PHYSICS LABORATORY

(Common to all B.E. / B.Tech. Students)

LAB MANUAL

Regulation – 2021

Department of Physics

Velammal College of Engineering & Technology

(An Autonomous Institution)

Madurai – 625 009

Regulation 2021

21PC101	PHYSICS AND CHEMISTRY LABORATORY	L	T	P	C
	(Common to all branches of B.E. / B. Tech Programmes)	0	0	4	2

Course Objectives:

- To learn the proper use of various kinds of physics laboratory equipment.
- To learn how data can be collected, presented and interpreted in a clear and concise manner.
- To learn problem solving skills related to physics principles and interpretation of experimental data.
- To determine error in experimental measurements and techniques used to minimize such error.
- To make the student an active participant in each part of all lab exercises.

PHYSICS LABORATORY - LIST OF EXPERIMENTS

(Any Seven Experiments)

1. Uniform bending - Determination of Young's modulus
2. Simple harmonic oscillations of cantilever
3. Laser- Determination of the wavelength of the laser using grating
4. Air wedge - Determination of thickness of a thin sheet/wire
5. a) Optical fibre -Determination of Numerical Aperture and acceptance angle
   b) Compact disc- Determination of width of the groove using laser.
6. Post office box -Determination of Band gap of a semiconductor.
7. Torsional pendulum - Determination of rigidity modulus of wire and moment of inertia of regular and irregular objects.
8. Ultrasonic interferometer – determination of the velocity of sound and compressibility of liquids.

Nota Bene:

- Laboratory classes are on alternate weeks for Physics and Chemistry
- **Total : 30 Periods**

Course Outcomes:

Upon completion of the course, the students will be able to

- Upon completion of the course, the students should be able to
- Understand the functioning of various physics laboratory equipment.
- Use graphical models to analyze laboratory data.
- Use mathematical models as a medium for quantitative reasoning and describing physical reality.
- Access, process and analyze scientific information.
- Solve problems individually and collaboratively.

Contents

Velammal College of Engineering & Technology

(Autonomous)

Madurai - 625009

Name of the Candidate: Roll Number :

Branch: Section :

Batch : Register Number:

Exp. No.	Name of the Experiment	Page Nos.	Marks obtained	Faculty Signature
CYCLE - I				
1.	Non -uniform bending – Determination of Young's modulus			
2.	Laser- Determination of the wavelength of the laser using grating			
3.	a) Torsional pendulum - Determination of rigidity modulus of wire.			
	b) Torsional pendulum – Moment of inertia of irregular body			
4.	a) Optical fibre -Determination of Numerical Aperture and acceptance angle			
	b) Compact disc- Determination of width of the groove using laser.			
CYCLE - II				
5.	Air wedge - Determination of thickness of a thin sheet/wire			
6.	Simple harmonic oscillations of cantilever			
7.	Post office box -Determination of Band gap of a semiconductor.			

This is to certify that the Mr. /Mrs. ________________________ Roll No. / Reg. No.___________________ of first sesester B.E. / B.Tech ________________________________has completed the 21PC101/ Physics laboratory observation work successfully

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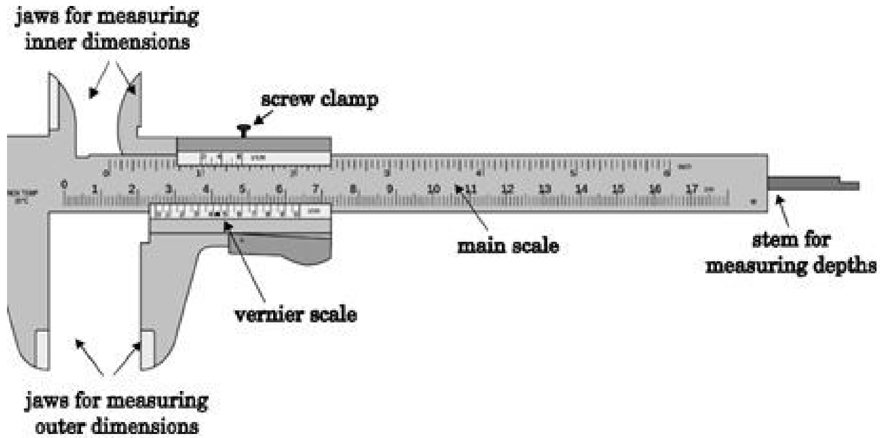
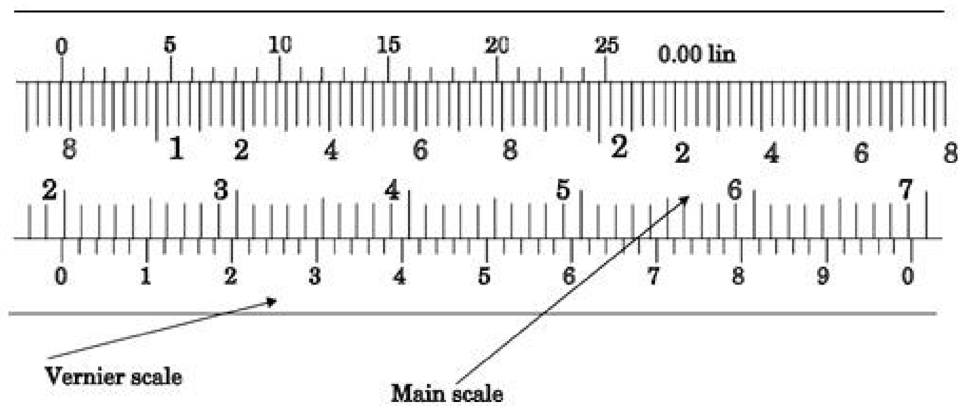
Signature of faculty in harge

Observation mark split up for each experiment

Parameters	Marks awarded
Observation Completion	07
Ontime submission	02
Performance and presentation	01
Total	10

Vernier Caliper





<u>To find the dimension of the given material</u>

Least Count = 0.01 cm

Sl.No.	Main Scale Reading (MSR)	Vernier Scale Coincidence (VSC)	Vernier Scale Reading (VSR = VSC x LC)	Total Reading (TR = MSR + VSR)
	cm	div	cm	cm
1				
2				
3				
4				
5				
6				
				Mean = cm

A. Vernier Caliper

Aim

To measure the dimension of the given material using vernier caliper

Least count calculation

Least Count = 1MSD - 1 VSD ………………………….. (1)

10 MSD = 1 cm

1MSD= $\frac{1}{10}$ cm ..……………………….. (2)

10 VSD = 9 MSD

1 VSD = $\frac{\mathbf{9}}{\mathbf{10}}$ **MSD** ………………………….. (3)

Substituting (2) in (3)

1 VSD = $\left[\frac{9}{10} \times \frac{1\text{ cm}}{10}\right] = \frac{9}{100}$ cm …………………………… (4)

Substituting (2) & (4) in (1)

Least count = 1 MSD - 1 VSD

$$= \frac{1\text{ cm}}{10} - \frac{9\text{ cm}}{100}$$

$$= \left[\frac{1}{10} - \frac{9}{100}\right]\text{ cm}$$

$$= \left[\frac{10-9}{100}\right]\text{ cm}$$

$$= \frac{1}{100}\text{ cm}$$

Least count = 0.01 cm

Result

The dimension of the given material using vernier caliper is =……………cm

= ………… x 10^{-2} m


Pitch scale
Head scale
Ratchet

B. Screw Gauge

Aim

To determine the dimension of the given material using screw gauge

Least count calculation

$$\text{Least Count} = \frac{\text{1 Pitch Scale Division}}{\text{Total number of Head Scale Divisions}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$\text{1 Pitch Scale Division} = \frac{\text{Distance moved by the head scale on the pitch scale}}{\text{No.of rotations given to the head scale}}$$

$$\text{Pitch Scale Division} = \frac{4\text{mm}}{4} = 1 \text{ mm} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Total # of Head Scale Divisions = 100 .... (3)

Substituting (2) & (3) in (1)

$$\text{Least count} = \frac{1\text{mm}}{100} = 0.01 \text{ mm}$$

∴Least Count = 0.01 mm

To find the dimension of the given material

Zero Error = +/- _______________ division

Zero Correction = - (ZE x LC) =

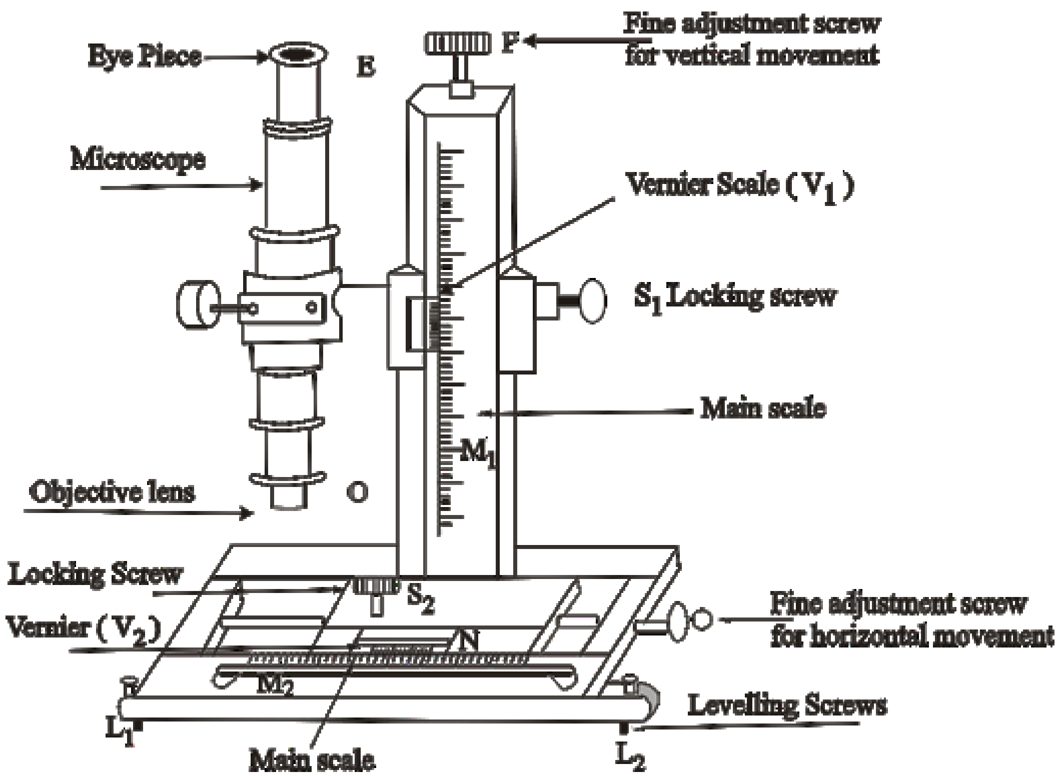
Least Count = 0.01 mm

Sl.No.	Pitch Scale Reading (PSR)	Head Scale Coincidence (HSC)	Head Scale Reading (HSR)	Total Reading (TR = PSR+HSR)	Corrected Reading (CR = TR+ZC)
	mm	div	mm	mm	mm
1.					
2.					
3.					
4.					
5.					
6.					
				Mean =	mm

Result

The dimension of the given material using screw gauge is ……………….. mm

= ____________________ x 10^{-3} m


Eye Piece
E
F
Fine adjustment screw
for vertical movement
Microscope
Vernier Scale (V_1)
S_1 Locking screw
Main scale
M_1
Objective lens
O
Locking Screw
S_2
Vernier (V_2)
N
Fine adjustment screw
for horizontal movement
M_2
Levelling Screws
L_1
L_2
Main scale

C. Travelling Microscope

Aim

To find the dimension of a given specimen

Least count calculation

Least Count = 1 MSD – 1 VSD ………………… (1)

20 MSD = 1 cm ………………… (2)

1 MSD = $\frac{1}{20}$ cm

50 VSD = 49 MSD

1 VSD = $\frac{49}{50}$ MSD ………………… (3)

Substituting (2) in (3)

1 VSD = $\frac{49}{10}$x $\frac{1cm}{20}$ = $\frac{49}{1000}$ cm ………………… (4)

Substituting (2) & (4) in (1)

Least count = 1 MSD - 1 VSD

Then Least Count = 0.05 - 0.049 = **0.001 cm**

$$= \left[\frac{1}{20} - \frac{49}{1000}\right] \text{cm}$$

$$= \left[\frac{50-49}{1000}\right] \text{cm}$$

$$= \frac{1}{1000} \text{cm}$$

= 0.001 cm

To find the dimension of a specimen

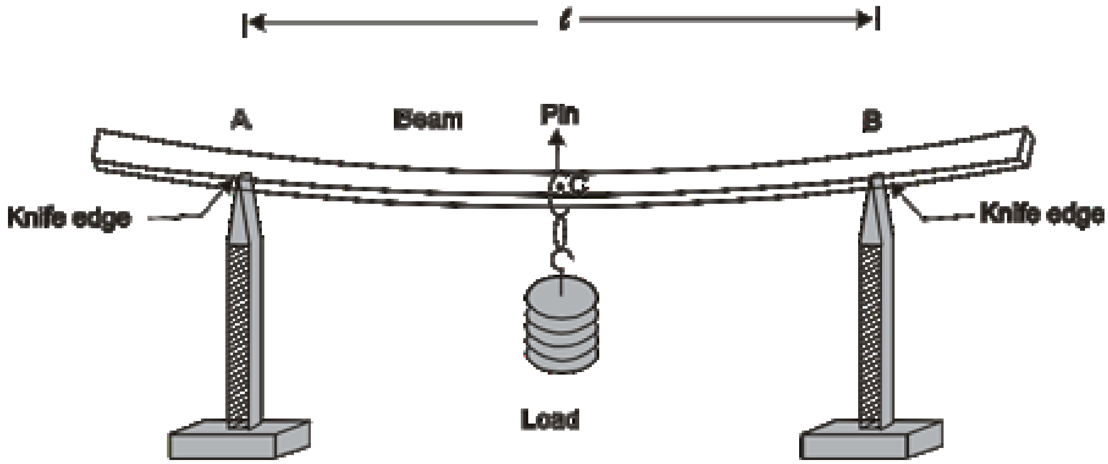
LC = 0.001 cm

S.No	Main Scale Reading (MSR)	Vernier Scale Coincidence (VSC)	Vernier Scale Reading (VSR= VSC x LC)	Total Reading (TR = MSR + VSR)
Unit	cm	div	cm	cm
1				
2				
3				
4				
5				
				Mean = cm

Result

The dimension of the specimen is ……….……………………………. cm

= …………………………….. x 10^{-2} m



Vernier caliper readings

To find the breadth of the beam (b) Least count (L.C.) = 0.01 cm

Sl. No	MSR	VSR = VSC x LC	Total reading (TR) = MSR+VSR
Unit	cm	cm	cm
1.			
2.			
3.			
4.			
	Mean (b) = ………………… $\times 10^{-2}$ m		

Screw gauge readings

To find the thickness of the beam (*d*)

Zero error ±………………div

Least Count (L.C.) = 0.01 mm

Zero correction ± …………mm

Sl. No	PSR	HSR = HSC x LC	Observed Reading = PSR + HSR	Correct Reading = OR ± ZC
Unit	mm	mm	mm	mm
1.				
2.				
3.				
4.				
	Mean (d) =………………………… $\times 10^{-3}$m			

Young's modulus – Non-uniform bending method

Expt. No.:

Date:

AIM

To determine Young's modulus of the beam (meter scale) by non-uniform bending method.

APPARATUS REQUIRED

1. Travelling Microscope 2. Two knife edges 3. slotted weights 4. Pin 5. Meter scale 6. Vernier caliper 7. Screw gauge

FORMULA

Young's modulus of the beam (Y) = $\frac{Mgl^3}{4bd^3y}$ N m^{-2}

Where

y - Elevation of the beam for a load M (m)

M - Load applied (Kg)

g - Acceleration due to gravity (m s^{-2})

l - Distance between the two knife edges (m)

b - Breadth of the beam (m)

d - Thickness of the beam (m)

PROCEDURE

The given experimental beam is placed horizontally above the knife edges. These knife edges are placed at equal distance away from the centre of the beam. A pin is fixed in inverted form using carpenter wax exactly at the centre of the beam and a weight hanger is suspended at the centre of the beam using thread. Using a travelling microscope the tip of the pin is viewed and the corresponding vertical scale reading in the microscope is noted. Now weights are added one by one in the hanger. The travelling microscope is adjusted such that the tip of the pin coincides with the vertical cross wire for each shift. The respective readings for loading from (W) to (W+200) grams are noted.

Since the end of loading is the beginning of unloading, weights are removed from (W+200) to (W) grams one by one. When the weight is removed, the tip of the pin gets displaced from the original position and travelling microscope is adjusted and the corresponding readings are noted. The width of the beam is found out using a vernier caliper and the thickness is found using a screw gauge. Using the above formula, the Young's modulus of the material of the given beam is calculated.

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TRAVELLING MICROSCOPE READINGS

To find the depression of the beam (y)

Total reading (TR) = Main scale reading (MSR) + Vernier Scale Reading (VSR)

VSR = VSC x L.C.

L.C. = 0.001 cm

Load gm	Loading			Unloading			Mean	Depression y for M kg (y) cm
	MSR cm	VSR cm	TR_1 cm	MSR cm	VSR cm	TR_2 cm	$\frac{TR_1 + TR_2}{2}$ cm	
W								
W+50								
W+100								
W+150								
W+200								
						Mean (y)……………………… cm		

Depression of the beam (y) = …………………………. cm = ………………………….. x 10^{-2} m.

Observation:

Mass of the load applied (M) = ……………….……….. gm = ……………………….……….. x 10^{-3} kg.

Distance between two knife edges (l) = ……………….. cm = ……………………………….. x 10^{-2} m.

Acceleration due to gravity (g) = 9.8 m s^{-2}

Breadth of the beam (vernier caliper) (b) = ……………….. cm = …………………….….. x 10^{-2} m.

Thickness of the beam (screw gauge) (d) = ……………….. mm = ……………………..…..x 10^{-3} m.

Depression y for load M kg is (y) = ………………………….cm = …………………….……x 10^{-2} m.

Calculation

$$Y = \frac{Mgl^3}{4bd^3 y}$$

(or) Y = ………………………….

RESULT

The young's modulus of the materials of the beam is (Y) = …………………………. X 10^{-10} N m^{-2}

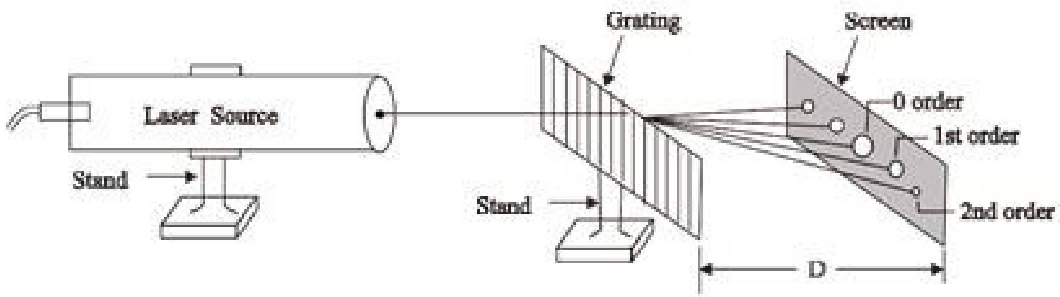
Parameters	Maximum marks	Marks obtained	Signature of faculty
Observation Completion	07		
Ontime submission	02		
Performance and presentation	01		
Total	10		

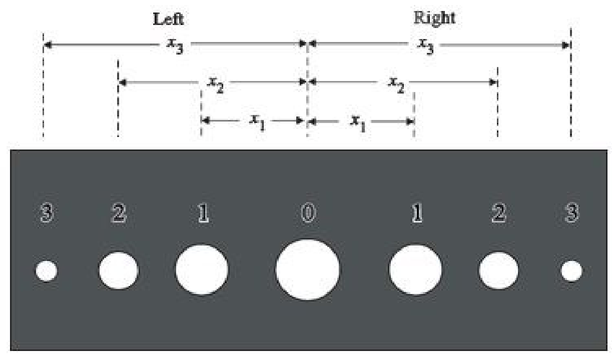
To determine the wavelength of the laser source

Distance between grating and screen (D) = cm

Number of lines in grating / meter (m) = lines /metre

Sl. No.	Order of Diffraction	Diffracted Readings						$Mean = \frac{\theta_1+\theta_2}{2}$	$\lambda = \frac{\sin\theta}{Nm}$
		Left Side			Right Side				
		Distance of different orders from the central spot (X_n)	$\tan\theta_1 = \frac{x}{D}$	$\theta_1 = \tan^{-1}\left(\frac{x}{D}\right)$	Distance of different orders from the central spot (X_n)	$\tan\theta_2 = \frac{x}{D}$	$\theta_2 = \tan^{-1}\left(\frac{x}{D}\right)$		
unit		cm		deg	cm		deg	deg	metre
1	1	X_1 =			X_1 =				
2	2	X_2 =			X_2 =				
3	3	X_3 =			X_3 =				
Mean wavelength of the given laser source (λ) =									





Wave length of laser source using grating

Expt. No.:
Date:

AIM

To determine the wavelength and divergence of the given laser source using grating

APPARATUS REQUIRED

- Diode laser
- Grating
- Screen
- Graph (or) Plane paper
- Scale arrangement

FORMULAE

(i) Wavelength of the given laser source is $\lambda = \frac{\sin\theta}{Nm}$ meter

where

θ -angle of diffraction (degrees)

N -number of lines per meter in the grating

n -order of diffraction

PROCEDURE

(i) **Wavelength of the laser source**

The diode laser source is placed horizontally at one end of the scale arrangement and the screen is placed at the other end. A grating is inserted in between the source and the screen. When the laser diode is switched ON, light from the source gets diffracted by the grating and as a result diffracted spots are seen in the screen. The distances from the source spot and the adjacent spots are measured as X_n. Also the distance between the screen and grating is noted from the scale arrangement as D. Using the above formula the angle of diffraction θ can be calculated.

Observation:

Number of lines / inch in grating: 2500

1 inch = 0.0254 m

Therefore, Number of lines / meter in grating (N) = ………………………. lines / meter

Distance between grating and screen (D) =…………… cm = ……………… x 10^{-2} m

Calculation

***n* = 1,** $\lambda_1 = \frac{\sin\theta}{N \times 1}$ = ……………………….x 10^{-7} m = ………………………. x 10^{-10} m

***n* = 2,** $\lambda_1 = \frac{\sin\theta}{N \times 2}$ = ……………………….x 10^{-7} m = ………………………. x 10^{-10} m

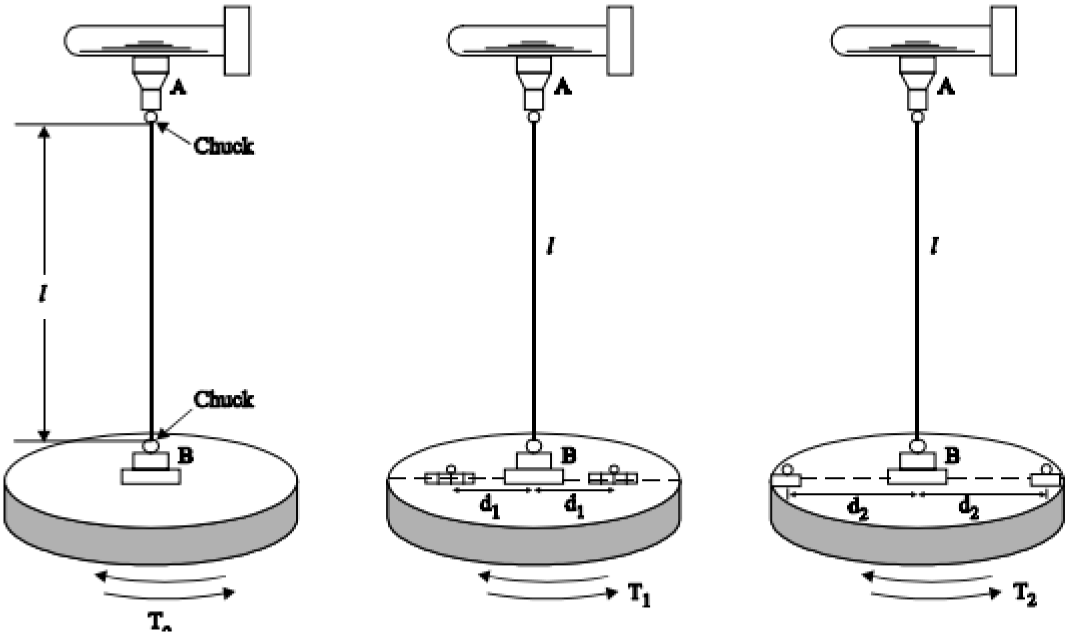
***n* = 3,** $\lambda_1 = \frac{\sin\theta}{N \times 3}$ = ……………………….x 10^{-7} m = ………………………. x 10^{-10} m

Mean $\lambda = \frac{\lambda_1 + \lambda_2 + \lambda_3}{3}$ = ………………………. x 10^{-10} m

RESULT

Wavelength of the laser light source =……………. m =…………………Å

Parameters	Maximum marks	Marks obtained	Signature of faculty
Observation Completion	07		
Ontime submission	02		
Performance and presentation	01		
Total	10		



(i) To find the period of oscillation of the disc at different stages

Length of the suspended wire (l) = ……………..cm

Position of the equal masses	Time for 10 Oscillations			Time taken for one Oscillation
	Trial - I	Trial - II	Mean	
unit	sec	sec	sec	sec
without masses				T_0=
with masses at distance d_1 = ……….cm				T_1=
with masses at distance d_2 = ……… .cm				T_2=

(a) Determination of rigidity modulus - Torsion Pendulum

Expt. No.:
Date:

Aim

To determine (i) the moment of inertia of the disc and
(ii) the rigidity modulus of the material of the given wire

Apparatus required

1. Circular metal disc 2. Experimental wire 3. Stop clock 4. Meter scale
5. Screw gauge 6. Two similar cylindrical masses

Formulae

(i) Moment of inertia of disc $I = \frac{2m(d_2^2 - d_1^2)T_0^2}{(T_2^2 - T_1^2)}$ Kgm^2

(ii) Rigidity modulus of the material of the wire $\eta = \frac{8\pi I l}{T_0^2 r^4}$ N/ m^2

where

m – mass of one of the symmetrical cylinders (Kg)

$\boldsymbol{d_1}$ - closest distance between the suspended wire and centre of any one of the symmetrical cylinders (m)

$\boldsymbol{d_2}$ - farthest distance between the suspended wire and the centre of any one of the symmetrical cylinders (m)

$\boldsymbol{T_0}$ - time period without any mass on the circular disc (sec)

$\boldsymbol{T_1}$ - time period for the masses placed at distance d_1 (sec)

$\boldsymbol{T_2}$ - time period for the masses placed at distance d_2 (sec)

l - length of the suspended wire (m)

r - radius of the suspended wire (m)

Procedure

A uniform metal wire of length approximately 1metre is taken whose rigidity modulus has to be found out. The wire is fixed by two split chucks at its ends. One of the chucks is clamped and mounted on the wall. On the other end, a heavy uniform circular disc is attached with the split chuck. The suspended disc is slightly twisted so that it executes torsional oscillations. Care must be taken to see that the disc oscillates without wobbling.

(ii) To find the radius (*r*) of the suspension wire using screw gauge

Zero Error :   Zero Correction: - (Zero Error x Least Count)

L.C. = 0.01mm

Sl.No.	Pitch Scale Reading (PSR)	Head Scale Reading (HSR =HSC x LC)	Total Reading (TR)	Corrected Reading (CR = TR+ZC)
UNIT	mm	mm	mm	mm
1				
2				
3				
4				
5				
6				
Mean diameter of the wire (d) =			mm	
Mean radius of the wire *(r)* = (d/2) =			mm	

Calculation

(i) **Moment of inertia of disc** $I = \frac{2m(d_2^2 - d_1^2)T_0^2}{(T_2^2 - T_1^2)}$ Kg m^2

Mass of one of the symmetrical cylinders (m) = ________ g = _______x 10^{-3} Kg

Closest distance between the suspended wire and Centre of any one of symmetrical cylinders (d_1) = ________cm= ________x 10^{-2} m

Farthest distance between the suspended wire and The centre of any one of symmetrical cylinders (d_2) = _________cm = ________x 10^{-2} m

Time period without any masses on the circular disc is (T_0) = ________________ sec

Time period for the masses placed at the distance d_1 is (T_1) = ________________ sec

Time period for the masses placed at the distance d_2 is (T_2) = ________________ sec

(ii) **Rigidity modulus of the material of the wire** $\eta = \frac{8\pi I l}{T_0^2 r^4}$ N/ m^2

Moment of inertia of disc (I) = ________ Kg m^2

Length of the suspended wire (*l*) = ________cm = ________x 10^{-2} m

Radius of the suspended wire (r) = ________mm = ________x 10^{-3} m

The time taken for 10 complete oscillations is noted. Two trials were taken and the mean time period T (time for one oscillation) is calculated.

Two similar cylindrical masses were placed over the disc on either side, closer to the lower split chuck. The distance 'd_1' from the centre of any one of the mass to the centre of the suspended wire is noted and executed torsional oscillation. Two trials were taken in each case and the time taken for 10 oscillations is noted. The mean time period 'T_1' is determined.

The two equal masses were moved to the extreme ends of the disc at equal distance. The distance 'd_2' from the centre of the mass of the cylinder to the centre of the suspended wire is noted. The disc with masses at distance 'd_2' is allowed to execute torsional oscillations by twisting the disc. The time taken for 10 oscillations is noted and time period 'T_2' is calculated.

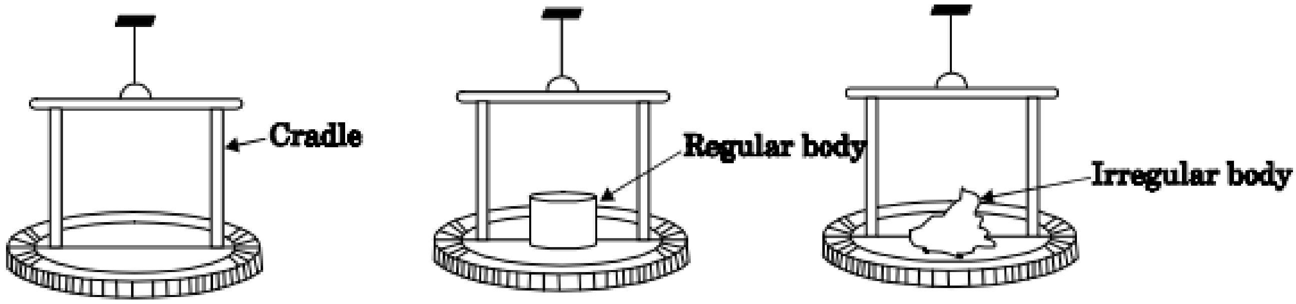
The mass of one of the cylinders placed on the disc is noted. The diameter of the wire is accurately measured using a screw gauge and the radius of the wire is calculated. The moment of inertia of the disc and the rigidity modulus of the wire were calculated using the above formula.

Result

(i) Moment of inertia of the disc (I) =……………………………… Kg m^2

(ii) Rigidity modulus of the given wire (η) =………………………………N m^{-2}

Parameters	**Maximum marks**	**Marks obtained**	**Signature of faculty**
Observation Completion	07		
Ontime submission	02		
Performance and presentation	01		
Total	10		



Torsional Pendulum with a cradle

Torsional Pendulum with a cradle and regular body

Torsional Pendulum with a cradle and irregular body

(b) Moment of Inertia of an Irregular Body

Expt. No.:

Date:

AIM

To determine the moment of inertia of an irregular body about an axis and perpendicular to its plane by dynamical method (inertia Table)

APPARATUS USED

Inertia Table, irregular body, regular body, stop watch, spirit level, physical balance, weight box and Vernier calipers.

FORMULA USED

The moment of inertia of the irregular body is $I_2 = I_2 \frac{(T_2^2 - T_0^2)}{(T_1^2 - T_0^2)}$

Where, I_1 Moment of inertia of regular body in kg. metre^2.

T_o - Time period of oscillation of cradle in second.

T_1 - Time period of oscillation cradle with regular body in second.

T_2 - Time period of oscillation cradle with of irregular body in second.

If regular body is in shape of disc having radius *R* and mass *M* then,

$$I_1 = \frac{1}{2} MR^2$$

THEORY

In this experiment, the torsion pendulum is formed by a cradle suspended by a steel wire. The cradle is in the form of a horizontal circular disc of aluminum fixed to rectangular metallic frame as shown in figure. At the centre of disc, there is a concentric circular grove to place the body. First the mean time period of oscillation T_0 of the cradle (without any mass) is determined

$$T_0 = 2\pi\sqrt{\frac{I_0}{C}} \text{ (or) } T_0 = \frac{4\pi^2 I_0}{C} \qquad (1)$$

Where I_0 = moment of inertia of the circle about the axis rotation. Now a regular body is placed on the cradle and the time period of the pendulum is determined.

$$T_1 = 2\pi\sqrt{\frac{I_0 + I_1}{C}}$$

Where I_1 = moment of inertia of the regular body which can be determines from the dimensions of the body.

(i) To find the period of oscillations

Length of the suspension wire (l) = …………………….. cm = …………………………. X 10^{-2} m.

System	**Time taken for 20 oscillations**			**Period of oscillation**
	Trial - 1	**Trial - 2**	**Mean**	
Unit	**Sec.**	**Sec.**	**Sec.**	**Sec.**
Cradle without any body				**T_0 =**
Cradle with regular body				**T_1 =**
Cradle with irregular body				**T_2 =**

$$T_1^2 = 4\pi^2\left(\frac{I_0 + I_1}{C}\right) \quad \textbf{(2)}$$

Now, the regular body is replaced by the irregular body and the time period of oscillation is noted.

$$T_2 = 2\pi\sqrt{\frac{I_0 + I_2}{C}} \qquad \text{(or)} \quad T_2^2 = 4\pi^2\left(\frac{I_0 + I_2}{C}\right) \quad (3)$$

Where I_2 – moment of inertia of the irregular body to be determined. From the relation (1) and (2), we have $T_1^2 - T_0^2 = \frac{4\pi^2 I_1}{C}$ (4)

From relations (1) and (3), we have

$$T_2^2 - T_0^2 = \frac{4\pi^2 I_2}{C} \quad (5)$$

Dividing equation (4) by equation (5), we have

$$\frac{T_1^2 - T_0^2}{T_2^2 - T_0^2} = \frac{\frac{4\pi^2 I_1}{C}}{\frac{4\pi^2 I_2}{C}} = \frac{I_1}{I_2} \qquad \text{(or)} \quad I_2 = I_1 \times \left(\frac{T_2^2 - T_0^2}{T_1^2 - T_0^2}\right)$$

Substituting the values of I_1, T_0, T_1, T_2 in the above equation, the value of the moment of inertia of the given irregular body is determined.

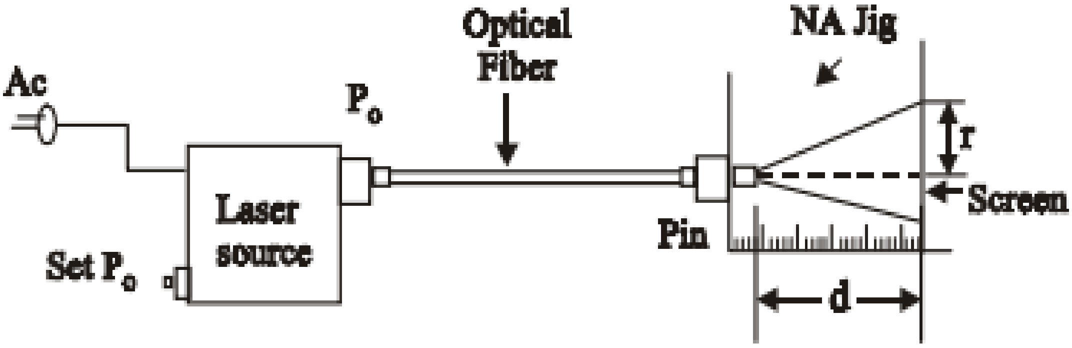
PROCEDURE

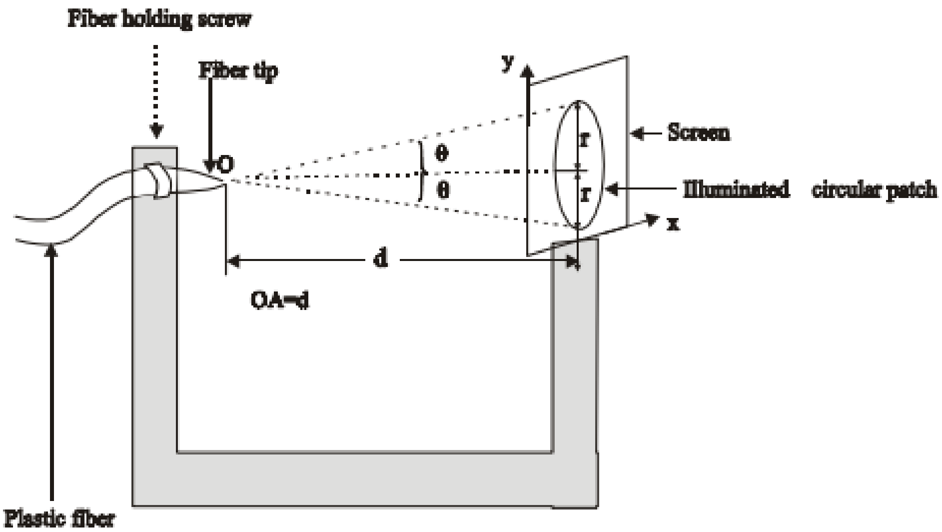
1. The slight twist is given to the cradle so that it begins to execute torsional in horizontal plane. Now the time for 20 oscillations is noted. It is repeated two times. his give us value of $T_0 = \frac{t_0}{20}$
2. Now the regular body is placed on the cradle and the step 1 is repeated. This gives us value of $T_1 = \frac{t_1}{20}$
3. After it, irregular body is placed on the cradle and the step 1 is repeated. This gives us value of $T_2 = \frac{t_2}{20}$
4. If given regular body is in shape of disc, then its mass is found with help of balance and also its diameter is found with help of Vernier calipers.

Result

The moment of inertia of irregular body = …………………………………….. kg m^2.

Parameters	**Maximum marks**	**Marks obtained**	**Signature of faculty**
Observation Completion	07		
Ontime submission	02		
Performance and presentation	01		
Total	10		





Sl.No	Distance between circular image and fibre end (d)		Radius of the circular image (r)	Numerical Aperture tan $\theta_0 = \frac{r}{d}$	Acceptance Angle $\theta_0 = \tan^{-1}\left(\frac{r}{d}\right)$
	cm	**mm**	**mm**	**degrees**	**degrees**
1					
2					
3					
4					
			Mean		

(a) Optical fiber – Determination of Numerical Aperture and Acceptance angle

Expt. No.:

Date:

AIM

To determine acceptance angle and numerical aperture of an optical fiber.

APPARATUS REQUIRED

1. Laser light source 2. Laser power meter 3. Optical fibre cables of various length
4. Optical fibre connectors 5. Numerical aperture jig 6. Mandrel for optical fibre.

FORMULA

Acceptance angle $\theta_0 = \tan^{-1}\left[\frac{r}{d}\right]$

Numerical aperture NA = sin θ_0

Where, r is the radius of circular image (m)

Distance from fibre end to circular image (m)

PROCEDURE

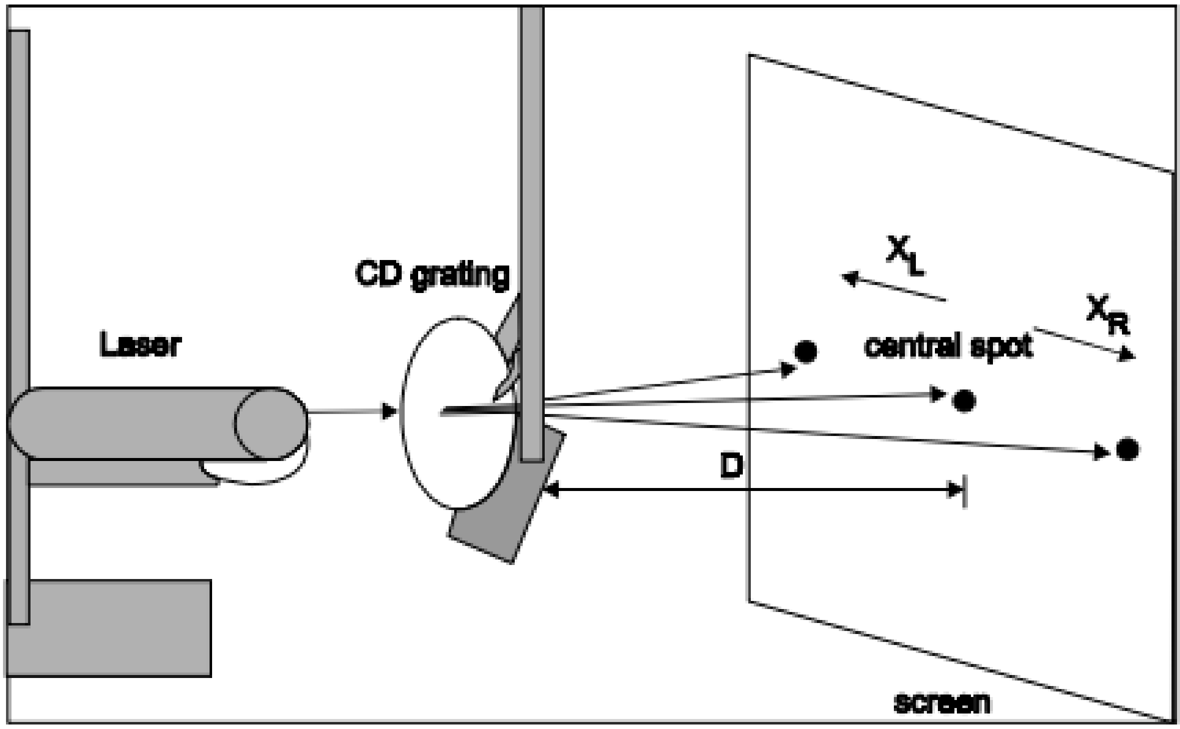
Using laser, we can find the numerical aperture of the fibre optic cable. The given laser source is connected to the optical fibre cable. The other end is exposed to the air medium in the dark place. The emerging light is exposed on a plain paper. (Fig.). Now, we get illuminated circular patch on the screen. The distance from the fibre end to circular image (d) is measured using meter scale. The radius of the circular image is also measured (Fig.). Thus, the acceptance angle is calculated. From the acceptance angle, the numerical aperture of the cable is found by using the given formula. $\theta_0 = \tan^{-1}\left[\frac{r}{d}\right]$

Result

(i) Acceptance angle of the optical fibre = radian

(ii) Numerical aperture of the optical fibre =

Parameters	Maximum marks	Marks obtained	Signature of faculty
Observation Completion	07		
Ontime submission	02		
Performance and presentation	01		
Total	10		



Order (n)	Distance of maxima from central bright $\times 10^{-2}$ m			$D \times 10^{-2}$ m	$\theta_n = \tan^{-1}\left(\frac{X}{D}\right)$ degree	$d = \frac{n\lambda}{\sin\theta_n} \times 10^{-6}$ m
	X_L	X_R	$X = \frac{X_L + X_R}{2}$			
1.						
2.						
					Mean	

Calculation

(b) Compact Disc - Determination of width of the groove using Laser

Expt. No.:

Date:

AIM

To determine groove width of CD using LASER**.**

APPARATUS REQUIRED

(i) CD (ii) Laser source (iii) Stand to hold CD and screen (iv) Ruler.

FORMULA

Width of the groove (or) track width is $d = \frac{n\lambda}{\sin\theta_n}$ **meters**

n	–	Order of diffraction (m)
λ	–	Wavelength of Laser light (m)
θ_n	–	Angle of diffraction for n^{th} order

PROCEDURE

The laser light source is placed firmly and horizontally using a stand. Another stand is used to position the CD in front of the laser for normal incident of laser light. The CD is placed close to the laser source. A blank wall or a white board can be used as a screen.

When a laser light is switched on, the diffraction pattern can be observed clearly on the screen. The diffraction pattern consists of a central bright spot and first order maxima on both sides of central bright spots. The second and third order spots may also be observed on the screen. If the diffraction spots are not in horizontal on the screen, the CD is rotated slightly until the images getting on a horizontal line.

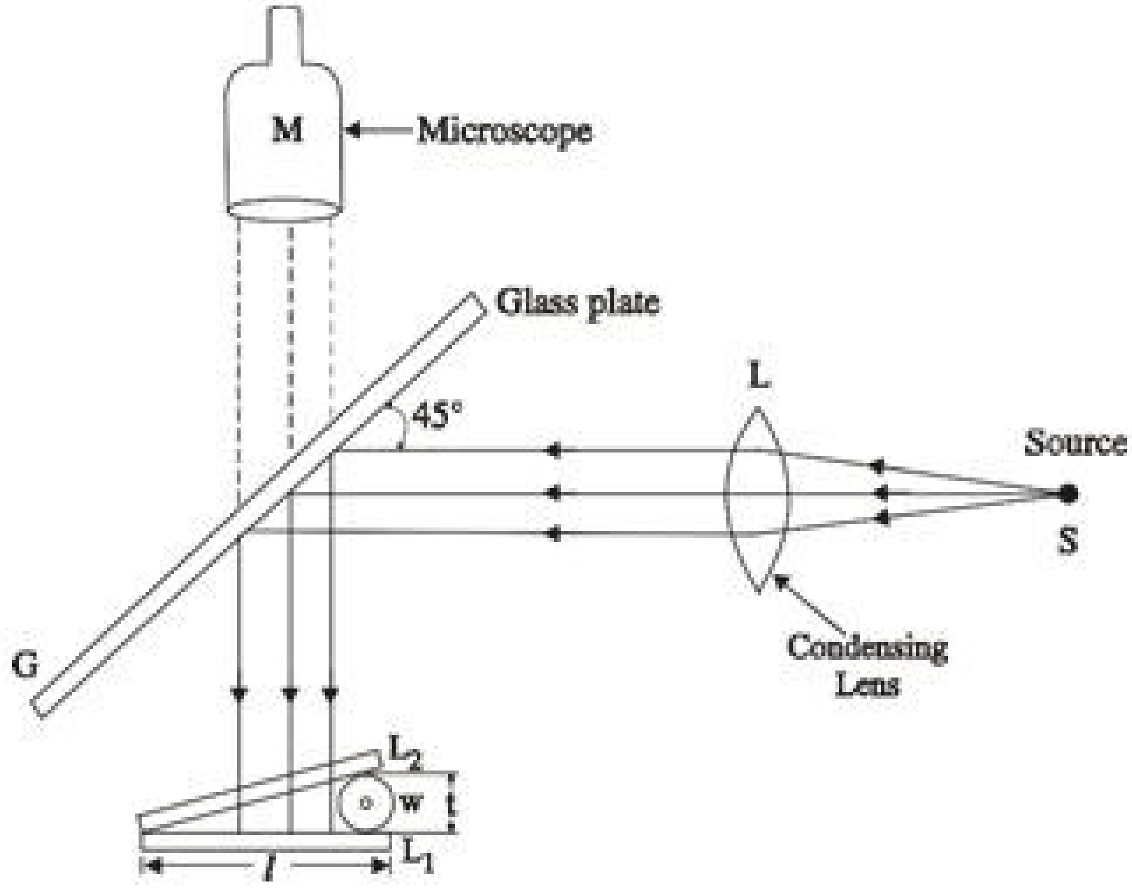
The distances of the different orders of maxima from central bright on either sides can be measured and tabulated. Finally, the distance of the CD to the screen (D) is measured.

Using, D and X_n, the diffraction angle θn and hence, groove width d can be measured.

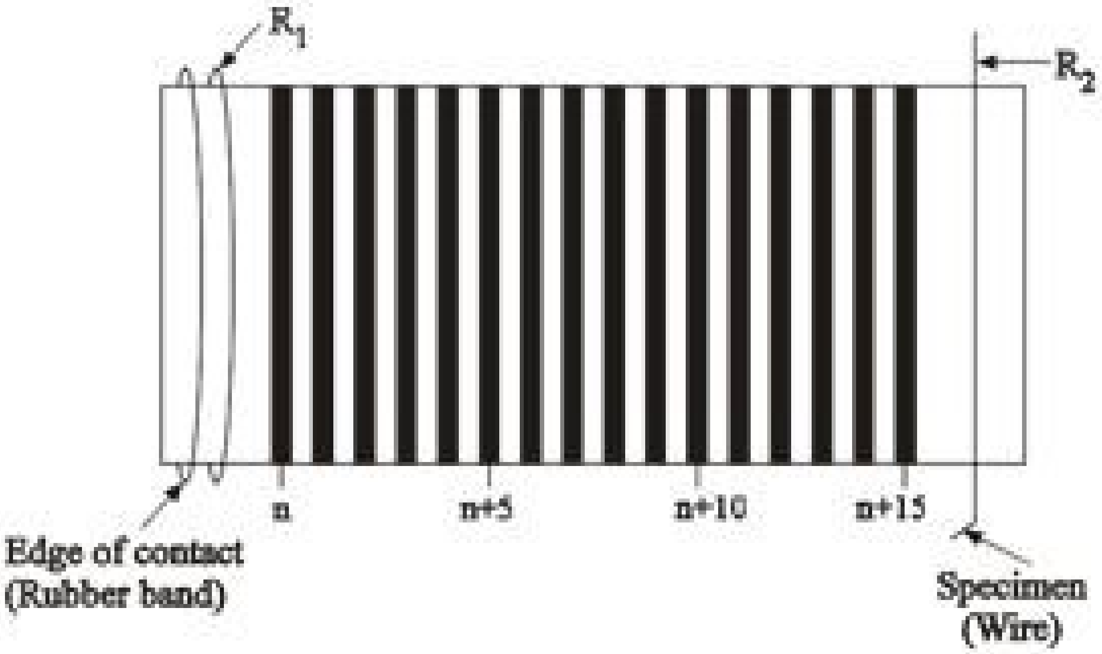
X_L, X_R distance between nth order maximum and central bright spot in left side and right side respectively.

Result

The groove width of CD using Laser …………………………………………… metre.



L_1, L_2 - Transparent plane glass plates w - Specimen (wire)



Air wedge - Determination of Thickness of a thin wire

Expt. No.:

Date:

AIM

To determine the thickness (diameter) of a thin wire by forming interference fringes using air-wedge arrangement.

APPARATUS REQUIRED

1. Travelling microscope 2. Sodium vapour lamp 3. Two optically plane rectangular glass plates 4. Condensing lens 5. Reading lens 6. Thin wire.

FORMULAE

Thickness of the thin wire is $t = \frac{\lambda l}{2\beta}$ metre

Where

λ - Wavelength of sodium light (m)

l - Distance of the wire from the edge of contact (m)

β - Mean width of one fringe (m)

PROCEDURE

An air wedge is formed by keeping two optically plane glass plates in contact along one of their edges. At the other end, thin wire is introduced with its length perpendicular to the length of the plate. The glass plates are tied together in this position by means of rubber band. It is then placed on the horizontal bed plate of the travelling microscope.

The interference pattern can be obtained with the help of the glass plate inclined at an angle 45° to the horizontal plane and a condensing lens. Light from the sodium vapour lamp is made to fall vertically on the air wedge. These interference fringes are viewed through the travelling microscope. A system of equi-spaced straight alternately dark and bright bands are obtained

The vertical cross wire of the microscope is adjusted to coincide with the centre of well-defined dark band near the edge of contact of the glass plates. It is taken as the n^{th} dark fringe. The reading on the horizontal scale of the microscope is noted.

The microscope is then moved in the same direction by using the horizontal transverse screw and made to coincide with every successive 5^{th} dark fringe. The readings are noted. This is continued till about 50

Travelling microscope readings

(i) To find the fringe width (β)

VSR = VSC X LC **TR = MSR + VSR** **L.C. = 0.001 cm**

Order of band	MSR	VSR	TR	Width of 5 bands	Mean width of one fringe (β)
Unit	cm	cm	cm	cm	cm
n					
$n + 5$					
$n + 10$					
$n + 15$					
$n + 20$					
$n + 25$					
$n + 30$					
$n + 35$					
$n + 40$					
$n + 45$					
$n + 50$					

Mean fringe width (β) = ………………………. 10^{-2} meter

(ii) To determine the distance between edge of contact and specimen

VSR = VSC x LC **L.C. = 0.001 cm**

Position	MSR	VSR	TR = MSR + VSR
	cm	cm	cm
Edge of contact (rubber band)			
Specimen wire			
$l = R_1 \sim R_2$ = ……………………. x 10^{-2} m.			

fringes are covered. The readings are tabulated. From these readings, the mean width of one fringe (β) is calculated.

The distance '*l*' between the edges of contact and the wire is measured with the help of the travelling microscope. Assuming the wavelength of sodium light, the thickness of the thin wire is calculated by using the given formula.

Observation

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

Distance between edge of contact and specimen (l) = …………….cm = …………….. x 10^{-2} m

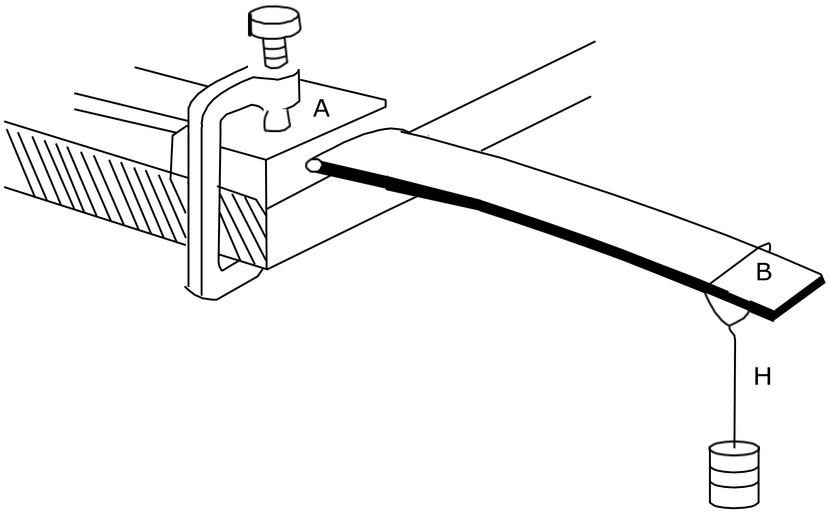
Fringe width of the specimen (β) = ……………………….cm = ………………… x 10^{-2} m.

$t = \frac{\lambda l}{2\beta}$ = ………………………………………… m

RESULT

Thickness of the given thin wire (t) =…………………………….. metre.

Parameters	Maximum marks	Marks obtained	Signature of faculty
Observation Completion	07		
Ontime submission	02		
Performance and presentation	01		
Total	10		



Period of Oscillations

Length cm	M_1 = 50 g Time for 10 Oscillations		Mean T_1	M_2 = 100 g Time for 10 Oscillations		Mean T_2	$\frac{l^3(M_2 - M_1)}{T_2^2 - T_1^2}$
	Trial 1	Trial 2		Trial 1	Trial 2		
	sec	*sec*	*sec*	*sec*	*sec*	*sec*	
70							
80							
						Mean	

=.......................**kg m³s⁻ ²**

Simple Harmonic Oscillations of cantilever

Expt. No.:

Date:

AIM

To determine Young's modulus of the material of cantilever by finding the period of vertical oscillations.

APPARATUS

Cantilever (meter scale), weight hanger with slotted weights, stop clock.

FORMULA

Young's modulus of the material of cantilever $Y = \frac{16\,\pi^2\, l^3}{b\, d^3} \times \left(\frac{M_2 - M_1}{T_2^2 - T_1^2} \right)$ N m^{-2}

Where

L - Length of the cantilever (m).

B - Breadth of the cantilever (m).

D - Thickness of cantilever (m).

M_1 - Mass added to the weight hanger (kg).

M_2 - Mass added to the weight hanger (kg).

T_1 - Mean period of oscillation when the mass M_1 is added to weight hanger (sec).

T_2 - Mean period of oscillation in second when the mass M_2 is added to weight hanger (sec).

PROCEDURE

A long rectangular beam of uniform cross section (cantilever) is clamped at one end A and a weight hanger *H* is suspended at the free end *B*. A small needle is fixed to the frame of the hanger [refer Fig.]. A mass M_1 (equal to say, 60 g) is added to the weight hanger so that it does not produce appreciable depression at the free end of the cantilever.

The free end of the cantilever is slightly depressed and is then released so as to execute vertical oscillations. The time for, (say 20) oscillations is noted using stop clock. The experiment is repeated twice and mean period of oscillation T_1 is found out.

Next, with adding a mass M_2 (equal to 100 g) the experiment is performed to find the corresponding period of oscillation T_2. The experiment is repeated for different lengths of cantilever and readings are tabulated as in Table.

Vernier caliper readings

To find the breadth of the beam (b) Least count (L.C.) = 0.01 cm

Sl.No	MSR	VSR = VSC x LC	Total reading (TR) = MSR+VSR
Unit	cm	cm	cm
1.			
2.			
3.			
4.			
			Mean (b) = ………………… $\times 10^{-2}$ m

Screw gauge readings

To find the thickness of the beam (*d*)

Zero error ± ....div

Least Count (L.C.) = 0.01 mm

Zero correction ± …………..mm

Sl. No	PSR	HSR = HSC x LC	Observed Reading = PSR + HSR	Correct Reading = OR ± ZC
Unit	mm	mm	mm	mm
1.				
2.				
3.				
4.				
Mean (d) =…………………………… $\times 10^{-3}$m				

Theory

Consider a uniform cantilever of length *l*, breadth *b* and thickness *d*, clamped at one end and carrying a mass *M* at free end. Let the cantilever be set oscillating in vertical plane. The period of oscillation is given by

$$T^2 = \frac{16\pi^2 l^3}{Ybd^3}\left(M + \frac{m}{3}\right)$$

Where *m* – mass of the cantilever, *Y* – Young's modulus of the material of the cantilever. If T_1 and T_2 are the periods of oscillation corresponding to masses M_1 and M_2 respectively, then

$$T_1^2 = \frac{16\pi^2 l^3}{Ybd^3}\left(M_1 + \frac{m}{3}\right)$$

and

$$T_2^2 = \frac{16\pi^2 l^3}{Ybd^3}\left(M_2 + \frac{m}{3}\right)$$

Using the above equations, the Young's modulus

$$Y = \frac{16\,\pi^2\,l^3}{b\,d^3} \times \left(\frac{M_2 - M_1}{T_2^2 - T_1^2}\right)$$

Observations

Breadth of cantilever (*b*) = …………………………..cm = ……………………….. x 10^{-2} m.

Thickness of cantilever (*d*) = …………………………..mm = ……………………… x 10^{-3} m.

Mean $\frac{l^3(M_2 - M_1)}{T_2^2 - T_1^2}$ = …………………………… kg m^2 s^{-2}.

Calculation:

Young's modulus (Y) $Y = \frac{16\,\pi^2\,l^3}{b\,d^3} \times \left(\frac{M_2 - M_1}{T_2^2 - T_1^2}\right)$ = ……………………………………….N m^{-2}.

Result

Young's modulus of the material of cantilever (Y) = ……………………………………. N m^{-2}.

Parameters	**Maximum marks**	**Marks obtained**	**Signature of faculty**
Observation Completion	07		
Ontime submission	02		
Performance and presentation	01		
Total	10		

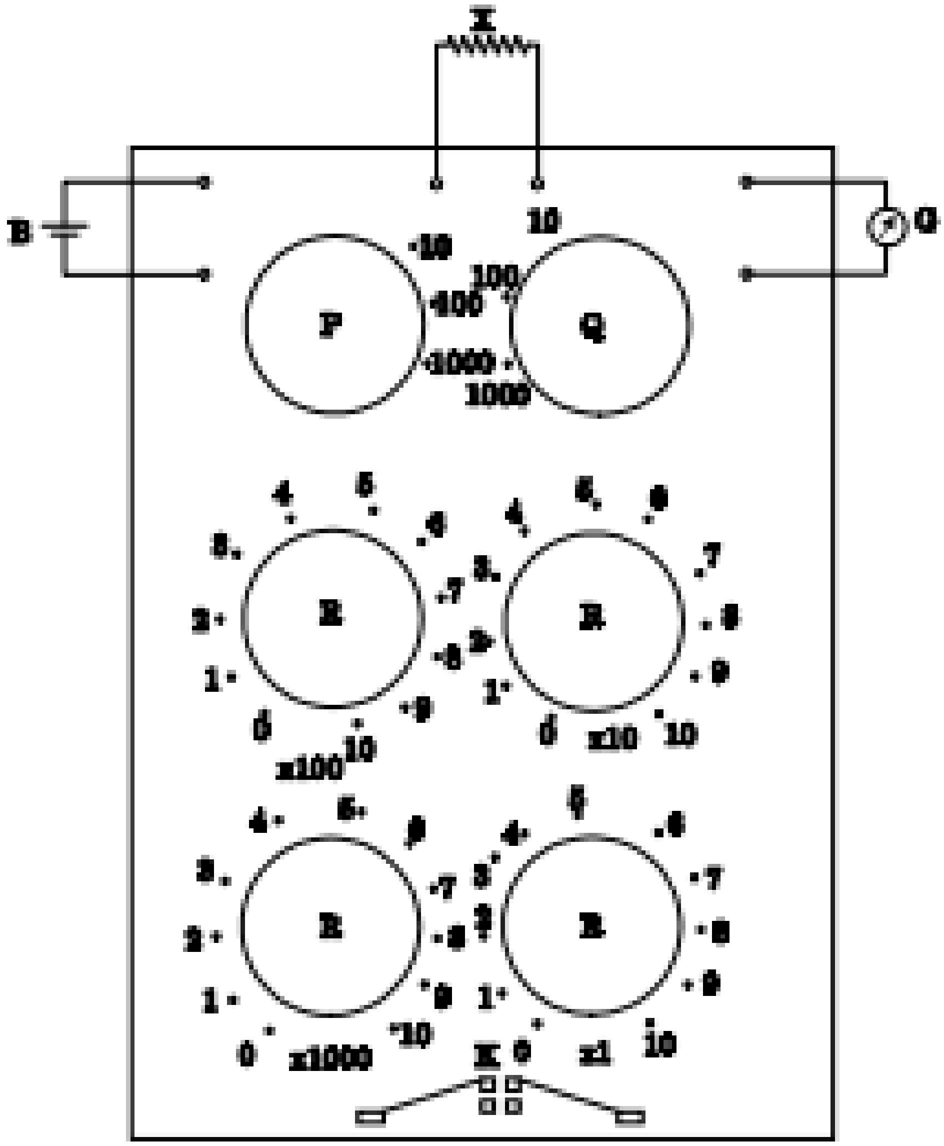
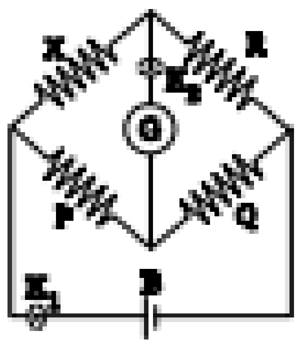


Fig. 10.1: Post Office Box



X – Thermistor (Temperature dependent resistor

By – Battery (Leclanche cell)

G – Galvanometer

P, Q, R – Variable resistances

K – Key

Band gap determination of a semiconductor

Expt. No.:

Date:

AIM

To find the band gap of the material of the given thermistor (semiconductor) using Post office box.

APPARATUS REQUIRED

1. Thermistor 2. Thermometer 3. Post office box 4. Power supply 5. Galvanometer 6. Insulating coil 7. Glass beakers.

FORMULA

Band gap for the given thermistor $E_g = 2k.\left(\frac{2.303\log_{10} R_T}{1/T}\right)$ eV.

Where k – Boltzmann constant (JK^{-1})

R_T – Resistance of the thermistor

PROCEDURE

The post of box is a Wheatstone bridge network. The connections are given as in the fig . '10' ohm resistances are taken in P and Q. Then the resistance in R is adjusted by pressing the tap key, until the deflection in the galvanometer crosses zero reading of the galvanometer, say from left to right. After finding an approximate resistance for this, two resistances in R, which differ by 1 ohm, are to be found out such that the deflections in the galvanometer for these resistances will be on either side of zero reading of galvanometer.

We know $R_T = \frac{Q}{P} \times R$, thus keeping the resistance in Q the same, the resistance in P is changed to 10, 100, 1000 ohms. Thus, the resistance of the thermistor is found out accurately to two decimals, at room temperature. The lower value may be assumed to be R_T (0.01 R).

Then, the thermistor is heated by keeping it immersed in insulating coil. For every 10°C rise in temperature, the resistance of the thermistor is found out. The readings are entered in the tabular column.

GRAPH

A graph is drawn between $\frac{1}{T}$ in x- axis and 2.303 $\log_{10}R_T$ in Y – axis which is shown in the figure from the graph

Temp. of thermistor t	Temp. of thermistor $T = t + 273$	$\left(\frac{1}{T}\right) \times 10^3$	Resistances in			Resistance of thermistor $X_T = \left(\frac{Q}{P}\right) \times R$	2.303 log 10 X_T
			P	Q	R		
°C	K	K^{-1}	Ω	Ω	Ω	Ω	
Room temperature T =			10	10			
55			100	10			
60			100	10			
65			100	10			
70			100	10			
75			100	10			

i.e.,, Band gap (E_g) = 2 k x slope of the graph

$$= 2k \times \frac{dy}{dx}$$

$$\because \frac{dy}{dx} = \frac{2.303\log_{10} R_T}{1/T}$$

Result

Band gap of the material of the thermistor ……………………. eV.

Details	Maximum marks	Marks obtained	Signature of faculty
Observation Completion	07		
Ontime submission	02		
Performance and presentation	01		
Total	10		

Appendix - I

Expt.: Torsional Pendulum – fixed support

Rigidity modulus of the material of the wire

Material	x 10^{10} Nm^{-2}
Brass	3.4 - 3.5
Copper	3.4 - 3.6
Steel	7.3 – 8.9

Expt.: Torsional pendulum -Cradle method

Moment of inertia of irregular body = 20 x10^{-6} kgm^{-2} - 40 x 10^{6} kgm^{-2}

Expt.: Non - Uniform Bending

Young's modulus by non-uniform bending (wood pulp) = 1 x 10^{10} N/m^2

Expt.: Simple harmonic Oscillation

Young's modulus by non-uniform bending (wood pulp) = 0.1 x 10^{10} N/m^2 – 1 x 10^{10} N/m^2

Expt.: Wavelength of laser

Wavelength of laser light source = 670nm to 790nm

Expt.: Acceptance angle and Numerical aperture

Acceptance angle of an optical fiber is 22˚ - 29˚

Expt: Laser diffraction – CD groove

Average Particle size = 1.5 x10^{-6} m – 2 x 10^{-6} m

Expt: Air wedge

The thickness of the thin wire (human hair or paint brush hair) = 60 μm – 90 μm

Expt.: Post office box method

Band gap of the given thermistor is 0.67 eV

Appendix - II

PHYSICAL CONSTANTS

Sl.No.	Name of the quantity	Symbol	Value	SI Unit
1	Speed of light	C	2.997925×10^{8}	ms^{-1}
2	Gravitational Constant	G	6.673×10^{-11}	$Nm^{2}kg^{-2}$
3	Acceleration due to gravity	g	9.8	ms^{-2}
4	Avogadro's Number	N	6.023×10^{23}	mol^{-1}
5	Boltzmann's Constant	k	1.38×10^{-23}	JK^{-1}
6	Planck's Constant	h	6.626×10^{-34}	J sec
7	Electron Charge	e	1.602×10^{-19}	C
8	Electron rest mass	m	9.11×10^{-31}	Kg