(i) To find the period (T) without masses.

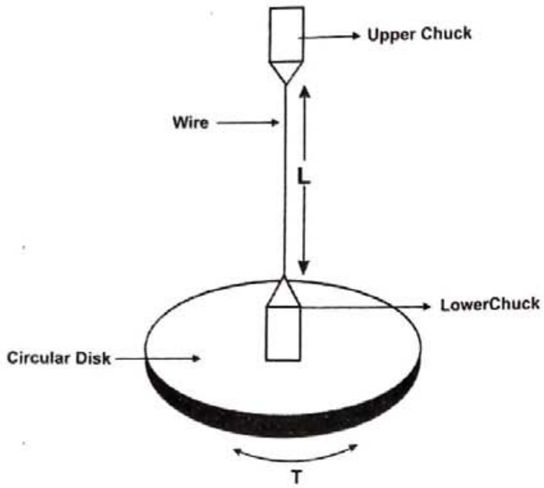


Fig. 1.3

(ii) To find time period (T_1), with Cylindrical masses kept at nearest distance (d_1)

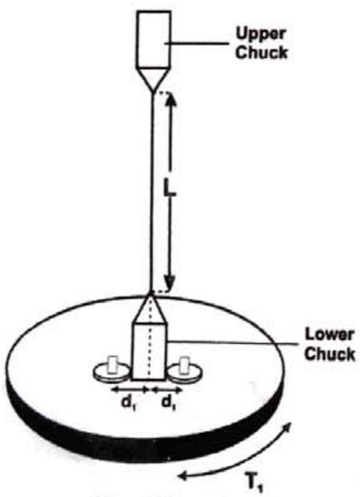


Fig. 1.4

(iii) To find time period (T_2), with Cylindrical masses kept at farthest distance(d_2)

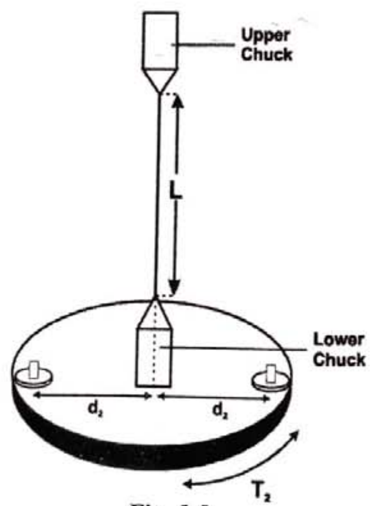


Fig. 1.5

EXPT.No. **ALITER** Date :

1B. TORSIONAL PENDULUM - DETERMINATION OF RIGIDITY MODULUS OF WIRE AND MOMENT OF INERTIA OF REGULAR OBJECT (WITH MASS)

Aim

To determine the moment of inertia of a regular object (disc) and rigidity modulus of the given material of a wire by torsional oscillations.

Apparatus required

Torsional pendulum in the form of circular metal disc, suspended wire, two equal cylindrical masses, biscuit balance, metre scale, stop watch, screw gauge, vernier caliper, etc.

Formulae

(i) Moment of inertia of the disc $I = \dfrac{2M(d_2^2 - d_1^2)T^2}{(T_2^2 - T_1^2)}$ Kg m^2

(ii) Rigidity modulus of the material of the given wire

$$n = \frac{8\pi IL}{r^4 T^2} \text{ Nm}^{-2}$$

Explanation of symbols

Symbol	Explanation	Unit
M	Mass of circular disc	kg
r	Radius of the given wire	metre
L	Length of the suspension wire	metre
d_1	Nearest distance between the centre of the disc and the centre of the cylindrical mass placed closer to the lower chuck.	metre
d_2	Farthest distance between the centre of the disc and the centre of the cylindrical masess places at the edges of the circular disc.	metre
T	Time period without cylindrical mass	second
T_1	Time period when the equal cylindrical masses are kept at the nearest distance (d_1).	second
T_2	Time period when the equal cylindrical masses are kept at the farthest distance (d_2)	second

R

(i) To find the time period of oscillation at various positions.

Length of the suspended wire L =..........$\times 10^{-2}$m

(from upper chuck to lower chuck)

Sl. No.	Position of the Circular disc		Time for 10 oscillations Trial - 1	Trial - 2	Mean	Time Period
Unit	Unit		Sec	Sec	Sec	Sec
1	Without cylindrical mass					T =
2	With cylindrical masses	Kept at nearest distance d_1=............$\times 10^{-2}$m				T_1 =
3		Kept at farthest distance d_2=............$\times 10^{-2}$m				T_2 =

(ii) Measurement of the diameter of the suspension wire using Screw gauge

LC = 0.01 mm

ZE = ...$\times 10^{-3}$ m

ZC = ...$\times 10^{-3}$ m

S.No.	Pitch scale Reading (PSR)	Head Scale Coincidence (HSC)	Observed reading OR = PSR+ (HSCxLC)	Correct Reading = OR $\pm$ZC
Unit	x 10^{-3} m	Div	x 10^{-3} m	x 10^{-3} m

Mean diameter = ...$\times 10^{-3}$ m

$\therefore$ Radius of the wire (r) = $\dfrac{\text{Mean diameter}}{2}$ = ... $\times 10^{-3}$m

Theory

The circular disc is rotated in a horizontal plane so that a twist is given to the wire which holds the disc. Hence the various elements of the wire undergo shearing strains. The restoring couples, which tend to restore the unstrained conditions are called into action. Now when the disc is released it starts executing torsional oscillations. The couple which acts on the disc produces in it an angular acceleration which is proportional to the angular displacement and is always directed towards its mean position. Hence the motion of the disc is a simple harmonic motion.

Procedure

A uniform thin wire whose rigidity modulus has to be found is suspended from a rigid support. The other end of the wire is attached to a circular disc using an adjustable chuck. The length of the suspension wire (L) between the point of suspension and the metal disc is the length of the torsional pendulum as shown in *Fig.1.3*

Step 1 : To find time period (T), without masses

Initially, without keeping the masses *(Fig. 1.3)* the length of the pendulum is adjusted, say 70 cm. Torsional oscillations are set up by giving a small twist to the disc. The time taken for 10 oscillations are found and hence time period, (T) which is nothing but the time taken for one oscillation is calculated.

Step 2 : To find time period (T_1), with cylindrical masses kept at nearest distance(d_1)

Keep the two equal cylindrical masses closely on either side of the lower chuck as shown in *Fig 1.4* and measure the nearest distance (d_1) between the centre of the circular disc and the centre of masses.

The circular disc is again twisted for torsional oscillation and the time taken for 10 oscillations are noted, from which the time period of oscillation (T_1) while keeping the masses at nearest distance (d_1) is calculated.

WORKSHEET FOR CALCULATION

Calculation

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

(ii) Rigidity modulus of the material of the given wire $n = \frac{8\pi IL}{r^4 T^2}$ Nm^{-2}

Step 3 : To find time period (T_2), with cylindrical masses kept at farthest distance (d_2)

Keep the two equal cylindrical masses at the edges of the circular disc as shown in *Fig 1.5* and note the farthest distance (d_2) between the centre of the disc and the centre of masses.

Now by setting up the torsional oscillations, the time taken for 10 oscillations are noted, from which the time period of oscillation (T_2) while keeping the masses at farthest distance (d_2) is calculated.

The radius of the wire (r) is found using screw gauge and the mass (M) of the metal disc is found using the biscuit balance. Substituting the values of T, T_1, T_2, d_1, d_2 and M in the given formula, the moment of inertia (I) can be calculated.

Now by substituting the value of moment of inertia (I), *r*, L and T^2 in the given formula, rigidity modulus (n) of the given wire can be calculated.

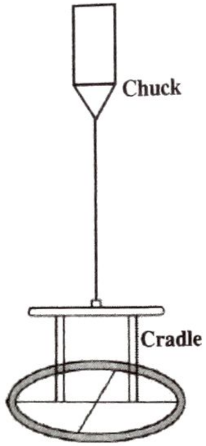
Result

(i) The moment of inertia of the regular object (disc) (I) = ... Kgm^2

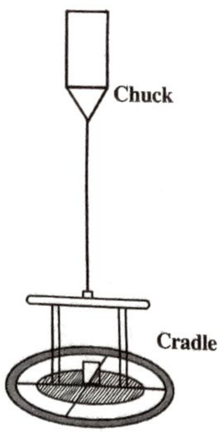
(ii) The rigidity modulus of the suspension wire (n)= .... Nm^{-2}

VIVA - VOCE

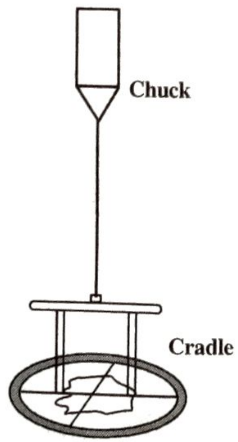
1. What is meant by elasticity?
2. Distinguish between rigidity modulus and Young's modulus.
3. Whether moment of inertia will vary with respect to radius of the disc?
4. What is meant by non-linear and linear oscillations?
5. Torsional oscillations are linear (or) non-linear oscillations?
6. What is meant by least count?
7. What is the difference between rigidity modulus and bulk modulus?
8. State moment, couple and torque.
9. What is the role of length of the wire in finding the rigidity modulus?
10. Whether the rigidity modulus will change, if the radius of the wire is increased? Justify.



Cradle alone
Fig. 1.6



Cradle with regular object
Fig. 1.7



Cradle with irregular object
Fig. 1.8

EXPT.No. Date :

1C. DETERMINATION OF MOMENT OF INERTIA OF AN IRREGULAR OBJECT

Aim

To determine the moment of inertia of an irregular object by torsional oscillations.

Apparatus required

Torsion pendulum in the form of a cradle, regular object, irregular object, stopwatch, etc.,

Formula

Moment of inertia of regular object $\Big\}\ I = MR^2/2$

Moment of inertia of the Irregular object $I' = I\left[\dfrac{T_2^2 - T^2}{T_1^2 - T^2}\right]$ kg m^2

Explanation of symbols

Symbol	Explanation	Unit
I	Moment of inertia of the regular object (known value)	kgm^2
T	Time period of the cradle alone	Second
T_1	Time period, when the regular object is placed over the cradle	Second
T_2	Time period, when the irregular object is placed over the cradle	Second

M Mass of the regular object kg

R Radius of the regular object. m

To find the time period of oscillation for various objects

Moment of inertia of the regular object I =

Sl. No.	Objects	Time for 10 oscillations			Time Period
		Trial - 1	Trial - 2	Mean	
Unit	Unit	Sec	Sec	Sec	Sec
1	Cradle alone				T =
2.	Cradle along with regular object				T_1 =
3.	Cradle along with irregular object				T_2 =

Description

The torsion pendulum consists of a cradle (c), which is in the form of a horizontal circular disc fixed to a rectangular metallic frame. The cradle is suspended from a fixed end with the help of a wire as shown in ***Fig.1.6.***

There is a concentric circular groove at the centre of the disc. So that any object for which the moment of inertia has to be found can be placed over it.

Procedure

The moment of inertia of an irregular object shall be determined by adopting the following steps. *viz.*

(1) Keep some distance (say 70 cm) between the chuck & cradle.

(2) Initially, the cradle alone is rotated and is set into torsional oscillations.

(3) With cradle alone, the time taken for 10 oscillations are found for trial-1 and trial-2 and hence the time period of oscillation (T) i.e., the time taken for one oscillation is found.

(4) A regular object (circular disc used in previous Expt. 1A (or) 1B) is placed over the cradle as shown in ***Fig. 1.7,*** and is allowed to produce torsional oscillations.

(5) With cradle and regular object together, the time taken for 10 oscillations are found for trial-1 and trial-2 and hence, the time period of oscillation (T_1) is found.

(6) The regular object is removed from the cradle and an irregular object is placed over the cradle as shown in ***Fig. 1.8*** and is allowed to produce torsional oscillations.

(7) With cradle and irregular object together, the time taken for 10 oscillations are noted for trial-1 and trial-2 and hence, the time period of oscillation (T_2) is found.

(8) Now by substituting the value of the time periods T, T_1, T_2 and the moment of inertia of the regular object (Already Determined from the previous experiment 1A (or) 1B) in the given formula, the moment of inertia of the irregular object (I′) can be calculated.

Note: If this experiment alone is asked in the university exam, then, the above procedure shall be repeated for various lengths of the suspended wire.

WORKSHEET FOR CALCULATION

Calculation

Moment of inertia of the irregular object (I′) = I $\left[\frac{T_2^2 - T^2}{T_1^2 - T^2}\right] kgm^2$

Result

The moment of inertia of the irregular object (I′) = ... Kgm^2

VIVA - VOCE

1. What is the difference between regular and irregular object?
2. What is meant by inertia.
3. Define moment of inertia.
4. Define moment and couple. Give examples.
5. Whether moment of inertia is same for regular and irregular objects? Justify.
6. Define Time period.
7. Why we need to note the time for 10 oscillations?
8. Define torque.
9. What is the use of Cradle in this experiment?
10. Give some applications of moment of inertia.

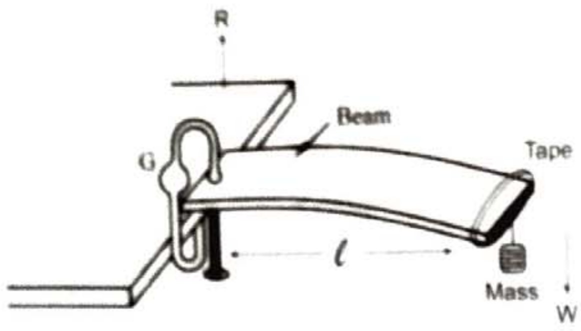


Fig. 2.1

(i) To find the ratio between mass and time period

Sl. No.	Distance between G-clamp and end of the cantilever (l)	Mass tied to the free end	Time for 10 oscillations			Time period	$\frac{M_2 - M_1}{T_2^2 - T_1^2}$
			Trial-1	Trial-2	Mean		
Unit	$\times 10^{-2}$ m	kg	sec	sec	sec	sec	kgs^{-2}
	l =	M_1 =				T_1 =	
		M_2 =				T_2 =	

EXPT.No. **Date:**

2. SIMPLE HARMONIC OSCILLATIONS OF CANTILEVER

Aim

To determine the Young's modulus of the cantilever beam by performing simple harmonic oscillations.

Apparatus required

Cantilever beam (wooden (or) steel scale), G-clamp, masses (0.5 kg, 1 kg, 2 kg etc.), stop watch, tape, etc.

Formula

The Young's modulus of the cantilever beam (wooden scale)

$$E = \frac{16\pi^2 l^3 (M_2 - M_1)}{b d^3 (T_2^2 - T_1^2)} \text{ Nm}^{-2}$$

Explanation of Symbols

Symbol	Explanation	Unit
l	Length of the cantilever from the G-clamp	metre
b	Breadth of the cantilever (wooden scale)	metre
d	Thickness of the cantilever (wooden scale)	metre
M_1, M_2	Masses tied to the end of the cantilever	kg.
T_1	Time period of oscillation of the cantilever with mass M_1	second
T_2	Time period of oscillation of the cantilever with mass M_2	second

(ii) To find the breadth (b) of the beam using vernier calipers

LC = 0.01 cm

ZE = ... $\times 10^{-2}$ m
ZC = ... $\times 10^{-2}$ m

S.No.	Main scale Reading (MSR)	Vernier Scale Coincidence (VSC)	Observed reading OR = MSR+ (VSCxLC)	Correct Reading = OR $\pm$ ZC
Unit	$\times 10^{-2}$ m	Div	$\times 10^{-2}$ m	$\times 10^{-2}$ m

Mean = ... $\times 10^{-2}$ m

(iii) To find the thickness (d) of the beam using screw gauge.

LC = 0.01 mm

ZE = ... $\times 10^{-3}$ m
ZC = ... $\times 10^{-3}$ m

S.No.	Pitch scale Reading (PSR)	Head Scale Coincidence (HSC)	Observed reading OR = PSR+ (HSCxLC)	Correct Reading = OR $\pm$ ZC
Unit	$\times 10^{-3}$ m	Div	$\times 10^{-3}$ m	$\times 10^{-3}$ m

Mean = ... $\times 10^{-3}$ m

Theory

A cantilever is a beam fixed horizontally at one end and loaded at the other end as shown in ***Fig. 2.1***

Due to the load applied at the free end, a couple is created between the two forces *viz.*,

(i) Force (load W) applied at the free end towards downward direction and

(ii) Reaction force (R) acting in the upward direction at the supporting end.

Now, if the free end with load is made to oscillate, then, it will perform simple harmonic oscillations.

Procedure

Take a one metre scale [l = 1 metre] and fix one end of the scale with the G-clamp as shown in ***Fig.2.1*** and tie a 0.5 kg mass (M_1) at the other end of the scale, so that this scale will now act as a cantilever.

The cantilever is made to oscillate vertically by applying a force with one hand gently and allow the cantilever to perform simple harmonic oscillations.

Take a stop watch and find the time taken for 10 oscillations and tabulate it in the tabular column as trial-1.

In the same manner take the second trial and then find the time period of oscillation T_1 i.e., time taken for one oscillation.

Now increase the mass to say 1 kg (M_2) at the free end and perform the same steps as detailed above and find the time period of oscillation T_2.

Find the the breadth (b) of the cantilever beam using vernier calipers and thickness (d) of the beam using screw guage.

WORKSHEET FOR CALCULATION

Calculation

The Young's modulus of the cantilever beam (wooden scale)

$$E = \frac{16\pi^2 l^3 (M_2 - M_1)}{b d^3 (T_2^2 - T_1^2)} \text{ Nm}^{-2}$$

Now by substituting the values of l, M_1, M_2, T_1, T_2, b and d in the given formula, we can find the Young's modulus of the cantilever.

Note: The experiment shall also be performed for various lengths between the G-clamp and the force end.

Result

1. Simple harmonic oscillations were performed using cantilever.
2. Young's modulus of the given material of the beam = ... Nm^{-2}.

VIVA-VOCE

1. What is meant by simple harmonic motion? Give examples.
2. What is meant by a cantilever?
3. Whether Young's modulus for the cantilever beam shall be found using any other method? Justify.
4. Is it possible to find the amplitude of oscillations using this method? Justify.
5. What will happen if the distance between the G-clamp and free end is varied?
6. Whether the Youngs modulus for wooden and steel scale is same?
7. What is meant by action force and reaction force? Give examples.
8. What are transverse and longitudinal waves?
9. What is meant by travelling and standing wave?
10. What type of waves are produced in SHM?

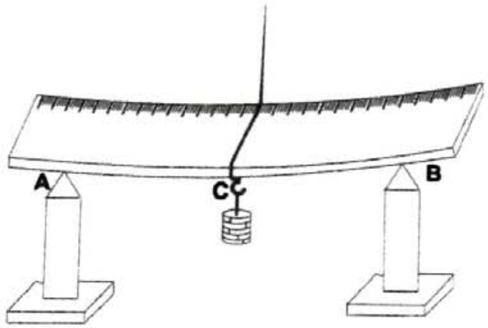


Fig. 3.1

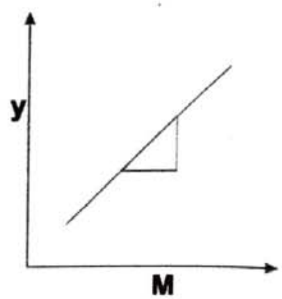


Fig. 3.2

(i) To find M/y

LC = 0.001 cm

TR = MSR + (VSC × LC)

Distance between the knife edges (l) = = ... $\times 10^{-2}$ metre

Sl. No.	Load (M)	Microscope Reading						Mean	Depres-sion (y)	M/y
		Increasing load			Decreasing load					
		MSR	VSC	TR	MSR	VSC	TR			
Unit	Kg.	$\times 10^{-2}$ m	Div.	$\times 10^{-2}$ m	$\times 10^{-2}$ m	Div.	$\times 10^{-2}$ m	Metre	Metre	Kg m^{-1}

Mean = ... kgm^{-1}

2

EXPT.No.

Date:

3. NON UNIFORM BENDING – DETERMINATION OF YOUNG'S MODULUS

Aim

To determine the young modulus of the given material of the beam by non-uniform bending.

Apparatus required

A long uniform beam usually a metre scale, travelling microscope, pin, weight hanger with slotted weights, vernier calipers, screw guage, knife edges etc.,

Formulae

The Youngs modulus of the given material of the beam

(i) By calculation $Y = \frac{g l^3}{4bd^3} \cdot \frac{M}{y}$ Nm^{-2}

$\frac{Mg l^3}{4bd^3 y}$

(ii) By Graphical method $Y = \frac{g l^3}{4bd^3} \cdot \frac{1}{K}$ Nm^{-2}

Explanation of Symbols

Symbol	Explanation	Unit
g = 9.8	Acceleration due to gravity	ms^{-2}
l = 80	Distance between the two knife edges	metre
b =	Breadth of the beam	metre
d =	Thickness of the beam	metre
y =	Depression produced for 'M' kg of load	metre
M =	Load applied	kg.
K =	Slope y/M from graph	mKg^{-1}

(3)

(ii) To find the breadth (b) of the beam using vernier calipers

LC = 0.01 cm

ZE = ...$\times 10^{-2}$ m

ZC = ...$\times 10^{-2}$ m

S.No.	Main scale Reading (MSR)	Vernier Scale Coincidence (VSC)	Observed reading OR = MSR+ (VSCxLC)	Correct Reading = OR $\pm$ZC
Unit	x 10^{-2} m	Div	x 10^{-2} m	x 10^{-2} m

Mean b = ...$\times 10^{-2}$m

(iii) To find the thickness (d) of the beam using screw gauge.

LC = 0.01 mm

ZE = ±14 ....$\times 10^{-3}$ m

ZC = 14 ....$\times 10^{-3}$ m

S.No.	Pitch scale Reading (PSR)	Head Scale Coincidence (HSC)	Observed reading OR = PSR+ (HSCxLC)	Correct Reading = OR $\pm$ ZC
Unit	x 10^{-3} m	Div	x 10^{-3} m	x 10^{-3} m

Mean = d ....$\times 10^{-3}$ m

(4)

Procedure

The given beam is placed on the two knife edges (A and B) at a distance say 70 cm or 80 cm.

A weight hanger is suspended at the centre(C) of the beam and a pin is fixed vertically on the frame of the hanger as shown in ***Fig. 3.1.***

Taking the weight hanger alone as the dead load the tip of the pin is focused by the microscope, and is adjusted in such a way that the tip of the pin just touches the horizontal cross wire. The reading on the vertical scale is noted.

Now the weight is added in steps of 50 grams. Each time the tip of the pin is made to touch the horizontal cross wire and the readings are noted from the vertical scale of the microscope. The procedure is followed until the maximum load is reached.

The same procedure is repeated by unloading the weight in steps of same 50 grams and the readings are tabulated in the tabular column. From the readings the mean of (M/y) is calculated.

The thickness and the breadth of the beam are measured using screw guage and vernier calipers respectively and are tabulated. By substituting the values in the given formula. The Youngs modulus of the material of the beam can be calculated.

A graph is drawn taking load (M) along **x** axis and depression 'y' along **y** axis as shown in ***Fig.3.2.*** The slope of the graph gives the value K = y/M. Substituting the value of the slope in the given formula, the Youngs modulus can be calculated.

WORKSHEET FOR CALCULATION

Calculation

The Youngs modulus of the given material of the beam

By calculation $Y = \frac{g l^3}{4 b d^3} \cdot \frac{M}{y}$ Nm^{-2}

Graphical method

The Youngs modulus of the given material of the beam

By Graphical method $Y = \frac{g l^3}{4 b d^3} \cdot \frac{1}{K}$ Nm^{-2}

Result

The Youngs modulus of the given material of the beam

(i) By calculation = ... Nm^{-2}

(ii) By Graph = ... Nm^{-2}

VIVA - VOCE

1. What is meant by non-uniform bending?
2. Define neutral axis.
3. Name any two methods used to determine the youngs modulus of the beam.
4. Define elasticity.
5. Will there be any change in youngs modulus of the material, if its thickness is increased? justify.
6. What are the basic assumption made for the theory of bending.
7. Why iron girders used in buildings are made in the form of I-section?
8. What is the use of keeping an optimum of 0.7 to 0.8 metre distance between the knife edges?
9. Define elastic limit.
10. What is meant by elastic constants?

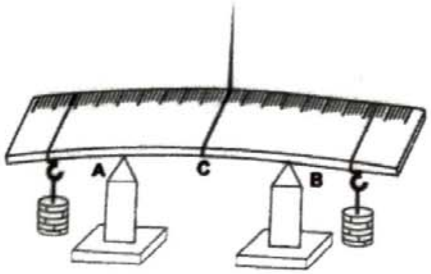


Fig. 4.1

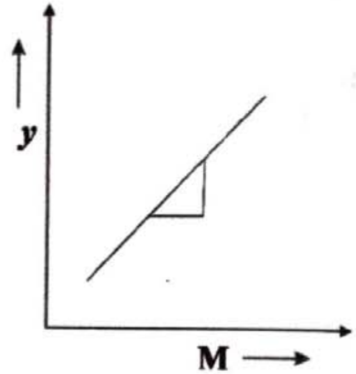


Fig. 4.2

(i) To find M/y

Distance between the weight hanger and any one of the adjacent knife edge (D) = ... $\times 10^{-2}$ metre

Distance between the knife edges (l) = = ... $\times 10^{-2}$ metre

LC = 0.001 cm TR = MSR+(VSC×LC)

Sl. No.	Load (M)	Microscope Reading						Mean	Elevation (y)	M/y
		Increasing load			Decreasing load					
		MSR	VSC	TR	MSR	VSC	TR			
Unit	Kg.	$\times 10^{-2}$ m	Div.	$\times 10^{-2}$ m	$\times 10^{-2}$ m	Div.	$\times 10^{-2}$ m	Metre	Metre	Kg m^{-1}

Mean = ... Kg m^{-1}

EXPT.No. Date:

4. UNIFORM BENDING-DETERMINATION OF YOUNG'S MODULUS

Aim

To determine the Young's Modulus of the given material of beam by uniform bending.

Apparatus required

The given beam (metre scale), travelling microscope, two weight hangers, pin, slotted weights, screw guage, vernier calipers, knife edges etc.

Formulae

The Young's Modulus of the given material of the beam

(i) By calculation $Y = \frac{3\,g\,D\,l^2}{2\,bd^3} \cdot \frac{M}{y}$ Nm^{-2}

(ii) By Graphical method $Y = \frac{3\,g\,D\,l^2}{2\,bd^3} \cdot \frac{1}{K}$ Nm^{-2}

Explanation of symbols

Symbol	Explanation	Unit
g	Acceleration due to gravity	ms^{-2}
D	Distance between the weight hanger and any one of the adjacent knife edge	metre
l	Distance between the two knife edges	metre
b	Breadth of the beam	metre
d	Thickness of the beam	metre
y	Elevation produced for 'M' kg of load	metre
M	Load applied	Kg.
K	Slope $\frac{y}{M}$ from graph	m Kg^{-1}

(ii) To find the breadth (b) of the beam using vernier calipers

LC = 0.01 cm

ZE = ...$\times 10^{-2}$ m
ZC = ...$\times 10^{-2}$ m

S.No.	Main scale Reading (MSR)	Vernier Scale Coincidence (VSC)	Observed reading OR = MSR+ (VSCxLC)	Correct Reading = OR $\pm$ ZC
Unit	$\times 10^{-2}$ m	Div	$\times 10^{-2}$ m	$\times 10^{-2}$ m

Mean = ...$\times 10^{-2}$ m

(iii) To find the thickness (d) of the beam using screw gauge.

LC = 0.01 mm

ZE = ...$\times 10^{-3}$ m
ZC = ...$\times 10^{-3}$ m

S.No.	Pitch scale Reading (PSR)	Head Scale Coincidence (HSC)	Observed reading OR = PSR+ (HSCxLC)	Correct Reading = OR $\pm$ ZC
Unit	$\times 10^{-3}$ m	Div	$\times 10^{-3}$ m	$\times 10^{-3}$ m

Mean = ...$\times 10^{-3}$ m

Procedure

The given beam is placed over the two knife edges (A and B) at a distance of 70 cm (or) 80 cm.

Two weight hangers are suspended, one each on either side of the knife edge at equal distance from the knife edge. A pin is fixed vertically exactly, at the centre of the beam as shown in ***Fig.4.1.***

A travelling microscope is placed in front of this arrangement. Taking the weight hangers alone as the dead load, the tip of the pin is focussed by the microscope and is adjusted in such a way that the tip of the pin just touches the horizontal cross-wire. The reading on the vertical scale of the travelling microscope is noted.

Now, equal weights are added on both the weight hangers, in steps of 50 grams. Each time the position of the pin is focussed and the readings are noted from the microscope. The procedure is followed until the maximum load is reached.

The same procedure is repeated by unloading the weight from both the weight hangers in steps of same 50 grams and the readings are tabulated in the tabular column. From the readings, the Mean of (M/y) is calculated.

The thickness and the breadth of the beam are measured using screw gauge and vernier calipers respectively and are tabulated. By substituting all the values in the given formula, the Youngs Modulus of the given material of the beam can be calculated.

A graph is drawn taking load (M) along **x**-axis and elevation 'y' along **y**-axis as shown in ***Fig.4.2.*** The slope of the graph gives the value of K=y/M. Now by substituting the value of the slope in the given formula, the Young's Modulus can be calculated, graphically.

WORKSHEET FOR CALCULATION

Calculation

The Young's Modulus of the given material of the beam

By calculation $$Y = \frac{3\,g\,D\,l^2}{2\,bd^3} \cdot \frac{M}{y}\ Nm^{-2}$$

Graphical method

The Young's Modulus of the given material of the beam

By Graphical method $$Y = \frac{3\,g\,D\,l^2}{2\,bd^3} \cdot \frac{1}{K}\ Nm^{-2}$$

Result

The Young's Modulus of the given material of the beam

(i) By calculation = ... Nm^{-2}

(ii) By graph = ... Nm^{-2}

VIVA - VOCE

1. What is meant by uniform bending?
2. What are the uses of a travelling microscope?
3. Distinguish between uniform bending and non-uniform bending.
4. Name the other experimental technique that can be employed for finding the Youngs Modulus by uniform and non-uniform bending.
5. What is the advantage of graphical method over experimental method.
6. Will the same experiment holds good for the materials say steel, brass, Iron etc. Justify.
7. Why two weight hangers are used in uniform bending and only one in non-uniform bending?
8. What is the use of the pin in the experiment?
9. Why the pin should be fixed exactly at the centre of the beam?
10. What is the reason behind suspending the weight hangers at equal distance from the knife edges, in the case of uniform bending?

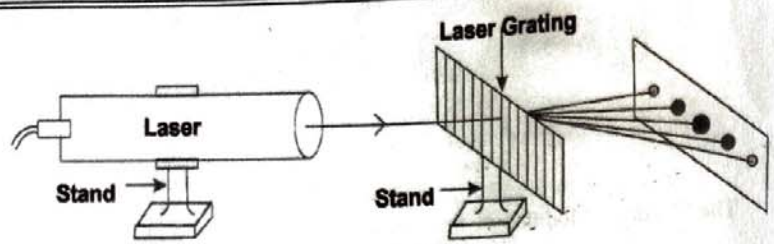


Fig. 5.1

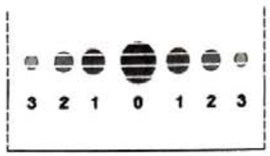


Fig. 5.2

To find the wavelength of the laser source

Number of rulings in the grating (N) = ...98425......lines/metre

Distance between the laser grating and the screen (D) = ... $\times 10^{-2}$m

S. No.	Order (m)	X_m LHS	X_m RHS	Mean X_m	X_m^2	D^2	$\sqrt{X_m^2 + D^2}$	λ
Unit	No.	$\times10^{-2}$ m	$\times10^{-2}$ m	$\times10^{-2}$ m	$\times10^{-4}$ m^2	$\times10^{-4}$ m^2	$\times10^{-2}$ m	Å
1.	First							
2.	Second							
3.	Third							
4.	Fourth							
5.	Fifth							
6.	Sixth							
7.	Seventh							
8.	Eighth							
9.	Ninth							
10.	Tenth							

EXPT. No. **Date :**

5. LASER - DETERMINATION OF THE WAVE LENGTH OF THE LASER USING GRATING

Aim

To determine the wavelength of the given laser source, using laser grating.

Apparatus required

A diode laser, given particle, laser grating, scale, screen etc.

Formula

Wavelength of the given laser source $\lambda = \dfrac{X_m}{Nm\sqrt{X_m^2 + D^2}}$ Å

Explanation of symbols

Symbol	Explanation	Unit
λ	Wavelength of the laser source	Å
N	Number of rulings in the grating	lines/metre
m	Order of spectrum	Unit
X_m	Distance of the mth order from Zeroth order	metre
D	Distance between the laser grating and the screen	metre

WORKSHEET FOR CALCULATION

Calculation

Wavelength of the given laser source $\lambda = \frac{X_m}{Nm\sqrt{X_m^2 + D^2}}$ Å

$N = 2500 / 2.54 \times 10^{-2}$

$N = 98425$

Procedure

To find wavelength of the laser source

The laser source and the laser grating are mounted on separate stands as shown in ***Fig. 5.1.*** A fixed distance (D) is kept between the laser grating and the screen. The laser source is switched ON and the beam of laser is allowed to fall on the laser grating. The diffracted beams are collected on the screen. The diffracted beams are in the form of spots as shown in ***Fig 5.2.***

In the ***Fig. 5.2*** the intensity of the irradiance is found to decrease, from zeroth order to higher orders, i.e. the first order is brighter than the second order and so on. The positions X_1, X_2, X_3... of the spots belonging to the first order, second order, third order etc., on either side of the central maximum are marked on the screen and is noted.

The experiment is repeated for various values of D and the positions of the spots are noted. Then by using the given formula the wavelength of the laser source can be calculated and the mean is taken.

Result

The wavelength of the given laser source =.........................Å

VIVA - VOCE

1. What is meant by LASER?
2. Is the diffraction possible if the laser light is replaced by ordinary light for the same particle?
3. State few properties of Laser.
4. What do you understand by the term, "Rulings" in a grating.
5. Why the order of spectrum increases with respect to the distance.
6. What is meant by wavelength? Mention any 4 wavelengths in visible spectrum.
7. What is the advantage of using the He-Ne laser (or) Semiconductor Laser than the CO_2 laser for this experiment.
8. What is meant by a diode laser?
9. Can LED be used for this experiment? Give reasons.
10. Mention any two diode laser sources.

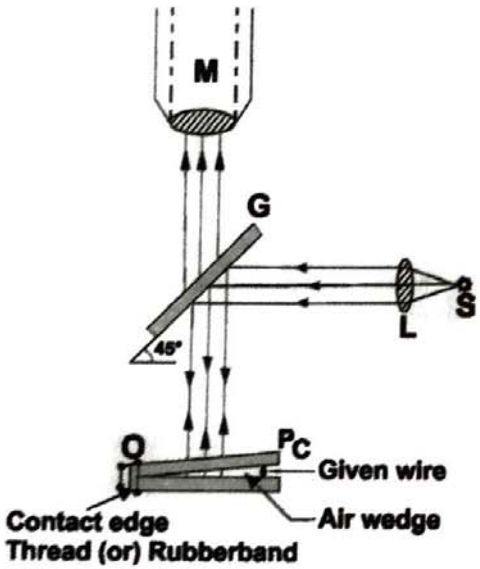


Fig. 6.1

EXPT. No.

Date:

6. AIR WEDGE - DETERMINATION OF THICKNESS OF A THIN SHEET/WIRE

Aim

To determine the thickness of a thin fiber (or) wire (or) hair (or) a sheet of paper by forming interference fringes due to an air-wedge.

Apparatus Required

Travelling microscope, two optically plane glass plates, given fiber (or) wire (or) thin sheet of paper, sodium vapour lamp etc.

Formula

Thickness of the thin sheet of paper (or) wire $t = \frac{l\lambda}{2\beta}$ metres

Explanation of symbols

Symbol	Explanation	Unit
l	Distance between edge of contact and the wire (or) paper	metre
λ	Wavelength of the monochromatic source of light [5893 Å]	metre
β	Mean fringe width	metre

Theory

Two plane glass plates are inclined at an angle by introducing a thin material. (e.g. thin fiber (or) hair), forming a wedge shaped air film. This film is illuminated by sodium light, interference occurs between the two rays, one reflected from the front surface and the other obtained by internal reflection at the back surface. Since in the case of a wedge shaped film, thickness of the material remains constant only in direction parallel to the thin edge of the wedge, straight line fringes parallel to the edge of the wedge are obtained.

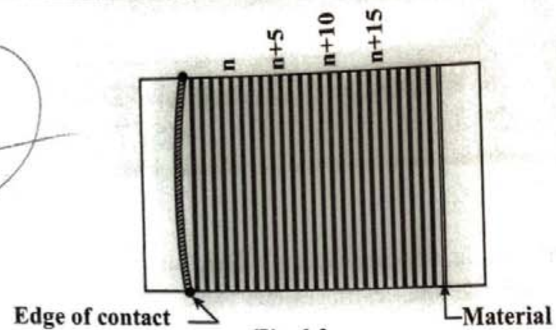


Fig.6.2

(i) To find the band width (β)

LC = 0.001 cm

TR=MSR + (VSC × LC)

Order of the fringes	Microscope reading MSR 10^{-2} m	Microscope reading VSC (Div)	Microscope reading TR $\times 10^{-2}$ m	Width of 20 fringes $\times 10^{-2}$ m	Fringe width (β) $\times 10^{-2}$ m
n					
n+5					
n+10					
n+15					
n+20					
n+25					
n+30					
n+35					
n+40					
n+45					
n+50					

Mean = ... $\times 10^{-2}$ m

Procedure

Two optically plane glass plates are placed one over the other and tied by means of a rubber band at one end. The given material of fiber (or) wire (or) paper is introduced on the other end, so that an air-wedge is formed between the plates as shown in ***Fig.6.1***. This set up is placed on the horizontal bed plate of the travelling microscope.

Light from the sodium vapour lamp (S) is rendered parallel by means of a condensing lens (L). The parallel beam of light is incident on a plane glass plate (G) inclined at an angle of 45° and gets reflected.

The reflected light is incident normally on the glass plates in contact P_C. Interference takes place between the light reflected from the top and bottom surfaces of the glass plates and is viewed through the travelling microscope(M). Hence large number of equally spaced dark and bright fringes are formed which are parallel to the edge of contact ***Fig.6.2***.

The microscope is adjusted so that the bright (or) dark fringe near the edge of contact is made to coincide with the vertical cross wire and this is taken as the n^{th} fringe. The reading from the horizontal scale of the travelling microscope is noted.

The microscope is moved across the fringes using the horizontal traverse screw and the readings are taken when the vertical cross wire coincides with every successive 5 fringes (5, 10, 15, 20...). The width of every 20 fringes is calculated and the width of one fringe is calculated. The mean of this gives the fringe width (β).

The cross wire is fixed at the inner edge of the rubber band and the reading from the microscope is noted. Similarly reading from the microscope is noted keeping the cross wire at the edge of the material. The difference between these two values gives the value of 'l'. Substituting 'β' and l in the given formula, the thickness of the given material can be determined.

(ii) To find the distance between the edge of contact and the material of fiber (or) wire (or) paper (or) sheet

$$TR = MSR + (VSC \times LC)$$

LC = 0.001 cm

Position of the Microscope	Microscope Reading			$l = R_1 \sim R_2$
	MSR $\times 10^{-2}$m	VSC Div.	TR $\times 10^{-2}$m	$\times 10^{-2}$m
At the edge of contact			(R_1)	
At the edge of material of fiber (or) wire (or) Paper			(R_2)	

WORKSHEET FOR CALCULATION

Calculation

Thickness of the thin sheet of paper (or) wire $t = \frac{l\lambda}{2\beta}$ metres

Result

The thickness of the given material of fiber (or) wire (or) paper (or) sheet = ... metres.

VIVA-VOCE

1. What is the principle behind the formation of fringes in Air wedge?
2. What is meant by an "Air Wedge" and explain how it can be formed?
3. What is meant by fringe width?
4. What is the theory of formation of thin films? Give examples.
5. What is the use of inserting 45° angled glass plate?
6. Why do we get straight line fringes in an airwedge?
7. Explain the reason for colour formation in soap bubbles, when white light falls on it.
8. What happens to the fringe width, if the thickness of the material is increased?
9. What is the condition for the formation of bright fringes?
10. Why do we get bright and dark fringes alternatively?

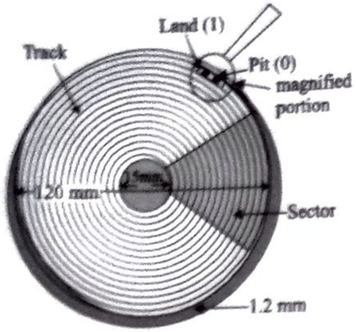


Fig. 7.2

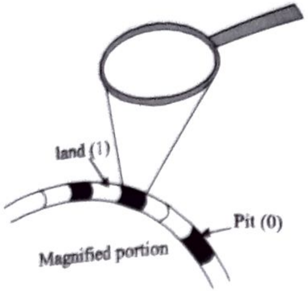


Fig. 7.3

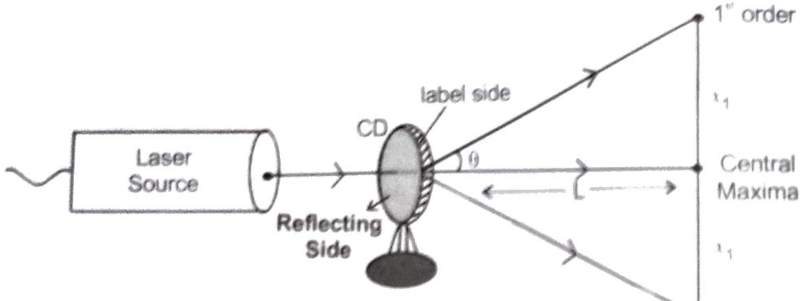


Fig. 7.4

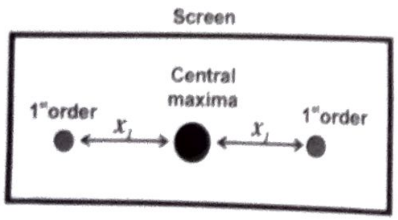


Fig. 7.5

EXPT.No. **Date:**

7 (b). COMPACT DISC - DETERMINATION OF WIDTH OF THE GROOVE USING LASER

Aim

To determine the width of the groove in a compact disc [CD] using laser.

Apparatus required

A compact disc [CD], laser source, screen, scale etc.

Formula

Width of the groove in a compact disc '*d*' $= \dfrac{n\lambda}{\sin\theta}$ metres.

Explanation of Symbols

Symbol	Explanation	Unit
n	Order of spectrum	Unit
λ	Wavelength of the laser source	Å
θ	Angle of diffraction	Degree

Theory

We know, when light is allowed to fall on the reflecting surfaces of the CD/DVD's etc., then it display streaks of colours.

In the CD the data is stored in tracks and sectors, which consist of pits and lands alternatively as shown in ***Fig. 7.2***. The digtal informations are stored in the CD's in the form of closely spaced rows ***Fig. 7.3*** and these rows act like a reflecting diffraction grating. Further, if the label in the CD is removed, then the CD will act as a transmission grating.

The distance between one pit/land to another is termed as the width of the groove in the CD. Let us find the width of the groove using the following procedure.

To find the width of the groove in CD

Wavelength of the laser light (λ) = ...6000... Å

Sl. No.	Distance between the CD and the screen (L)	Order of spectrum (n)	Distance between central maxima to the first order spectrum LHS (x_1)	RHS (x_1)	Mean (x_1)	$\theta = \tan^{-1}\frac{x_1}{L}$	$d = \frac{n\lambda}{\sin\theta}$
Unit	$\times 10^{-2}$ m	unit	$\times 10^{-2}$ m	$\times 10^{-2}$ m	$\times 10^{-2}$ m	Degree	μm

Conversion of CD into transmission grating

Take an empty compact disc (CD). First we need to remove the label surface from the CD. For this fix, a packing tape (Brown colour) on the label surface and peel off the tape so that the label surface will come along with the tape. Now, the CD will look like a transparent material. This CD will now act as a transmission grating.

Procedure

The width of the groove in a CD shall be determined by adopting the following steps. *viz*

1. Fix the transparent CD, in a stand using a clip, in such a way that the reflecting side should face the laser source as shown in ***Fig. 7.4.***
2. Keep the screen at a distance say 90 cm from the CD.
3. Switch ON the laser source and allow the laser beam to pass through the transparent area of reflecting side of the CD, so that we will get first order diffraction pattern in the screen as shown in ***Fig. 7.5***
4. Measure the distance between the central maxima and the first order spectrum on both the left and right sides of the central maxima.
5. Repeat the experiment by varying the distance say 80 cm, 70 cm etc., between the CD and the screen and find the diffraction angle using the given formula.
6. Now, by substituting the diffraction angle (θ) and wavelength (λ) of the laser source in the given formula we can find the width of the groove in a compact disc.

Note: The width of the groove in DVD shall also be determined using the same procedure.

WORKSHEET FOR CALCULATION

Calculation

Width of the groove in a compact disc 'd' = $\frac{n\lambda}{\sin\theta}$ metres.

Result

Width of the groove in a compact disc = ... μm.

VICE-VOCE

1. What is meant by a compact disc. Give its use.
2. What type of laser has to be used to find the width of the groove in a CD.
3. Whether the width of the groove in CD and DVD is same? Justify.
4. What is the principle used to find the width of the groove in a CD and DVD.
5. Why we need to peel the label of the CD, before passing the laser beam.
6. Whether the CD act as a transmission grating (or) reflection grating (or) both ? Justify.
7. Whether incandescent lamp shall be used instead of laser in this experiment? Justify.
8. Why we get only first order diffraction alone clearly in this experiment.
9. What is the advantage of using empty CD instead of CD with data for diffraction.
10. List any two applications of diffraction principle.

3(c). NUMERICAL APERTURE AND ACCEPTANCE ANGLE IN A OPTICAL FIBER

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

$$\text{Acceptance angle} \quad \theta_o = \tan^{-1}\left(\frac{r}{d}\right) \text{ radians}$$

$$\text{Numerical aperture} \quad NA = \sin\theta_o$$

Symbol	Explanation	Unit
r	Radius of the circular image	metre
d	Distance from fibre end to circular image	metre

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. 3.5)

Now, we get illuminated circular patch on the screen. The distance from the fibre end to circular image (d) is measured using metre scale. The radius of the circular image is also measured (Fig.3.6). Thus, the acceptance angle is calculated. From the acceptance angle, the numerical aperture of the cable is found by using the given formula.

Result

(i) Acceptance angle of the optical fibre = ________________ radian

(ii) Numerical aperture of the optical fibre = ________________

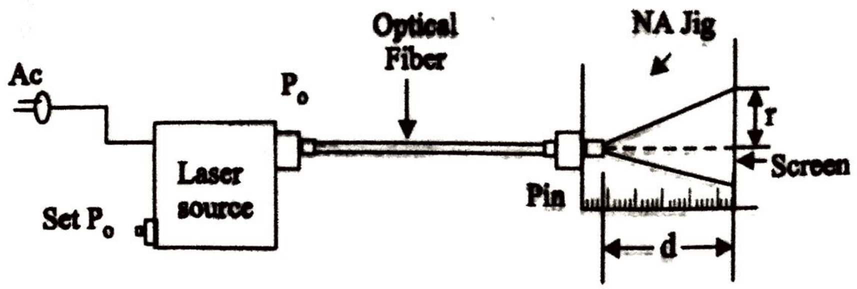


Fig. 3.5 Experimental setup for numerical aperture measurement

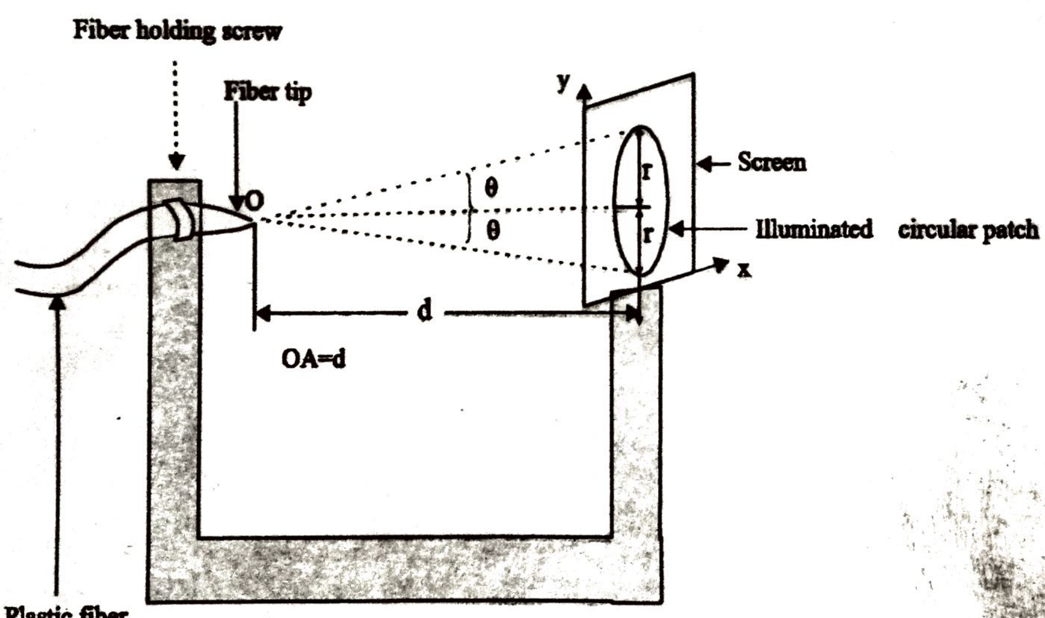


Fig. 3.6 Numerical Aperture Measurement Jig

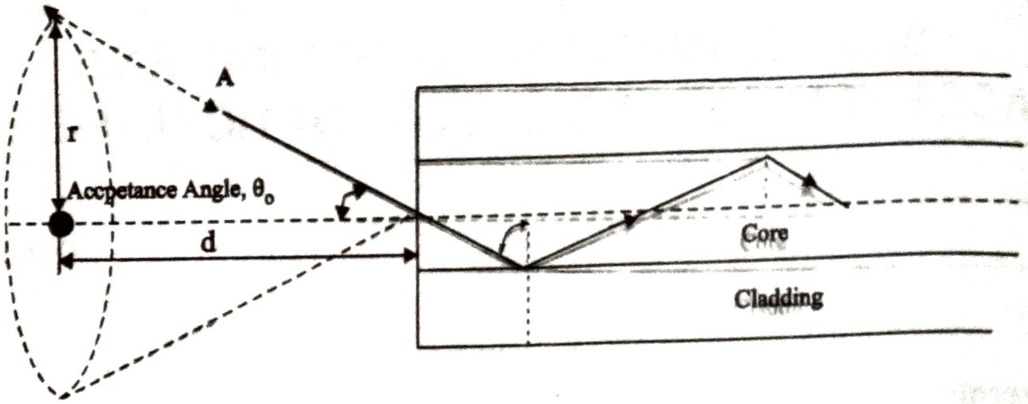


Fig 3.7

$$\tan\theta_o = \frac{r}{d} \qquad \theta_o = \tan^{-1}\left(\frac{r}{d}\right)$$

Determination of acceptance angle and numerical aperture

Diameter of ring

S.No.	Distance from the fibre end to circular image (d) d	Radius of the circular image (r)	Acceptance angle $\theta_o = \tan^{-1}\left(\frac{r}{d}\right)$	NA = $\sin\theta_o$
	cm	mm		
1	1.			
2	1.2			
3	1.4			
4	1.6			
5				
6				
		Mean		