1. TORSIONAL PENDULUM- DETERMINATION OF RIGIDITY MODULUS

AIM: To determine

i) Moment of inertia of the disc
ii) Rigidity modulus of a wire

APPARATUS REQUIRED:

Torsional pendulum, two equal cylindrical masses, Stop clock, Screw gauge. Metre scale.

FORMULA:

Moment of inertia of the disc

$$I = \frac{2m(d_2^2 - d_1^2)T_0^2}{T_2^2 - T_1^2} \text{ kg m}^2$$

Rigidity modulus of a wire

$$n = \frac{8\pi IL}{T_0^2 r^4} \text{ N/m}^2$$

Where

m -- Mass placed on the disc (kg)

d_1- Distance between suspension wire and the centre of mass of the cylinder(m)

d_2- Distance between suspension wire and the centre of mass of the cylinder(m)

T_0 – Time period without mass placed on the disc (sec)

T_1 – Time period when equal masses are placed at a distance d_1 (sec)

T_2 - Time period when equal masses are placed at a distance d_2 (sec)

L - Length of the suspension wire(m)

r – Radius of the wire (m)

PROCEDURE:

- One end of a long, uniform wire whose rigidity modulus is to be determined is clamped by a vertical chuck.
- To a lower end, a heavy uniform circular disc is attached by another chuck. The length of the suspension wire (L) is fixed to a particular value.
- The suspended disc is slightly twisted so that it felicitates torsional oscillations. Avoid vibration while in rotation.

- The first few oscillations are not considered. By using the pointer, the time taken for 10 complete oscillations is noted. Two trials are taken. The mean time period To is found.
- Two equal masses are placed on the disc symmetrically on either side; close to the suspension wire .The closest distance d_1 is noted.
- The disc with masses at a d_1 is made to rotate torsional oscillations by twisting the disc.
- The time taken for 10 complete oscillations is noted. Two trials are taken. The mean time period T_1 is found.
- Two equal masses are moved to the extreme ends so that the edges of masses coincide with the edge of the disc. The maximum distance d_2 is noted.
- Then the disc is allowed to rotate by twisting the disc. The time taken for 10 complete oscillations is noted. Two trials are taken. The mean time period T_2 is found.
- The diameter of the wire is measured at different places along its length using screw gauge. Then the radius of wire is calculated.
- The moment of inertia of the disc and rigidity modulus of the wire are calculated.

To determine the time period of the disc:

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

Position of the equal masses	Time for 10 oscillations			Time period(one oscillation) sec
	Trial-1 sec	Trial-2 sec	Mean sec	
Without any masses				T_0
With masses at $d_1 = 2.5 \times 10^{-2}$m				T_1
With masses at $d_2 = 4.5 \times 10^{-2}$m				T_2

To determine the radius of the wire

Least count = 0.01 mm. Zero error = divisions ZC= mm

S.No	PSR mm	HSC div	Observed reading=PSR+(HSCXLC) mm	Correct reading=OR+ZC mm
1				
2				
3				
4				
5				

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

CALCULATION:

Moment of inertia of the disc,

$$I = \frac{2m(d_2^2 - d_1^2)T_0^2}{T_2^2 - T_1^2} \text{ kg m}^2$$

m= d_1= d_2=

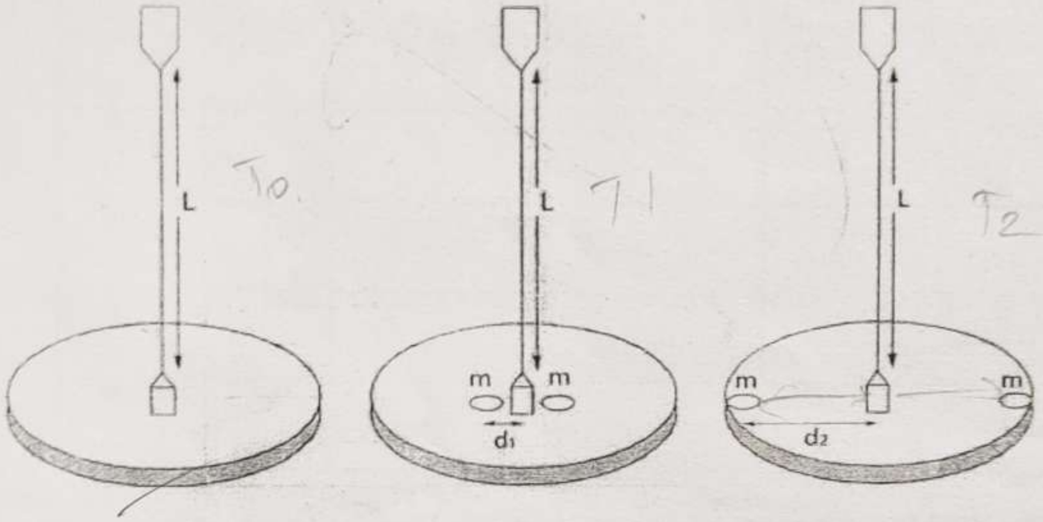
T_0=

T_1= T_2=

Rigidity modulus of a wire,

$$n = \frac{8 \pi I L}{T_0^2 r^4} \text{ N/m}^2$$

I= T₀= r =



Torsional Pendulum (without masses)

Torsional Pendulum (with masses at d_1 close to the axis)

Torsional Pendulum (with masses at d_2 away from the axis)

Figure 1.1 Torsional Pendulum

RESULT:

Moment of inertia of the disc, I= .... kgm^2

Rigidity modulus of the wire, n =.......... N/m^2

Outcomes: At the end of the experiment, the students should be able

- To understand the motion of the torsion pendulum satisfies the simple harmonic
- To understand period (or angular frequency) of the simple harmonic motion of the torsion pendulum is independent of the amplitude of the motion
- To determine torsion constant and the moment of inertia of the torsion pendulum

2. YOUNG'S MODULUS – NON UNIFORM BENDING

AIM:

To determine the Young's modulus of the material of a uniform bar by non uniform bending.

APPARATUS REQUIRED:

Travelling microscope, knife edges, Slotted weight, meter scale, Vernier caliper, screw gauge, pin.

FORMULA:

Young's modulus of the material of the beam,

$$Y = \frac{Mgl^3}{4bd^3y} \quad \text{Newton/metre}^2$$

Where

M – Load applied (kg)

y - Mean depression for a load (m)

g – Acceleration due to gravity (m/s^2)

l – Distance between two knife edges (m).

b – Breadth of the beam (m)

d -- Thickness of the beam (m).

PROCEDURE:

- The experimental bar belongs to elastic material for loading and unloading it by slotted weights.
- The weight hanger is taken as the dead weight (W).
- The bar is placed on the knife edges at a distance of l.
- A pin is fixed at the middle of the scale.
- The dead weight suspended from the mid point, the microscope is adjusted such that the horizontal cross wire coincides with the image of the tip of the pin.
- The reading of the vertical scale is taken.
- The experiment is repeated by adding weights (Loading) for W+50, W+100 up to W+250.
- Every time the microscope is adjusted and the vertical scale reading (MSR and VSC) is taken.
- Then the load is decreased by 50gms and the readings are taken.
- From the readings, the mean depression of the mid-point for a given load and m/y can be found.
- The bar is removed and its mean breadth b is measured using vernier caliper and its mean thickness d using screw gauge

To determine depression (y):

L.C =0.001cm

M = 50x 10^{-3}kg.

S.No	Load $x10^{-3}$kg	Microscope reading						Mean	Depression y for m kg
		Loading			Unloading				
		MSR cm	VSC div	TR cm	MSR Cm	VSC div	TR cm	cm	cm
1	W								
2	W+50								
3	W+100								
4	W+150								
5	W+200								
6	W+250								

Mean(y) = ….. $*10^{-2}$m

To determine breadth of the beam (b):

Least count = 0.01 cm. Zero Error = ---- divisions Zero Correction =

S.No	MSR cm	VSC div	Observed reading = MSR+(VSCXLC) cm	Correct reading = OR+ZC cm
1				
2				
3				
4				
5				

Mean = …….. $*10^{-2}$m

To determine the thickness of the beam (d)

Least count = 0.01 mm. ZE = divisions ZC=

S.No	PSR mm	HSC div	Observed reading = SR+(HSCXLC) mm	Correct reading = OR+ZC mm
1				
2				
3				
4				
5				

Mean = …….. **$\times 10^{-3}$m**

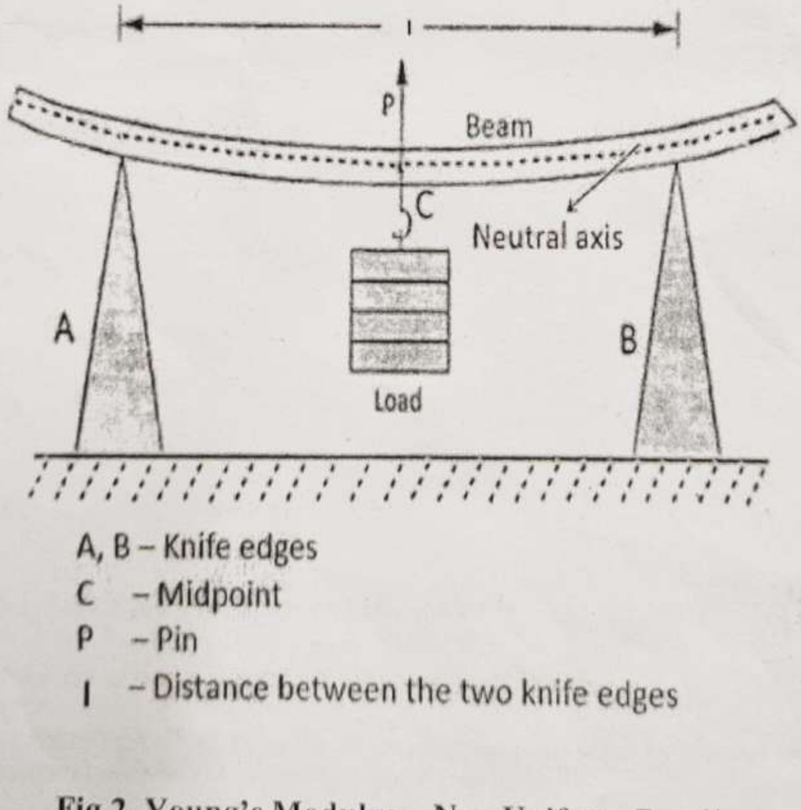


Fig 2 Young's Modulus – Non Uniform Bending

CALCULATION:

M – Load applied (kg) =
y - Mean depression for a load (m) =
g – Acceleration due to gravity (m/s^2) =
l – Distance between two knife edges =
b – Breadth of the beam (m) =
d – Thickness of the beam (m) =

Young's modulus of the material of the beam,

$$Y = \frac{Mgl^3}{4bd^3y} \text{ Newton/metre}^2$$

RESULT:

Young's modulus of the given bar (metre scale) = ……… N/m^2

Outcomes: At the end of the experiment, the students would be able

- To understand the elastic behavior of the given wooden beam by pin and microscope experimental method and to find its Young's modulus