KARPAGAM ACADEMY OF HIGHER EDUCATION

(Deemed to be University)
(Established Under Section 3 of UGC Act 1956)
COIMBATORE-21
(For the candidates admitted from 2016 onwards)

DEPARTMENT OF PHYSICS

SUBJECT: PROPERTIES OF MATTER AND ACOUSTICS PRACTICAL
SEMESTER: I
SUB.CODE:18PHU112 **CLASS: I B.Sc PHYSICS**

ANY SIX EXPERIMENTS

1. To determine the Young's Modulus of the wooden by Optical Lever Method.
2. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
3. To determine the Young's modulus of the bar using pin and microscope – Non-uniform method.
4. To determine the Young's modulus of the bar using cantilever – Non-uniform method.
5. To determine the surface tension of water – capillary rise method
6. To determine the coefficient of viscosity by Stoke's method
7. Verification of laws of transverse vibration and frequency of tuning fork – Sonometer
8. Rigidity modulus – Torison pendulum
9. To determine the Young's modulus of the bar – Koenig's method
10. To determine the coefficient of viscosity of the liquid – Poiseuille's method

SUGGESTED READINGS

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practical, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. Elements of Properties of Matter by D.S. Mathur, S.Chand & Co.

List of Experiments

1. To determine the Young's Modulus of the wooden by Optical Lever Method.
2. To determine the Young’s modulus of the bar using pin and microscope – Non-uniform method.
3. To determine the Young’s modulus of the bar using cantilever – Non-uniform method.
4. To determine the surface tension of water – capillary rise method
5. To determine the coefficient of viscosity by Stoke’s method
6. Rigidity modulus – Torison pendulum

SUGGESTED READINGS

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practical, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. Elements of Properties of Matter by D.S. Mathur, S.Chand & Co.

YOUNG'S MODULUS - NON UNIFORM BENDING
(PIN AND MICROSCOPE METHOD)

Expt No:

Date:

Aim

To find the Young's modulus of the given material bar by non uniform bending using pin and microscope method.

Apparatus

Pin and Microscope arrangement, Scale, Vernier calipers, Screw gauge, Weight hanger, Material bar or rod.

Theory

Young’s modulus is named after Thomas Young, 19th century, British scientist. In solid mechanics, Young’s modulus is defines as the ratio of the longitudinal stress over longitudinal strain, in the range of elasticity the Hook’s law holds (stress is directly proportional to strain). It is a measure of stiffness of elastic material.

If a wire of length L and area of cross-section 'a' be stretched by a force F and if a change (increase) of length 'l' is produced, then

$$Young's\ modulus = \frac{Normal\ stress}{Longitudinal\ strain} = \frac{F/a}{l/L}$$

Non Uniform Bending Using Pin and Microscope

Here the given beam (meter scale) is supoorted symmetrically on two knife edges and loaded at its centre. The maximum depression is produced at its centre. Since the load is applied only one point of the beam, the bending is not uniform through out the beam and the bending of the beam is called non- uniform bending.

In non-uniform bending (central loading), the Young's modulus of the material of the bar is given by

$$Y = \frac{mgl^3}{48Ie} \quad (1)$$

I is the moment of inertia of the bar.

For a rectangular bar,

$$I = \frac{bd^3}{12}$$

Substituting (4) in (3)

In non uniform bending, the young's modulus of the material of the bar is given by,

$$Y = \frac{mgl^3}{4bd^3e} \qquad (2)$$

m - Mass loaded for depression.

g - Acceleration due to gravity.

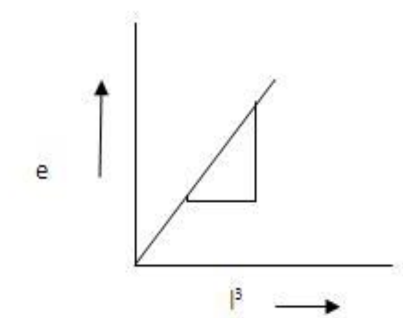
l - Length between knife edges.

b - Breadth of the bar using vernier calipers.

d - Thickness of the bar using screw gauge.

e - Depression of the bar.

Graph between depression and length



From graph $\frac{l^3}{e}$ can be calculated.

Non-Uniform Bending

The given bar is supported symmetrically on two knife edges. The length l of the bar between the knife edges is measured. A weight hanger is suspended exactly at the midpoint of the bar. A pin is fixed vertically at the midpoint of the bar. A pin is fixed vertically at the midpoint of the bar with its pointed end upwards. The microscope is arranged in front of the pin and focused at the tip of the pin. The slotted weights are added one by one on both the weight hangers and removed one by one a number of times, so that the bar is brought into an elastic mood. With the some "dead load" W_0 on each weight hanger, the microscope is adjusted so that the image of the tip of the pin coincides with the point of intersection of cross wires. The reading of the vernier scale and vernier of microscope are taken. Weights are added one by one and corresponding reading are taken. From these readings, the mean depression (e) of the mid-point of the bar for a given mass is determined. From the microscope reading, the mean depression (e) for a given mass is found. The value of $\frac{l^3}{e}$ is calculated and hence calculate the young's modulus of the given material bar.

Observations and Calculations of Non-Uniform Bending

Value of 1 m.s.d = 1/20

Number of divisions on the vernier, n = 50

Least count of microscope = 1 m.s.d/n = 1/1000 = 0.001 cm

No	Distance of the knife edges , l (cm)	Load M(kg)	Telescope reading			depression for load 4m, e (cm)	Mean e (cm)	$\frac{l^3}{e}$ (cm^3)	Mean $\frac{l^3}{e}$ (cm^3)
			Loading (cm)	unloading (cm)	mean (cm)				
1		Wo Wo+m Wo+2m Wo+3m Wo+4m Wo+5m Wo+6m Wo+7m			Xo X1 X2 X3 X4 X5 X6 X7	X4-X0 X5-X1 X6-X2 X7-X3			

Thickness of the material bar "d" = ………………………….. mm.

Breadth of the material bar "b" = ……………………………cm.

Mean value of l^3/e = …………………………..m.

Load applied for depression "e" = ………………………… m.

Young's modulus of the material bar, $Y = \frac{mgl^3}{4bd^3e}$ = …………………………N/m^2.

Result

Young's modulus of the given material using non uniform bending method =.............Nm^{-2}.

VIVA QUESTIONS

1] Define modulus of elasticity.

2] State Hooke's law.

3] Define elastic limit.

4] Define young's modules.

5] Give SI unit of young's modulus.

YOUNG'S MODULUS - NON UNIFORM BENDING
(CANTILEVER METHOD)

Expt No:

Date:

Aim:

To determine Young's modulus of the given beam by cantilever method

Apparatus/Materials:

Meter rule, A half-meter rule, A G-clamp, A retort stand and clamp, Thread, A 50 g slotted mass hanger, Telescope.

Theory:

A cantilever is a beam supported on only one end. The beam carries the load to the support where it is resisted by moment and shear stress. Cantilever construction allows for overhanging structures without external bracing. In most applications, objects are assumed to be rigid for the purpose of simplification. When supposedly rigid materials are subject to great forces, there is a permanent deformation. When subject to a particular stress, or force per unit area, materials will respond with a particular strain, or deformation. If the stress is small enough, the material will return to its original shape after the stress is removed, exhibiting its elasticity. If the stress is greater, the material may being capable of returning to its original shape, causing it to be permanently deformed. At some even greater value of stress, the material will break. There are different types of stress: tension or tensile stress, compression or compressive stress, shear stress, and hydraulic stress. The quantity for all types of stress, however, can be defined as follows:

$$\text{stress} = \text{force/area}$$

where

F -is the force applied and

A-is the cross-sectional area of the material. The standard units of stress are [N/m2]. The quantity strain can be defined as follows:

$$\text{Strain} = \Delta L/L$$

where

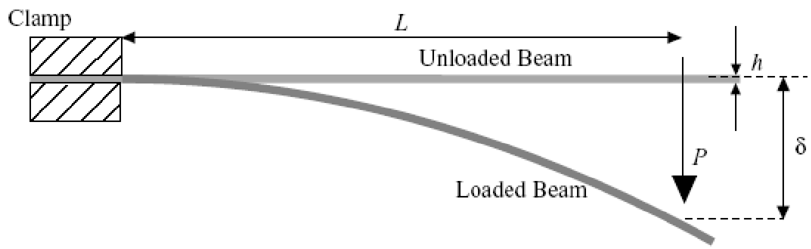
L is the original length of the material, and

ΔL is the change in length that results after the stress is applied. The Young's modulus E of wood of the meter rule is given by

$$E = 4gL^3/bt^3\ (1/s)$$

s = gradient of graph

d against M



Experimental Procedure

1. The average thickness of the meter rule is measured by using a vernier caliper and the reading is recorded
2. By using a micrometer screw gauge, the average width of the meter rule is measured and the reading is recorded.
3. The apparatus is set up as shown in figure 1.
4. A 10 g of slotted mass is hung and the length of the deflection is observed.
5. The reading obtained is tabulated in a table.
6. Step 4 and 5 is repeated by using a slotted mass of 20 g, 30 g, 40 g, 50 g and60 g.
7. A graph of deflection of the end of the ruler, d against mass, M is plotted.
8. The Young's modulus, E of wood of the meter rule is calculated

Observations and Calculations of Non-Uniform Bending

Value of 1 m.s.d = 1/20

Number of divisions on the vernier, n = 50

Least count of microscope = 1 m.s.d/n = 1/1000 = 0.001 cm

No	Distance of the knife edges, l (cm)	Load M(kg)	Telescope reading			depression for load 4m, e (cm)	Mean e (cm)	$\frac{l^3}{e}$ (cm^3)	Mean $\frac{l^3}{e}$ (cm^3)
			Loading (cm)	unloading (cm)	mean (cm)				
1		Wo Wo+m Wo+2m Wo+3m Wo+4m Wo+5m Wo+6m Wo+7m			Xo X1 X2 X3 X4 X5 X6 X7	X4-X0 X5-X1 X6-X2 X7-X3			

Thickness of the material bar "d" = ……………………….. mm.

Breadth of the material bar "b" = ……………………………cm.

Mean value of l^3/e = ………………………….m.

Load applied for depression "e" = ………………………… m.

Young's modulus of the material bar, $E= 4gL^3/bt^3$ (1/s) = … N/m^2.

Result

Young's modulus of the given material using cantilever =.............Nm^{-2}.

VIVA QUESTIONS

1] Define modulus of elasticity.

2] State Hooke's law.

3] Define elastic limit.

4] Define young's modules.

5] Give SI unit of young's modulus.

SURFACE TENSION- CAPILLARY RISE METHOD

Expt No:

Date:

AIM :

To determine the surface tension of water by capillary rise method.

APPARATUS:

Travelling microscope, beaker, capillary tube, pointer, burette stand with clamp and water.

FORMULA:

Surface Tension of **Water** $T = \dfrac{r h g \rho}{2}$ $N\,m^{-1}$

Where,

h $\rightarrow$ Height of water column in the capillary tube.

r $\rightarrow$ Radius of the capillary tube .

$\rho \rightarrow$ Density of the water (1000 kg m^{-3}).

g $\rightarrow$ Acceleration due to gravity (9.8 m s^{-2})

EXPERIMENTAL PROCEDURE:

A capillary tube of uniform cross sectional area is cleaned well. The capillary tube and a pointer are clamped vertically to a stand. A beaker of water is placed below the capillary tube such that the capillary tube is partially immersed in water. The pointer is adjusted so that the lower end just touches the surface of the water in the beaker. Due to surface tension of water rises to a definite height in the capillary tube.

[1] <u>To find the capillary raise (h):-</u>

The microscope is focused on the capillary tube. The horizontal cross wire of the microscope is adjusted to be tangential to lower meniscus of water in the capillary tube and the reading (h_1) in the vertical scale is taken. The beaker of water is removed without disturbing the pointer. The horizontal cross wire is now focused at the tip of the pointer and again the reading (h_2) in the vertical scale is taken. The difference between the two readings gives the capillary raise $h = h_1 \sim h_2$

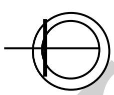
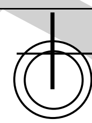
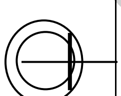
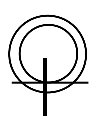
[2] To find the radius (r) of the capillary tube :-

The capillary tube is held horizontally. The horizontal cross wire is made to coincide with the top of the bore of the capillary tube. The reading in the vertical scale is taken. Again the horizontal cross wire is adjusted to be tangential to the bottom of the bore of the capillary tube the reading in the vertical scale is taken. The difference between the two readings gives the diameter,

Similarly using vertical cross wire the reading in the horizontal scale corresponding to left and right edge of the bore of the capillary tube are taken. The difference between the two readings gives the diameter.

Diameter of the capillary tube (d) :-

Least Count = ------------ x 10^{-2} m

Position	Horizontal Cross Section			Position	Vertical Cross Section		
	MSR (cm)	**VSR (div)**	**MSR+ [VSR x LC] x 10^{-2} m**		**MSR (cm)**	**VSR (div)**	**MSR+[VSR xLC] x 10^{-2} m**
			D_1=				D_1=
			D_2=				D_2=

$D_1 \sim D_2 = d_1$ $D_1 \sim D_2 = d_2$

Height of water in capillary tube (h):

Least count of Travelling microscope:

Least Count = $\frac{1 \text{ x Value of 1 MSD}}{n}$

Value of 1MSD = -------------- cm

No. of Vernier scale divisions (n) = -------------- div

Least Count = -------------- x 10^{-2} m

S. No.	Water level in capillary tube			Water level in beaker			Capillary rise
	MSR (cm)	VSR (div)	MSR+ [VSR x LC] h_1 x 10^{-2} m	MSR (cm)	VSR (div)	MSR+[VSRxLC] h_2 x 10^{-2} m	h =h_1-h_2 x 10^{-2} m
1.							
2.							

Mean **(h)** = ---------------- x 10^{-2} m

Difference d_1 = --------------- x 10^{-2} m   Difference d_2 = --------------- x 10^{-2} m

Average diameter of the capillary tube d = $\frac{d_1 + d_2}{2}$ = ---------------- x 10^{-2} m

Average radius of the capillary tube (r) = $\frac{d}{2}$ = ---------------- x 10^{-2} m

CALCULATION:

Radius of capillary tube (r) = ---------------- x 10^{-2} m

Height of water in capillary tube (**h**) = ---------------- x 10^{-2} m

Density of water ρ = 1000 kg m^{-3}

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

Surface tension of Water

$$T = \frac{r h g \rho}{2} \text{ Nm}^{-1}$$

T= ------------ Nm^{-1}

RESULT :

The surface tension of water **T = -------------- Nm^{-1}**

VIVA QUESTIONS :-

1] Define surface tension

2] Define capillary rise

3] What is the least count of Traveling microscope?

4] What is the S.I unit of surface tension?

5] What is the value of surface tension of water?

6] Does surface tension depends on density of liquid?

CO-EFFICIENT OF VISCOSITY - STOKE'S METHOD

Expt No:

Date:

AIM:

To find the coefficient of viscosity of highly viscous liquid (castor oil) using Stoke's method .

APPARATUS:

Tall glass jars, highly viscous liquid castor oil, glass beads, stop watch, screw gauge.

FORMULA:

The coefficient of viscosity of highly viscous liquid

$$\eta = \frac{2 r^2 t (\rho - \sigma) g}{9 h} \quad N s m^{-2}$$

Where,

r → Radius of the spherical glass beads

ρ→ Density of spherical glass beads (2600 kg m^{-3})

σ→ Density of highly viscous liquid (970 kg m^{-3})

g→ Acceleration due to gravity (9.8 ms^{-2})

h→ Distance between A and B

t → Time taken to travel the distance h .

PROCEDURE:

After determining the zero correction and least count of screw gauge the radii of the given spherical glass beads (r) are measured. Castor oil is taken in the glass jar making A and B on the tall glass such that AB = h. The spherical glass beads are gently placed over the surface of the castor oil. The stopwatch is started when the spherical glass beads crossed A. Now the stopwatch is stopped when it crossed B. The time (t) to be taken for h distance. Similarly the time taken by the various spherical glass beads are noted. The readings are tabulated. The last column r^2t, is found to be constant. Because it is the terminal velocity of the spherical glass beads.

The value of r^2t :

Ball	Radius x 10^{-3} m (**r**)	r^2 x 10^{-6} m^2	Time taken to cross AB **t** sec	$\mathbf{r^2 t}$ x 10^{-6} m^2 sec
1.				
2.				
3.				
4.				

Mean = ------ x 10^{-6} m^2 sec

OBSERVATION:

Radii of the spherical glass beads :

Zero error = ------------ x10^{-3}m

LC = -------------- x 10^{-3} m

Zero correction = ------------- x10^{-3}m

Balls	S.No	PSR x 10^{-3} m	HSD division	Observation readings PSR + [HSD x LC] x 10^{-3} m	Correct reading OR $\pm$ ZC x 10^{-3} m	Mean diameter x 10^{-3} m	Mean radius x 10^{-3} m
Ball 1	1.						
	2.						
	3.						
	4.						
Ball 2	1.						
	2.						
	3.						
	4.						
Ball 3	1.						
	2.						
	3.						
	4.						

CALCULATION:

Least count:

Least count [LC] = ---------- x LC x 10^{-3} m

Zero error [ZE] =----------- x LC x 10^{-3} m

Zero correction [ZC] = ---------- x LC x 10^{-3} m

Density of spherical glass beads (ρ) = 2600 kg m^{-3}

Density of high viscous liquid (σ) = 970 kg m $^{-3}$

Distance between **A** and **B** (h) = ---------------- x 10^{-2} m

The mean value $\mathbf{r^2t}$ = ---------------- x 10^{-6} m^2 sec

The coefficient of viscosity of highly viscous liquid

$$\eta = \frac{2 r^2 t (\rho - \sigma) g}{9h} \quad N\,s\,m^{-2}$$

η = --------------- N s m^{-2}

RESULT:

The co-efficient of viscosity of highly viscous liquid (castor oil) **= --------- Nsm^{-2}**

VIVA QUESTIONS:-

1] Define viscosity of liquid.

2] Define co-efficient of viscosity.

3] What is the SI unit dimensional formula for coefficient of viscosity?

4] Give example of low viscous and high viscous liquids.

5] What is terminal velocity?

RIGIDITY MODULUS-TORSION PENDULUM

Expt No:

Date:

Aim:

To determine the moment of inertia and rigidity modulus of the given disc using Torsion pendulum, with identical masses.

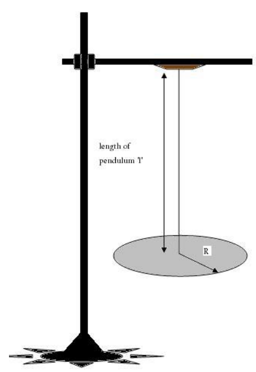
Apparatus:

The given torsion pendulum, two identical cylindrical masses, stop watch, meter scale, etc.

Theory:

A body suspended by a thread or wire which twists first in one direction and then in the reverse direction, in the horizontal plane is called a torsional pendulum. The first torsion pendulum was developed by Robert Leslie in 1793.

A simple schematic representation of a torsion pendulum is given below,



The period of oscillation of torsion pendulum is given as,

$$T = 2\pi\sqrt{\frac{I}{C}} \quad \ldots\ldots\ldots\ldots (1)$$

Where I=moment of inertia of the suspended body; C=couple/unit twist

But we have an expression for couple per unit twist C as,

$$C = \frac{1}{2}\frac{\pi n r^4}{l} \text{..........} [2]$$

Where l =length of the suspension wire; r=radius of the wire; n=rigidity modulus of the suspension wire

PART 1: Determination of Rigidity modulus using Torsion pendulum alone

1. The radius of the suspension wire is measured using a screw gauge.
2. The length of the suspension wire is adjusted to suitable values like 0.3m,0.4m,0.5m,.....0.9m,1m etc.
3. The disc is set in oscillation. Find the time for 20 oscillations twice and determine the mean period of oscillation ' T_0 '.
4. Calculate moment of inertia of the disc using the expression, I = (1/2)MR^2.
5. Determine the rigidity modulus from the given mathematical expression.

PART 2: Determination of moment of inertia using torsion pendulum with identical masses

1. The radius of the suspension wire is measured using a screw gauge.
2. The length of the suspension wire is adjusted to suitable values like 0.3m, 0.4m, 0.5m, ...0.9m, 1m etc.
3. The disc is set in oscillation. Find the time for 20 oscillations twice and determine the mean period of oscillation ' T_0 '.
4. The two identical masses are placed symmetrically on either side of the suspension wire as close as possible to the centre of the disc, and measure d_1 which is the distance between the centers of the disc and one of the identical masses.
5. Find the time for 20 oscillations twice and determine the mean period of oscillation ' T_1 '.
6. The two identical masses are placed symmetrically on either side of the suspension wire as far as possible to the centre of the disc, and measure d_2 which is the distance between the centers of the disc and one of the identical masses.
7. Find the time for 20 oscillations twice and determine the mean period of oscillation ' T_2 '.
8. Find the moment of inertia of the disc using the given formulae.

Observations:

Length of the suspension wire=................m

Radius of the suspension wire=..............m

Mass of each identical masses=.............kg

d_1=...........m

d_2=...........m

Length of the suspension wire l (m)	Time for 20 oscillations (s)			Period of oscillation To	I = $MR^2/2$ (kg/m^2)	η = $(8\pi I)/(r^4T^2)$ (Nm^{-2})
	1	2	Mean			

Length of the suspension l (cm)	Time for 20 oscillations in seconds	Period of oscillation	$T_o^2/(T_2^2-T_1^2)$	$I/(T_2^2-T_1^2)$ (ms^{-2})
Without mass at d0				
With mass at d1				
With mass at d2				

Calculations:

T_0 = ...s

T_1 = ...s

T_2 = ...s

Moment of inertia of the given disc,

$$I_0 = 2m\left(d_2^{\,2} - d_1^{\,2}\right)\frac{T_0^{\,2}}{\left(T_2^{\,2} - T_1^{\,2}\right)} = \ldots\ldots\ldots\ldots kgm^2$$

The rigidity modulus of the suspension wire,

$$n = \frac{16\pi m\left(d_2^{\,2} - d_1^{\,2}\right)}{r^4}\left(\frac{l}{T_2^{\,2} - T_1^{\,2}}\right) = \ldots\ldots\ldots\ldots Nm^{-2}$$

Result

Rigidity modulus of the suspension wire = -------Nm^{-2}

Viva questions

1. What is called rigidity modulus?
2. Define moment of Inertia.
3. What is called time period?