Manonmaniam Sundaranar University,

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Tirunelveli - 627 012 Tamilnadu, India

OPEN AND DISTANCE LEARNING (ODL) PROGRAMMES

(FOR THOSE WHO JOINED THE PROGRAMMES FROM THE ACADEMIC YEAR 2023–2024)

B.Sc. Physics

Course Material

PHYSICS PRACTICAL-1

Properties of Matter

Prepared

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Tirunelveli - 12

1.Determination of rigidity modulus without mass using Torsional pendulum.

Aim

To Determination of rigidity modulus without mass using Torsional pendulum.

Apparatus required

Torsional pendulum, Stop clock, Meter scale, screw gauge.

Formula

Moment of inertia of the disc,

$$I = \frac{MR^2}{2} (kgm^2)$$

Rigidity modulus of the material of the wire,

$$n = \frac{8\pi I}{r^4} \frac{L}{T^2} \quad (N/m^2)$$

Where;

I - Moment of inertia of the pendulum Kg m^2.

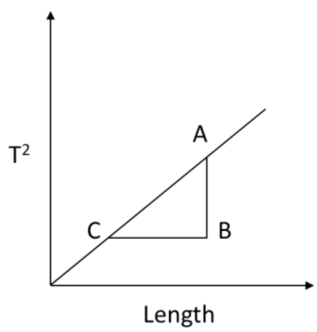
R - Radius of the wire in meter.

L - Length of the pendulum from the fixed end in meter.

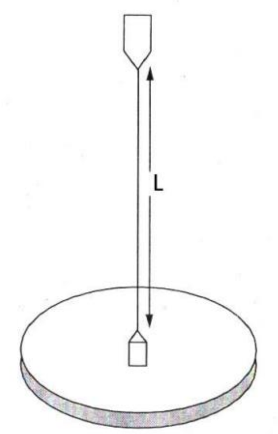
M - Mass of the disc in Kg.

T - Time period for ten oscillations in sec

Model graph



Experimental setup



Torsional Pendulum
(without masses)

Procedure

1. The wire's substance is secured at one end with a vertical chuck. At the opposite end of the cable is a metallic disc.
2. The radius of the wire(r) is found using a screw gauge.
3. Measure the length L of the pendulum from the fixed end in meter. Vary the length and note different readings.
4. The suspension wire's length is set at a specific length. To produce torsional oscillations, the disc is slightly twisted.
5. A stop clock is used to record the amount of time needed for ten oscillations. For every length, two trials are collected. We find the mean time period T.
6. Repeat the above step for various length as in step 2 and tabulated the values and plot the graph.

Observation

i.To find R

$$2\pi R \quad = \qquad\qquad \times 10^{-2} m$$

R = m

ii.Mass of the disc,

M = m

Table 1 - To measure the radius of the wire R

L.C = mm; Z.R = mm

S.No.	(PSR) in mm	(HSC) in div	HSR= (HSC×LC)	Observed reading OR=PSR+HSR	Correct Reading =OR±ZC
1					
2					
3					
4					
5					

Diameter D = $\times \mathbf{10^{-3}m}$

Radius R = $\times \mathbf{10^{-3}}$

Table 2 - To find L/ T^2,

S.No.	Length (cm)	Time for 10 Oscillation (sec)			Period T (sec)	T^2 (sec^2)	L/ T^2 (m/sec^2)
		Trial 1	Trial2	Mean			
1.							
2.							
3.							
4.							
5.							

Mean - **(m/sec^2)**

Calculation

I. From Calculation:

Moment of inertia of the disc,

$$I = \frac{MR^2}{2} (kgm^2)$$

Rigidity modulus of the material of the wire,

$$n = \frac{8\pi I}{r^4} \frac{L}{T^2} \quad ({}^N/_m 2)$$

II. From graph:

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

$$n = \frac{8\pi I}{r^4} \frac{1}{slope} \quad ({}^N/_m 2)$$

Result

The rigidity modulus of the wire of the torsional pendulum is determined without mass

i. From Calculation **n** = $({}^{\boldsymbol{N}}/_{\boldsymbol{m}}\,\mathbf{2})$.

ii. From graph **n** = $({}^{\boldsymbol{N}}/_{\boldsymbol{m}}\,\mathbf{2})$.

2.Determination of rigidity modulus with masses using Torsional pendulum.

Aim

To determine the rigidity modulus with masses using Torsional pendulum.

Apparatus required

Torsional pendulum, Stop clock, Meter scale, screw gauge, Two equal masses.

Formula

Moment of inertia,

$$\boldsymbol{I = 2m\left(d_2^2 - d_1^2\right)\left(\frac{T_0^2}{T_2^2 - T_1^2}\right) \quad kg\, m^2}$$

Rigidity modulus,

$$\boldsymbol{N = \frac{8\pi I}{r_4}\left(\frac{l}{T_0^2}\right) \quad Nm^{-2}}$$

Where;

I - Moment of inertia of the disc ($kg\ m^2$)

N - Rigidity modulus of the material of the wire (Nm^{-2})

M - Mass placed on the disc(kg)

d_1 - Closest distance between two suspension wire and center of mass (m)

d_2 - Farthest distance between two suspension wire and center of mass (m)

T_0 - Time period without any mass placed on the disc (s)

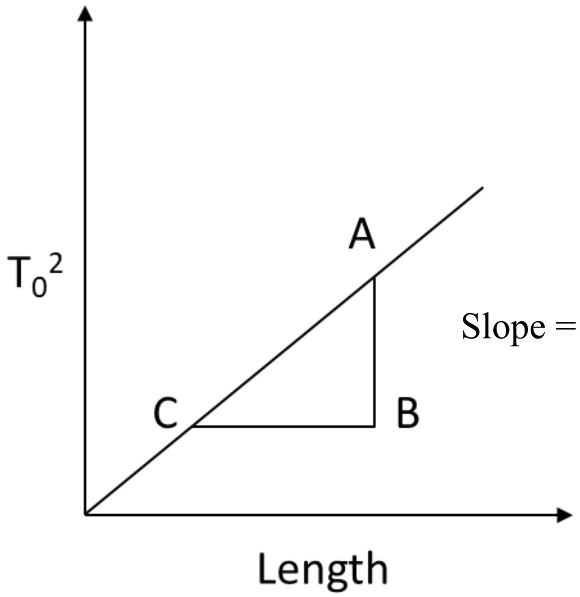
T_1 - Time period when equal masses are placed at a distance d_1(s)

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

L - Length of the suspension wire (m)

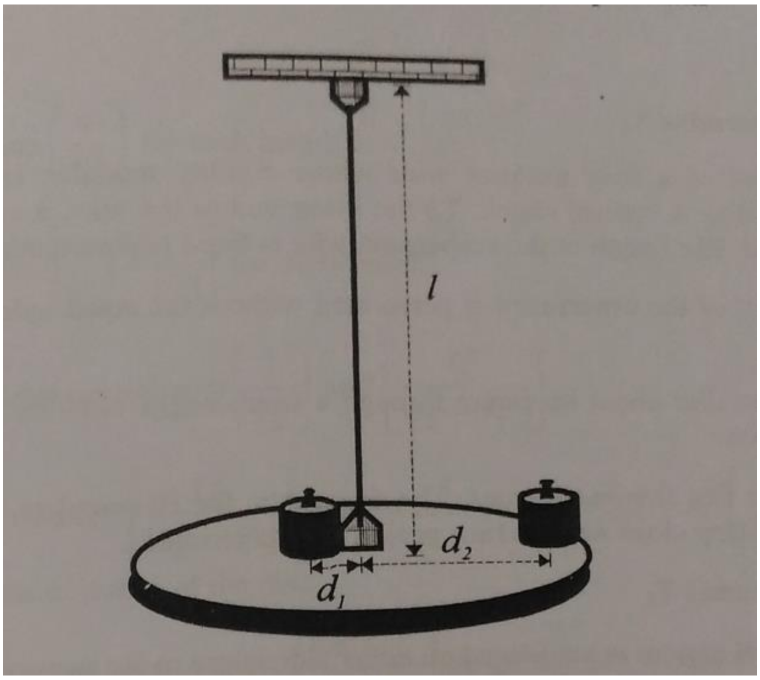
r - Radius of the wire (m)

Model graph



Slope = CB/AB

Experimental setup



Torsional pendulum

Procedure

1. A vertical chuck clamps one end of a long, uniform wire, the stiffness modulus of which needs to be calculated. The wire has a circular metallic disc fastened to its lower end. The suspension wire's length is set at a specific length (say 50 cm).
2. In this section of the experiment, the equal cylindrical masses on the disc are not used. Turn the disc in a tiny circle around its centre. At this point, the disc oscillates torsionally.
3. Leave out the initial few oscillations. The stop clock is used to record the duration of 10 full oscillations, and the time period T_o is calculated.
4. Near the suspension wire, on either side, are two equal masses, m.
5. Find the nearest distance (dl) between the suspension wire's centre and the centre of mass.
6. The disc with masses at distance dl is made to execute torsional oscillations. After noting how long it takes for ten oscillations, compute the time interval T_1
7. Arrange the equal masses so that their centres are equally spaced apart and their edges line up with the disc's edge.
8. Calculate the d2 distance between the disc's centre and the mass's centre.
9. Note how long it takes the pendulum to oscillate ten times when it is set to torsional oscillations. Determine the duration T_2.
10. Repeat the above procedure for various length of wire.

Observation

Mass placed on the disc (m)= $\times 10^{-3}$kg

Distance (d_1) = $\times 10^{-2} m$

Distance (d_2) = $\times 10^{-2} m$

Mean radius of the wire (r) = $\times 10^{-3} m$

Table 1 – To measure the diameter of the wire.

L.C = mm; Z. R = mm; Z.C = mm

S.No	(PSR) in mm	(HSC) in div	HSR= (HSC×LC)	Observed reading OR=PSR+HSR	Correct Reading =OR$\pm$ZC
1					
2					
3					
4					

Mean D

Table 2 – To determine the $\left(\frac{l}{T_0^2}\right)$and $\left(\frac{T_0^2}{T_2^2-T_1^2}\right)$

S.No.	Length of the suspension (m)	Time taken for 10 oscillations(s)			Time period (s)			$\left(\frac{l}{T_0^2}\right)$ (ms^{-2})	$\left(\frac{T_0^2}{T_2^2-T_1^2}\right)$
		Without mass	With mass at d_1	With mass at d_2	T_0	T1	T2		

Mean:

Calculation

Diameter D = cm

Radius r = $\frac{D}{2} =$ cm

Calculate $\left(\frac{l}{T_0^2}\right)(ms^{-2})$ and $\left(\frac{T_0^2}{T_2^2 - T_1^2}\right)$

Moment of inertia,

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

Rigidity modulus,

$$N = \frac{8\pi I}{r_4}\left(\frac{l}{T_0^2}\right) \quad Nm^{-2}$$

By graph slope = $\left(\frac{l}{T_0^2}\right) = \frac{CB}{AB}$

Result

Moment of inertia of disc = **km m²**

The rigidity modulus of the wire

i. By calculation = $\boldsymbol{Nm^{-2}}$

ii. By graph = $\boldsymbol{Nm^{-2}}$

3.Moment of inertia of an irregular body

Aim

To determine the moment of inertia of an irregular body using the inertia table.

Apparatus required

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

Formula

Moment of inertia of regular body,

$$\boldsymbol{I_1 = \frac{1}{2}MR^2 \quad kgm^2}$$

Moment of inertia of the irregular body,

$$\boldsymbol{I_2 = I_1 \frac{(T_2^2 - T_0^2)}{(T_1^2 - T_0^2)} \quad kgm^2}$$

Where;

I_1 -Moment of inertia of regular body in kgm^2.

I_2 -Moment of inertia of irregular body in kgm^2.

T_0 -Time period of oscillation of inertia table in sec.

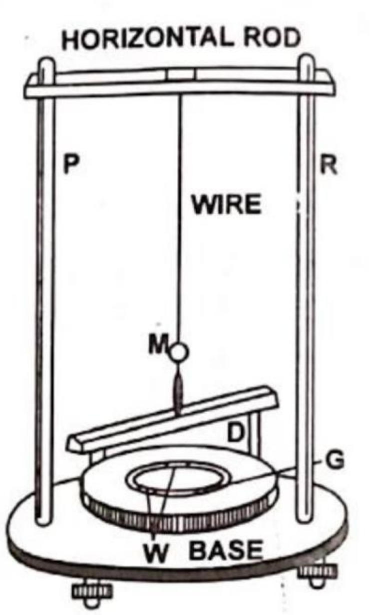
T_1 -Time period of oscillation of irregular body in sec.

T_2 -Time period of oscillation of regular body in sec.

M -Mass of regular body in kg.

R -Radius of regular body in meter.

Experimental setup



Procedure

1. Rotate screws S1 and S2 to make the plane of inertia table's base horizontal using a spirit level.
2. By inserting the balancing rings into the grooves so that the pointer in the inertia disc's base just lies above the pointer on the base of the inertia table, you can balance the inertia table.
3. Give the table a small twist to have it start to execute torsional in the horizontal plane. Now record the duration of 20 oscillations using a lamp, scale, telescope, or your eyes. Do it three times. You will then have a value of T0=t0/20.
4. Now set the normal body down on the table and repeat step 3 one again. You will then have the value T1=t1/20.
5. After that, set the asymmetrical body down on the table and repeat step 3 one more. You will then have the value T2=t2/20.

6. If a normal body is supplied that is shaped like a disc, use physical balance to determine its mass, and use Vernier callipers to determine its diameter.

Observation

Least count of stop watch = sec

Mass of the body = gm

Table 1

S. No	Body	Time for 20 oscillations				Time period (sec)
		Trial1	Trial2	Trial3	Mean	
1	Inertia table alone				t_0	
2	Regular body				t_1	
3	Irregular body				t_2	

Table 2

To determine the diameter of the regular body

$$LC = \frac{value\ of\ one\ division\ in\ main\ scale}{number\ of\ division\ on\ vernier\ scale}\ cm$$

VSR = VSC×LC CVSR=VSR±ZC

ZR= cm ZC= cm

S. No	MSR (cm)	VSC (div)	VSR (cm)	CVSR (cm)	OR= CVSR +MSR (cm)
1.					
2.					
3.					

Radius = D/2 = cm

Calculation

Moment of inertia of regular body,

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

Moment of inertia of the irregular body,

$$I_2 = I_1 \frac{(T_2^2 - T_0^2)}{(T_1^2 - T_0^2)} \quad kgm^2$$

Result

The moment of inertia of irregular body = **$\mathbf{kgm^2}$**

4.Verification of parallel axes theorem on moment of inertia.

Aim

To verify the parallel axes theorem using moment of inertia.

Apparatus required

Bar pendulum, meter scale, stop clock etc.

Formula

i. The bar pendulum's moment of inertia with respect to an axis that runs through its center of gravity and parallel to the suspension axes is:

$$\boldsymbol{I_0 = \frac{ML^2}{12}\ kgm^2} \ldots..(\mathbf{1})$$

ii. The bar pendulum's moment of inertia with respect to an axis that runs parallel to the axis through the center of gravity is:

$$\boldsymbol{I = \frac{MgxT^2}{4\pi^2}\ \ kgm^2} \ldots\ldots(\mathbf{2})$$

iii. Moment of inertia

$$\boldsymbol{I = I_0 + Mx^2\ \ kgm^2} \ldots\ldots..(\mathbf{3})$$

Where;

M - Mass of the bar pendulum in Kg.

L - Length of the bar pendulum in m.

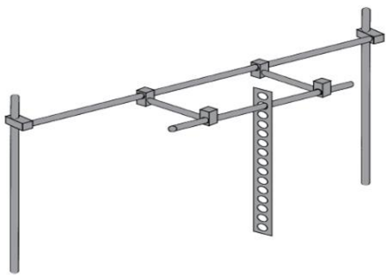
g - Acceleration due to gravity 9.8 m/s.

x - Distance of the axis of rotation from the centre of gravity in m.

T - Period of Oscillation in sec.

CG - Centre of gravity.

Experimental setup - Bar pendulum setup



Procedure

1. With a balance, the mass of the bar pendulum (M) is found.
2. Using a metre scale, the bar pendulum's length (L) is calculated.
3. The formula is used to determine the bar pendulum's moment of inertia (I_0) about an axis that runs through its centre of gravity and parallel to the axis of suspension (1).
4. There is a marking at the bar pendulum's centre of gravity. This is used as a reference while counting hole numbers. On one side, the holes 2, 4, 6, and 8's distances (x) are measured from the CG.
5. The bar pendulum is suspended over a supporting surface, and the knife edge is fastened to the second hole. The pendulum is designed to oscillate with a small amplitude in a vertical plane.
6. For three trials, the time for 20 oscillations is recorded separately. The period (T) is computed based on the mean time.
7. Formula (2). is used to get the bar pendulum's moment of inertia about an axis parallel to the axis passing through the centre of gravity (I).
8. The theoretical value of I is calculated using the formula (3), and its experimental value is compared with it.
9. Repeatedly, the experiment is conducted for holes 4, 6, and 8. The measurements are tabulated.

Observation

Mass of the pendulum = Kg

Length of the pendulum = m

Acceleration due to gravity = 9.8 m/s

Table

Hole No.	Distance from centre of gravity x (m)	Time for 20 oscillations(sec)				Period T (sec)	Experimental Value $I = \frac{MgxT^2}{4\pi^2}$	Theoretical Value $I = I_0 + Mx^2$
		Trial1	Trial2	Trial3	Mean			
2								
4								
6								
8								

Calculation

Experimental Value

$$I = \frac{MgxT^2}{4\pi^2} \quad kgm^2$$

Theoretical Value

$$I_0 = \frac{ML^2}{12}\ kgm^2$$

$$I = I_0 + Mx^2 \ \ kgm^2$$

Result

Hole No.	Experimental Value	Theoretical Value
2		
4		
6		
8		

The close match between experimental and theoretical value of the moment of inertia of a bar pendulum on a parallel axis passing through the centre of gravity verified the parallel axes theorem on moment of inertia.

5.Verification of perpendicular axes theorem on moment of inertia.

Aim

To verify the perpendicular axes theorem using moment of inertia.

Apparatus required

Bar pendulum, rectangular plate, stand, stop clock, etc.

Formula

By perpendicular axes theorem,

$$T_z^2 = T_x^2 + T_y^2$$

Since,

$$I \alpha T$$

Where;

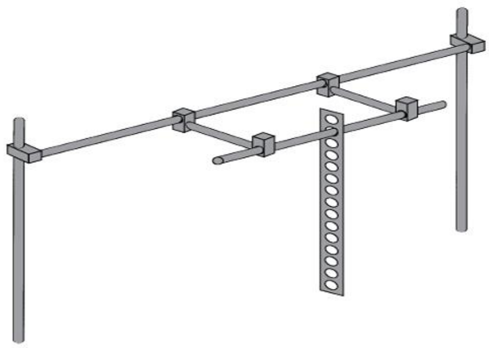
I -moment of inertia about axis of rotation.

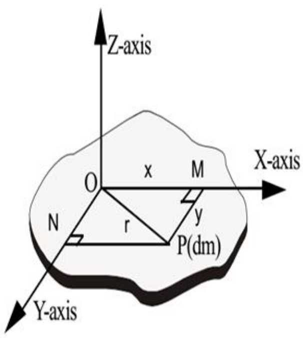
T_z - moment of inertia about an axis perpendicular to the plane of the plate.

T_x - moment of inertia about an axis parallel to the breadth of the plate.

T_y - moment of inertia about an axis parallel to the length of the plate.

Experimental setup





Procedure

1. As seen in the figure, suspend the rectangular plate.
2. Determine the oscillation period by setting into torsional oscillations.
3. For a different axis, repeat steps 1-2.
4. Verify $T_z^2 = T_x^2 + T_y^2$

Table1

Axis passing through the centre and perpendicular to the plane T_z

Body	Time for 20 oscillations "t (s)				Time period T = t/20	Mean T_z (s)
	No.of. oscillations	Time (s)	No.of. oscillations	Time (s)		
Rectangular plate	0					
	5					
	10					
	15					

Table2

Axis passing through the centre and Perpendicular to the breadth T_x

Body	Time for 20 oscillations "t (s)				Time period T = t/20	Mean T_x (s)
	No.of. oscillations	Time (s)	No.of. oscillations	Time (s)		
Rectangular	0					
	5					

plate	10					
	15					

Table3

Axis passing through the centre and Perpendicular to the length T_y

Body	**Time for 20 oscillations "t (s)**				**Time period T = t/20**	**Mean T_y (s)**
	No.of. oscillations	**Time (s)**	**No.of. oscillations**	**Time (s)**		
Rectangular plate	**0**					
	5					
	10					
	15					

Calculation

$T_z =$

$T_x + T_y =$

$T_z^2 = T_x^2 + T_y^2$

Result

Experimentally it is found that $T_z^2 = T_x^2 + T_y^2$ for a rectangular plate and hence perpendicular axis theorem is verified.

6. Determination of moment of inertia and g using Bifilar pendulum.

Aim

To determine the moment of inertia and g using Bifilar pendulum.

Apparatus required

The bifilar pendulum, stop clock, Connecting needle, Scale, Screw gauge, Vernier calliper etc.,

Formula

Moment inertia dimensionless method,

$$I_{xy} = M\left[\frac{L^2 + B^2}{12}\right] kgm^2$$

$$I_{yz} = M\left[\frac{B^2 + D^2}{12}\right] kgm^2$$

$$I_{zx} = M\left[\frac{D^2 + L^2}{12}\right] kgm^2$$

Moment of inertia Experimental method,

$$I = \frac{Mga_1a_2}{4\pi^2}\left(\frac{T^2}{l}\right) kgm^2$$

Acceleration due to gravity,

$$g = \frac{4\pi^2 L}{T^2}$$

Where;

M = mass of the pendulum.

T = time period for 10 oscillations.

g = acceleration due to gravity.

B = breadth of the pendulum(y).

D = thickness of the pendulum(z).

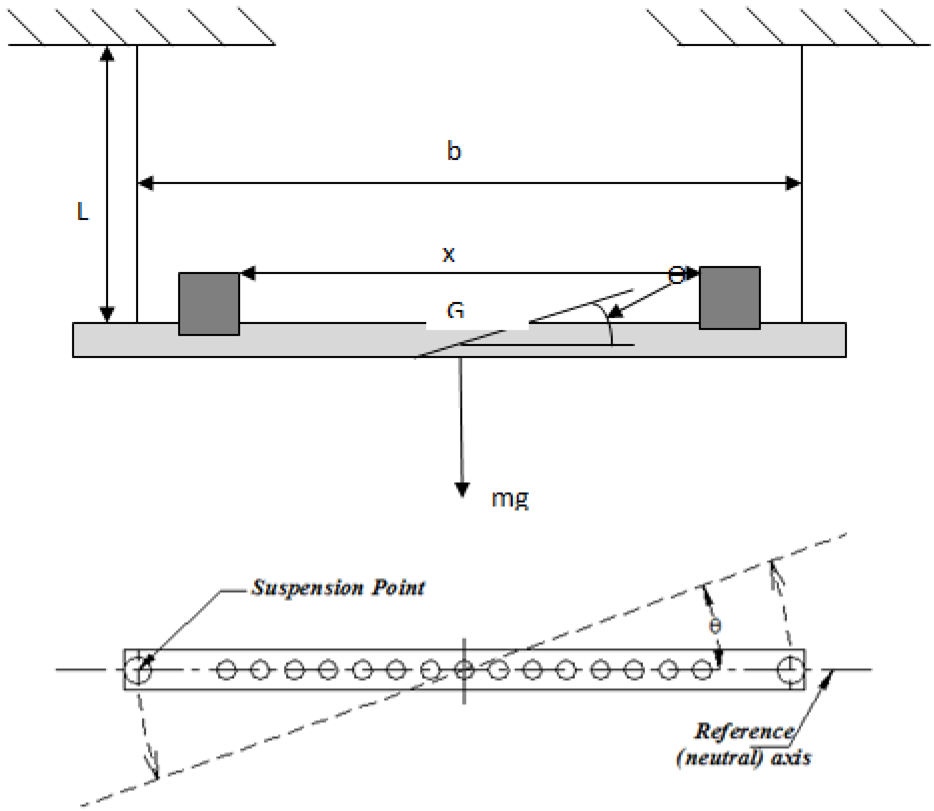
L = length of the pendulum (x).

l = length of the wire hangs the pendulum.

a_1 = distance between the two screws on the pendulum.

a_2 = distance between the two screws on the pendulum hanger.

Experimental setup



Model graph

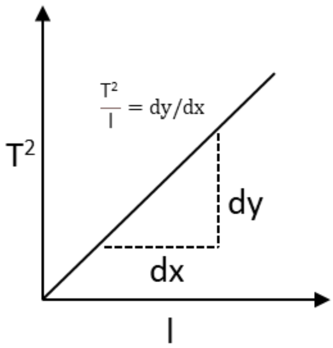


Table 1

To determine the thickness (D) of the beam using screw gauge.

$$LC = \frac{Pitch}{Number\ of\ head\ scale}$$

$$Pitch = \frac{Distance\ moved}{Number\ of\ rotations\ given}$$

Least count (LC) = 0.01 mm

(Z.E) Zero error : mm

(Z.C) Zero correction : mm

PSR (mm)	HSC (Div)	HSR =HSC×LC	TR =MSR+VSR	MEAN D (mm)

Table 2

To determine the breadth (B) of the beam using vernier calliper.

$$LC = \frac{\text{Value of 1 Main Scale Division (MSD)}}{\text{Number of divisions in the vernier}}$$

$$LC = \frac{0.1}{10} = 0.01 \text{ cm}$$

(Z.E) Zero error : cm

(Z.C) Zero correction : cm

S.No.	MSR (cm)	VSC (Div)	VSR =VSC×LC	TR =MSR+VSR	MEAN B (cm)
1.					
2.					
3.					
4.					

Table 3

To determine $\frac{T^2}{l}$

Length of the wire l	Load M	Time for 10 oscillations			Time period T (s)	$\frac{T^2}{l}$
		T1 (s)	T2 (s)	Mean (s)		

Calculation

Moment inertia dimensionless method,

$$I_{xy} = M\left[\frac{L^2 + B^2}{12}\right] kgm^2$$

$$I_{yz} = M\left[\frac{B^2 + D^2}{12}\right] kgm^2$$

$$I_{zx} = M\left[\frac{D^2 + L^2}{12}\right] kgm^2$$

Moment of inertia Experimental method,

$$I = \frac{Mga_1a_2}{4\pi^2}\left(\frac{T^2}{l}\right) kgm^2$$

Acceleration due to gravity,

$$g = \frac{4\pi^2 L}{T^2}$$

Result

Using bifilar pendulum following were determined

i. Acceleration due to gravity $\boldsymbol{g =}$ $\boldsymbol{m/s}$

ii. Moment of inertia $\boldsymbol{I =}$ $\boldsymbol{kgm^2}$

7. Determination of Young's modulus by stretching of wire with known masses.

Aim

To determine the value of Young's modulus of the material of the supplied wire by using Searl's apparatus.

Apparatus required

Searl's apparatus, Screw gauge, meter scale, slotted weight, wire.

Formula

$$Youngs\ modulus\ (Y) = \frac{\text{Longitudinal stress}}{\text{Longitudinal Strain}} = \frac{\text{F/A}}{\text{l/L}} = \frac{\text{FL}}{\text{Al}}$$

$$\boldsymbol{Y = \frac{4gL}{\pi d^2}\ \left(\frac{m}{l}\right)\ N/m^2}$$

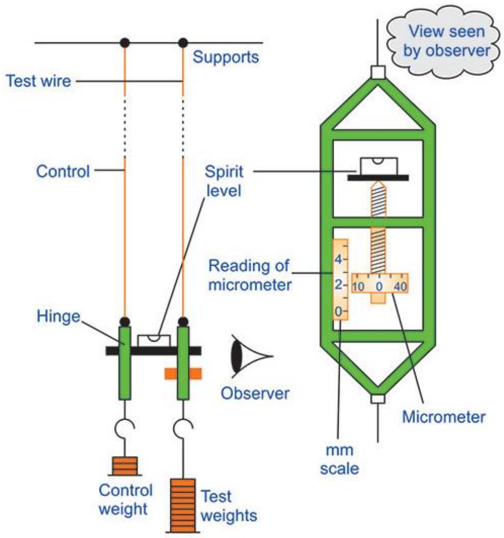
Where;

Y - Youngs modulus of the wire in $\frac{N}{m^2}$.

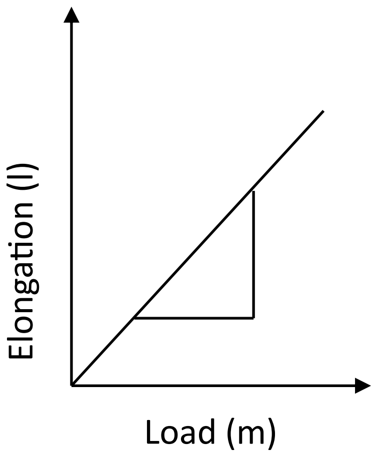
g - Acceleration due to gravity in m/s.

d - Diameter of the given wire in cm.

Experimental setup



Model graph



Procedure

1. Using a meter scale, find the wire's starting length L.
2. Using a screw gauge, find the wire's diameter (d). At each location along the wire, the diameter should be measured at many locations and in mutually perpendicular directions. To find the average diameter, take the mean value of these readings.
3. Turn the micro-meter to bring the spirit level into the horizontal position. To use the micrometer reading as a reference, note its value.
4. Add one more weight to the test wire. The test wire's elongation causes the spirit level to tilt.
5. Take note of the micrometer reading after repositioning the spirit level horizontally by adjusting the micrometer screw.
6. Repeat the preceding steps to measure the elongation by increasing the load (loading) on the test wire from the lowest value to the maximum value. Reducing the test weight from the highest value to the lowest value in an equal number of steps (unloading).

7. Elongation for equal step weights can be found.
8. Plot the weight-loaded versus elongation graph; it should be a straight line that passes through the origin. Calculate Y and ascertain the slope's value.

Observations

Initial Length of wire L = cm

Diameter of the wire, d = cm

Initial length of wire, L = cm

Acceleration due to gravity, g = 9.80 m/s

Table 1 - Measurement of diameter d of the wire.

Least count of screw gauge = cm

Zero error of screw gauge = cm

S.No.	(PSR) in mm	(HSC) in div	HSR= (HSC×LC)	Observed reading OR=PSR+HSR	Correct Reading =OR±ZC
1					
2					
3					
4					
5					

Mean d = cm

Table 2 – For load and extension

Least count of micro-meter screw = mm = cm

Additional load m (gm)	Micrometer reading load increasing		$x_1 = R_1 - R_2$	Micrometer reading load decreasing		$x_2 = R_1 - R_2$	$D = \left(\frac{x_1+x_2}{2}\right) L \cdot C$	Elongation l (cm)
	C.S.R Beginning of the step (R_1)	C.S.R End of the step(R_2)		C.S.R Beginning of the step (R_1)	C.S.R End of the step(R_2)			
0								
500								
1000								
1500								
2000								
2500								
3000								

Calculations

From graph:

$$\frac{m}{l} = \frac{1}{slope} = \frac{gm}{cm}$$

Youngs modulus,

$$Y = \frac{4gL}{\pi d^2} \left(\frac{m}{l}\right) N/m^2$$

Result

The young's modulus of the wire by stretching is found to be

$\boldsymbol{Y =}$ $\boldsymbol{N/m^2}$.

8.Verification of Hook's law by stretching of wire method.

Aim

To verify the Hook's law by stretching of wire method.

Apparatus required

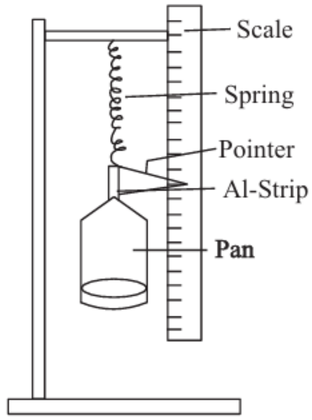
The spring, a weight box, a half-meter scale, a laboratory stand, a pan that can be suspended beneath the spring, and a light aluminum strip with a pointer.

Formula

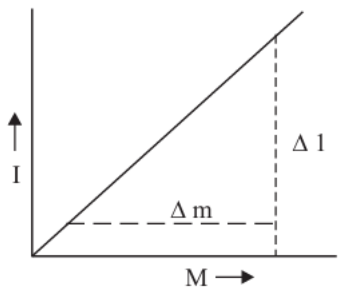
By Hook's law spring constant

$$\boldsymbol{k = \frac{mg}{l}}$$

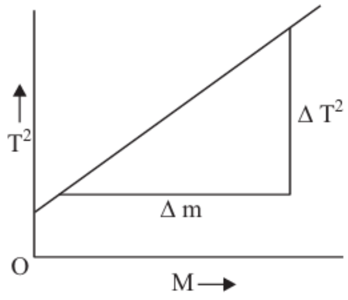
Experimental setup



Model graph



Between Mass and Extension



Between Mass and Time period

Procedure

1. Observe the pointer on the scale indicating zero when there are no weights in the pan.
2. Note the updated reading on the scale after adding a proper weight, M, to the pan.
3. Due to the weight M, the difference between the two readings indicates the spring's extension, l. Step-by-step raise the weights in the pan, making note of where the pointer is for each load.
4. Reduce the weights using the same procedures once the proper maximum load has been obtained.
5. Once more, take note of where the cursor is for each load. The pointer will reset to its initial position after each load if your maximum load hasn't permanently strained the spring.
6. Errors in observation are possible.
7. Determine the two measurements' mean and then the extension for each load as a result.
8. Draw a graph with the load M on the x-axis and the extension l on the y-axis. Draw the optimal straight line—zero extension for zero load—through the plotted points and the origin.
9. Determine the graph's slope and then the constant k.

Table

S.No.	Load M (Kg)	Scale reading		Mean	Extension l (cm)
		Load increasing	Load decreasing		

Calculation

Slope extension vs load $\frac{\Delta l}{\Delta M}=$ mkg^{-1}

Spring Constant K = $(slope)^{-1} \ =$ Nm^{-1}

Result

i. Extension versus load graph is a straight line passing through origin, $\boldsymbol{M\alpha l}$ Hook's law is verified.

ii. Spring constant, $\boldsymbol{K} =$ $\boldsymbol{Nm^{-1}}$

9. Determination of Young's modulus by uniform bending – load depression graph.

Aim

To determine the Young's modulus by uniform bending – load depression graph.

Apparatus required

Wooden beam, Weight hanger with slotted weights, Knife edges, Travelling microscope, Vernier calliper, Screw gauge, Metre scale

Formula

Young's modulus of the material of the beam,

$$\boldsymbol{Y = \frac{Magl^2}{2sbd^3} \quad \mathrm{N/m2}.}$$

Where;

Y = Young's modulus of the material of the beam

M = Load applied

L = Distance between the knife edges

a = Distance between the load and the nearest knife edge

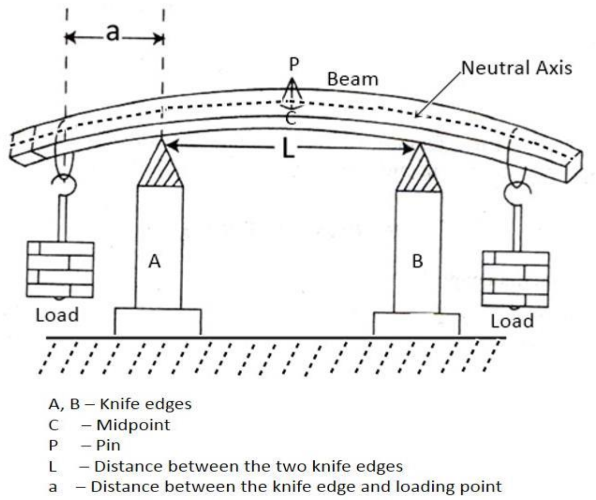
g = Acceleration due to gravity

b = Breadth of the beam

d = Thickness of the beam

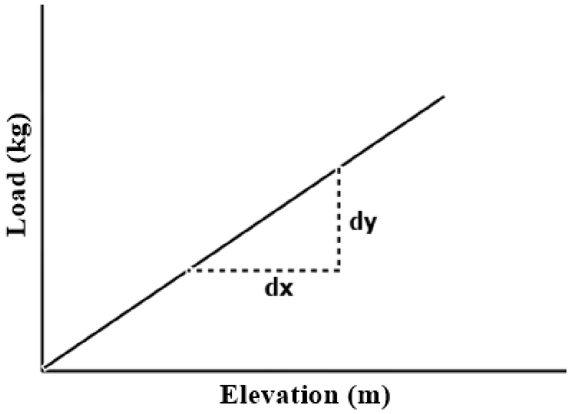
s = Elevation produced for 'M' kg load

Experimental setup



Young's modulus- Uniform bending

Model graph



Procedure

1. The specified beam is supported by two knife edges that are "L" apart in distance. At the middle, a pin is fixed vertically.
2. To ensure that their distances from the closer knife edge are identical, two weight hangers are strung, one on each side of the knife edges. Repeatedly loading and reloading the beam creates an elastic mood.

3. Under a microscope, the pin is focused using the dead load 'W'. The horizontal crosswire and pin tip coincide when the microscope is adjusted. The reading from the microscope is taken.
4. The weight is adjusted in increments of 0.05 kg, and when loading and unloading, a microscope reading is obtained in each instance. The measurements are tabulated. For 'M' kg, the elevation at the midpoint is computed.
5. Using a metre scale, the distance (L) between the knife edges is calculated. A vernier calliper and a screw gauge are used to determine the beam's width (b) and thickness (d), respectively.
6. Plot the graph between the load and elevation and find the slope by finding the division between the dy and dx.

Table 1

To determine the thickness (d) of the beam using screw gauge

Zero Error (ZE) : Div ;

Zero Correction (ZC) : mm

$$LC = \frac{Pitch}{Number\ of\ head\ scale}$$

$$Pitch = \frac{Distance\ moved}{Number\ of\ rotations\ given}$$

Least count (LC) = 0.01 mm

S. No.	Pitch Scale Reading (PSR) 10^{-3} m	Head Scale Coincidence (HSC) Div	Observed Reading OR = PSR + (HSC x LC) (10^{-3} m)	Correct Reading CR = OR ±ZC (10^{-3} m)

Table 2

To determine the breadth (b) of the beam using vernier calliper.

$$LC = \frac{\text{Value of 1 Main Scale Division (MSD)}}{\text{Number of divisions in the vernier}}$$

$$LC = \frac{0.1}{10} = 0.01 \text{ cm}$$

Zero Error (ZE): Zero Correction (ZC):

S. No.	Main Scale Reading (MSR) (10-2 m)	Vernier Scale Coincidence (VSC) (div)	Observed Reading OR = MSR + (VSC × LC) (10-2 m)	Correct Reading CR = OR ± ZC (10-2 m)

Table 3 - To find elevation 's'

Least count for travelling microscope:

$$LC = \frac{\text{Value of 1 Main Scale Division (MSD)}}{\text{Number of divisions in the vernier}}$$

$$\text{Value of 1 MSD } = \frac{1}{20} = 0.05 \text{ cm}$$

$$LC = \frac{0.05}{50} = 0.001 \text{ cm}$$

Load M (10-3 kg)	Microscope reading						Elevation 's' for M kg (10^{-2}m)
	Loading			Unloading			
	MSR	VSC (div)	TR	MSR	VSC (div)	TR	

Mean (s) = **………. × 10^{-2}m**

Observation:

Mass for the elevation **M** = 10^{-3}kg

Distance between two knife edges **L** = 10^{-2}m

Acceleration due to gravity **g**	=	ms^{-2}
Breadth of the beam **b**	=	10^{-2}m
Thickness of the beam **d**	=	10^{-3}m
Elevation produced for 'M' kg of load **s**	=	10^{-2}m
Distance between one of the knife edges and the adjacent weight hanger **a**	=	10^{-2}m

Calculation

Young's modulus of the material of the beam,

$$Y = \frac{Magl^2}{2sbd^3} \quad \text{N/m2.}$$

Result

The Young's modulus of the material of the given beam,

Y = $\times$ **10^{10} N/m^2.**

10.Determination of Young's modulus by non-uniform bending – scale and telescope.

Aim

To find the Young's modulus of the given material of the beam by non-uniform bending.

Apparatus required

Wooden beam, weight hanger with slotted weights, knife edges, travelling microscope, vernier calliper, screw gauge, metre scale.

Formula

Young's modulus,

$$\boldsymbol{Y = \frac{MgL^3}{4sbd^3} Nm^{-2}}$$

Where;

Y- Young's modulus of the material of the beam N/m^2.

M- Load applied in kg.

L- Distance between the knife edges in metre.

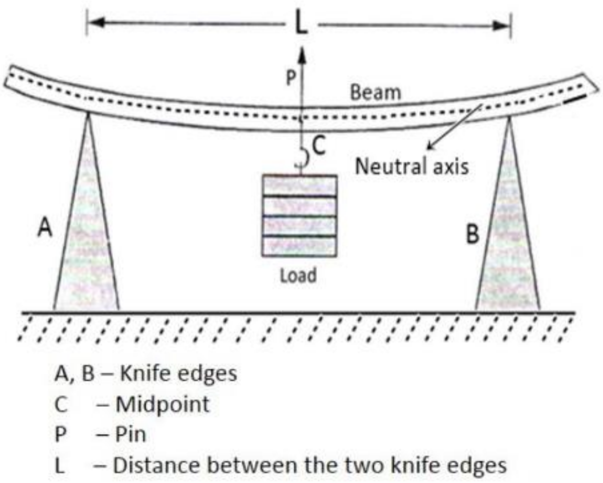
g- Acceleration due to gravity in m/s^2.

b- Breadth of the beam in metre.

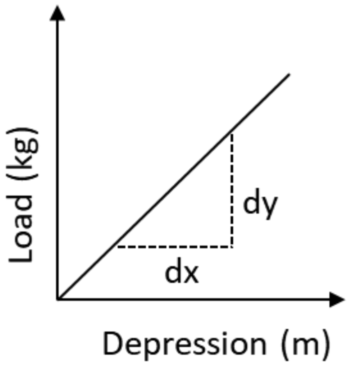
d- Thickness of the beam in metre.

s- Depression produced for 'M' kg load in metre.

Experimental setup



Model Graph



Procedure:

1. The beam in question is supported by two knife edges that are "L" apart. At the middle is a vertically fastened pin. At the middle of the beam, there is a weight hanger. Repeatedly loading and reloading the beam creates an elastic mood.

2. Under a microscope, the pin is focused using the dead load 'W'. The horizontal crosswire and pin tip coincide when the microscope is adjusted. The reading from the microscope is taken.

3. The weight is adjusted in increments of 0.05 kg, and when loading and unloading, a microscope reading is obtained in each instance. The measurements are tabulated. For "M" kg, the midpoint depression is computed.

4. Using a metre scale, the distance (L) between the knife edges is calculated. A vernier calliper and a screw gauge are used to determine the beam's width (b) and thickness (d), respectively.

Observations

Table 1

To determine the thickness (d) of the beam using screw gauge

Zero Error (ZE) : Div ; Zero Correction (ZC) : mm

$$LC = \frac{Pitch}{Number\ of\ head\ scale}$$

$$Pitch = \frac{Distance\ moved}{Number\ of\ rotations\ given}$$

Least count (LC) = 0.01 mm

S. No.	Pitch Scale Reading (PSR) 10^{-3} m	Head Scale Coincidence (HSC) Div	Observed Reading OR = PSR + (HSC x LC) (10^{-3} m)	Correct Reading CR = OR ±ZC (10^{-3} m)

Table 2

To determine the breadth (b) of the beam using vernier calliper.

$$LC = \frac{\text{Value of 1 Main Scale Division (MSD)}}{\text{Number of divisions in the vernier}}$$

$$LC = \frac{0.1}{10} = 0.01 \text{ cm}$$

Zero Error (ZE):

Zero Correction (ZC):

S. No.	Main Scale Reading (MSR) (10-2 m)	Vernier Scale Coincidence (VSC) (div)	Observed Reading OR = MSR + (VSC × LC) (10-2 m)	Correct Reading CR = OR ± ZC (10-2 m)

Mean b =

Table 3

To find depression's

LC = 0.001 cm

TR = MSR + (VSC * LC)

Load M Kg	Microscope reading							Depression S for M Kg
	Loading			Unloading			Mean	
	MSR	VSC	TR	MSR	VSC	TR		
W								
W|+50								
W+100								
W+150								
W+200								

Calculation

Young's Modulus,

$$y = \frac{MgL^3}{4sbd^3} Nm^{-2}$$

Result:

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

Y= $\times 10^{10}\, \boldsymbol{Nm^{-2}}$**.**

11.Determination of Young's modulus by cantilever –load depression graph.

Aim

To determine the Young's modulus by cantilever –load depression graph.

Apparatus required

Cantilever beam, Scale with stand, Hanger, Slotted weight.

Formula

Youngs modulus,

$$Y = \frac{4L^3 m}{b\,d^3 l}\ Nm^{-2}$$

Where;

l - Depression in cm.

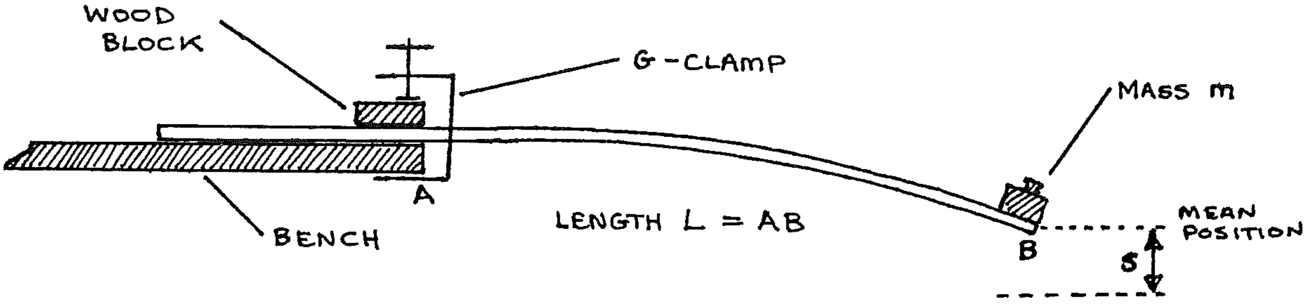
m - Load of mass in kg.

b - Breadth of the bar in cm.

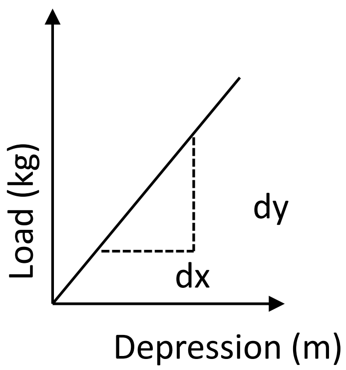
d - Thickness of the bar in cm.

L - Length of the bar in cm.

Experimental setup



Model graph



Procedure

1. Measure the length of the cantilever beam
2. Measure the breadth of the beam using vernier calliper
3. Measure the thickness of the beam using screw gauge
4. Measure the reading with No load on the hanger at the free end of the cantilever beam using the scale attached with the stand.
5. Repeat the above step with the slotted weight.
6. Gradually increase the load and note the depression value for a minimum of five readings.
7. Remove the loads gradually and record the data.
8. Determine the increasing and decreasing load data in the table.

Table 1

To determine the thickness (d) of the beam using screw gauge

Zero Error (ZE) : Div ; Zero Correction (ZC) : mm

$$LC = \frac{Pitch}{Number\ of\ head\ scale}$$

$$Pitch = \frac{Distance\ moved}{Number\ of\ rotations\ given}$$

Least count (LC) = 0.01 mm

S. No.	**Pitch Scale Reading (PSR) 10^{-3} m**	**Head Scale Coincidence (HSC) Div**	**Observed Reading OR = PSR + (HSC x LC) (10^{-3} m)**	**Correct Reading CR = OR ±ZC (10^{-3} m)**

Table 2

To determine the breadth (b) of the beam using vernier calliper.

$$LC = \frac{\text{Value of 1 Main Scale Division (MSD)}}{\text{Number of divisions in the vernier}}$$

$$LC = \frac{0.1}{10} = 0.01 \text{ cm}$$

Zero Error (ZE): Zero Correction (ZC):

S. No.	Main Scale Reading (MSR) (10-2 m)	Vernier Scale Coincidence (VSC) (div)	Observed Reading OR = MSR + (VSC × LC) (10-2 m)	Correct Reading CR = OR ± ZC (10-2 m)

Table 3

Determination of load vs depression

No.of.Obs.	Load applied m (gm)	Scale reading			Depression l (cm)
		Load increasing A (cm)	Load Decreasing B(cm)	Mean $\frac{A+B}{2}$	

Calculation

Youngs modulus,

$$Y = \frac{4L^3 m}{b\, d^3 l}\ Nm^{-2}$$

Result

Young's modulus by cantilever $\boldsymbol{Y} =$ $\boldsymbol{Nm^{-2}}$.

12.Determination of Young's modulus by cantilever – oscillation method

Aim

To determine the Young's modulus by cantilever – oscillation method

Apparatus required

Meter scale, Rigid support, Weights, Vernier calliper, Screw gauge etc.,

Formula

Young's modulus,

$$\boldsymbol{Y = \frac{16\pi^2 L^3}{bd^3} \times \frac{m_1 - m_2}{T_1^2 - T_2^2}\left(\frac{N}{m^2}\right)}$$

Where;

L= length of the projecting part of the bar.

b = Breadth of the bar

d = Thickness of the bar

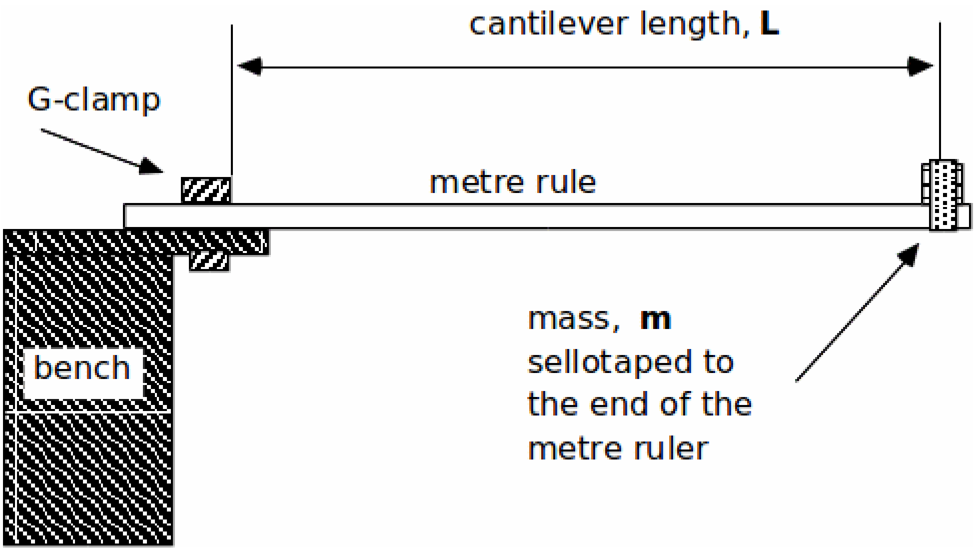
T_1= Period with mass m1 attached to the bar

T_2= Period with mass m2 attached to the bar

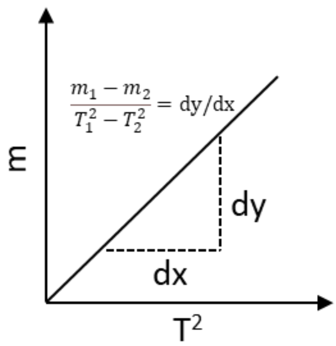
m_1=Mass 1 attached to the cantilever.

m_2=Mass 2 attached to the cantilever.

Experimental setup



Model graph



Procedure

1. Calculate the breadth and depth of the cantilever using vernier calliper and screw gauge respectively.
2. Fix the given scale to form cantilever.
3. Fix its one end and the other end should be free.
4. Note the projected length of the beam.
5. Load the beam with loads of 50 gm at the free end.
6. Give oscillations and make sure the time for 30 oscillations.

7. Same procedure should be followed for the remaining masses and projectile length.
8. Follow the same procedure and record the readings.
9. Plot a graph between m and T^2, obtain the value $\frac{m_1-m_2}{T_1^2-T_2^2}$ from the graph and substitute in the formula to calculate the young's modulus.

Table1

S.No.	Length of projectile Part of bar L	Mass attached m	Time for 30 oscillations			Mean t	$T = \frac{t}{30}$	T^2
			t_1	t_2	t_3			

Table 2

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

$$LC = \frac{Pitch}{Number\ of\ head\ scale}$$

$$Pitch = \frac{Distance\ moved}{Number\ of\ rotations\ given}$$

Least count (LC) = 0.01 mm

(Z.E) Zero error : mm

(Z.C) Zero correction : mm

PSR (mm)	**HSC (Div)**	**HSR =HSC×LC**	**TR =MSR+VSR**	**MEAN (mm)**
5.				
6.				
7.				
8.				

Table 3

To determine the breadth (b) of the beam using vernier calliper.

$$LC = \frac{\text{Value of 1 Main Scale Division (MSD)}}{\text{Number of divisions in the vernier}}$$

$$LC = \frac{0.1}{10} = 0.01 \text{ cm}$$

(Z.E) Zero error : cm

(Z.C) Zero correction : cm

S.No.	**MSR (cm)**	**VSC (Div)**	**VSR =VSC×LC**	**TR =MSR+VSR**	**MEAN (cm)**
5.					
6.					
7.					
8.					

Observation

Length of the bar L = cm

Breadth of the bar b = mm

Thickness of the bar d = cm

$\frac{m_1 - m_2}{T_1^2 - T_2^2}$ =

Calculation

Young's modulus,

$$Y = \frac{16\pi^2 L^3}{bd^3} \times \frac{m_1 - m_2}{T_1^2 - T_2^2} \left(\frac{N}{m^2}\right)$$

Result

Young's modulus by cantilever – oscillation method $\boldsymbol{Y} =$ $\left(\frac{\boldsymbol{N}}{\boldsymbol{m^2}}\right)$

13.Determination of Young's modulus by Koenig's method – (or unknown load)

Aim

To determine the Young's modulus by Koenig's method.

Apparatus required

A rectangular bar, Scale, Two mirrors, Telescope, Slotted weight etc.,

Formula

Youngs modulus,

$$\boldsymbol{Y = \frac{3mgl^2(L+2D)}{2b\,d^3x}\ Nm^{-2}}$$

Where;

m - Load in gm

l - Distance between knife edges in cm.

L - Distance between two mirrors in cm.

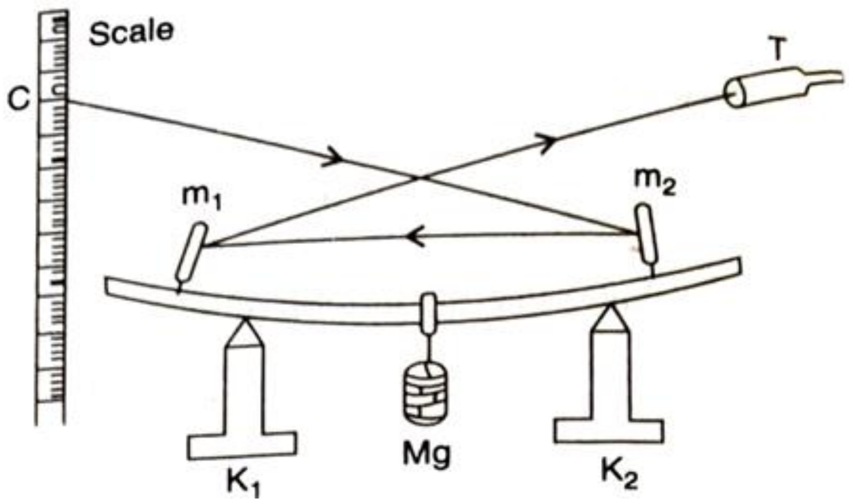
D - Distance between the scale and the remote mirror, m_2

b - Breath of the bar in cm.

d - Depth of the bar in cm.

x - Change in scale reading for M in gm.

Experimental setup



Model graph

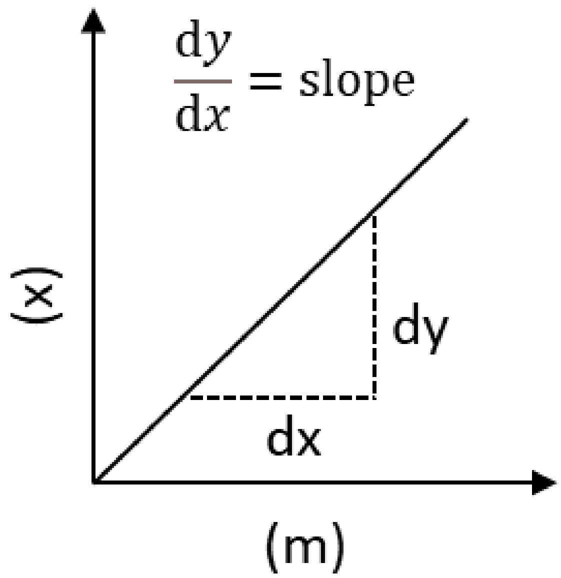


Table 1

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

$$LC = \frac{Pitch}{Number\ of\ head\ scale}$$

$$Pitch = \frac{Distance\ moved}{Number\ of\ rotations\ given}$$

Least count (LC) = 0.01 mm

(Z.E) Zero error : mm

(Z.C) Zero correction : mm

PSR (mm)	HSC (Div)	HSR =HSC×LC	TR =MSR+VSR	MEAN (mm)

Table 2

To determine the breadth (b) of the beam using vernier calliper.

$$LC = \frac{\text{Value of 1 Main Scale Division (MSD)}}{\text{Number of divisions in the vernier}}$$

$$LC = \frac{0.1}{10} = 0.01\text{ cm}$$

(Z.E) Zero error : cm

(Z.C) Zero correction : cm

S.No.	MSR (cm)	VSC (Div)	VSR =VSC×LC	TR =MSR+VSR	MEAN (cm)
9.					
10.					
11.					
12.					

Table 3

Load in gm	Scale reading telescope		Mean	Depression for M gm(x)
	Load increasing	Load decreasing		
0				
50				
100				
150				
200				
250				

Procedure

1. Find the center of gravity of given bar
2. Place the bar on two rigid knife edges at an equidistant from center of gravity
3. Measure the distance (l) between the knife edges.
4. Determine the thickness (d) of the beam using screw gauge.
5. Determine the breadth (b) of the beam using vernier calliper.

6. Experimental setup should be set as shown in the figure.
7. Place the loads and measure the loading and unloading readings in the scale using telescope.
8. Take at least five such readings for loading and unloading the rectangular bar.
9. Plot the values in Table 3 and create a graph where the load (m) and depression (x) are shown. The slope is then determined.

Calculation

From graph

$$Y = \frac{3gl^2(\alpha + 2D)}{2b\,d^3} \times \frac{m}{x} \quad Nm^{-2}$$

$$Y = \frac{3gl^2(\alpha + 2D)}{2b\,d^3} \times \frac{1}{slope} \quad Nm^{-2}$$

Result

Young's modulus by Koenig's method $\boldsymbol{Y} =$ $\boldsymbol{Nm^{-2}}$

14.Determination of rigidity modulus by static torsion.

Aim

To determine the rigidity modulus by static torsion method.

Apparatus required

Meter scale, Screw gauge, Thread, Load, Mirror etc.,

Formula

Rigidity modulus,

$$\boldsymbol{n = \frac{4mgR}{\pi r^4} \times \frac{lD}{s} Nm^{-2}}.$$

Where;

M = mass suspended.

G = acceleration due to gravity.

r = radius of the rod.

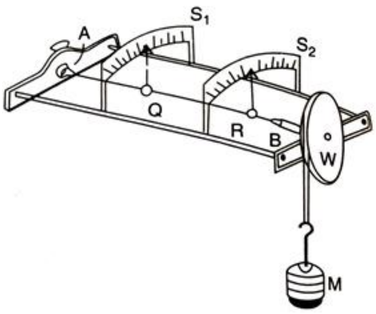
L = length of the rod.

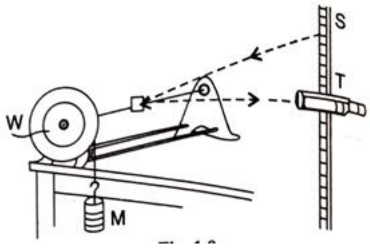
D = distance of the scale from the mirror.

S = shift for m in Kg.

R = radius of the wheel.

Experimental setup





Procedure

1. Setup the Searles apparatus as shown in the figure.
2. Measure the length of the rod using a meter scale.
3. Measure the diameter d and radius using the screw gauge.
4. Tabulate the values in the table 2.
5. Place the loads in the increasing order to find the loading and unloading value using the telescope.
6. Record the readings in the table and follow the calculations to determine the rigidity modulus.

Observation

Radius of the wheel, R	$= C/2\pi$	m
Radius of the rod, r	=	m
Value of load, m	=	kg
Distance between scale and mirror, D	=	m

Table1

To find $\frac{lD}{s}$

Distance between scale and mirror, D= m

Length l (m)	Load	Telescope reading								Mean Shift (S) for	$\frac{lD}{s}$
		Clockwise				Anticlockwise					
		Loadin	unloadi	Mean	Shift for4m	Loadin	Unload	Mean	Shift for4m		
0.4	W			X_0				Y_0			
	W+m			X_1				Y_1			
	W+2m			X_2				Y_2			
	W+3m			X_3				Y_3			
	W+4m			X_4	$X_4 - X_0$			Y_4	$Y_4 - Y_0$		
	W+5m			X_5	$X_5 - X_1$			Y_5	$Y_5 - Y_1$		
	W+6m			X_6	$X_6 - X_2$			Y_6	$Y_6 - Y_2$		
	W+7m			X_7	$X_7 - X_3$			Y_7	$Y_7 - Y_3$		

Mean $\frac{lD}{s}$ = m

Table 2

To determine the diameter (d) of the beam using screw gauge.

$$LC = \frac{Pitch}{Number\ of\ head\ scale}$$

$$Pitch = \frac{Distance\ moved}{Number\ of\ rotations\ given}$$

Least count (LC) = 0.01 mm

(Z.E) Zero error : mm

(Z.C) Zero correction : mm

PSR (mm)	HSC (Div)	HSR $=HSC \times LC$	TR $=MSR+VSR$	MEAN (mm)

Calculation

Rigidity modulus,

$$n = \frac{4mgR}{\pi r^4} \times \frac{lD}{s}$$

Result

Rigidity modulus of the material, $\boldsymbol{n} =$ $\times \mathbf{10^{10}} \boldsymbol{Nm^{-2}}$.

15.Determination of elastic constants Y, n and K by Searle's double bar method.

Aim

To determine Y, n and K by Searle's double bar method.

Apparatus required

Two identical round or square-section rods (bars) with a hanging arrangement, a thin wire of thirty centimetres in length, a stopwatch, a screw gauge, vernier callipers, inextensible thread, a metre scale, a weight box, and a physical balance are all included.

Formula

Young's modulus,

$$Y = \frac{8\pi L}{T_1^2 r^4} M \left(\frac{l^2}{12} + \frac{R_C^2}{4} \right) dyne\ cm^{-2}$$

Rigidity modulus,

$$n = \frac{8\pi L}{T_2^2 r^4} M \left(\frac{l^2}{12} + \frac{R_C^2}{4} \right) dyne\ cm^{-2}$$

Poisson ratio,

$$\sigma = \frac{y}{2n} - 1$$

Bulk modulus,

$$k = \frac{1}{3} \frac{Y}{(1 - 2\sigma)}\ dyne\ cm^{-2}$$

Where;

L = Length of the wire

I = Moment of inertia

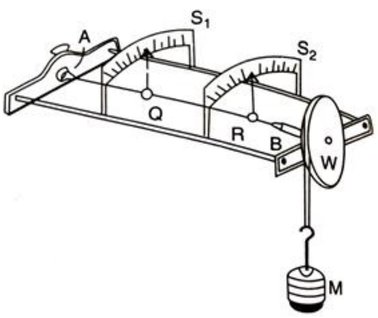
T = Time period

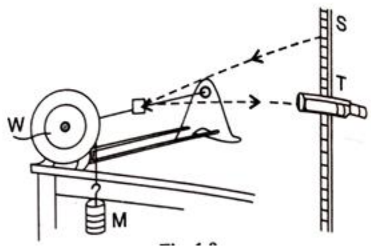
M = Mass of the rod

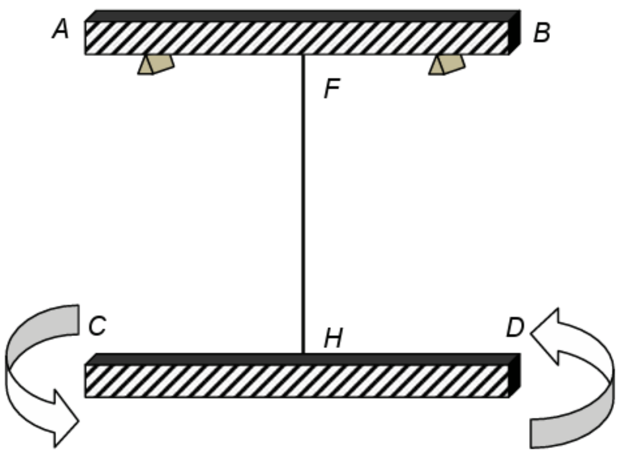
l = length of the rod

b = Breadth of the rod

Experimental setup







Procedure

1. The rods AB and CD should be in the same horizontal plane when the apparatus is set up as indicated. You will need two 60-cm-long inextensible cotton or silk threads for this.

2. When the Searle's apparatus is in the equilibrium position and the rods are at rest, set up a pointer in the centre of one of the rods and mark the rod in line with the pointer.
3. Encircle ends A and C with a cotton loop. This will assist you in making a tiny angle and drawing these ends closer one another. Verify that the system that is limited is in a state of rest.
4. Burn the cotton loop. The rods will start to oscillate after ends A and C are released. Verify that these rods' oscillation amplitudes are modest—roughly three. After using the stop watch to measure time (t) for, say, 20 oscillations, note its lowest count and enter it in the observation table.
5. You can get the mean value of the time period by repeating Steps (3) and (4) as described above at least five times. From T
6. As illustrated in experimental setup, remove the threads (made of cotton or silk) holding the rods in the suspension arrangement and clamp one of the rods, let's say AB, horizontally with a stiff support. Verify that the wire is vertical before continuing.
7. Rotate one end of the rod CD in a horizontal plane at a slight angle to twist the wire, then let go of it. The rod will oscillate in a torsional manner. Make sure the rod is stable before beginning to record time (t) for, say, 20 oscillations.
8. At least five times through, repeat Step 7, and note your readings in the Observation Table.
9. Using a screw gauge, measure the wire's diameter at least four distinct locations throughout its length in the mutually perpendicular directions. Take note of your readings in Table 2 of Observation. Keep in mind that since the fourth power of the radius appears in the formulas of elastic constants, even a tiny inaccuracy in it will have a big impact on the values

of those constants. Furthermore, because of its tiny magnitude, you have to be extremely careful while determining r.

10. Using a metre rod, measure the length (L) of the wire under study and record the result in Observation Table 2.
11. Accurately calculate the mass M and length of the rod CD, then note these values at the top of the Observation Table 3. Sieve the rod CD's radius (R_c) with a vernier calliper. Record the results of at least five readings taken at various locations in Observation Table 3.

Table 1

Measurement of time period T_1 and T_2

No. of oscillations = 20

SI.No.	t	t'
1.		
2.		
3.		
4.		
5.		

$T_1 = \frac{\text{sum of t}}{100}$ $T_2 = \frac{\text{sum of } t'}{100}$

= s = s

Table 2

To determine the diameter (d) of the wire using screw gauge.

$$LC = \frac{Pitch}{Number\ of\ head\ scale}$$

$$Pitch = \frac{Distance\ moved}{Number\ of\ rotations\ given}$$

Least count (LC) = 0.01 mm

(Z.E) Zero error : mm

(Z.C) Zero correction : mm

PSR (mm)	HSC (Div)	HSR =HSC×LC	TR =MSR+VSR	MEAN (mm)

Mean diameter of wire, d =cm

Mean radius of wire, r =cm

Length of wire, L =cm

Table 3

To determine the radius r of the rod using vernier calliper.

$$LC = \frac{\text{Value of 1 Main Scale Division (MSD)}}{\text{Number of divisions in the vernier}}$$

$$LC = \frac{0.1}{10} = 0.01 \text{ cm}$$

(Z.E) Zero error : cm

(Z.C) Zero correction : cm

S.No.	MSR (cm)	VSC (Div)	VSR =VSC×LC	TR =MSR+VSR	MEAN (cm)
13.					
14.					
15.					
16.					

Mean diameter d of the rod CD = cm

Mean radius R_c of the rod CD = cm

Observation

Mass of rod CD = M = g

Length of the rod CD, l = cm

Calculation

Young's modulus,

$$Y = \frac{8\pi L}{T_1^2 r^4} M \left(\frac{l^2}{12} + \frac{R_C^2}{4}\right) dyne\ cm^{-2}$$

Rigidity modulus,

$$n = \frac{8\pi L}{T_2^2 r^4} M \left(\frac{l^2}{12} + \frac{R_C^2}{4}\right) dyne\ cm^{-2}$$

Poisson ratio,

$$\sigma = \frac{y}{2n} - 1$$

Bulk modulus,

$$k = \frac{1}{3}\frac{Y}{(1-2\sigma)}\ dyne\ cm^{-2}$$

Result

Elastic constants Y, n and K by Searle's double bar method were determined as follows

$$\boldsymbol{Y =} \qquad\qquad \boldsymbol{dyne\ cm^{-2}}$$

$$\boldsymbol{n =} \qquad\qquad \boldsymbol{dyne\ cm^{-2}}$$

$$\boldsymbol{k =} \qquad\qquad \boldsymbol{dyne\ cm^{-2}}$$

16.Determination of surface tension and interfacial surface tension by drop weight method.

Aim

To determine the surface tension and interfacial surface tension by drop weight method.

Apparatus required

A glass fitted with a rubber tube, glass tube, beaker, stand, stop clock, screw gauge, pinch cock.

Formula

I. Surface tension,

$$\boldsymbol{T1 = \frac{mg}{3.8R}(Nm^{-1})}$$

II. Interfacial surface tension,

$$\boldsymbol{T_2 = \frac{mg}{3.8R}\left[1 - \frac{P_2}{P_1}\right](Nm^{-1})}$$

Where;

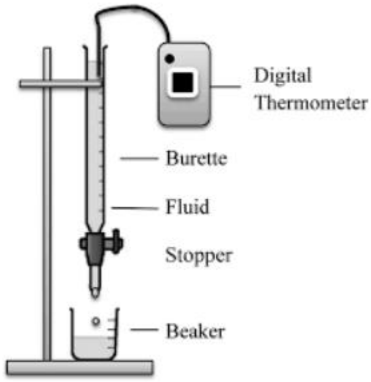
m - average mass of one drop of water.

R - external radius of glass tube

g - acceleration due to gravity

P_1, P_2 - densities of water and kerosene

Experimental setup



Procedure

1. The figure displays the experimental configuration. Under the glass tube, there is a beaker. Water that has fallen from the funnel is collected in the weighed beaker. The stop clock is set to produce eight to ten liquid drips per minute at a slow pace. In the beaker, a predetermined number of drops—say let's 25—are gathered.
2. Once more, the mass of the beaker filled with water is determined. The difference between the two values yields the mass of 25 drops of water, from which the mass of each drop is computed.
3. After repeating the process, the average mass of a single water drop in metres is determined. A screw gauge is also used to accurately measure the glass tube's exterior radius.
4. The above formula (|) is used to determine the surface tension of water at laboratory temperature.
5. The mass of the beaker with kerosene oil is found the beaker is placed
6. below the glass tube such that water drops are formed inside the
7. kerosene oil as shown in the fig

8. The mass of each of the 25 water droplets that are gathered in the kerosene is calculated. The previous experiment is conducted again.
9. Using formula (||), one can determine the interfacial tension between water and kerosene.

Table1

To determine the radius of glass tube (R) using screw gauge.

$$LC = \frac{Pitch}{Number\ of\ head\ scale}$$

$$Pitch = \frac{Distance\ moved}{Number\ of\ rotations\ given}$$

Least count (LC) = 0.01 mm

(Z.E) Zero error : mm

(Z.C) Zero correction : mm

PSR (mm)	HSC (Div)	HSR =HSC×LC	TR =MSR+VSR	MEAN (mm)

Radius R = m

Table2

Determination of the surface tension of water by the drop-weight method

Liquid drops	m_0 (g)	$m_0 + m_{liq} = m_{total}$(g)	m_{liquid} (g)	Average mass One drop m (Kg)
0				
25				
75				

Table3

Determination of the surface tension of kerosene by the drop-weight method

Liquid drops	m_0 (g)	$m_0 + m_{liq} = m_{total}$(g)	m_{liquid} (g)	Average mass One drop m (Kg)
0				
25				
75				

Calculation

I. Surface tension,

$$T1 = \frac{mg}{3.8R} (Nm^{-1})$$

II. Interfacial surface tension,

$$T_2 = \frac{mg}{3.8R}\left[1 - \frac{P_2}{P_1}\right] (Nm^{-1})$$

Result

I. Surface tension of water $\boldsymbol{T1} =$ $(\boldsymbol{Nm^{-1}})$

II. Interfacial surface tension between kerosene in water $\boldsymbol{T_2} =$ $(\boldsymbol{Nm^{-1}})$

17.Determination of co-efficient of viscosity by Stokes' method – terminal velocity.

Aim

To determine the co-efficient of viscosity of the given liquid by Stoke's method

Apparatus required

A long cylindrical glass jar, highly viscous liquid, meter scale, spherical ball, stop clock, thread.

Formula

Co-efficient of Viscosity,

$$\boldsymbol{\eta = \frac{2r^2(\rho - \sigma)g}{9V} \; (Nsm^{-2})}$$

Velocity,

$$\boldsymbol{V1 = \frac{d}{t} \quad \left(\frac{m}{s}\right)}$$

Terminal velocity,

$$\boldsymbol{V = V_1(1 + \frac{2.4r}{R})}$$

Where;

r = Radius of the sphere in meter.

D = Inner diameter of the glass jar in meter.

t = Time taken to travel the distance in seconds.

R = Inner radius of the glass jar in meter.

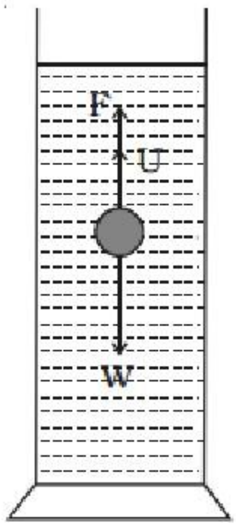
g = Acceleration due to gravity in meter per seconds squared.

V = Terminal velocity.

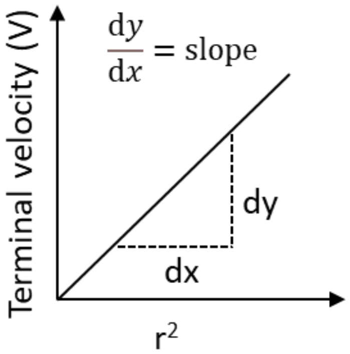
η = Co-efficient of Viscosity in Nsm^{-2}.

$V1$ = Velocity of the sphere travelled in meter per second.

Experimental setup



Model graph



Procedure

1. Determine the screw gauge's least count and zero correction.
2. Using the screw gauge, determine the ball's diameter (d). At this point, the formula to find the ball's radius (r) is r = d/2.
3. After cleaning, pour the thick liquid into the glass jar.
4. Next to the jar, place a vertical metre scale.
5. Using a vernier calliper, determine the jar's inner diameter. Thus, it is possible to determine the jar's inner radius, R.
6. Using two threads, mark reference points A and B on the jar. The marking A is placed well below the liquid's free surface, so that the ball will have reached its terminal velocity (v) by the time it gets there.
7. To ensure that there is 60 centimetres between A and B, reposition thread B.
8. A known-diameter ball is carefully dropped into the liquid. For around a third of the height, it descends at an accelerated speed into the liquid. After then, it descends with a constant terminal velocity.
9. Set the stop watch to begin when the ball crosses point A, and record how long it takes the ball to get to point B.

Observation

Density of the liquid, ρ = kg/m3

Density of the sphere, σ = kg/m3

Distance travelled by the sphere, s = 10-2 m

Table 1

To determine the diameter (d) of the sphere using screw gauge.

$$LC = \frac{Pitch}{Number\ of\ head\ scale}$$

$$Pitch = \frac{Distance\ moved}{Number\ of\ rotations\ given}$$

Least count (LC) = 0.01 mm

(Z.E) Zero error : mm

(Z.C) Zero correction : mm

PSR (mm)	HSC (Div)	HSR =HSC×LC	TR =MSR+VSR	MEAN d (mm)

Table 2

To determine the inner diameter D of the glass jar using vernier calliper.

$$LC = \frac{\text{Value of 1 Main Scale Division (MSD)}}{\text{Number of divisions in the vernier}}$$

$$LC = \frac{0.1}{10} = 0.01\text{ cm}$$

(Z.E) Zero error : cm

(Z.C) Zero correction : cm

S.No.	MSR (cm)	VSC (Div)	VSR =VSC×LC	TR =MSR+VSR	MEAN D (cm)
1.					
2.					
3.					
4.					

Table 3

To find the terminal velocity of sphere

No.of. sphere	Radius of sphere (r)	Time taken to travel distance (t)	Velocity (V1)	Terminal velocity (V)	$\frac{r^2}{V}$ (m/s)

Calculation

Radius of the sphere, r = d/2

= mm

= m

Inner radius of the glass jar, R =D/2

= cm

= m

velocity,

$$V1 = \frac{d}{t} \quad \left(\frac{m}{s}\right)$$

Terminal velocity,

$$V = V_1(1 + \frac{2.4r}{R})$$

Experimental

Coefficient of viscosity,

$$\eta = \frac{2r^2(\rho - \sigma)g}{9V} \ (Nsm^{-2})$$

$$= \qquad\qquad (Nsm^{-2})$$

Graphical

Coefficient of viscosity,

$$\eta = \frac{2(\rho - \sigma)g}{9slope} \ (Nsm^{-2})$$

$$= \qquad\qquad (Nsm^{-2})$$

Result

The coefficient of viscosity of the given liquid, η

i. **By calculation** = $(\boldsymbol{Nsm^{-2}})$

ii. **From graph** = $(\boldsymbol{Nsm^{-2}})$

18.Determination of critical pressure for streamline flow.

Aim

To determine the critical pressure for streamline flow.

Apparatus required

Reynolds apparatus, vernier calliper, Potassium permanganate dye, water supply, etc.,

Formula

Reynolds number R_e

$$\boldsymbol{R_e = \frac{\rho V D}{\mu}}$$

Critical velocity V_c

$$\boldsymbol{V_C = \frac{R_e \times \mu}{\rho \times D}}$$

Critical pressure P_c

$$\boldsymbol{P_c = P + \frac{\rho V_c^2}{2}}$$

Where;

ρ = Density of the fluid in kg/m^3.

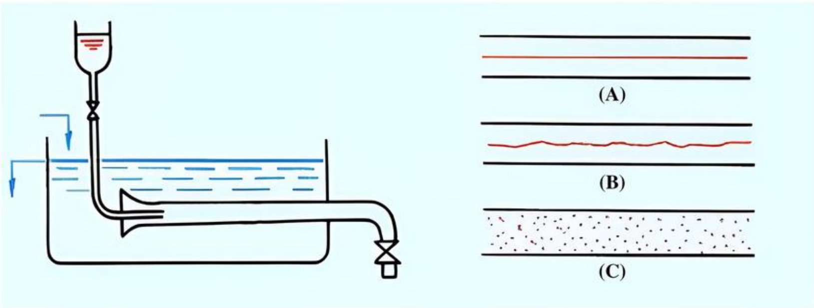
D = Diameter of the glass tube.

μ = Dynamic viscosity of the fluid $kgm^{-1}s^{-1}$.

V = velocity of fluid in m/s.

P = Pressure at inlet in pascal.

Experimental setup



Procedure

1. As seen in the illustration, set up the experimental setup.
2. Using the vernier calliper, find the glass tube's diameter (D).
3. To see the type of flow, load the dye potassium permanganate.
4. Make a note of the tube's Pascal inlet pressure.
5. Once the streamline flow has been observed, note the V0 and note the time t.
6. To find the discharge Q, enter the mean value into the formula.
7. Determine the fluid's velocity (V) and replace it with the Reynolds number.
8. It is possible to calculate the critical pressure and velocity.

Table1

To determine the diameter D of the glass tube using vernier calliper.

$$LC = \frac{\text{Value of 1 Main Scale Division (MSD)}}{\text{Number of divisions in the vernier}}$$

$$LC = \frac{0.1}{10} = 0.01 \text{ cm}$$

(Z.E) Zero error : cm

(Z.C) Zero correction : cm

S.No.	MSR (cm)	VSC (Div)	VSR =VSC×LC	TR =MSR+VSR	MEAN (cm)
17.					
18.					
19.					
20.					

Table2

S.No.	t (sec)	V_0 (ml)	Flow type
1.			Streamline flow
2.			
3.			
4.			

Observation

Diameter of the glass tube **D** =

Density of the fluid $\boldsymbol{\rho}$ =

Viscosity of the fluid $\boldsymbol{\mu}$ =

Pressure at inlet in pascal **P** =

Calculation

$$Q = \frac{V_0 \times 10^{-6}}{t} \quad \left(\frac{m^3}{\text{sec}}\right)$$

$$A = \frac{\pi}{4} D^2 \quad (m^2)$$

$$V = \frac{Q}{A}$$

Reynolds number R_e

$$R_e = \frac{\rho V D}{\mu}$$

Critical velocity V_c

$$V_C = \frac{R_e \times \mu}{\rho \times D}$$

Critical pressure P_c

$$P_c = P + \frac{\rho V_c^2}{2}$$

Result

Critical pressure P_c for streamline flow, $\boldsymbol{P_c} =$ $\qquad\qquad$ $\boldsymbol{pascal}$

19.Determination of Poisson's ratio of rubber tube.

Aim

To determine the Poisson's ratio of rubber tube.

Apparatus required

Rubber tube with metal sleeve and rubber stopper, meter scale, small pointer, slotted weights of 250gm, hanger, Burette and rubber stopper.

Formula:

Poisson's ratio for rubber,

$$\boldsymbol{\sigma = \frac{1}{2}\left(1 - \frac{1}{A}\frac{dV}{dL}\right)}$$

Where;

A = Area of cross-section of rubber tube

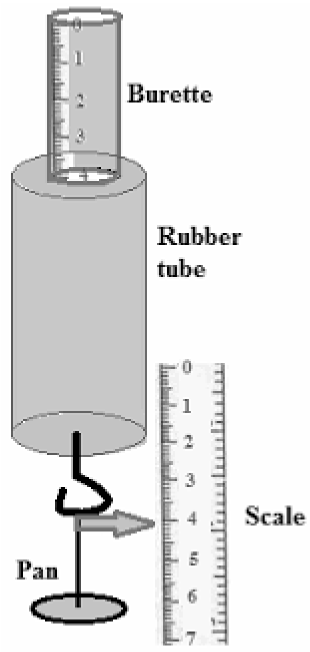
A = $\pi r^2 = \pi D^2/4$

D = Diameter of rubber tube

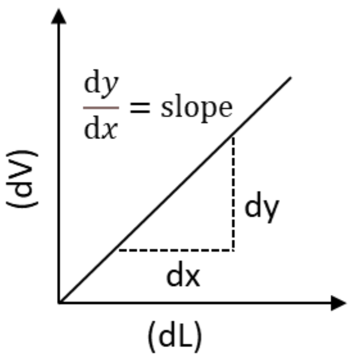
dV = Small increase in the volume of the tube when stretched by a small weight

dL = corresponding increase in the length of the tube.

Experimental setup



Model graph



Procedure:

1. To begin, hang the device from a clamp that is adjusted to a comfortable height, then fill the rubber tube with water until the water meniscus about reaches the top of the burette.
2. When there is no load, use Vernier callipers to measure the rubber tube's diameter.

3. When there is no load, record the water meniscus reading in the burette and the pointer's location on the scale. You now have a zero-mass reading for L and V.
4. Now, hang the hanger (mass=250gm) at the rubber tube's lower end, and record the water meniscus reading in the burette as well as the pointer's location on the scale. You can now read l and V for a 250 g mass. 5. Increase the load in increments of 250 g to 1250 g while recording the water meniscus and pointer readings. This provides you with the corresponding mass readings for L and V.
5. To decrease the weights, follow the same process as before. The values of l and V for the last load will be the same whether the load is growing or decreasing.
6. Calculate the average of the two burette readings—one for the same load on the hanger and the other for increasing and decreasing load. Apply a similar method to reading scales.
7. To find the change in volume dV of the rubber tube for different loads on the hanger, subtract the mean readings for zero load on the hanger from the mean reading for any load. (For example, to get dV, subtract each mean V value from the zero-burette reading.)
8. In the same way, repeat step 8 to determine dL in the scale reading scenario. (For example, to calculate the value of dL, subtract each L reading from the zero-scale reading.)
9. Determine the mean value of dV/dL by computing the value for each set of observations independently.
10. Plot a graph with the value of dV along the Y-axis and dL along the X-axis. The result will be a straight line. Its slope will provide the dV/dL average.
11. Determine s by taking the mean of the two dV/dL values that you calculated individually.

Observations

Radius of the tube r, = D/2

= cm

Table1

To determine the diameter of rubber tube when its unloaded using vernier calliper.

$$LC = \frac{\text{Value of 1 Main Scale Division (MSD)}}{\text{Number of divisions in the vernier}}$$

$$LC = \frac{0.1}{10} = 0.01 \text{ cm}$$

(Z.E) Zero error : cm

(Z.C) Zero correction : cm

S.No.	MSR (cm)	VSC (Div)	VSR =VSC×LC	TR =MSR+VSR	MEAN (cm)
21.					
22.					
23.					
24.					

Table2

To determine Change in volume dV

S.No.	Load On hanger	Reading of burette			Change in volume dV dV= 0-Load
		Load Increasing X	Load Decreasing Y	Mean $\left(\frac{X+Y}{2}\right)$	
1.	0				
2.	250				
3.	500				
4.	750				
5.	1000				
6.	1250				

Table3

To determine Change in volume dL

S.No.	Load On hanger	Reading of burette			Change in length dL dL= 0-Load
		Load Increasing X1	Load Decreasing Y1	Mean $\left(\frac{X1+Y1}{2}\right)$	
1.	0				
2.	250				
3.	500				
4.	750				
5.	1000				
6.	1250				

Table4

To determine $\frac{dV}{dL}$

S.No.	Change in volume dV	Change in length dL	$\frac{dV}{dL}$	Mean $\frac{dV}{dL}$
1.				
2.				
3.				
4.				
5.				
6.				

Calculation

$\frac{dV}{dL}$ = (from Table);

$\frac{dV}{dL}$ = dy/dx

= (from graph)

A = πr^2

$\pi D^2/4$=

Poisson's ratio for rubber,

$$\sigma = \frac{1}{2}\left(1 - \frac{1}{A}\frac{dV}{dL}\right)$$

Result

The Poisson's ratio of rubber tube **(σ)=**

20.Determination of viscosity by Poiseuille's flow method.

Aim

To determine the coefficient of viscosity of the given liquid by Poiseuille's method.

Apparatus required

Burette, Rubber tube, capillary tube, Pinch cock, travelling microscope, Stop clock, Meter scale, Beaker.

Formula

Coefficient of viscosity,

$$\eta = \frac{\pi \rho g r^4 (ht)}{8LV} (Nsm^{-2})$$

Where;

ρ = Density of the given liquid in Kg m^{-3}.

g = Acceleration due to gravity in ms^{-2}.

r = Internal radius of the capillary tube in m.

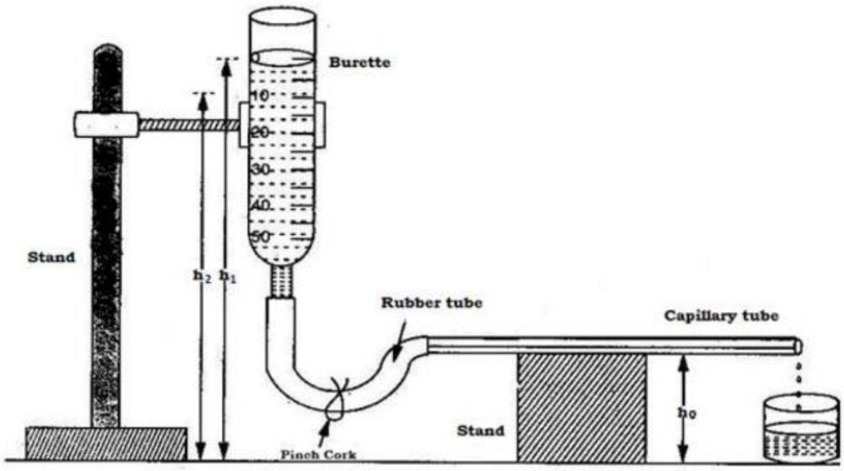
L = Length of the capillary tube in m.

h = Driving height of the liquid in m.

t = Time taken for the flow of liquid in s.

V = Volume of the liquid collected in m^3.

Experimental setup



Procedure

1. The liquid for which the viscosity is to be measured is completely filled into the burette, which is mounted vertically in the stand.
2. A rubber tube is used to join a capillary tube to the lower end of the burette.
3. On a table, the capillary tube is positioned such that it is horizontal.
4. With this configuration, gravity is not a factor and the liquid can pass freely through the capillary tube.
5. When the burette's bottom knob is turned, water is let to drain down the capillary tube. The stop clock is initiated when the liquid level reaches the zero-mark level.
6. It is documented how long it takes to reach 10, 20,..., 50 cc. Next, the time intervals 0–10, 10–20,..., 40–50, for each 10 cc are identified and recorded. Each marking's height (H), which is 0, 10—-50 cc, is calculated using the table. Additionally, the table's axis of the capillary tube's height (h0) is found. The relation (H – h0) is then used to determine the actual height of each marker.
7. [(h1+h2)/2] is the driving height, or h. -h0 is determined by taking the height of the beginning marking (represented by h1) and the final marking (represented by h2) for each of the following ranges: 0–10, 20–30, 40–50.
8. One computes the mean value of (ht/V). A travelling microscope is used to measure the capillary tube's diameter, from which the radius (r = diameter/2) is computed.
9. It is possible to compute the coefficient of viscosity by changing the parameters in the provided formula.

Table1

To find time of flow (t) and height

Burette reading (10-6 m3)	Time taken (s)	Height of burette reading from the table H (10-2 m)
0		
10		
20		
30		
40		
50		

Table2

To find 'ht'

S.No.	Volume of the liquid (10-6 m3)	Time of flow t (s)	h1 (10^{-2} m)	h2 (10^{-2} m)	h= [(h1+h2)/ 2]- h0 (10-2 m)	ht (10-2 ms)
1.	0-10					
2.	10-20					
3.	20-30					
4.	30-40					
5.	40-50					

Mean 'ht' = ms

Table3

To find the internal radius of the capillary tube

$$LC = \frac{\text{Value of 1 Main Scale Division (MSD)}}{\text{Number of divisions in the vernier}}$$

$$LC = \frac{0.1}{10} = 0.01 \text{ cm}$$

(Z.E) Zero error : cm

(Z.C) Zero correction : cm

Position	MSR (cm)	VSC (Div)	VSR =VSC×LC	TR =MSR+VSR	MEAN (cm)
25.Left					
26.Right					
27.Top					
28.Bottom					

Mean '2r' = m

Radius r = m

Observation

Density of the given liquid ρ = Kg m^{-3}.

Acceleration due to gravity g = ms^{-2}.

Inner radius of the capillary tube r = m.

Length of the capillary tube L = m.

Volume of the liquid V = m^3.

Mean value of ht = ms.

Calculation

Coefficient of viscosity,

$$\eta = \frac{\pi \rho g r^4 (ht)}{8LV} (Nsm^{-2})$$

Result

The co-efficient of viscosity of the given liquid $\boldsymbol{\eta} =$ $(\boldsymbol{Nsm^{-2}})$.

21.Determination of radius of capillary tube by mercury pellet method.

Aim

To determine the radius of capillary tube by mercury pellet method.

Apparatus required

Capillary tube, Mercury, China dish, Stopwatch, Burette, Vernier caliper, Balance, Measuring cylinder, Meter scale, Water etc.,

Formula

Radius of capillary tube

$$r = \sqrt{\frac{m}{\pi l d}} \quad meter.$$

Co-efficient of viscosity

$$\eta = \frac{\pi \rho g r^4}{8L}\left(\frac{ht}{V}\right) Nsm^{-2}$$

Where;

m = Mass of the mercury pellet.

l = length of the mercury pellet inside the tube.

d = density of mercury

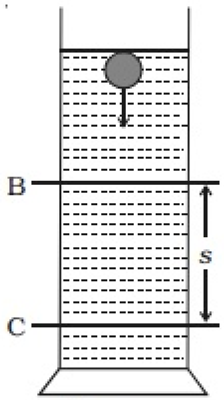
ρ = density of the liquid in capillary tube.

L =length of the capillary tube.

h1 = height of the burette from ground level

h2 = height of the burette from ground level to the value of liquid present

Experimental setup



Procedure

1. Clean the capillary tube and dry it properly.
2. Measure the mass of the China dish (m1).
3. Insert the mercury into the capillary tube using the China dish.
4. Measure the combined mass of the China dish and mercury pellet (m2).
5. Calculate the mass of the mercury pellet (m = m2 - m1).
6. Measure the length of the mercury pellet (l).
7. Measure the length of the capillary tube (L).
8. Determine the density of mercury (d = 13600 kg/m^3).
9. Note the height of the burette from the ground level (h1).
10. Fill the burette with water and note the level (h2).
11. Calculate h = (h1 + h2)/2 - H, where H = 10 m.
12. Set up a table to record the time of flow of liquid and corresponding burette readings at regular intervals.
13. Start the stopwatch and note the time when the liquid reaches certain levels in the burette.
14. Repeat this process for different intervals until a sufficient amount of data is collected.
15. Record the time of flow of liquid and corresponding burette readings.

16.Calculate $\left(\frac{ht}{V}\right)$for each interval using the given formula.

Table1

Time of flow of liquid

Burette reading	Time of flow liquid		
	Minutes	Seconds	Total seconds
0			
5			
10			
15			
20			

Table2

To find $\left(\frac{ht}{V}\right) H = \quad m$ **V=5cc =5×** 10^{-6}**m³**

S.No.	Time of flow of liquid (s)	h1 (m)	h2 (m)	$h = \frac{h_1 + h_2}{2} - H$ (m)	$\left(\frac{ht}{V}\right)$ $\left(\frac{sec}{m^2}\right)$
1.	0-5				
2.	5-10				
3.	10-15				
4.	20-25				
5.	30-35				
6.	40-45				

$\left(\frac{ht}{V}\right)=$ $\left(\frac{sec}{m^2}\right)$

Observation

Mass of China dish, m1 = kg

Mass of China dish +mercury pellet, m2 = kg

Mass of mercury pellet, m =m2-m1

= kg

Length of the mercury pellet	l	=	m
Length of capillary tube,	L	=	m
Density of mercury,	d	=13600	kgm^{-3}.
	H	=10	

Calculation

Radius of capillary tube

$$\boldsymbol{r = \sqrt{\frac{m}{\pi l d}}\quad meter}.$$

Co-efficient of viscosity

$$\boldsymbol{\eta = \frac{\pi \rho g r^4}{8L}\left(\frac{ht}{V}\right) Nsm^{-2}}$$

Result

i. Radius capillary tube by mercury pellet method $\boldsymbol{r =}$ $\boldsymbol{meter}$.

ii. Co -efficient of viscosity $\boldsymbol{\eta =}$ $\boldsymbol{Nsm^{-2}}$

22.Determination of g using compound pendulum.

Aim

To determine the acceleration due to gravity g using compound pendulum.

Apparatus required

Bar pendulum, stop watch and meter scale etc,

Formula

Acceleration due to gravity,

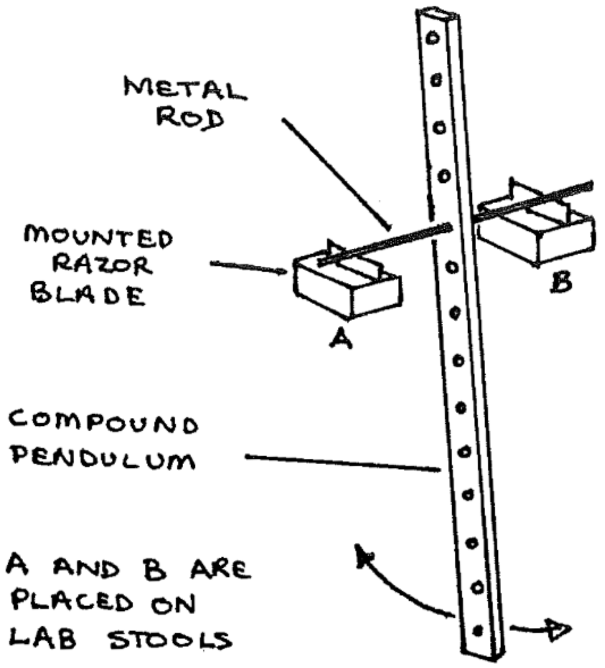
$$g = \frac{4\pi^2 L}{T^2} \quad m/s$$

Where;

L = length of the pendulum bar.

T = time period for 10 oscillations.

Experimental setup



Procedure

1. Gather a stick with evenly spaced holes along its length.
2. Set up a wire to suspend the stick horizontally.
3. Use a scale to measure and record the mass of the stick.
4. Start with the wire in the hole nearest one end of the stick.
5. Release the stick and record the time required for 20 oscillations of small amplitude.
6. Calculate T using the formula: T = (time for 20 oscillations) / 20.
7. Record the distance from each hole to the end of the stick where the wire was initially placed.
8. Repeat this process for each hole along the length of the stick.
9. Plot T^2 on the y-axis and d on the x-axis to create a graph.
10. This graph will display a pair of roughly parabolic curves symmetric about a line parallel to the y-axis.
11. Choose six values of T from the data obtained.
12. Draw lines parallel to the x-axis through these selected values of T on the graph.
13. The lines drawn should intersect each curve twice.
14. Identify the points of intersection between the lines and the curves.
15. Measure the distance along the x-axis from left to right between the first point of intersection with the left-hand curve and the first point of intersection with the curve on the right.
16. Record this value as L.
17. Create a table with columns for d, T, T^2, and L.
18. Tabulate the corresponding values of T, T^2, and L for each distance (d) along the stick.

Table 1

Distance from hole to end (d)	Time for 20 oscillations	Period T (s)	T^2 (s^2)	L (m)	$\frac{L}{T^2}$ (ms^{-2})

Average $\frac{L}{T^2}$ = (ms^{-2})

Calculation

Acceleration due to gravity,

$$g = \frac{4\pi^2 L}{T^2} \quad m/s$$

Result

Using compound pendulum acceleration due to gravity determined as

$g = \quad 9.8 \qquad m/s$