1. MOMENT OF INERTIA OF A SOLID SPHERE OF KNOWN MASS USING VERNIER CALIPER

AIM To determine the moment of inertia of a solid sphere of known mass using Vernier caliper

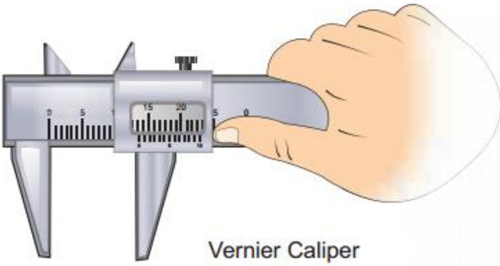
APPARATUS REQUIRED Vernier caliper, Solid sphere

FORMULA Moment of inertia of a solid sphere about its diameter $I_d = \frac{2}{5} MR^2$

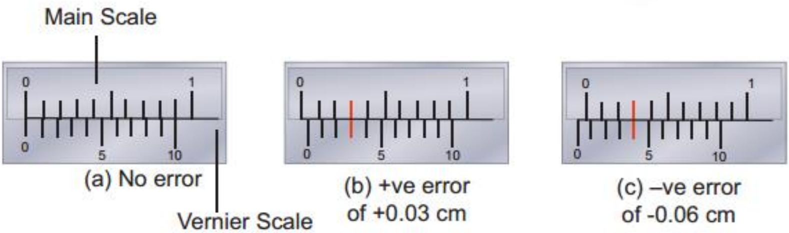
Where $M \rightarrow$ Mass of the sphere (known value to be given) in kg

$R \rightarrow$ Radius of the sphere in metre

DIAGRAM



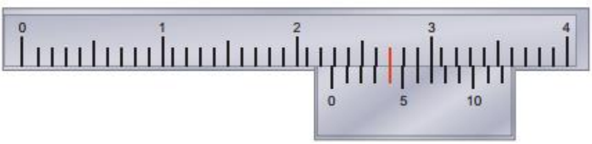
Vernier Caliper



(a) No error

(b) +ve error of +0.03 cm

(c) –ve error of -0.06 cm



(d) Vernier reading

A model reading
MSR = 2.2 cm ; VSC = 4 divisions;
Reading = [2.2 cm+(4x0.01cm)] = 2.24 cm

PROCEDURE

- The Vernier caliper is checked for zero errors and error if found is to be noted
- The sphere is kept in between the jaws of the Vernier caliper and the main scale reading (MSR)is noted.
- Vernier scale division which coincides with some main scale division (VSD) is noted. Zero correction made with this VSD gives Vernier scale reading (VSR).
- Multiply this VSR by Least Count (LC) and add it with MSR. This will be the diameter of the sphere.
- Observations are to be recorded for different positions of the sphere and the average value of the diameter is found. From this value radius of the sphere R is calculated.
- Using the known value of the mass of the sphere M and calculated radius of the sphere R the moment of inertia of the given sphere about its diameter can be calculated using the given formula.

LEAST COUNT (LC)

One main scale division (MSD) = ... cm

Number of Vernier scale divisions = ...

Least Count (LC) = $\frac{\text{1 Main Scale Division (MSD)}}{\text{Total Vernier scale divisions}}$

= .... cm

OBSERVATIONS

Zero error =

Zero correction =

Sl.No.	MSR cm	Vernier coincidence VSD	VSR = (VSD ± ZC)	Diameter of the sphere = 2R = (MSR +VSR x LC) cm
1				
2				
3				
4				
5				
6				

Mean diameter 2R = ... cm

Radius of the sphere R = ... cm

R = ... m

CALCULATION

Mass of the sphere M = ... kg

(Known value is given)

Radius of the sphere R =. . . . . .metre

Moment of inertia of a solid sphere

about its diameter $I_d = \frac{2}{5} MR^2$ = ... kg m^2

RESULT

The moment of inertia of the given solid sphere about its diameter using Vernier caliper I_d = ... kg m^2

2. NON – UNIFORM BENDING – VERIFICATION OF RELATION BETWEEN LOAD AND DEPRESSION USING PIN AND MICROSCOPE

AIM To verify the relation between the load and depression using non-uniform bending of a beam.

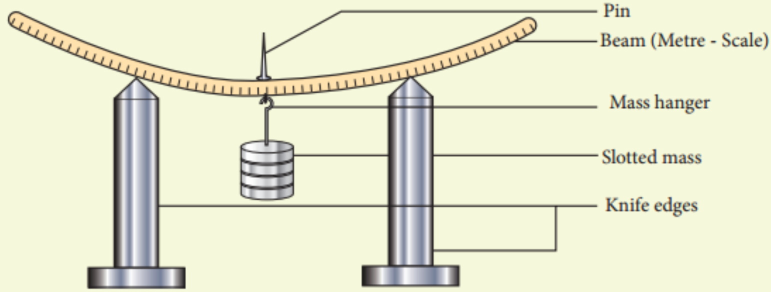
APPARATUS REQUIRED A long uniform beam (usually a metre scale), two knife – edge supports, mass hanger, slotted masses, pin, vernier microscope

FORMULA $\frac{M}{s}$ = a constant

where M $\rightarrow$ Load applied (mass) (kg)

s $\rightarrow$ depression for the applied load(metre)

DIAGRAM



EXPERIMENTAL SETUP OF NON - UNIFORM BENDING PIN AND MICROSCOPE

PROCEDURE

- Place the two knife – edges on the table.
- Place the uniform beam (metre scale) on top of the knife edges.
- Suspend the mass hanger at the centre. A pin is attached at the centre of the scale where the hanger is hung.
- Place a vernier microscope in front of this arrangement
- Adjust the microscope to get a clear view of the pin

- Make the horizontal cross-wire on the microscope to coincide with the tip of the pin. (Here mass hanger is the dead load M).
- Note the vertical scale reading of the vernier microscope
- Add the slotted masses one by one in steps of 0.05 kg (50 g) and take down the readings.
- Then start unloading by removing masses one by one and note the readings.
- Subtract the mean reading of each load from dead load reading. This gives the depressions for the corresponding load M.

OBSERVATIONS

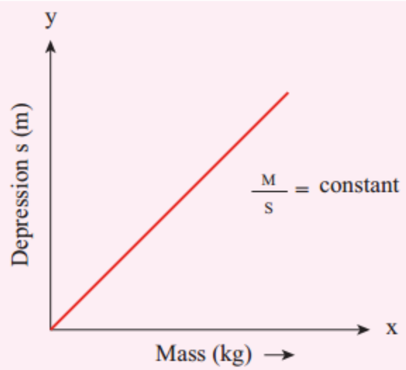
To find M/s

LOAD (kg)	MICROSCOPE READINGS (m)			DEPRESSION FOR M (kg) (s)	M/s kg m^{-1}
	INCREASING LOAD	DECREASING LOAD	MEAN		
M					
M + 0.05					
M + 0.10					
M + 0.15					
M + 0.20					
M + 0.25					
				Mean	

MODEL GRAPH

Load (M) vs Depression (s)

A graph between M and s can be drawn by taking M along X- axis and s along Y – axis. This is a straight line.



Relation between Mass and depression

CALCULATION

(i) $\frac{M}{s} =$

(ii) $\frac{M}{s} =$

(iii) $\frac{M}{s} =$

(iv) $\frac{M}{s} =$

(v) $\frac{M}{s} =$

RESULT

- The ratio between mass and depression for each load is calculated. This is found to be constant.
- Thus the relation between load and depression is verified by the method of non-uniform bending of a beam.

3. SPRING CONSTANT OF A SPRING

AIM To determine the spring constant of a spring by using the method of vertical oscillations

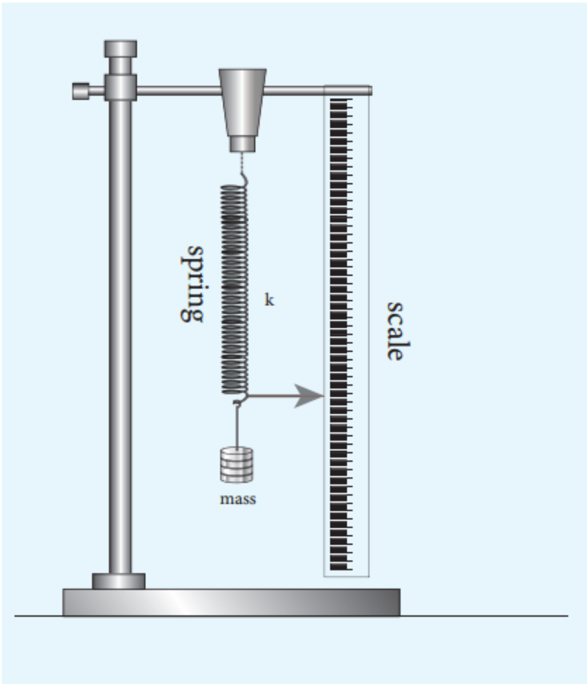
APPARATUS REQUIRED Spring, rigid support, hook, 50 g mass hanger, 50 g slotted masses, stop clock, metre scale, pointer

FORMULA Spring constant of the spring $k = 4\pi^2 \left(\frac{M_2 - M_1}{T_2^2 - T_1^2}\right)$

where $M_1, M_2 \rightarrow$ selected loads in kg

$T_1, T_2 \rightarrow$ time period corresponding to masses M_1 and M_2 respectively in second

DIAGRAM



PROCEDURE

- A spring is firmly suspended vertically from a rigid clamp of a wooden stand at its upper end with a mass hanger attached to its lower end. A pointer fixed at the lower end of the spring moves over a vertical scale fixed.

- A suitable load M (eg; 100 g) is added to the mass hanger and the reading on the scale at which the pointer comes to rest is noted. This is the equilibrium position.
- The mass in the hanger is pulled downward and released so that the spring oscillates vertically on either side of the equilibrium position.
- When the pointer crosses the equilibrium position a stop clock is started and the time taken for 10 vertical oscillations is noted. Then the period of oscillation T is calculated.
- The experiment is repeated by adding masses in steps of 50 g to the mass hanger and period of oscillation at each time is calculated.
- For the masses M_1 and M_2 (with a difference of 50 g), if T_1 and T_2 are the corresponding periods, then the value $M_2 - M_1 / T_2^2 - T_1^2$ is calculated and its average is found.
- Using the given formula the spring constant of the given spring is calculated.

OBSERVATIONS

Sl. No.	Load M (g)	Time taken for 10 oscillations (s)			Period of oscillation T (s)	T^2 (s^2)	$\frac{M_2 - M_1}{T_2^2 - T_1^2}$ $g\ s^{-2}$
		Trial 1	Trial 2	Mean			
1	100						
2	150						
3	200						
4	250						
5	300						

Mean = ... g s^{-2}

= . . . . . kg s^{-2}

CALCULATION

Spring constant of the spring $k = 4\pi^2 \left(\frac{M_2 - M_1}{T_2^2 - T_1^2}\right)$

k = ... kg s^{-2}

RESULT

The spring constant of the given spring k = ... kg s^{-2}

4 ACCELERATION DUE TO GRAVITY USING SIMPLE PENDULUM

AIM To measure the acceleration due to gravity using a simple pendulum

APPARATUS REQUIRED Retort stand, pendulum bob, thread, meter scale, stop watch.

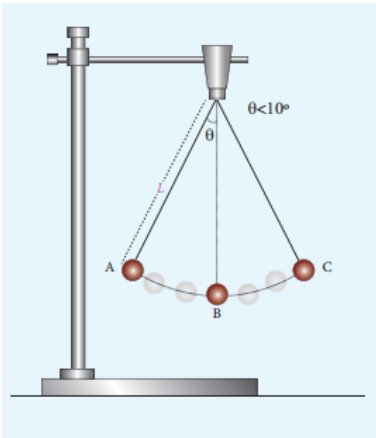
FORMULA Acceleration due to gravity $g = 4\pi^2\left(\frac{L}{T^2}\right)$ (m s^{-2})

where T $\rightarrow$ Time period of simple pendulum (second)

g $\rightarrow$ Acceleration due to gravity (metre sec^{-2})

L $\rightarrow$ Length of the pendulum (metre)

DIAGRAM



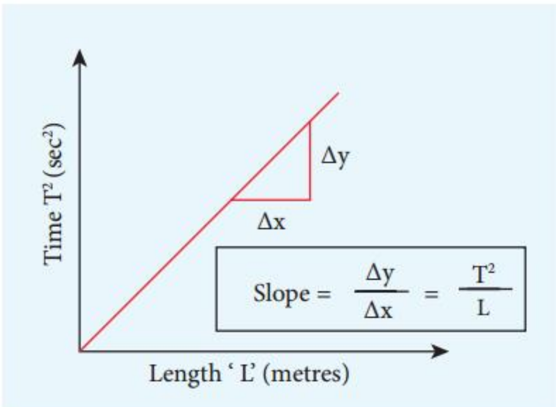
PROCEDURE

- Attach a small brass bob to the thread
- Fix this thread on to the stand
- Measure the length of the pendulum from top to the middle of the bob of the pendulum. Record the length of the pendulum in the table below.
- Note the time (t) for 10 oscillations using stop watch
- The period of oscillation $T = \frac{t}{10}$
- Repeat the experiment for different lengths of the pendulum 'L'. Find acceleration due to gravity g using the given formula.

OBSERVATIONS To find the acceleration due to gravity 'g'

Length of the pendulum L (metre)	Time taken for 10 oscillations t (s)			Period of oscillation $T = \frac{t}{10}$ (s)	T^2 (s^2)	$g = \frac{4\pi^2 L}{T^2}$ $m\,s^{-2}$
	Trial 1	Trial 2	Average			
					Mean g =	

MODEL GRAPH



$slope = \frac{\Delta y}{\Delta x} = \frac{T^2}{L}$; 1/slope = L/$T^2$

RESULT

The acceleration due to gravity 'g' determined using simple pendulum is

i) By calculation = ... m s^{-2}

ii) By graph = ... m s^{-2}

5. VELOCITY OF SOUND IN AIR USING RESONANCE COLUMN

AIM To determine the velocity of sound in air at room temperature using the resonance column.

APPARATUS REQUIRED Resonance tube, three tuning forks of known frequencies, a rubber hammer, one thermometer, plumb line, set squares, water in a beaker.

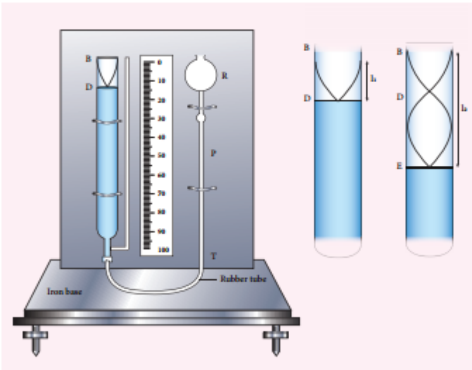
FORMULA $V = 2\nu\,(l_2 - l_1)$ m s^{-1}

where $V \rightarrow$ Speed of sound in air (m s^{-1})

l_1 and $l_2 \rightarrow$ The length of the air column for the first and second resonance respectively (m)

$\nu \rightarrow$ Frequency of the tuning fork (Hz)

DIAGRAM



PROCEDURE

- The inner tube of the resonance column is lowered so that the length of air column inside the tube is very small.
- Take a tuning fork of known frequency and strike it with a rubber hammer. The tuning fork now produces longitudinal waves with a frequency equal to the natural frequency of the tuning fork.
- Place the vibrating tuning fork horizontally above the tube. Sound waves pass down the total tube and reflect back at the water surface.
- Now, raise the tube and the tuning fork until a maximum sound is heard.
- Measure the length of air column at this position. This is taken as the first resonating length, l_1

- Then raise the tube approximately about two times the first resonating length. Excite the tuning fork again and place it on the mouth of the tube.
- Change the height of the tube until the maximum sound is heard.
- Measure the length of air column at this position. This is taken as the second resonating length l_2
- We can now calculate the velocity of sound in air at room temperature by using the relation.

  $V = 2v(l_2 - l_1)$
- Repeat the experiment with forks of different frequency and calculate the velocity.
- The mean of the calculated values will give the velocity of sound in air at room temperature.

OBSERVATIONS

Sl. No.	Frequency of tuning fork v (Hz)	First resonating length $l_1(cm)$			Second resonating length $l_2(cm)$			$l_2 - l_1$ $(\times 10^{-2} m)$	Velocity of sound $V = 2v(l_2 - l_1)$ (m s^{-1})
		Trial 1	Trial 2	Mean	Trial 1	Trial 2	Mean		
1									
2									
3									
								Mean V =	

CALCULATION

Room temperature, t = ____________ ° C

Velocity sound in air at room temperature, $V = 2v(l_2 - l_1)$ = ____________ m s^{-1}

RESULT

Velocity of sound in air at room temperature, (V) = ____________ m s^{-1}

6. VISCOSITY OF A LIQUID BY STOKE'S METHOD

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, metre scale, spherical ball, stop clock, thread.

FORMULA

$$\eta = \frac{2r^2(\delta - \sigma)g}{9V} \ \mathrm{N\,s\,m^{-2}}$$

where η – Coefficient of viscosity of liquid ($\mathrm{N\,s\,m^{-2}}$)

$r \rightarrow$ radius of spherical ball (m)

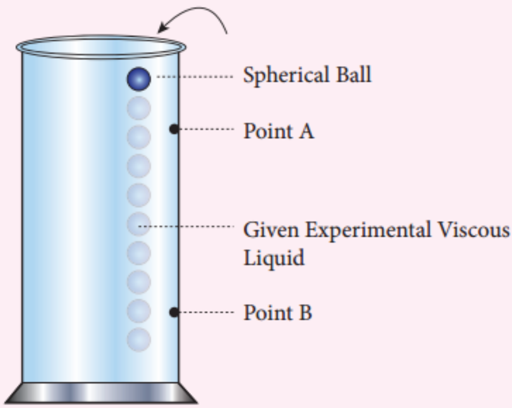
$\delta \rightarrow$ density of the steel sphere ($kg\ m^{-3}$)

$\sigma \rightarrow$ density of the liquid ($\mathrm{kg\ m^{-3}}$)

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

$V \rightarrow$ mean terminal velocity ($\mathrm{m\ s^{-1}}$)

DIAGRAM



EXPERIMENTAL SET UP OF MEASURING VISCOSITY BY STOKE'S METHOD

PROCEDURE

- A long cylindrical glass jar with markings is taken.
- Fill the glass jar with the given experimental liquid.
- Two points A and B are marked on the jar. The mark A is made well below the surface of the liquid so that when the ball reaches A it would have acquired terminal velocity V.
- The radius of the metal spherical ball is determined using screw gauge.
- The spherical ball is dropped gently into the liquid.
- Start the stop clock when the ball crosses the point A. Stop the clock when the ball reaches B.
- Note the distance between A and B and use it to calculate terminal velocity.
- Now repeat the experiment for different distances between A and B. Make sure that the point A is below the terminal stage.

OBSERVATIONS

To find Terminal Velocity:

S.No.	Distance covered by the spherical ball (d) (m)	Time taken (t) (s)	Terminal Velocity (V) d/t ($m\,s^{-1}$)
		MEAN	

CALCULATION

Density of the spherical ball δ = ________ $kg\,m^{-3}$

Density of the given liquid σ = ________ $kg\,m^{-3}$

Coefficient of viscosity of the liquid $\eta = \dfrac{2r^2 g(\delta - \sigma)}{9V}$ = ________ $N\,s\,m^{-2}$

RESULT

The coefficient of viscosity of the given liquid by stoke's method η = ________ $N\,s\,m^{-2}$

7. SURFACE TENSION BY CAPILLARY RISE METHOD

AIM

To determine surface tension of a liquid by capillary rise method.

APPARATUS REQUIRED

A beaker of Water, capillary tube, vernier microscope, two holed rubber stopper, a knitting needle, a short rubber tubing and retort clamp.

FORMULA

The surface tension of the liquid $T = \frac{hr\sigma g}{2} \quad N m^{-1}$

where $T \rightarrow$ Surface tension of the liquid ($N m^{-1}$)

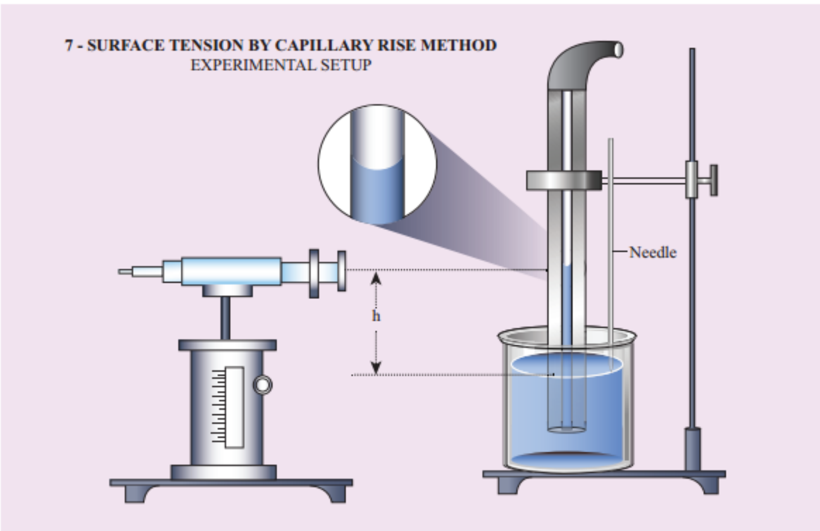
$h \rightarrow$ height of the liquid in the capillary tube (m)

$r \rightarrow$ radius of the capillary tube (m)

$\sigma \rightarrow$ Density of water ($kg\ m^{-3}$) $\quad$ ($\sigma = 1000\ kg\ m^{-3}$)

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

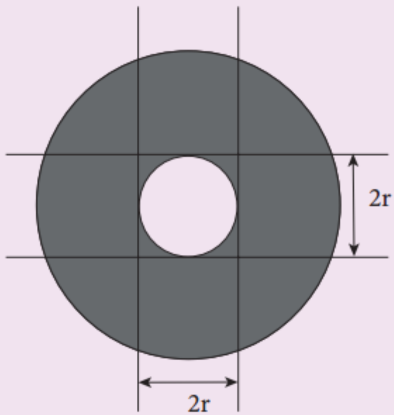
DIAGRAM



PROCEDURE

- A clean and dry capillary tube is taken and fixed in a stand
- A beaker containing water is placed on an adjustable platform and the capillary tube is dipped inside the beaker so that a little amount of water is raised inside.

- Fix a needle near the capillary tube so that the needle touches the water surface
- A Vernier microscope is focused at the water meniscus level and the corresponding reading is taken after making the cross wire coincidence.
- Vernier microscope is focused to the tip of the needle and again reading is taken and noted.
- The difference between the two readings of the vertical scale gives the height (h) of the liquid raised in the tube.
- Now to find the radius of the tube, lower the height of the support base and remove the beaker, carefully rotate the capillary tube so that the immersed lower end face towards you.
- Focus the tube using Vernier microscope to clearly see the inner walls of the tube.
- Let the vertical cross wire coincide with the left side inner walls of the tube. Note down the reading (L_1)
- Turn the microscope screws in horizontal direction to view the right side inner wall of the tube. Note the reading (R_1). Thus the radius of the tube can be calculated as $\frac{1}{2}(L_1 - R_1)$.
- Finally calculate the surface tension using the given formula.



RADIUS OF THE CAPILLARY TUBE

OBSERVATIONS

To measure height of the liquid (h)

Least count of the microscope = ________ $\times 0.001 cm$

Trial No.	Microscope reading for the position of Lower meniscus of liquid			Microscope reading for the position of Lower tip of the needle			Height of the liquid h (cm)
	MSR	VSR	TR (cm)	MSR	VSR	TR (cm)	
						Mean h =	

Radius of the capillary tube

Tube	Microscope reading for the position of inner left wall of the tube L_1			Microscope reading for the position of inner right wall of the tube R_1			Radius of the capillary tube $r = \frac{1}{2}(L_1 - R_1)$ (cm)
	MSR	VSR	TR (cm)	MSR	VSR	TR (cm)	

CALCULATION

Mean rise of the liquid in the capillary tube h = __________ cm

__________ m

Diameter of the capillary tube 2r = __________ cm

Radius of the capillary tube r = __________ m

Density of the liquid $\sigma = 1000 \text{ kg m}^{-3}$

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

Surface tension $$T = \frac{hr\sigma g}{2}$$

= __________ $N\,m^{-1}$

RESULT

Surface tension of the given liquid by capillary rise method T = __________ $N\,m^{-1}$

8. NEWTON'S LAW OF COOLING USING CALORIMETER

AIM

To study the relationship between the temperature of a hot body and time by plotting a cooling curve.

APPARATUS REQUIRED

Copper calorimeter with stirrer, one holed rubber cork, thermometer, stop clock, heater / burner, water, clamp and stand

NEWTON'S LAW OF COOLING

Newton's law of cooling states that the rate of change of the temperature of an object is proportional to the difference between its own temperature and the ambient temperature. (i.e., the temperature of its surroundings)

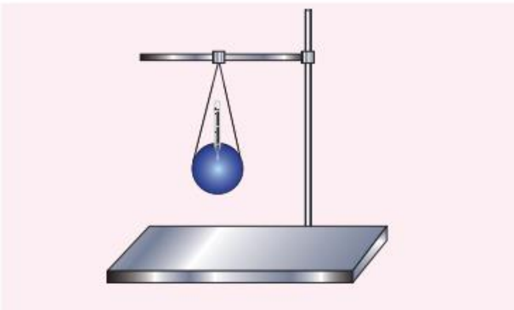
$$\frac{dT}{dt} \propto (T - T_0)$$

where $\frac{dT}{dt} \rightarrow$ Rate of change of temperature (°C)

$T \rightarrow$ Temperature of water (°C)

$T_0 \rightarrow$ Room Temperature (°C)

DIAGRAM



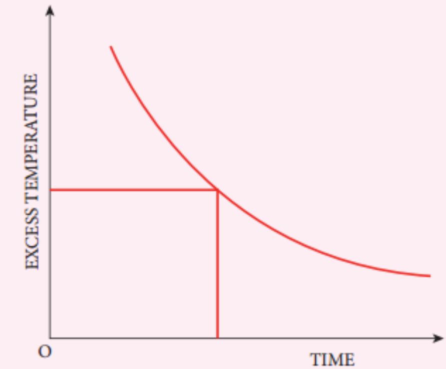
EXPERIMENTAL SETUP OF NEWTON'S LAW OF COOLING

PROCEDURE

- Note the room temperature as (T_0) using the thermometer.
- Hot water about 90°C is poured into the calorimeter.
- Close the calorimeter with one holed rubber cork
- Insert the thermometer into calorimeter through the hole in rubber cork
- Start the stop clock and observe the time for every one degree fall of temperature from 80°C

- Take sufficient amount of reading, say closer to room temperature
- The observations are tabulated
- Draw a graph by taking time along the x axis and excess temperature along y axis.

MODEL GRAPH



RELATION BETWEEN TIME AND TEMPERATURE

ROOM TEMPERATURE (T_0) = _______°C

OBSERVATIONS

Measuring the change in temperature of water with time

Time (s)	Temperature of water (T) °C	Excess temperature ($T - T_0$) °C

RESULT

The cooling curve is plotted and thus Newton's law of cooling is verified.

9. STUDY OF RELATION BETWEEN FREQUENCY AND LENGTH OF A GIVEN WIRE UNDER CONSTANT TENSION USING SONOMETER

AIM

To study the relation between frequency and length of a given wire under constant tension using a sonometer.

APPARATUS REQUIRED

Sonometer, six tuning forks of known frequencies, Metre scale, rubber pad, paper rider, hanger with half – kilogram masses, wooden bridges

FORMULA

The frequency n of the fundamental mode of vibration of a string

is given by $n = \frac{1}{2l}\sqrt{\frac{T}{m}}\ Hz$

a) For a given m and fixed T.

$n \propto \frac{1}{l}$ (or) $nl =$ constant

where $n \rightarrow$ Frequency of the fundamental mode of vibration of the string (Hz)

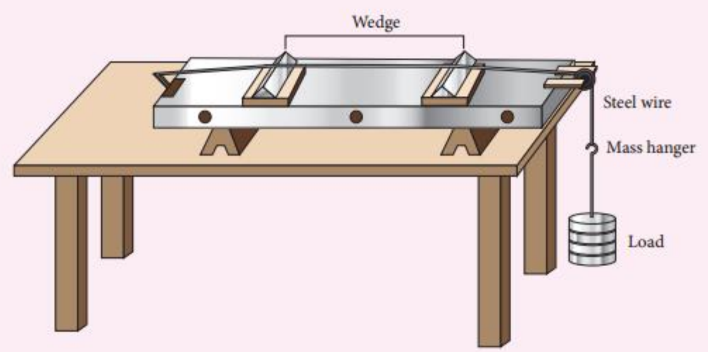
$m \rightarrow$ Mass per unit length of the string ($kg\ m^{-1}$)

$l \rightarrow$ Length of the string between the wedges (m)

$T \rightarrow$ Tension in the string (including the mass of the hanger) = Mg (N)

$M \rightarrow$ Mass suspended, including the mass of the hanger (Kg)

DIAGRAM



SONOMETER - STUDY OF RELATION BETWEEN FREQUENCY AND LENGTH OF A GIVEN WIRE UNDER CONSTANT TENSION USING SONOMETER

PROCEDURE

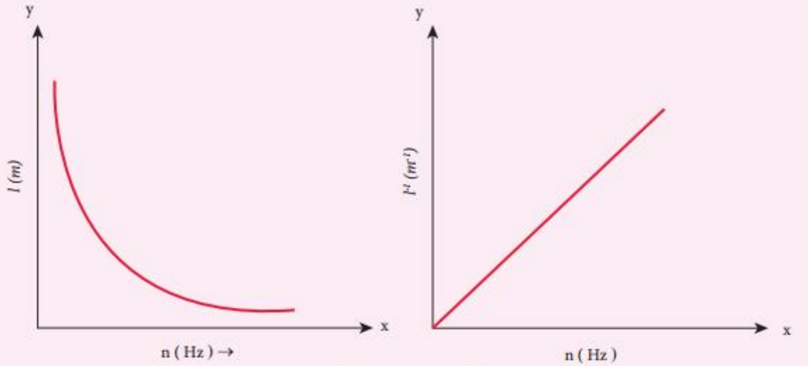
- Set up the sonometer on the table and clean the groove on the pulley to ensure minimum friction
- Stretch the wire by placing suitable mass in the hanger
- Set the tuning fork into vibrations by striking it against the rubber pad. Plug the sonometer wire and compare the two sounds.
- Adjust the vibrating length of the wire by sliding the bridge B till the sounds appear alike.
- For the final adjustment, place a small paper rider R in the middle of the wire AB.
- Sound the tuning fork and place its shank stem on the bridge A or on the sonometer box and slowly adjust the position of bridge B until the paper rider is agitated violently indicating resonance.
- The length of the wire between the wedges A and B is measured using meter scale. It is the resonant length. Now the frequency of vibration of the fundamental mode equals the frequency of the tuning fork.
- Repeat the above procedure for other tuning forks by keeping the same load in the hanger.

OBSERVATIONS

Tension (constant) on the wire (mass suspended from the hanger including its own mass)
T = ________ N

Variation of frequency with length		
Frequency of the tuning fork 'n ' (Hz)	Resonant length 'l'	nl
n_1 =		
n_2 =		
n_3 =		
n_4 =		
n_5 =		
n_6 =		

GRAPH:



Graph 1: Relation between frequency and length

Graph 2: Relation between frequency and inverse of length

Sonometer - study of relation between length of the given wire and tension for a consant frequency

CALCULATION

The product nl for all the tuning forks remain constant (last column in the table)

RESULT

- For a given tension, the resonant length of a given stretched string varies as reciprocal of the frequency (i.e., $n \propto \frac{1}{l}$)
- The product nl is a constant and found to be ______ (Hz m)

10. STUDY OF RELATION BETWEEN LENGTH OF THE GIVEN WIRE AND TENSION FOR A CONSTANT FREQUENCY USING SONOMETER

AIM

To study the relationship between the length of a given wire and tension for constant frequency using a sonometer

APPARATUS REQUIRED

Sonometer, tuning fork of known frequency, meter scale, rubber pad, paper rider, hanger with half – kilogram masses, wooden bridges.

FORMULA

The frequency of the fundamental mode of vibration of a string is given by,

$$n = \frac{1}{2l}\sqrt{\frac{T}{m}}$$

If n is a constant, for a given wire (m is constant)

$$\frac{\sqrt{T}}{l}$$ is constant.

where n → Frequency of the fundamental mode of vibration of a string (Hz)

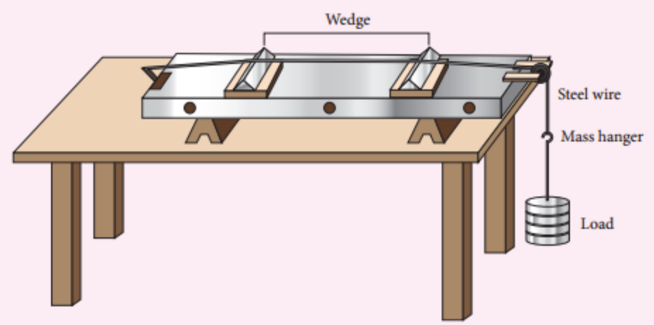
m → Mass per unit length of string ($kg\ m^{-1}$)

T → Tension in the string (including the weight of the hanger) = Mg (N)

l → Length of the string between the wedges (metre)

M → Mass suspended, including the mass of the hanger (kg)

DIAGRAM

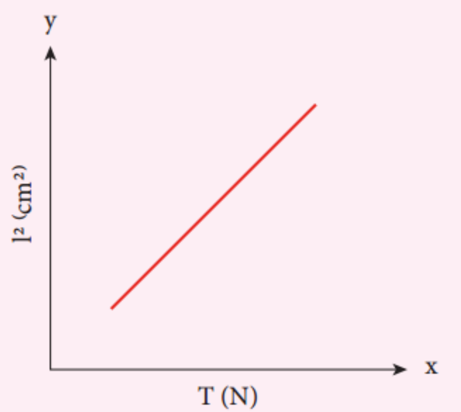


STUDY OF RELATION BETWEEN LENGTH OF THE GIVEN WIRE AND TENSION FOR A CONSTANT FREQUENCY USING SONOMETER

PROCEDURE

- Set up the sonometer on the table and clean the groove on the pulley to ensure that it has minimum friction.
- Set a tuning fork of known frequency into vibration by striking it against the rubber pad. Plug the sonometer wire and compare the sound due to the vibration of tuning fork and the plugged wire.
- Adjust the vibrating length of the wire by the adjusting the bridge B till the two sounds appear alike.
- Place a mass of 1 kg for initial reading in the load hanger.
- For final adjustment place a small paper rider R in the middle of the wire AB.
- Now, strike the tuning fork and place its shank stem on the bridge A and then slowly adjust the position of the bridge B till the paper rider is agitated violently (might eventually falls) indicating resonance.
- Measure the length of the wire between wedges at A and B which is the fundamental mode corresponding to the frequency of the tuning fork.
- Increase the load on the hanger in steps of 0.5 kg and each time find the resonating length as done before with the same tuning fork.
- Record the observations in the tabular column.

MODEL GRAPH



Relation between tension T (N) and length l^2 (cm^2)

OBSERVATIONS

Frequency of the tuning fork = ________ Hz

Variation of resonant length with tension

Sl.No.	Mass M (kg)	Tension T=Mg (N)	$\sqrt{T}$	Vibrating length l (m)	$\frac{\sqrt{T}}{l}$

CALCULATION

Calculate the value $\frac{\sqrt{T}}{l}$ for the tension applied in each case.

RESULT

- The resonating length varies as square root of tension for a given frequency of vibration of a stretched string.
- $\frac{\sqrt{T}}{l}$ is found to be a constant.