2}$ is calculated.

Then the frequency of the fork is calculated using the formula.

$$n = \sqrt{\frac{g}{4m}\left(\frac{M}{l^2}\right)} \text{.......(1)}$$

(B) Longitudinal Mode of Vibration



The apparatus is arranged as shown in the diagram, with the prongs perpendicular to the string. Then the fork vibrates in a direction parallel to the string or string vibration in the longitudinal mode.

The experiment is performed exactly as before for different masses and the mean value of $\frac{M}{l^2}$ is found. Then the frequency of the fork is calculated using the formula.

$$n = \sqrt{\frac{g}{m}\cdot\left(\frac{M}{l^2}\right)} \text{.......(2)}$$

OBSERVATIONS

Load in the pans		Turning points		Resting point	Sensibility $S = \frac{0.01\,gm}{R_1 - R_2}$	Correct wt $= W + S\,(R_1 - R_0)$
Left	Right	Left	Right			
Nil	Nil	-	-	$R_0 =$		
Scalepane	W	-	-	$R_1 =$		
	W+0.01 gm	-	-	$R_2 =$		
10 metre length of string						

Length of the string = ...m

Mass of the string = ...gm = ...kg.

Linear density m = ...kg/m

Mass of the scale pan = ...gm = ...kg

Acceleration due to gravity, $g = 9.8\ ms^{-2}$

A) Transverse Mode

Trial No	Mass in the scale pan in Kg	Total mass including the mass of pan M kg	Number of loops X	Length of X loops L metre	Length of one loop $l = \frac{L}{X}$ m	$\frac{M}{l^2}$
1						
2						
3						
4						
5						

$$\text{Mean } \frac{M}{l^2} = \ldots\ldots\ldots\ldots\ldots$$

Frequency of the fork, $n = \sqrt{\frac{g}{4m} \cdot \frac{M}{l^2}}$

$= \ldots\ldots\ldots\ldots\ldots\ldots$ Hertz

B) Longitudinal Mode

Trial No	Mass in the scale pan in Kg	Total mass including the mass of pan M kg	Number of loops X	Length of X loops L metre	Length of one loop $l = \frac{L}{X}$ m	$\frac{M}{l^2}$
1						
2						
3						
4						
5						

$$\text{Mean } \frac{M}{l^2} = \ldots\ldots\ldots\ldots\ldots$$

The frequency of the fork $n = \sqrt{\frac{g}{m} \cdot \frac{M}{l^2}}$

$= \ldots\ldots\ldots\ldots\ldots$ Hertz

RESULT

The mean frequency of the fork $= \ldots\ldots\ldots\ldots$ Hz

EXPERIMENT 8

CHARACTERISTICS OF ZENER DIODE

AIM

To draw the forward and reverse bias characteristic of Zener diode.

APPARATUS

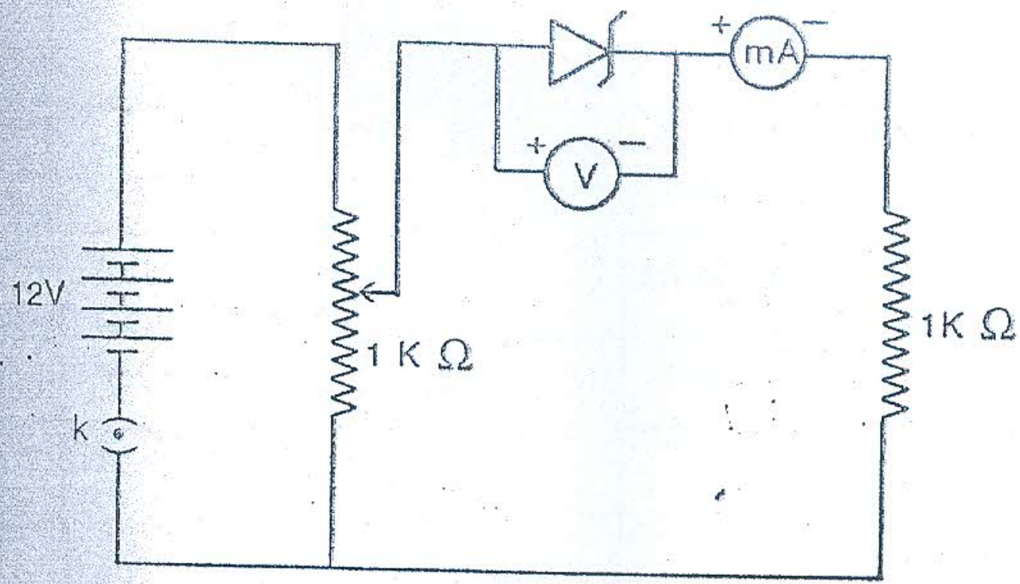
Zener diode (3.6V, 4.1V or 5.6 V), rheostat (1k.ohm)., sensitive milliammeter (0 – 50 mA), Voltmeter (0 – 10V), battery or D.C power-supply (12V), a resistance (1k.ohm $^1/_4$ Watt) etc.

PRINCIPLE

In the forward biased condition Zener diode acts as the normal diode. But in the reverse biased condition, the reverse current shoots up at a particular voltage called zener voltage or break down voltage.

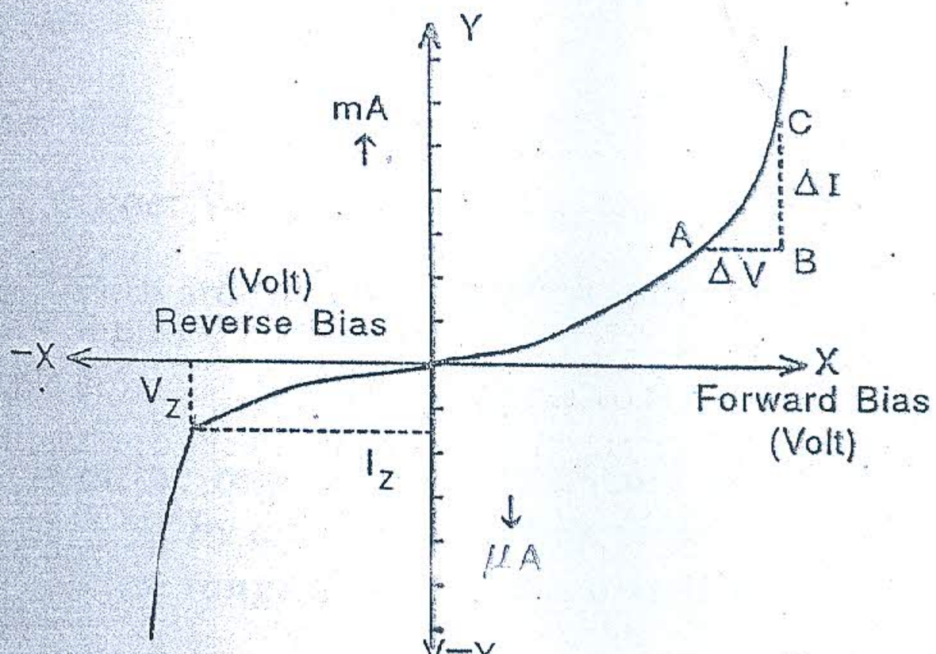
PROCEDURE

Connections are made as shown in the circuit diagram. The zener diode is connected in series with a milliammeter (0–50mA) and a load resistance (1k.ohm) to the potential divider arrangement (12V). A voltmeter (0 – 10V) is connected in parallel with zener diode. Since the anode of the diode is connected to the positive potential point with respect to its cathode, the diode is in the forward biased condition. The potential difference applied to the diode is increased gradually insteps from 0 volt to a maximum using the potential divider arrangement. In each step Voltmeter and Ammeter readings



are noted. Then the forward characteristic is drawn. The reciprocal of the slope of the graph gives the forward resistance.

To obtain the reverse characteristic, the diode alone is reverse connected. The voltage across the diode is increased form zero in equal steps (say 0.4V, 0.8V, 1.2 V etc). The corresponding milliammeter readings are noted. Till the Zener break down occurs the current will be very small (μ A). Then the graph is drawn with reverse voltage on – X axis and reverse current on – Y axis. It is as shown in the figure.



OBSERVATIONS

FORWARD BIAS

Voltmeter Reading V (Volt)	Ammeter Reading I (mA)

REVERSE BIAS

Voltmeter Reading V (Volt)	Ammeter Reading I (μ A)

CALCUATOION

Forward resistance (r_f) = $\frac{\Delta V}{\Delta I} = \frac{1}{SLOPE} = \frac{AB(Volt)}{BC(Amp)}$

(dynamic resistances)

r_f = ...ohms.

Results

1. Zener Voltage = ...Volt
2. Forward (dynamic) resistance = ...ohms

Note

In the reverse biased circuit the milliammeter can be replaced by a suitable and sensitive microammerter (μ A) with the range either 0 - 500 μ A or 0 - 1000 μ A.

Experiment 9

ZENER DIODE - VOLTAGE REGULATION

AIM

To study the voltage regulation characteristic of a Zener diode and to plat its line and load regulation characteristic.

APPARATUS

Zener diode, resistor, rheostat (2kΩ) Voltmeter (0 – 20V) milli-ammeter (0 – 100mA), D.C voltage source (20 Volt).

PRINCIPLE

When a zener diode is operated in the reverse breakdown region in a circuit, the zener voltage (V_Z) remains almost constant irrespective of current through it (I_Z). A series resistor (R_S) is used to limit the zener current to less than its maximum current rating. The current in the series resister (I_S) is given by the relation

$$I_S = I_Z + I_L \text{ ....(1)}$$

when I_L is the current through the load resister (R_L). The values of R_L and R_S are given by the expressions.

$$R_L = \frac{V_0}{I_L} = \frac{V_Z}{I_L} \text{ ....(2)}$$

$$R_S = \frac{V_i(\text{mini}) - V_Z}{I_L(\text{max.})} \text{ ....(3)}$$, where V_i (mini) is the minimum value of input voltage and I_L (max) is the maximum value of current through load resistor.

If V_{NL} and V_{FL} are the output voltages in the absence of load (no load or zero load current ie $I_L = 0$) and in the presence of full load (ie load current I_L in maximum), then percentage voltage regulation is given by the expression.

$$V_R = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100 \quad \ldots\ldots\ldots\ldots\ldots (4)$$

PROCEDURE

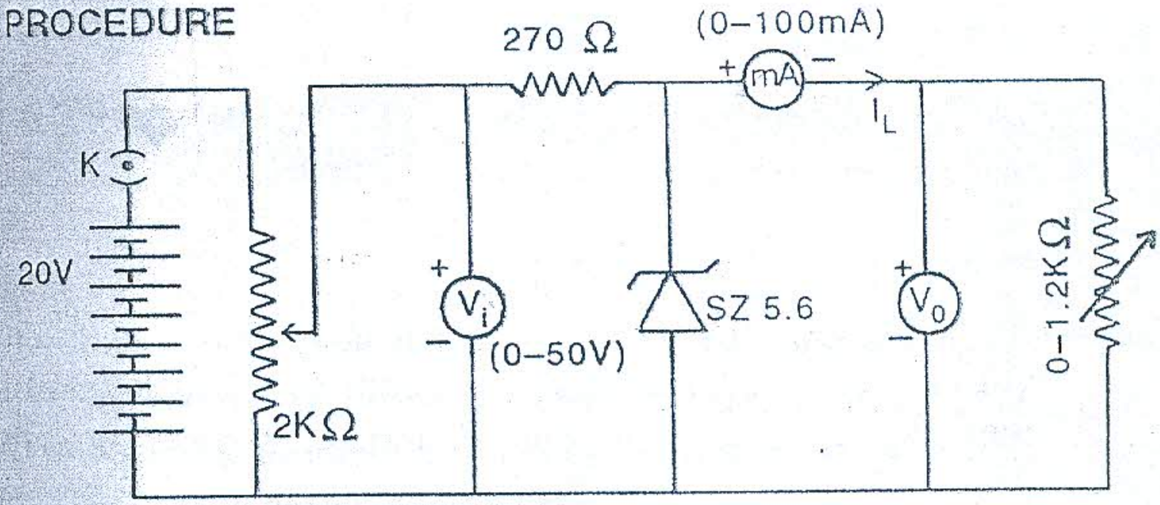


Fig. 1.

The circuit diagram is made as shown in the figure (1). The input voltage (V_i) is adjusted to be 7 Volt. The load resistance is adjusted so that the milli ammeter indicates 10 mA. The load resistance is kept at this value. Now the input voltage is varied from 7 Volts to 10 Volts in equal steps of 1 Volt. Note the corresponding current in each case. Then a graph is plated with V_i along X-axis and V_0 along Y-axis. It is called line regulation graph and in as shown in figure (2).

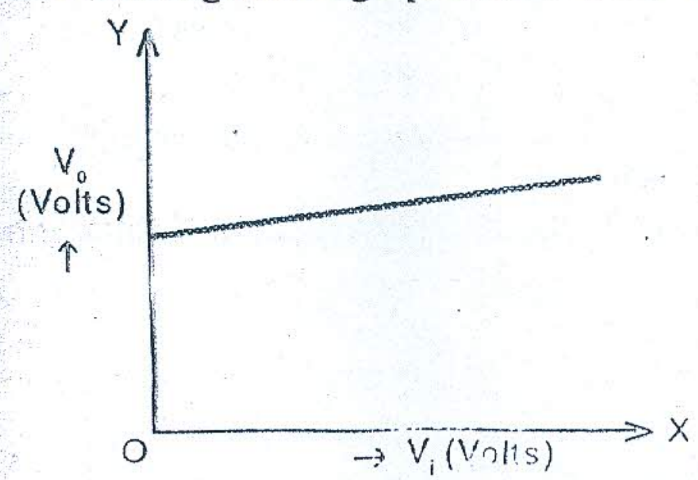


Fig. 2

Again, keep the input voltage constant (say $V_i = 10V$) by adjusting the potential divider in the input supply. The load resistance is varied so that the load current (I_L) increases from 0 to 10mA in equal steps. In each step the output voltage (V_0) is noted. Plot a graph with I_L along X-axis and V_0 along Y-axis. It is called load regulation graph and is as shown in figure (3).

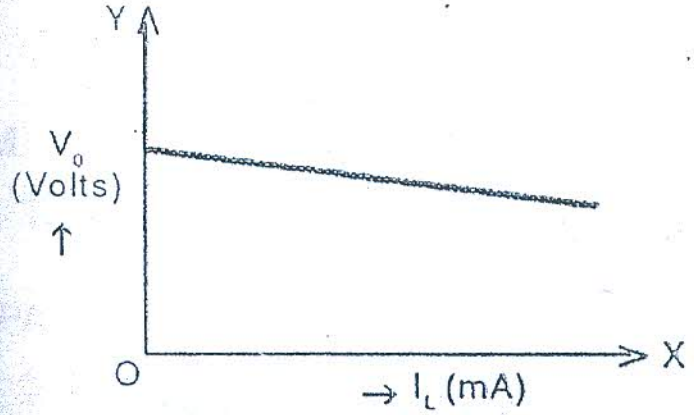


Fig. 3

Mark two points along Y-axis on the load regulation graph to get V_{NL} and V_{FL}. Then percentage voltage regulation of the power supply in calculated.

OBSERVATION

Line regulation

$I_L = 10mA$

V_i (Volts)	V_0 (Volts)

Load regulation

$V_i = 10V$

I_L (mA)	V_0 (Volt)

RESULT

1. Line regulation graph is drawn
2. Load regulation graph drawn
3. % of voltage regulation is found out.

Experiment 10

CHARACTERISTIC OF PHOTO DIODE

AIM

To draw the characteristic of a photo diode.

APPARATUS

2 D.C. power supplys (0 – 10V), and (0 – 30V), Photo diode, ordinary torch bulb (10V, 0.05 or 0.1A), voltmeters (0 – 10V) and (0 – 30V), rheostats (2kΩ and 5 kΩ), sensitive multi ammeter (0 – 10mA), resistors 680 Ohms and 1000ohms. (1kΩ), 2 plug keys (k_1 and k_2).

PRINCIPLE

If the photo diode is forward biased, then the amount of current flowing may be very large and hence additional current due to photo effect may not be dominent. On the other hand, if the junction is reverse biased, the original current is very small. Hence under this condition, if the diode is exposed to light, then an appreciable increase in the reverse current is observed.

PROCEDURE

The circuit is completed as shown in the diagram. The bulb is kept at a suitable distance (say 5cm) from the photo diode. The circuit is closed using the plug keys k_1 and k_2. The reading of the voltmeter across the bulb (V_b) is adjusted to be 2 volt. The reverse voltage of the photo diode (V_R) is varied from O to the maximum value, in steps of 1 volt. In each step, the corresponding current (I_R) is noted. Plot a graph with V_R on X axis and I_R on Y-axis. for V_b =

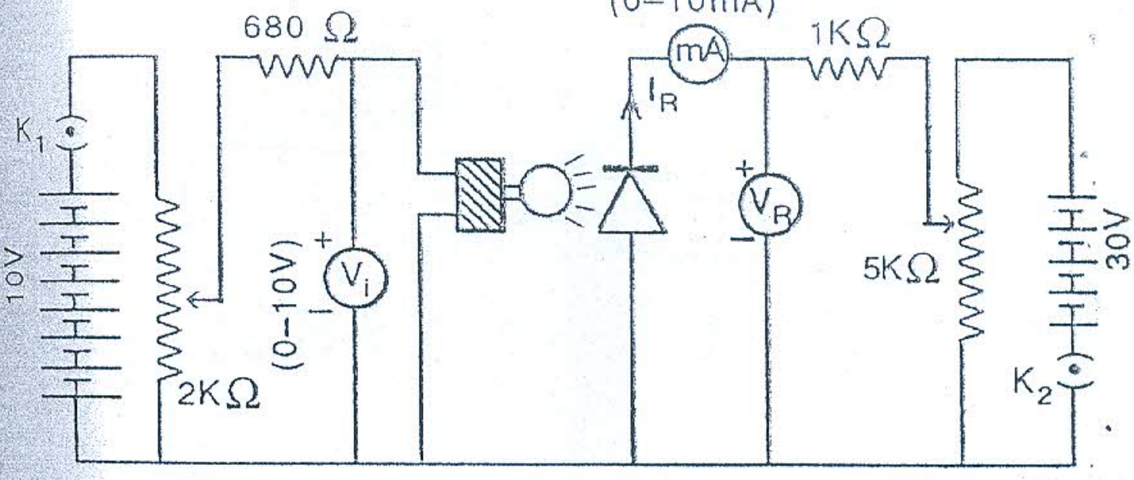


Fig. 1

2V as shown in the figure (2).

The experiment is repeated for V_b = 4V, 6V etc. and the corresponding graphs are plotted.

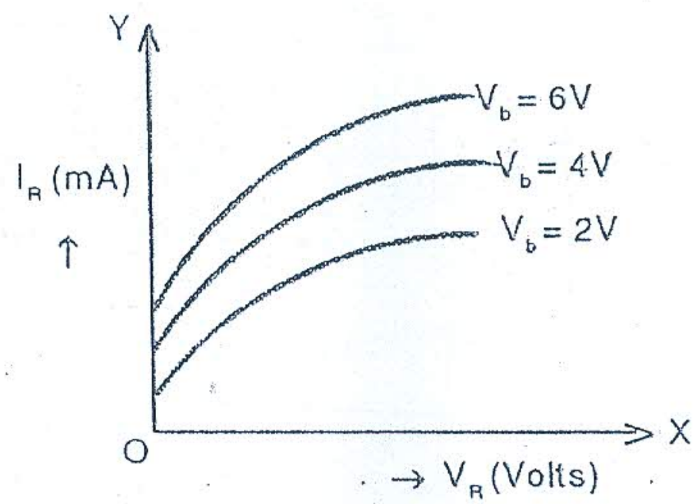


Fig. 2

OBSERVATION

V_b (VOLT)	V_R (VOLT)	I_R (mA)
2 V	0 1 2 3 4 5 6	
4 V	0 1 2 3 4 5 6	
6 V	0 1 2 3 4 5 6	

RESULT

Characteristic of curve (volt-ampere) of the photo diode is drawn.

EXPERIMENT II

STATIC TRANSISTER CHARACTERISTICS

AIM

To draw the static characteristics of a transister in common emitter configuration and hence to calculate (i) input resistance (ii) output resistance and (iii) current gain of the transister.

APPARATUS

The given pnp or npn transister, a 2 volts and a 10 volts batteries, rheostats, keys, milliammeter, microammeter, two voltmeters etc.

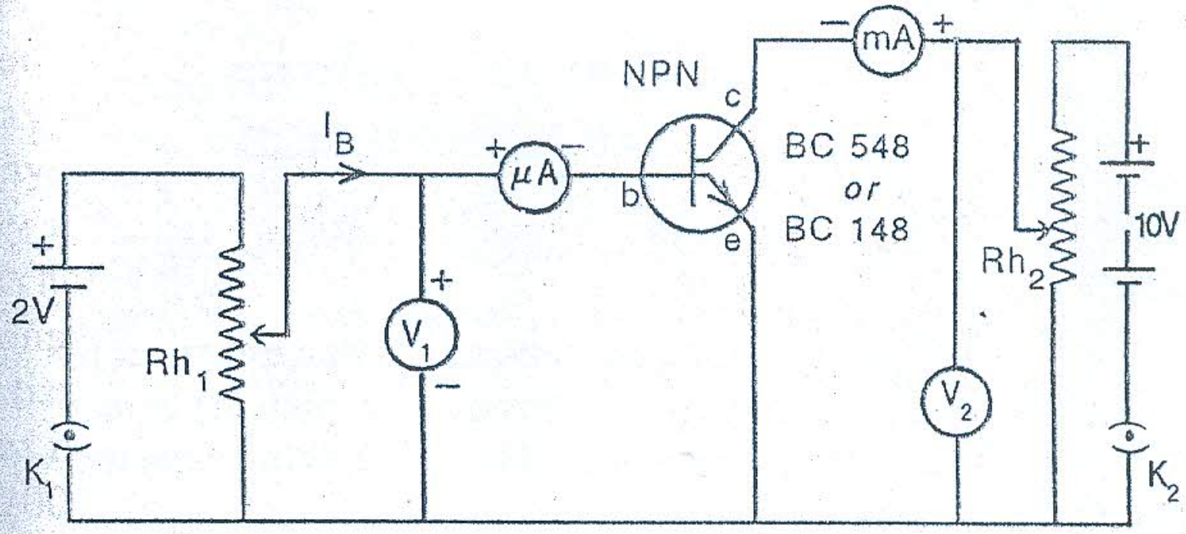
PROCEDURE

Connections are made as shown in the circuit diagram. The rheostat Rh_1 is used to vary the input voltage V_{BE}. The input voltage can be measured by the voltmeter V_1. The input current I_B is measured by the microammeter (μA). The output voltage can be varied by adjusting the rheostat Rh_2. The output voltage V_{CE} is measured by the voltmeter V_2 and the output current I_c is measured by the milliammeter (mA)

(1) To draw input characteristics

Input characteristic is a graphical relation between the input current I_B and the input voltage V_{BE} for a constant output voltage V_{CE}.

The voltage V_{CE} is kept constant at 1V by adjusting the rheostat Rh_1. The input voltage V_{BE} is varied from zero in steps of 0.1 volt up to the rated voltage of the transister, by



adjusting the rheostat Rh_1. In each step the input current I_B is noted. A graph is drawn with V_{BE} along the X-axis and I_B along the Y-axis. This is the input characteristic of the transister in common emitter configuration for an output voltage 1 volt. Similarly input characteristic is drawn with constant output voltage 3V, 5V etc.

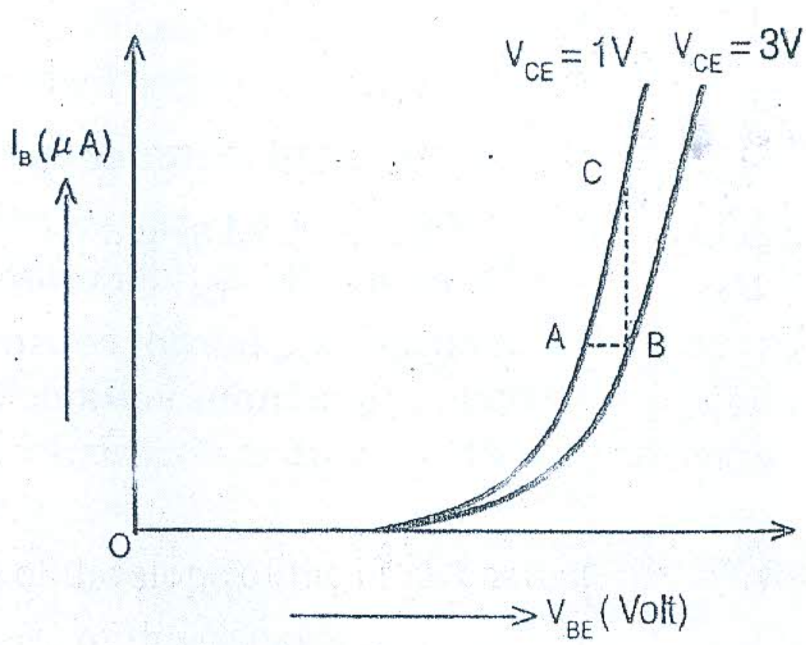
The reciprocal of the slope of the input characteristic gives the input resistance r_i of the transister.

$\delta V_{BE} = AB$

$\delta I_B = BC$

$$r_i = \frac{\delta V_{BE}}{\delta I_B}$$

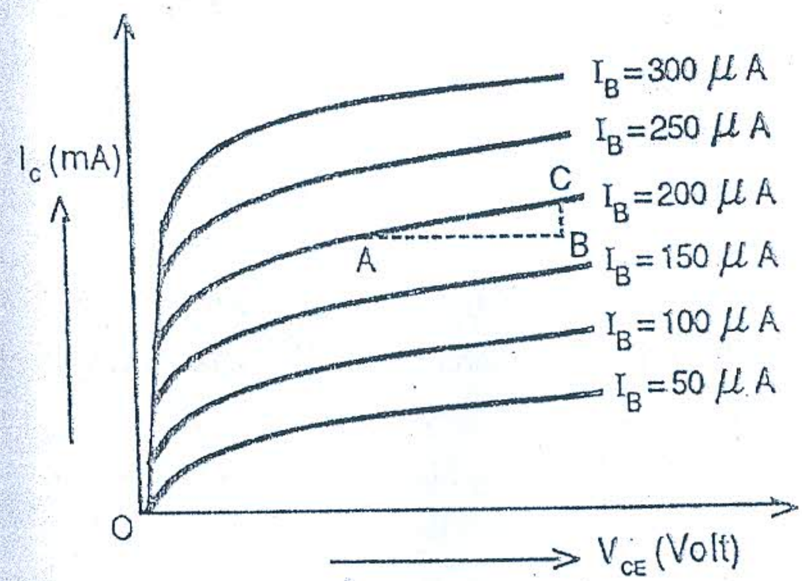
$$= \frac{AB}{BC}$$



II) To draw the output Characteristic

The output characteristic is a graph connecting output current I_c and output voltage V_{CE} for a constant input current I_B.

The rheostat Rh_1 is adjusted to keep the input current I_B constant, say at 50 μ A. The output voltage V_{CE} is increased in step of say 0.5 volt up to the maximum rated voltage of the transister by adjusting the rheostat Rh_2. In each step the output current I_C is noted. A graph is drawn with I_C along the Y-axis and V_{CE} along the X-axis. This gives the output characteristic. of the transister for a constant input current $I_B = 50\ \mu$ A. The experiment is repeated for other values of I_B say 100 μ A, 150 μ A, 200 μ A etc and graphs are drawn.



The reciprocal of the slope of the graph gives output resistance (r_0)

$$\delta V_{CE} = AB, \ \delta I_C = BC$$

$$r_o = \frac{\delta V_{CE}}{\delta I_C}$$

$$= \frac{AB}{BC}$$

iii) To draw the transfer characteristic

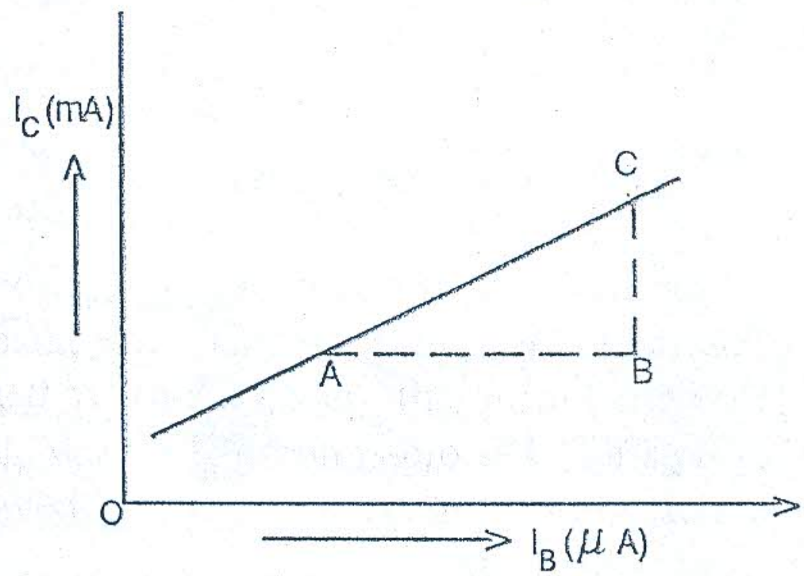
This is a graph connecting I_C and I_B for a constant V_{CE}.

The output voltage V_{CE} is kept constant, say at 2V by adjusting the rheostat Rh_2. The input current I_B is varied from zero in step of 10μ A. In each step, the output current I_C is noted. Then the I_C versus I_B graph is plotted. This gives the transfer characteristic of the transister. Since I_C is almost independent of V_{CE}, it is not necessary to repeat the experiment for different values of V_{CE}.

The slope of the transfer characteristic gives the current gain (α)

$$\alpha = \frac{\delta I_C}{\delta I_B}$$

$$= \frac{BC}{AB}$$



OBSERVATIONS

(i) To draw input characteristic

V_{CE}	V_{BE} (Volt)	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7
1 V	I_B(mA)								
V_{CE}	V_{BE}								
3V	I_B								
V_{CE}	V_{BE}								
5V	I_B								

(ii) To draw output charcteristic

I_B (mA)	V_{CE} (Volt)	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
	I_C (mA)									
I_B	V_{CE}	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
	I_C									
I_B	V_{CE}	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
	I_C									
I_B	V_{CE}	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
	I_C									

(iii) To draw transfer characteristic

V_{CE} 2V	I_B (μ A)	0	10	20	30	40	50	60	70	80
	I_C (mA)									

RESULT

The static characteristics of a transister are drawn.

The input resistance = ...

The output resistance = ...

The current gain of the transister. α = ...

EXPERIMENT 12

SPECIFIC ROTATION BY POLARIMETER

AIM

To determine the specific rotation of sugar solution using polarimeter.

APPARATUS

Polarimeter, source of monochromatic light, sugar, water, beaker etc.

PRINCIPLE

The specific rotation 's' of monochromatic light when passing through sugar solution is given by

$$s = \frac{10\theta}{l\,c}$$

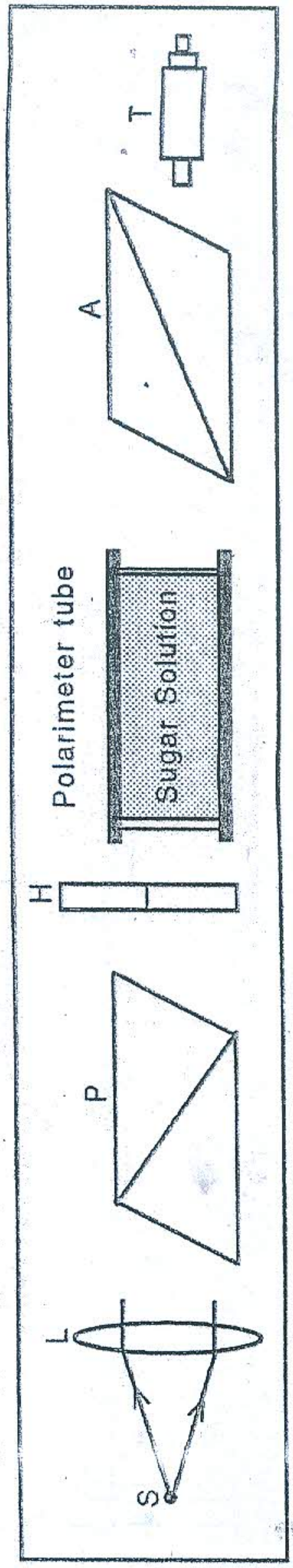
Where l = length of tube in cms containing solution

θ = angle of rotation in degrees and

c = concentration of sugar solution

DESCRIPTION

Polarimeter consists of a horizontal glass tube containing the given solution, a polariser P, analyser A, Laurent's half shade H, and a telescope T. These are arranged coaxially. S is a source producing monochromatic light and it is placed at the focus of the convex lens L. The parallel beam emerging from the lens passes normally through Laurent's half shade H and sugar solution in the tube. This polarized light is analysed by the analyser A and is observed through the telescope T. The analyser A can be rotated about a horizontal axis and the angle of rotation can be noted from a vernier scale arrangement.



PROCEDURE

The polarimeter - glass tube is cleaned well and filled with pure water without any air bubbles. Observing through the telescope, the analyser is slowly rotated so that both the halves of the half shade are equally bright. The reading of this position is noted by taking the main scale reading and vernier scale reading. Sugar solution is made with 10% concentration and pure water is replaced by this solution. Now the analyser is rotated so that both the halves are again equally bright. This position is also noted by taking main scale reading and vernier scale reading . The difference between these two sets of readings gives the angle of rotation θ of plane of polarsation by sugar solution. The angle of rotation θ is decided for clockwise and anticlockwise directions. The length 'l' of the glass tube is measured. Knowing the concentration c, specific rotation of sugar solution s is calculated from the equation $s = \frac{10\theta}{l c}$ where l is in cms. The experiment is repeated using different concentrations and using tubes of different lengths

OBSERVATIONS

Length of polarimeter tube l = ...cms

Value of 1 m.s.d = ...

Number of divisions on vernier scale n = ...

Least count LC $= \frac{\text{Value of 1msd}}{n}$

= .... minute

With water in the polarimeter tube

Trial No	Clockwise			Anti clockwise			Mean reading
	MSR	VSR	Total x_1	MSR	VSR	Total x_2	$R_1 = \frac{x_1 + x_2}{2}$
1							
2							
3							

With solution in the polarimeter tube

Concentration c %	Clockwise			Anti clockwise			Mean	Angle of rotation	
	MSR	VSR	Total x_1	MSR	VSR	Total x_2	$R_2 = \frac{x_1 + x_2}{2}$	$\theta = R_1 \sim R_2$	$s = \frac{10\theta}{l c}$
10%									
20%									
30%									

RESULT

Specific rotation of sugar solution = ...degrees/dm/kg/m^3

WAVELENGTH OF LASER USING GRATING

AIM

To determine the wavelength of laser beam using a plane transmission grating.

APPARATUS

A.5 mW He-Ne laser, Plane transmission grating, upright (vertical stand with a screen) etc.

PRINCIPLE

For a plane transmission grating, the grating equation is given by

$\sin\theta = Nm\lambda$ where

λ = Wavelength of laser beam

θ = angle of diffraction,

N = Number of lines per unit length

m = Order of Spectrum

$N = \frac{1}{d}$ where $d = a + b$ and

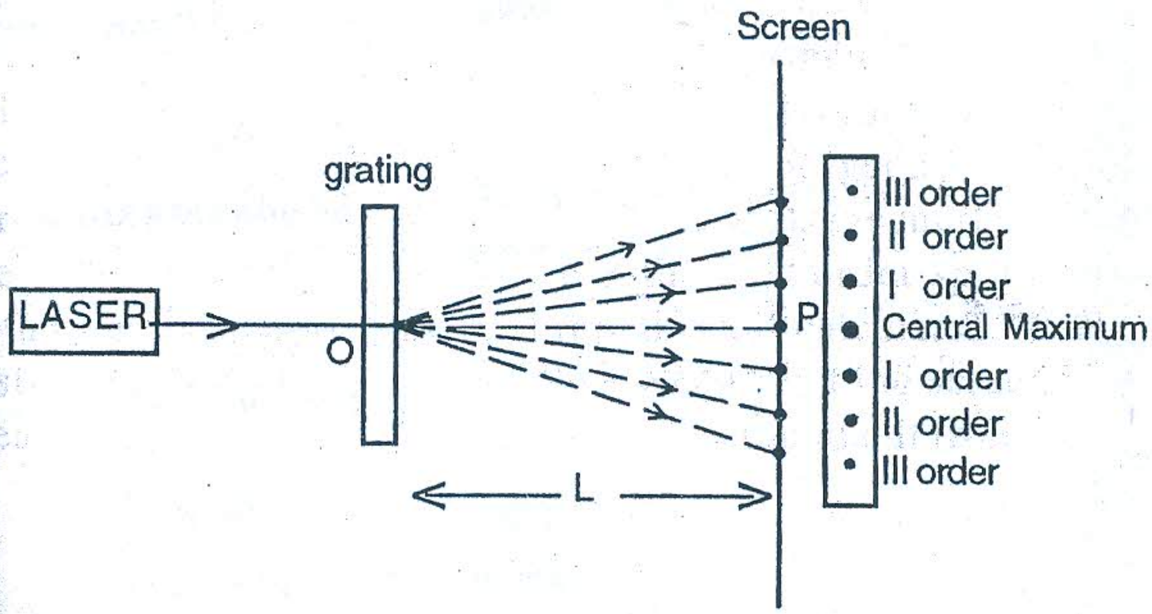
(a+b) is called grating element or grating constant. From this, wavelength λ of laser beam can be determined.

DESCRIPTION

A plane transmission grating consists of a large number of equidistant parallel slits separated by opaque portions. A grating is constructed by making a large number of rulings on a glass plate using fine diamond point. These rulings behave like opaque portions while the spacings in between the rulings behave like transparent slits.

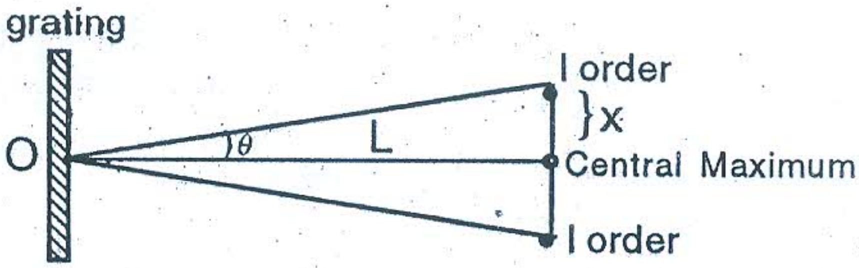
Laser beam is highly unidirectional monochromatic and coherent beam. When a He-Ne laser is used, the most prominent line 6328 Å is produced in the visible region.

PROCEDURE



A.5mW He-Ne laser is mounted horizontally so that it produces horizontal laser beam. The given plane transmission grating is held vertically on an upright at a distance (about 50cms) from the laser. A screen is placed at a distance L from the grating (1 metre).

When current is switched on, the most dominent laser beam is produced from it. This beam is incident normally on the transmission grating. The laser beam is diffracted into different angles and hence we get clear, well defined and bright images (spots) on the screen. The screen is moved slowly



towards or away from the laser so that seven or nine spots are obtained. The central larger bright spot is due to the diffracted rays passing through the incident direction (Angle of diffraction $\theta = 0$). This is the central maximum. On either side of this central maximum we get I order, II order, III order etc spots. The intensity and size of these spots get decreased for higher orders. The positions of these spots are marked on the screen. The distance between the first order spots on both sides is measured as 2x. From this x is calculated. The distance between the grating and the centre of the screen is measured as L. Angle of diffraction θ is found out from

$$\tan\theta = \frac{x}{L}$$

Now λ for the first order (m = 1) can be found out from the grating equation

$$\text{Sin}\ \theta = Nm\lambda$$

where N is the number of lines per unit length. N is calculated from a same type of experiment using a sodium vapour lamp with a beam of wavelength of 5893 $\overset{0}{A}$. (N is also written on the side of the grating). Similarly distances x for the second order, third order, fourth order etc is measured. λ is calculated for each order of the image. From these sets of orders mean value of λ is determined.

OBSERVATIONS

Number of lines per cm =

Distance between screen and grating L cm	Order m	Distance 2x cms between left & right spots	x cms	$\tan\theta = \frac{x}{L}$	θ	$\lambda = \frac{\sin\theta}{Nm}$ $\overset{0}{A}$
	1 2 3					
	1 2 3					

mean λ = ... $\overset{0}{A}$

RESULT

Wavelength of Laser beam λ = ... $\overset{0}{A}$

NB: If the laser is of 2mW, the distances must be so adjusted to get clear and well defined images.

REFRACTIVE INDICES OF ORDINARY and EXTRA-ORDINARY RAYS - SPECTROMETER

AIM

To determine the principal refractive indices of a doubly refracting crystal like calcite or quartz for Ordinary and Extra-ordinary rays.

APPARATUS

A spectrometer, a calcite or quartz prism, sodium vapour lamp, etc.

PRINCIPLE

The principal refractive index of the crystal for Ordinary ray,

$$\mu_O = \frac{\sin\left(\frac{A+D_O}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

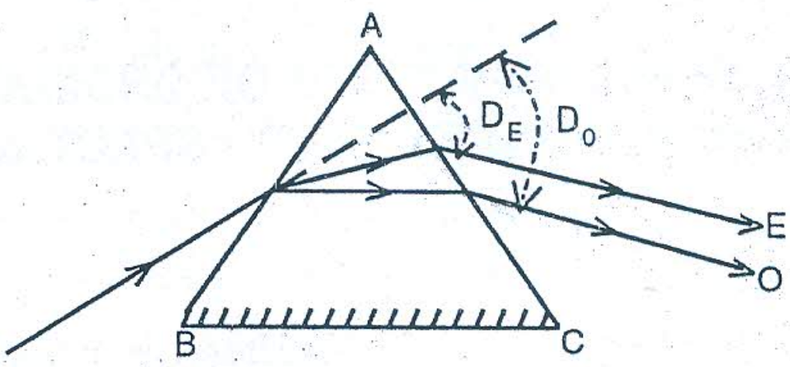
The principal refractive index of the crystal for Extra-ordinary ray

$$\mu_E = \frac{\sin\left(\frac{A+D_E}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

where A is the angle of the prism,

D_O is the angle of minimum deviation for the ordinary and

D_E is the angle of minimum deviation for the extra-ordinary ray.



When a ray of light falls on a doubly refracting crystal, such as calcite or quartz, it gives rise to two refracted rays. This phenomenon is called double refraction. One refracted ray obeys the laws of refraction and is called Ordinary ray (o-ray). The other refracted ray does not obey the laws of refraction. It is called Extra-ordinary ray (e-ray). Both O-ray and E-ray are found to be plane polarised in mutually perpendicular directions.

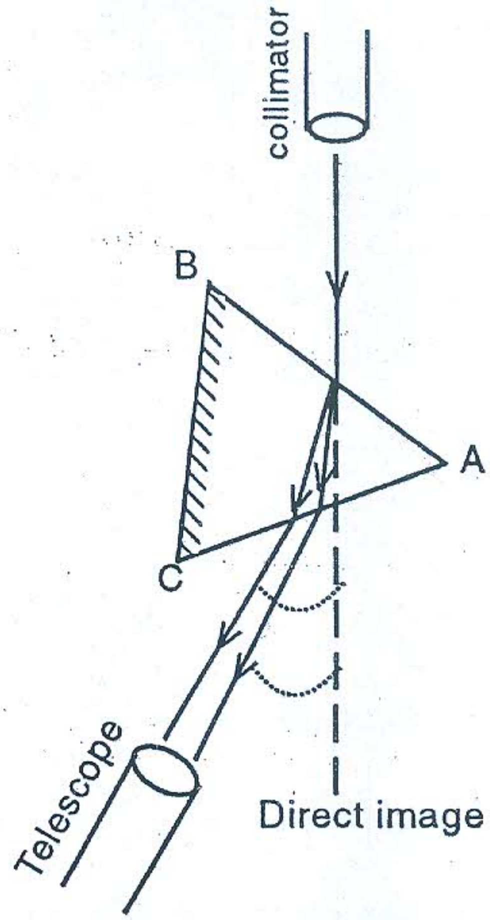
The refractive index of the crystal for O-ray (μ_O) and that for E-ray (μ_E) are different. For positive crystals like quartz, $\mu_E > \mu_O$. For negative crystals like calcite, $\mu_O > \mu_E$.

PROCEDURE

The preliminary adjustments of the spectrometer are done.

(a) To find the angle of the prism

The quartz or the calcite prism is mounted on the prism table with its refracting edge A pointing towards the collimator. The light from the collimator falls partially on the face AB and partially on the face AC. The vernier table is

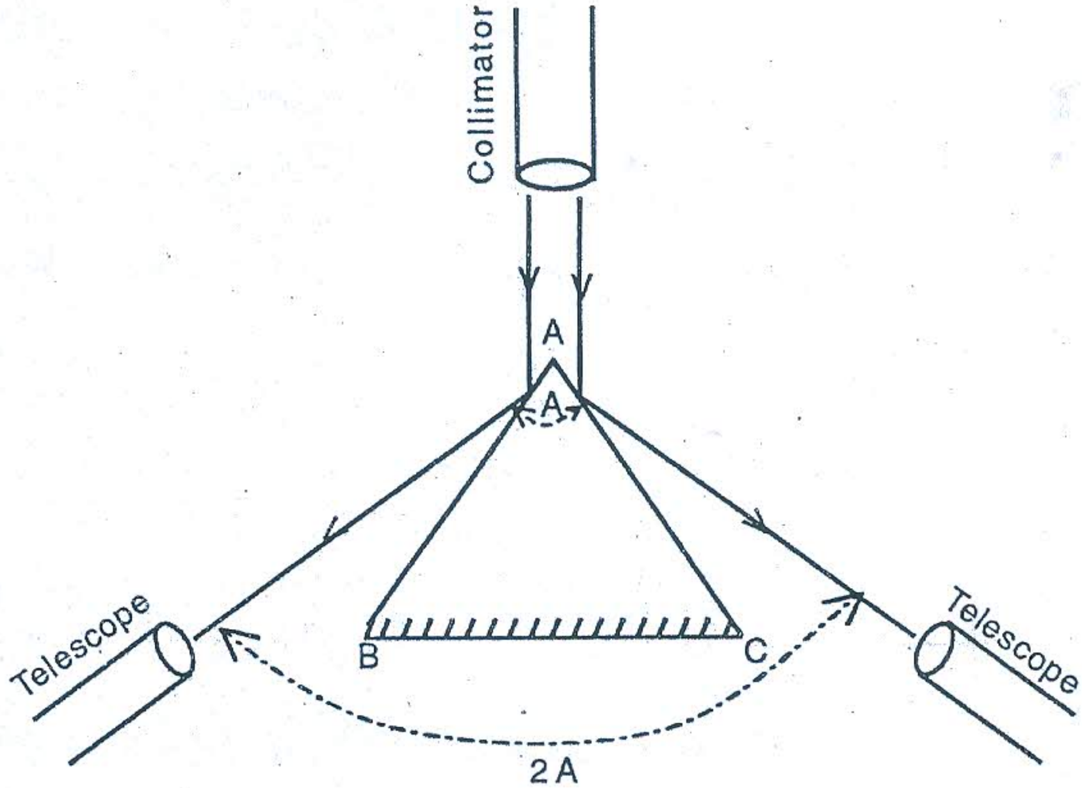


the slit are observed. One of the images is observed and the prism table is slowly rotated so that the image moves towards the position of the direct image, remains stationary for a while and then just begins to move in the opposite direction. When the image is stationary, rotation of the prism table is stopped. This is the minimum deviation position of the image. The telescope is adjusted so that the image is at the cross-wire. The readings of vernier I and vernier II are noted.

Next, the other refracted image is observed and is adjusted for minimum deviation as before. The telescope is adjusted so that the cross-wire is at the centre of the image. The readings of vernier I and vernier II are noted.

The prism is removed. The telescope is then brought in line with the collimator to get the direct image. The cross-wire is kept at the centre of the image. The readings of vernier I and vernier II are noted. The angle of minimum deviation for each image is then calculated.

clamped. The telescope is turned to get the image of the slit reflected from the face AB of the prism.



The telescope is then clamped. The tangential screw is adjusted so that the cross-wire is at the centre of the image. The readings of Vernier I and the Vernier II are noted. The telescope is then unclamped and turned to get the image of the slit reflected from the face AC of the prism. The telescope is then clamped. The tangential screw is adjusted so that the cross-wire is at the centre of the image. The readings of vernier I and vernier II are noted. The difference in readings of the corresponding verniers gives twice the angle of the prism. The mean value of 2A is found and hence A is calculated.

(b) To find the angle of minimum deviation D_O and D_E

The vernier table is unclamped and rotated so that the base BC of the prism is almost parallel to the collimator. The telescope is turned to get the refracted image on the cross-wire. Two yellow images of

OBSERVATIONS

(a) To find the least count

Value of 1 ms d........... =

No.of divisions on the vernier n =

$$\text{Least count (LC)} = \frac{1\text{msd}}{n} =$$

= .... minute

(b) To Find A

VERNIER	READING OF REFLECTED RAY						Difference $= x_1 \sim x_2 = 2A$	A
	From face AB (x_1)			From face AC (x_2)				
	MSR	VSR	TOTAL	MSR	VSR	TOTAL		
I								
II								

Mean A = ...

(c) To Find D_o and D_E

RAY	Vernier	Reading of Refracted Image			Reading of Direct Image			Difference $(x_1) \sim (x_2)$	Mean
		M.S.R	VSR	Total (x_1)	M.S.R	VSR	Total (x_2)		
o-ray	V_1								$D_o =$
	V_2								
e-ray	V_1								$D_E =$
	V_2								

The refractive index of the material of the prism for O-ray is

$$\mu_O = \frac{\operatorname{Sin}\left(\frac{A+D_O}{2}\right)}{\operatorname{Sin}\left(\frac{A}{2}\right)} = \text{........................}$$

The refractive index of the material of the prism for E-ray is

$$\mu_E = \frac{\operatorname{Sin}\left(\frac{A+D_E}{2}\right)}{\operatorname{Sin}\left(\frac{A}{2}\right)} = \text{......................}$$

RESULTS

(a) The refractive index of the material of the prism for the O-ray, μ_o = ...

(b) The refractive index of the material of the prism for the E-ray μ_E = ...

CHARACTERISTIC OF LED

AIM

To study the characteristic of Light Emitting Diode (LED)

APPARATUS

LED, 200Ω resistor, D.C. power supply (10 Volt), milliammeter, voltmeter, rhestat (500 Ω)etc.

PRINCIPLE

A light emitting diode (LED) is a semiconducting p-n junction device which produces light energy when it is forward biased. At the forward biased state, the electrons from the n region and the holes from the 'p' region recombine at the interspace releasing light energy. This property is called electro luminescence. There is a transition of electrons from the conduction band to the valence band where they combine with holes emitting photons. The holes thus created in the n region also combine with electrons releasing photons. The energy of the photon emitted E_g in electron volts is given by

$$E_g = h\upsilon = \frac{ch}{\lambda}$$

where υ is frequency of photon emitted

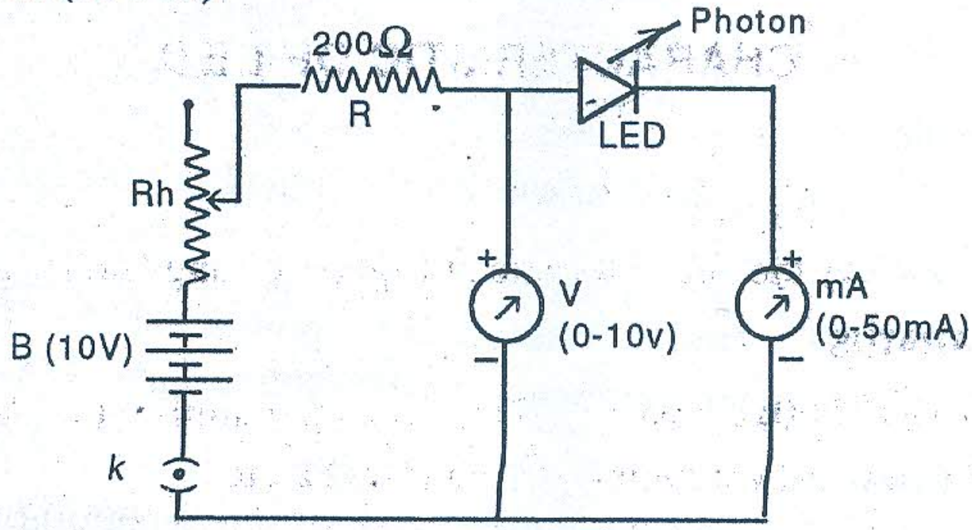
λ is the wavelength of photon and

c is the velocity of light.

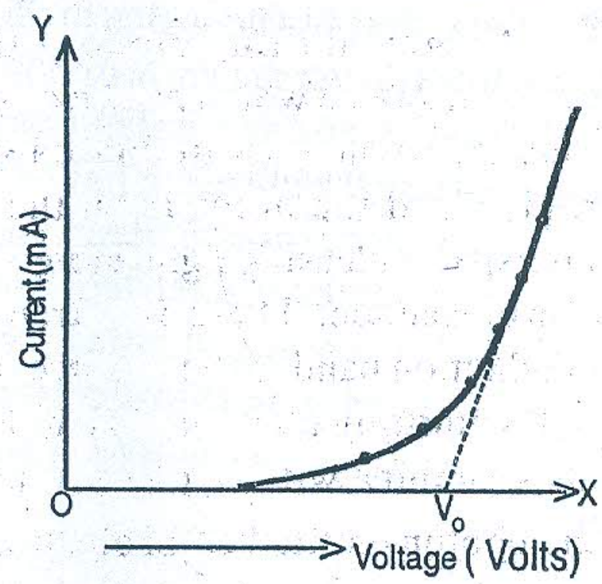
LED is usually made up of gallium phosphide (GaP) and gallium arsenide phosphide (Ga AsP)

PROCEDURE

Connections are made as in the diagram. An LED is connected in series with a battery, a resistor R (200 Ω) a milliameter (0-50 mA) and rhestat (500 Ω)



A voltmeter V (0-10 volts) is used to measure the p.d applied. LED is forward biased and the battery is switched on. The voltage is varied in small steps and in each step, current is noted from the milliameter. The readings are recorded. A graph is plotted with voltage on X-axis and current on Y-axis. The curve obtained is the characteristic of LED and it is similar to the characteristic of a forward p-n junction.



The voltage Vo at which conduction just begins can be noted from this characteristic.

OBSERVATIONS

Voltmeter Reading V (Volt)	Ammeter Reading I (mA)

Charge of an electron $e = 1.6 \times 10^{-19}$ coulombs

Voltage at which conduction begins Vo = ... Volts.

Energy of Photon Emitted, $E_g = e V_0$

$= ....$

Wavelength $\lambda = \dfrac{ch}{eV_0}$

$= ....$ Å

RESULT

Characterstic of LED is drawn.

Wavelength λ of light = ... Å

Cantilever Bending
Pin and Microscope

Aim

To determine the Young's modulus of the material of the bar, by cantilever bending by measuring the depression using pin and microscope.

Apparatus

The experimental bar, rigid support with clamp, stand, weight hanger with slotted weights, pin and microscope, metre scale, screw gauge and vernier calipers.

Principle

Consider a rectangular bar of breadth b, thickness d is subjected to cantilever bending. The length of the cantilever which is clamped at the end A and loaded with a weight Mg at the end B is l. The vertical depression of the loaded end of the cantilever is given by

$$z = \frac{Mgl^3}{3Y\,AK^2}$$

or the Young's modulus of the material of the bar

$$Y = \frac{4\,Mg}{bd^3}\left(\frac{l^3}{z}\right)$$

where $AK^2 = bd^3/12$ is the geometrical moment of inertia of the bar. Thus for a mass M, the value of l^3/z is a constant (Figure 1).

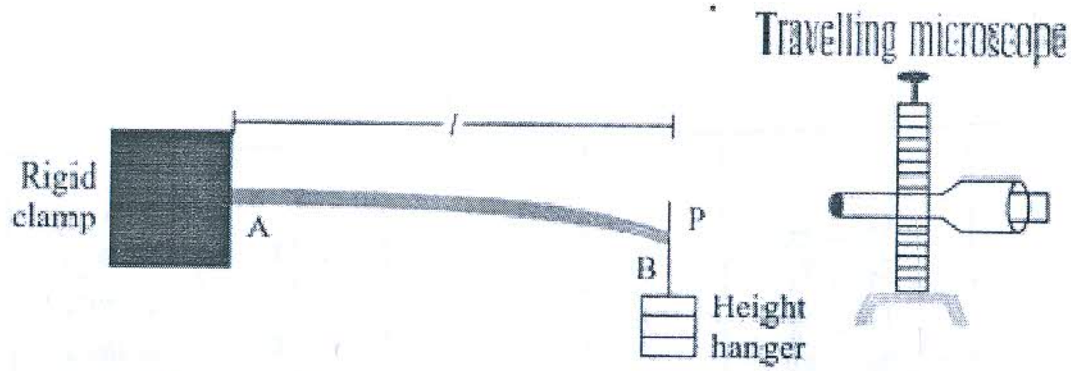


Figure 1 Cantilever bending—pin and microscope.

Procedure

The experimental bar is clamped on a rigid support at A. A weight hanger is suspended at the end B such that the length of the cantilever AB is $l (= 0.6$ m). A pin P is placed in a vertical position just above the hanger and a travelling microscope is arranged infront of it. Align the eyepiece to get a clear view of the cross wires without parallax and adjust the microscope to focus at the tip of the pin. By loading and unloading, the bar is brought into an elastic mood.

With the weight hanger alone (mass m_0), by looking through the microscope adjust the vertical movement till the tip of the pin coincides with the cross wire and determine the microscope reading (MSR + VSR × LC). The experiment is carried out by loading with a mass m (200 g) in steps up to $7m$ and then unloading sequentially. The mean value of the microscope reading for each mass is found and the depression for a mass $4m$ $(= M)$ is calculated as z, from which l^3/z is calculated. The experiment is repeated by changing the length of the cantilever l (0.7, 0.8 m) and find the mean value of l^3/z.

The thickness d of the bar is determined by using a screw gauge and the breadth b is measured using a vernier calipers. The Young's modulus of the material of the bar is calculated by

$$Y = \frac{4\,Mg}{bd^3}\left(\frac{l^3}{z}\right)$$

Observations

To find l^3/z

Trial no.	*Length of the cantilever* l(m)	*Mass suspended* m(kg)	*Microscope reading* MSR + VSR × LC (cm)			*Depression* for $4m$ (= M) (cm)	*Mean* depression z(m)	$\frac{l^3}{z}$ (m²)
			Loading	*Unloading*	*Mean*			
1.		$m_0 =$	$x_0 =$					
		$+m =$	$x_1 =$					
		$+2m =$	$x_2 =$					
		$+3m =$	$x_3 =$					
		$+4m =$	$x_4 =$			$x_4 - x_0 =$		
		$+5m =$	$x_5 =$			$x_5 - x_1 =$		
		$+6m =$	$x_6 =$			$x_6 - x_2 =$		
		$+7m =$	$x_7 =$			$x_7 - x_3 =$		
2.								
3.								

Mean value of l^3/z	= ... m^2
Value of mass $4m$ (= M)	= ... kg
Thickness of the bar (using screw gauge) d	= ... m
Breadth of the bar (using vernier calipers) b	= ... m

Young's modulus of the material of the bar $Y = \dfrac{4\,Mg}{bd^3}\left(\dfrac{l^3}{z}\right)$ = ... Nm^{-2}

Result

The Young's modulus of the material of the bar = ... Nm^{-2}.

Question

Find the Young's modulus of the material of the bar by cantilever bending by measuring the depression using pin and microscope.