पुणा International School

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Class–XI **Subject:Physics** **Experiment(2026-27)**

Physics practical (2026-27)	
Sr.No	**Aim**
1	To measure diameter of a small spherical cylindrical body using Vernier Callipers
2	To measure internal diameter and depth of a given beaker/calorimeter using Vernier Callipers and hence find its volume
3	To measure diameter of a given wire using screw gauge
4	To determine radius of curvature of a given spherical surface by a spherometer
5	To find the force constant of a helical spring by plotting a graph between load and extension.
6	To find the weight of a given body using parallelogram law of vectors.
7	Using a simple pendulum, plot its L-T^2 graph and use it to find the effective length of second's pendulum.
8	To study the relation between frequency and length of a given wire under constant tension using sonometer.
Activiy	
1	To make a paper scale of given least count, e.g., 0.2cm, 0.5 cm.
2	To determine mass of a given body using a metre scale by principle of moments
3	To plot a graph for a given set of data, with proper choice of scales and error bars.
4	To observe change of state and plot a cooling curve for molten wax
5	To study the factors affecting the rate of loss of heat of a liquid
6	To observe and explain the effect of heating on a bi-metallic strip.

Experiment – 1

Aim

To measure diameter of a small spherical cylindrical body using Vernier Callipers.

Apparatus

Vernier callipers, a spherical body (pendulum bob) or a cylinder and a magnifying lens.

Theory

If with the body between the jaws, the zero of vernier scale lies ahead of Nth. division of main scale, then main scale reading (M.S.R.) = N.
If nth division of vernier scale coincides with any division of main scale, then vernier scale reading (V.S.R.)
= n x (L.C.) (L.C. is least count of vernier callipers)
= n x (V.C.) (V.C. is vernier constant of vernier callipers)
Total reading, T.R. = M.S.R. + V.S.R. (L.C. = V.C.)
= N + n x (V.C.).

Diagram

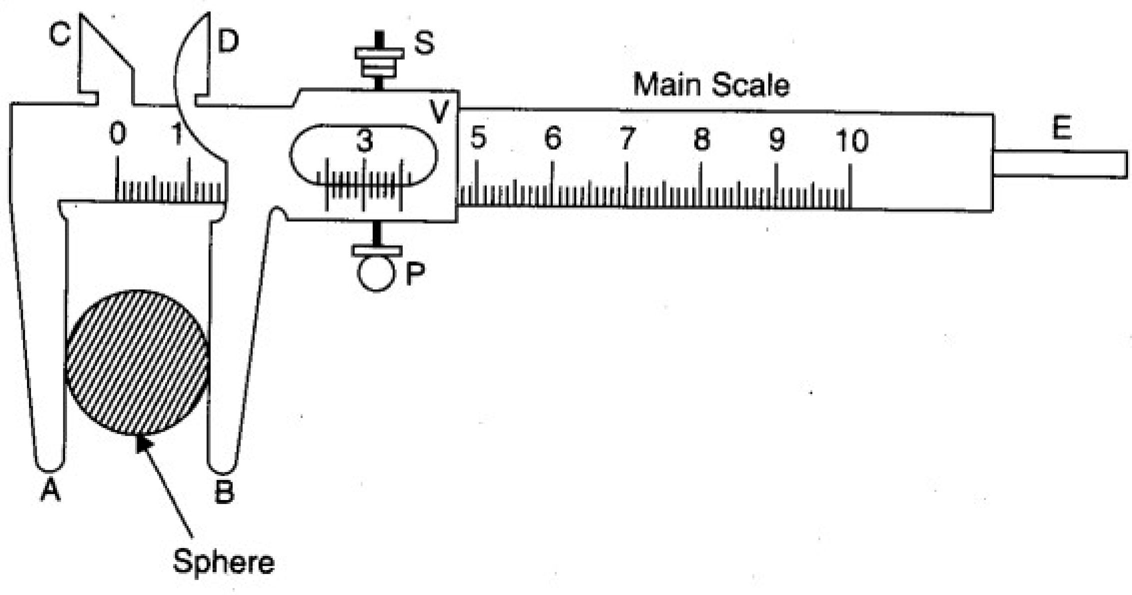


Fig. Vernier callipers—Measuring diameter of a sphere.

Procedure

1. Determine the vernier constant (V.C.) i.e. least count (L.C.) of the vernier callipers and record it step wise.

2. Bring the movable jaw BD in close contact with the fixed jaw AC and find the zero error. Do it three times and record them. If there is no zero error, record zero error nil.
3. Open the jaws, place the sphere or cylinder between the two jaws A and B and adjust the jaw DB, such that it gently grips the body without any undue pressure on it. Tight the screw S attached to the vernier scale V.
4. Note the position of the zero mark of the vernier scale on the main scale. Record the main scale reading just before the zero mark of the vernier scale. This reading (1ST) is called main scale reading (M.S.R.).
5. Note the number (n) of the vernier scale division which coincides with some division of the main scale.
6. Repeat steps 4 and 5 after rotating the body by 90° for measuring the diameter in a perpendicular direction.
7. Repeat steps 3, 4, 5 and 6 for three different positions. Record the observations in each set in a tabular form.
8. Find total reading and apply zero correction.
9. Take mean of different values of diameter and show that in the result with proper unit.

Observations

1. Determination of Vernier Constant (Least Count) of the Vernier Callipers
   1 M.S.D. = 1mm
   10VS.D.=9M.S.D.
   .-. 1 V.S.D. = 9/10 M.S.D. = 0.9 mm.

   Vernier Constant, V.C. = 1 M.S.D. – 1 V.S.D. = (1 – 0.9) mm = 0.1 mm = 0.01 cm.

Observations Table

Sr. No	(Main Scale Reading) M.S	Vernier Scale reading (V.S), (V.S. X LC)	Total Reading (M.S + V.S)in cm
1			
2			
3			

Calculation

Result

The diameter of the given sphere/cylinder is   cm.

Precautions

1. Motion of vernier scale on main scale should be made smooth (by oiling if necessary).
2. Vernier constant and zero error should be carefully found and properly recorded.
3. The body should be gripped between the jaws firmly but gently (without undue pres-sure on it from the jaws).
4. Observations should be taken at right angles at one place and taken at least as three different places.

Sources of Error

1. The vernier scale may be loose on main scale.
2. The jaws may not be at right angles to the main scale.
3. The graduations on scale may not be correct and clear.
4. Parallax may be there in taking observations.

Experiment – 2

Aim
To measure internal diameter and depth of a given beaker/calorimeter using Vernier Callipers and hence find its volume.

Apparatus
Vernier callipers, a beaker or a calorimeter, magnifying glass.

Theory
(i) For measuring internal diameter and depth. Same as in Experiment 1A.
(ii) For volume:

or $$V = \pi\left(\frac{D}{2}\right)^2 . d$$

where, D = internal diameter of beaker/calorimeter
d = depth of beaker/calorimeter.

Volume of beaker or calorimeter = internal area of cross section x depth

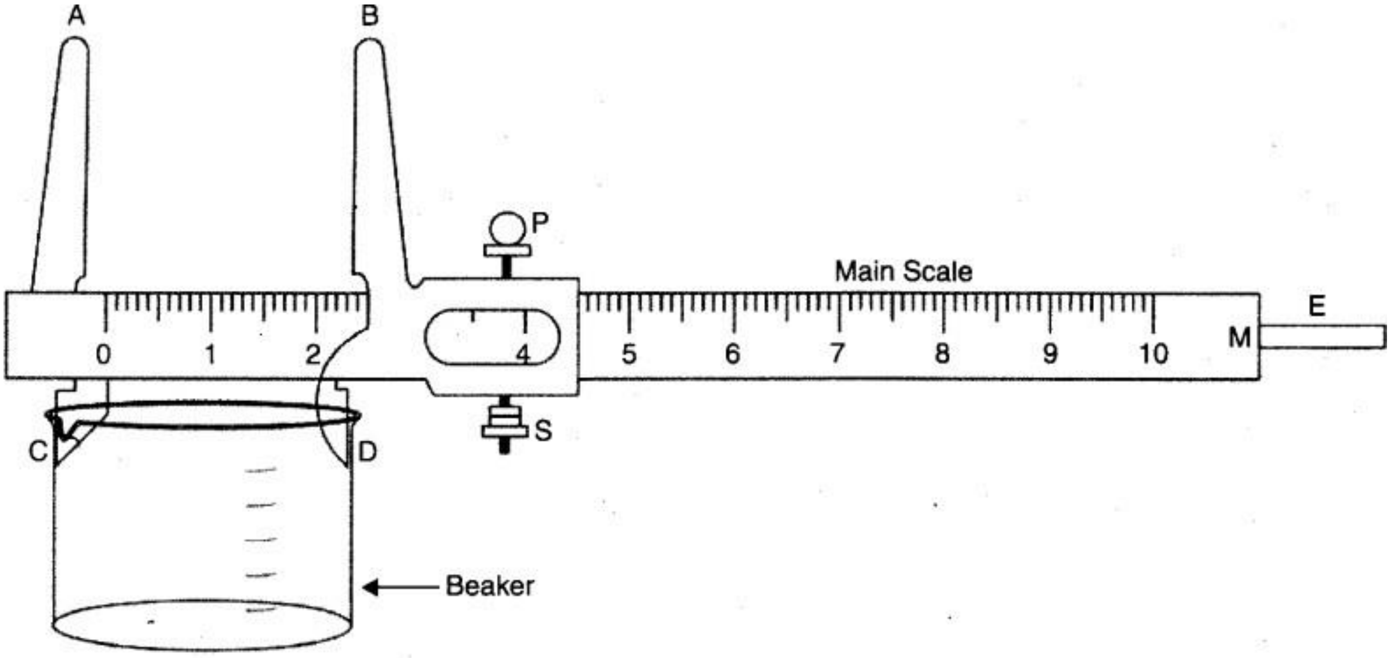
Diagram


Fig. (*a*) Internal diameter of beaker.

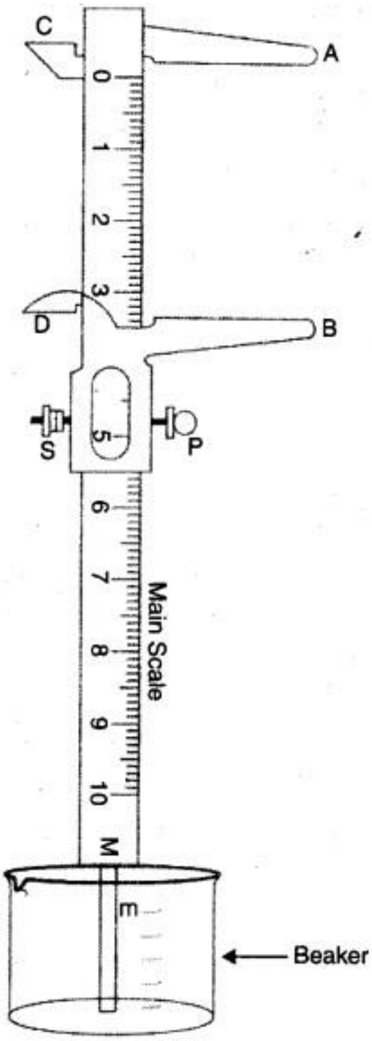


Fig. (*b*) Depth of beaker.

Procedure

1. Determine the vernier constant (V.C.) i.e., least count of the vernier callipers and record it stepwise.
2. Bring the movable jaw BD in close contact with the fixed jaw AC and find the zero error. Do it three times and record it. If there is no zero error, then record, zero error nil.
   Measurement of internal diameter
3. Put the jaws C and D inside the beaker or calorimeter and open them till each of them touches the inner wall of the beaker or calorimeter, , without any undue pressure on the walls. Tight the screw attached to the vernier scale gently.
4. Note the-position of the zero mark of the vernier scale on the main scale. Record the main scale reading just before the zero mark of the vernier scale. This reading (IV) is called main scale reading (M.S.R.).

5. Note the number (n) of the vernier scale division which coincides with some division of the main scale.
6. Repeat steps 4 and 5 after rotating the vernier callipers by 90° for measuring internal diameter in a perpendicular direction.
7. Find total reading and apply zero correction.
   Measurement of depth
8. Keep the edge of the main scale of vernier callipers on its peripheral edge. This should be done in such a way that the tip of the strip is able to go freely inside the beaker along its depth.
9. Keep sliding the moving jaw of the vernier callipers until the strip just touches the bottom of the beaker. Take care that it is just perpendicular to the bottom surface. Now tighten the screw of the vernier callipers.
10. Repeat steps 4 and 5 for four different positions along the circumference of the upper edge of the beaker or calorimeter.
11. Find total reading and apply zero correction.
12. Take mean of two different values of internal diameter and four different values of the depth.
13. Calculate the volume by using proper formula and show that in the result with proper unit.

Observations

1. Determination of Vernier Constant (Least Count) of the vernier callipers
   1 M.S.D. = 1 mm 10 V.S.D. = 9 M.S.D.
   ∴ 1 V.S.D. = 9/10 M.S.D. = 0.9 mm

   Vernier constant, V.C. = 1 M.S.D. – 1 V.S.D. = (1 – 0.9) mm

   = 0.1 mm = 0.01 cm.

Observations Table

Table for the Internal Diameter (D)

Sr. No	(Main Scale Reading) M.S	Vernier Scale reading (V.S), (V.S. X LC)	Total Reading (M.S + V.S)in cm
1			
2			
3			

Table for the depth (d)

Sr. No	(Main Scale Reading) M.S	Vernier Scale reading (V.S), (V.S. X LC)	Total Reading (M.S + V.S)in cm
1			
2			
3			

Calculations

Mean corrected internal diameter,

$$D = \frac{D_1(a) + D_1(b)}{2} = \ldots\ldots \text{ cm}$$

Mean corrected depth,

$$d = \frac{d_1 + d_2 + d_3 + d_4}{4} = \ldots\ldots \text{ cm}$$

Volume of beaker/calorimeter $= \pi \left(\frac{D}{2}\right)^2 d = \ldots\ldots \text{ cm}^3$

Result

The volume of the beaker/calorimeter is cm^3.

Precautions

1. Motion of vernier scale on main scale should be made smooth (by oiling if necessary).
2. Vernier constant and zero error should be carefully found and properly recorded.
3. The body should be gripped between the jaws firmly but gently (without undue pres-sure on it from the jaws).
4. Observations should be taken at right angles at one place and taken at least as three different places.

Sources of Error

1. The vernier scale may be loose on main scale.
2. The jaws may not be at right angles to the main scale.
3. The graduations on scale may not be correct and clear.

4. Parallax may be there in taking observations.

Experiment – 3

Aim

To measure diameter of a given wire using screw gauge.

Apparatus

Screw gauge, wire, half-metre scale and magnifying lens.

Theory

1. If with the wire between plane faces A and B, the edge of the cap lies ahead of Mb division of linear scale.
Then, linear scale reading (L.S.R.) = N.

If nth division of circular scale lies over reference line.

Then, circular scale reading (C.S.R.) = n x (L.C.) (L.C. is least count of screw gauge) Total reading (T.R.) = L.S.R. + C.S.R. = N+n x (L.C.).
2. If D be the mean diameter and l be the mean length of the wire,Volume of the wire,

$$V=\pi\left(\frac{D}{2}\right)^2 l.$$

Diagram

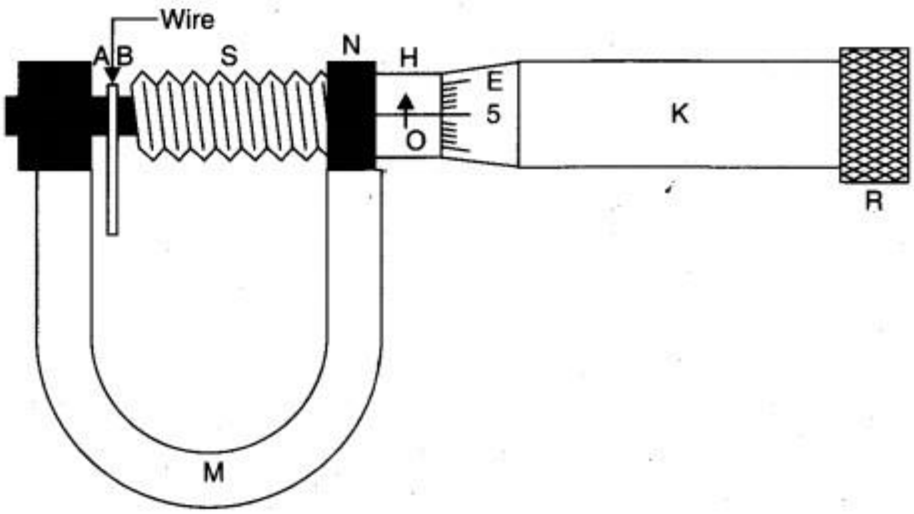


Fig. Screw gauge measuring diameter of the wire.

Procedure

1.Find the value of one linear scale division (L.S.D.).
2.Determine the pitch and the least count of the screw gauge and record it step wise. 3.Bring the plane face B in contact with plane face A and find the zero error. Do it
three times and record them. If there is no zero error, then record zero error nil.

4. Move the face B away from face A. Place the wire lengthwise over face A and move the face B towards face A using the ratchet head R. Stop when R turns (slips) without moving the screw.
5. Note the number of divisions of the linear scale visible and uncovered by the edge of the cap. The reading (IV) is called linear scale reading (L.S.R.).
6. Note the number (n) of the division of the circular scale lying over reference line. 7.Repeat steps 5 and 6 after rotating the wire by 90° for measuring diameter in a
perpendicular direction.
8. Repeat steps 4, 5, 6 and 7 for five different positions separated equally throughout the length of the wire. Record the observations in each set in a tabular form.
9. Find total reading and apply zero correction in each case.
10. Take mean of different values of diameter.
11. Measure the length of the wire by stretching it along a half-metre scale. Keeping one end of wire at a known mark, note the position of other end. Difference in position of the two ends of the wire gives the length of the wire. Do it three times and record them.

Observations

1. Determination of Least Count of the Screw Gauge . 1 L.S.D. = 1 mm
   Number of full rotations given to screw = 4
   Distance moved by the screw = 4 mm
   Hence, pitch p = 4 mm/4 = 1 mm
   Number of divisions on circular scale = 100
   Hence, least count, =1 mm/100 = 0.01 mm = 0.001 cm.

Observations Table

Calculations

Length of the wire, l = (*i*) ...... cm, (*ii*) ...... cm, (*iii*) ...... cm.

Mean diameter of the wire,

$$D = \frac{D_1(a) + D_1(b) + \ldots\ldots + D_3(a) + D_3(b)}{6} = \ldots\ldots \text{ mm} = \ldots\ldots \text{ cm}$$

Mean length of the wire,

$$l = \frac{l_1 + l_2 + l_3}{3} = \ldots\ldots \text{ cm}$$

Volume of the wire,

$$V = \pi\left(\frac{D}{2}\right)^2 l = \ldots\ldots \text{ cm}^3.$$

Result

The volume of the given wire is… cm^3.

Precautions

1. To avoid undue pressure; the screw should always be rotated by ratchet R and not by cap K.
2. The screw should move freely without friction.
3. The zero correction, with proper sign should be noted very carefully and added algebraically.
4. For same set of observations, the screw should be moved in the same direction to avoid back-lash error of the screw.
5. At each place, the diameter of the wire should be measured in two perpendicular directions and then the mean of the two be taken.
6. Readings should be taken at least for five different places equally spaced along the whole length of the wire.
7. Error due to parallax should be avoided.

Sources of error

1. The screw may have friction.
2. The screw gauge may have back-lash error.
3. Circular scale divisions may not be of equal size.
4. The wire may not be uniform.

Experiment – 4

Aim

To determine radius of curvature of a given spherical surface by a spherometer.

Apparatus

Spherometer, convex surface (it may be unpolished convex mirror), a big size plane glass slab or plane mirror.

Diagram

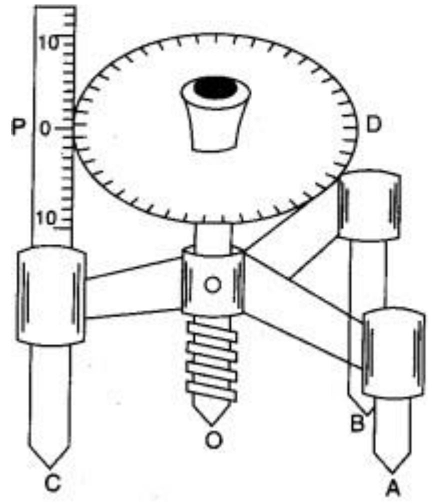


Fig. 2.14. Spherometer.

Theory

It works on the principle of micrometre screw (Section 2.09) It is used to measure either very small thickness or the radius of curvature of a spherical surface that is why it is called a spherometer.

Procedure

1. Raise the central screw of the spherometer and press the spherometer gently on the practical note-book so as to get pricks of the three legs. Mark these pricks as A, B and C.
2. Measure the distance between the pricks (points) by joining the points as to form a triangle ABC.
3. Note these distances (AB, BC, AC) on notebook and take their mean.
4. Find the value of one vertical {pitch) scale division.
5. Determine the pitch and the least count of the spherometer [Art. 2.13(c)] and record it step wise.
6. Raise the screw sufficiently upwards.
7. Place the spherometer on the convex surface so that its three legs rest on it.

8. Gently, turn the screw downwards till the screw tip just touches the convex surface. (The tip of the screw will just touch its image in the convex glass surface).
9. Note the reading of the circular (disc) scale which is in line with the vertical (pitch) scale. Let it be a (It will act as reference).
10. Remove the spherometer from over the convex surface and place over a large size plane glass slab.
11. Turn the screw downwards and count the number of complete rotations (n_1) made by the disc (one rotation becomes complete when the reference reading crosses past the pitch scale).
12. Continue till the tip of the screw just touches the plane surface of the glass slab.
13. Note the reading of the circular scale which is finally in line with the vertical (pitch) scale. Let it be b.
14. Find the number of circular (disc) scale division in last incomplete rotation.
15. Repeat steps 6 to 14, three times. Record the observation in tabular form.

Observations

1. Distance between two legs of the spherometer

In ΔABC marked by legs of the spherometer

AB = ... cm

BC = ... cm

AC = ... cm

Mean value of $l = \frac{AB + BC + CA}{3}$ = ... cm

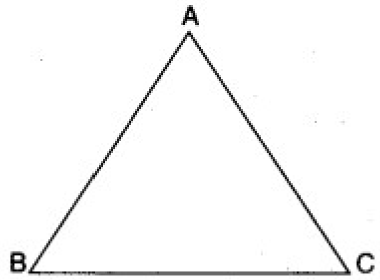


Fig. Distance between the two legs of the spherometer.

2. Least count of spherometer

1 Pitch scale division = 1 mm

Number of full rotations given to screw = 5

Distance moved by the screw = 5 mm

Hence, pitch, $p = \frac{5\text{ mm}}{5} = 1\text{ mm}$

Number of divisions on circular (disc) scale = 100

Hence, least count $= \frac{1\text{ mm}}{100}$

$= 0.01$ mm

$= 0.001$ cm.

Observations Table

Calculations

1. Find value of h in each observation and record it in column 5.
2. Find mean of value of h recorded in column 5

$$\text{Mean value of } h = \frac{h_1 + h_2 + h_3}{3} \text{ mm}$$

$$= \text{......} \text{ mm} = \text{.....} \text{ cm.}$$

3. Calculate

$$R = \frac{l^2}{6h} + \frac{h}{2} \text{ cm}$$

$$= \text{......} \text{ cm.}$$

Result

The radius of curvature of the given convex surface is cm.

Precautions

1. The screw should move freely without friction.
2. The screw should be moved in same direction to avoid back-lash error of the screw.
3. Excess rotation should be avoided.

Sources of error

1. The screw may have friction.
2. The spherometer may have back-lash error.
3. Circular (disc) scale divisions may not be of equal size.

EXPERIMENT - 5

Aim
To find the force constant of a helical spring by plotting a graph between load and extension.

Apparatus
Spring, a rigid support, a 50 g or 20 g hanger, six 50 g or 20 g slotted weights, a vertical wooden scale, a fine pointer, a hook.

Theory
When a load F suspended from lower free end of a spring hanging from a rigid support, increases its length by amount l,

then $$F \propto l$$

or $$F = Kl,$$

where K is constant of proportionality.

It is called the force constant or the spring constant of the spring,
From above if l = 1, F = K.
Hence, force constant (or spring constant) of a spring may be defined as the force required to produce unit extension in the spring.

Diagram

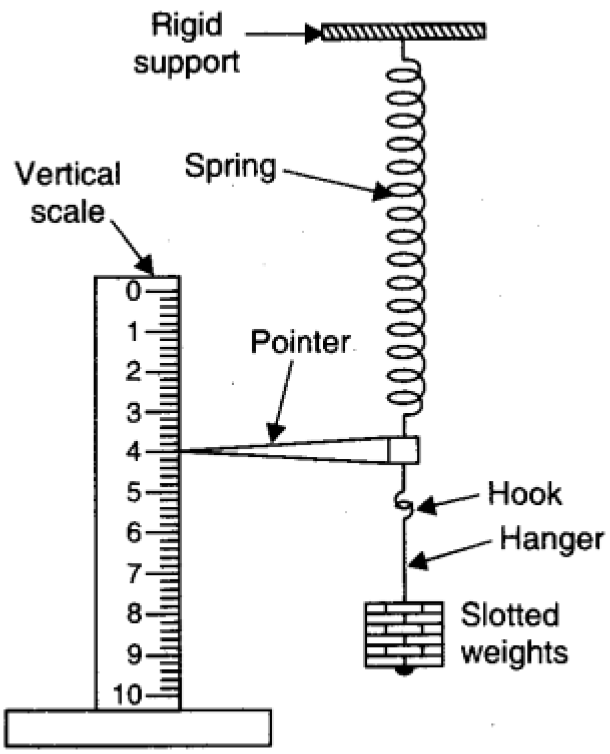


Fig. Extension of spring.

Procedure

1. Suspend the spring from a rigid support. Attach a pointer and a hook from its lower free end.
2. Hang a 50 g hanger from the hook.
3. Set the vertical wooden scale such that the tip of the pointer comes over the divisions on the scale but does not touch the scale.
4. Note the reading of the position of the tip of the pointer on the scale. Record it in loading column against zero load.
5. Gently add suitable load of 50 g or 20 g slotted weight to the hanger. The pointer tip moves down.
6. Wait for few minutes till the pointer tip comes to rest. Repeat step 4.
7. Repeat steps 5 and 6 till six slotted weights have been added.
8. Now remove one slotted weight. The pointer tip moves up. Repeat step 6. Record the reading in unloading column.
9. Repeat step 8 till only hanger is left.
10. Record your observations as given below.

Observations

Least count of vertical scale = 0.1 cm.

Table for load and extension

Serial No. of Obs.	Load on hanger (W) = Applied force (F) (g wt)	Reading of position of pointer tip			Extension l (cm)
		Loading x (cm)	Unloading y (cm)	Mean $z = \frac{x+y}{2}$ (cm)	
1.	0				
2.	50				
3.	100				
4.	150				
5.	200				
6.	250				
7.	300				

Graph

Plot a graph between F and l taking F along X-axis and l along Y-axis. The graph comes to be a straight line as shown below.

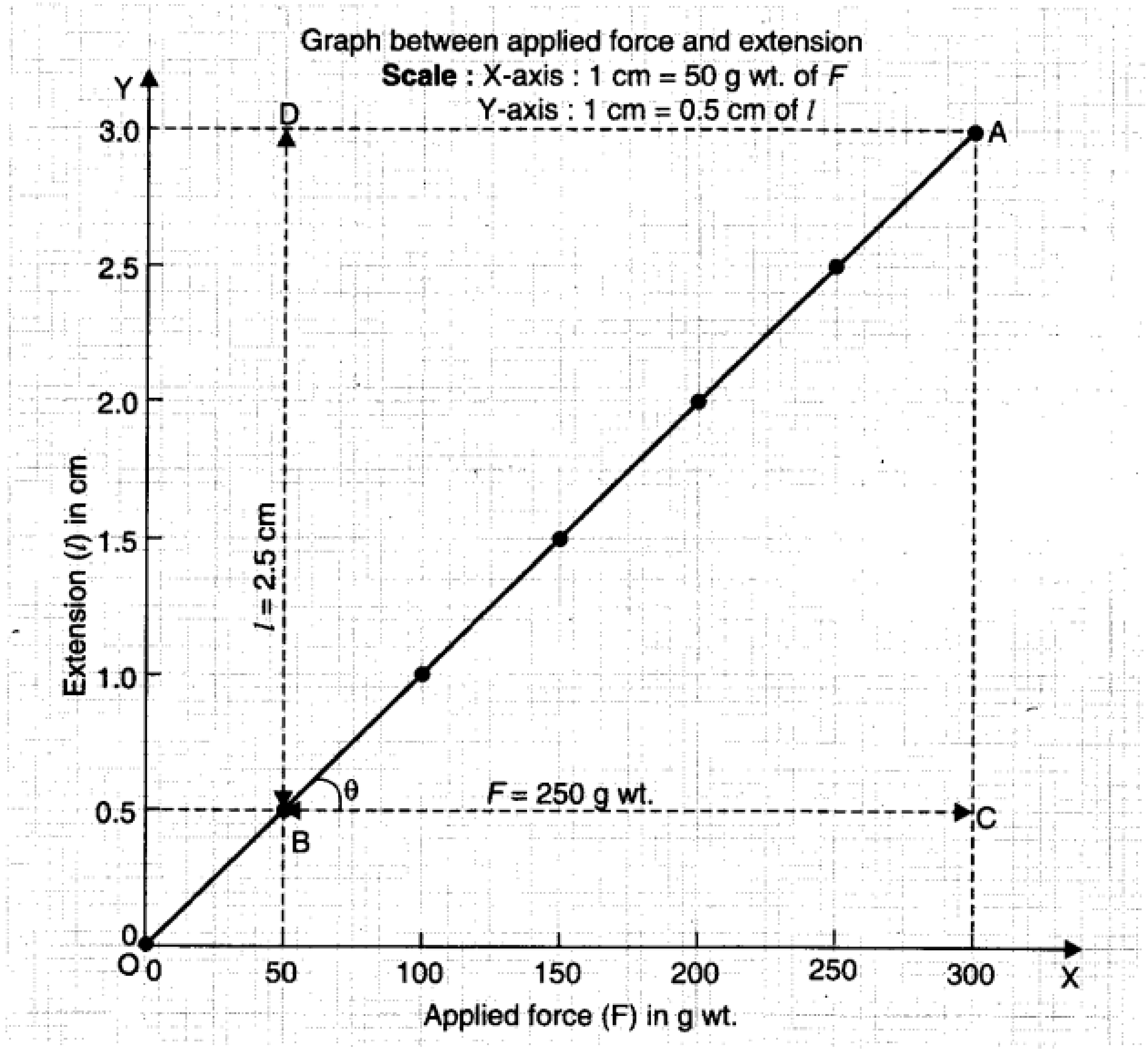


Fig. Graph between F and l. It is a straight line.

from graph, change of F from B to C changes l from B and D. It means that 250 g wt produces 2.5 cm extension.

$$K = \frac{F}{l} = \frac{BC}{AC}$$

$$K = \frac{250}{2.5} = 100 \text{ g wt per cm.}$$

Result

The force constant of the given spring is 100 g wt per cm. [Remember with this spring, a spring balance of range 1 kg will have a scale of length 10 cm]

Precautions

1. Loading and unloading of weight must be done gently.
2. Reading should be noted only when tip of pointer comes to rest.
3. Pointer tip should not touch the scale surface.
4. Loading should not be beyond elastic limit.

Sources of error

1. The support may not be rigid.
2. The slotted weights may not have correct weight.

EXPERIMENT – 6

Aim

To find the weight of a given body using parallelogram law of vectors.

Apparatus

Parallelogram law of forces apparatus (Gravesand's apparatus), plumb line, two hangers with slotted weights, a body (a wooden block) whose weight is to be determined, thin strong or thread, white drawing paper sheet, drawing pins, mirror strip, sharp pencil, half metre scale, set squares, protractor.

Theory

If the body of unknown weight S suspended from middle hanger, balances weights P and Q suspended from other two hangers, then $\vec{P} + \vec{Q} + \vec{S} = 0$

or
$$S = \sqrt{P^2 + Q^2 + 2PQ\cos\theta} \quad ...(1)$$

The unknown weight can be calculated from equation (1).

Diagram

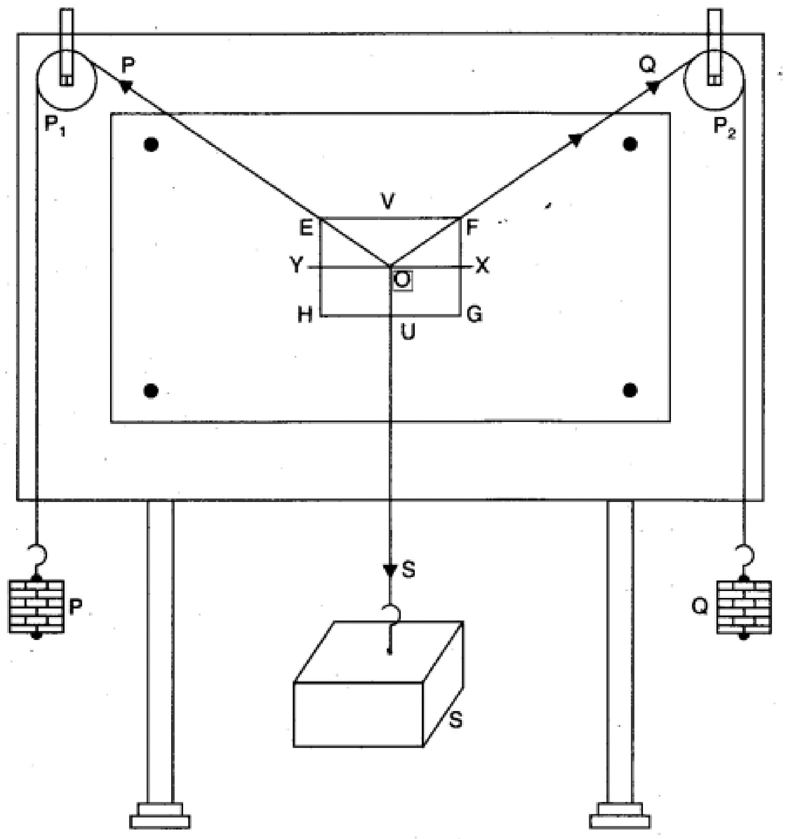


Fig. Gravesand's apparatus.

Procedure

1. Set up the Gravesand's apparatus with its board vertical, tested with the help of a plumb line.
2. Test that pulleys P_1 and P_2 are frictionless. Oil them if necessary.
3. Fix the white drawing paper sheets on the board with the help of drawing pins.
4. Take three pieces of strong thread and tie their one end together to make knot O. This knot becomes junction of the three threads.
5. From the other ends of two threads, tie a hanger with some slotted weights in each. These serve as the weights P and Q. From the other end of third thread tie the given body S.
6. Pass threads with weights P and Q over the pulleys and let the third thread with given body S, stay vertical in the middle of the board.
7. Adjust the weights P and Q (forces) such that the junction O stays in equilibrium slightly below the middle of the paper.
8. The weights P, Q and wooden block S act as three forces
   $\vec{P}, \vec{Q}$ and $\vec{S}$
   acting along the three threads at the junction O. The forces are in equilibrium.
9. See that all the weights hang freely and none of them touches the board or the table.
10. Mark the position of junction O on the white paper sheet by a sharp pencil.
11. Disturb weights P and Q and leave them.
12. Note position of junction O. It must be very close to earlier position. (If not, oil the pulleys to remove friction.)
13. Keeping mirror strip lengthwise under each thread, mark the position of the ends of the image of thread in the mirror, covering the image by the thread (this removes parallax error). The position are P_1 ,P_2 for thread of weight P, Q_1 and Q_2 for thread of weight Q and S_1 ,

S_2 for thread of weight S as shown in figure.

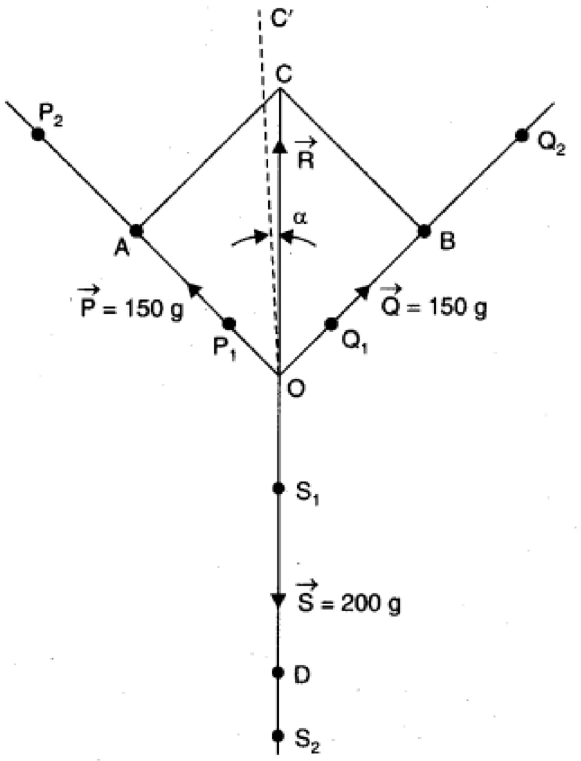


Fig. Determination of weight of a wooden block.

14. Remove paper from the board.
15. With the help of a half metre scale draw lines through points P_1 and P_2 to represent P, through points Q_1 and Q_2 to represent Q and through points S_1 and S_2 to represent S. These lines must meet at point O.
16. Taking a scale, 1 cm = 50 g, take OA = 3 cm and OB = 3 cm to represent P = 150 g and Q = 150 g.
17. Complete parallelogram OACB using set squares and join OC. It represents R.
18. Measure OC. It comes to be 3.9 cm.
19. For different sets of observation, change P and Q suitably.
20. Find weight of the wooden block by a spring balance.

Observation

Least count of spring balance = g

Zero error of spring balance = g

Weight of unknown body by spring balance = g

Scale. Let 1 cm = 50 g.

Serial No. of Obs	Forces		Sides			Resultant force R (g wt)	Unknown weight S (g wt)	Weight by spring balance (g wt)	Error (g wt)
	P (g wt)	Q (g wt)	OA (cm)	OB (cm)	OC (cm)				
1.	150	150	3	3	3.9	195	195	200	5
2.									
3.									

(**Note.** *Observation 1 is as sample*)

Calculations

OC = 3.9 cm, $R = 50 \times 3.9 = 195$ g

Unknown weight $S = 195$ g.

Mean unknown weight $S = \dfrac{S_1 + S_2 + S_3}{3} = 195$ g

Weight by spring balance = 200 g

Difference = 5 g.

Result

The unknown weight of given body = 195 g

The error is within limits of experiment error.

Precautions

1. The board should be stable and vertical.
2. The pulleys should be friction less.
3. The hangers should not touch the board or table.
4. Junction O should be in the middle of the paper sheet.
5. Points should be marked only when weights are at rest.
6. Points should be marked with sharp pencil.
7. Arrows should be marked to show direction of forces.
8. A proper scale should be taken to make fairly big parallelogram.

Sources of error

1. Pulleys may have friction.
2. Weights may not be accurate.
3. Points may not be marked correctly.
4. Weight measured by spring balance may not be much accurate.

E

XPERIMENT – 7

Aim

Using a simple pendulum, plot its L-T^2 graph and use it to find the effective length of second's pendulum.

Apparatus

A clamp with stand, a split cork, thread, bob, vernier callipers, stop clock/watch, metre scale and a piece of chalk.

Theory

1. Simple Pendulum. An ideal simple pendulum consists of a heavy point mass (called bob) tied to one end of a perfectly in extensible, flexible and weightless string. There is no ideal simple pendulum. In practice, we make a simple pendulum by tying a metallic spherical bob to a fine cotton stitching thread.
2. Length of Simple Pendulum. The distance between the point of suspension of ,the pendulum and its C.G. (which is C.G. of the bob), is called the length of the simple pendulum. It is represented by the symbol l.

$$T = 2\pi\sqrt{\frac{l}{g}} \quad \text{or} \quad T^2 = \frac{4\pi^2 l}{g} \quad \text{or} \quad l = \frac{gT^2}{4\pi^2}$$

Knowing the value of T and g, l can be calculated.

Diagram

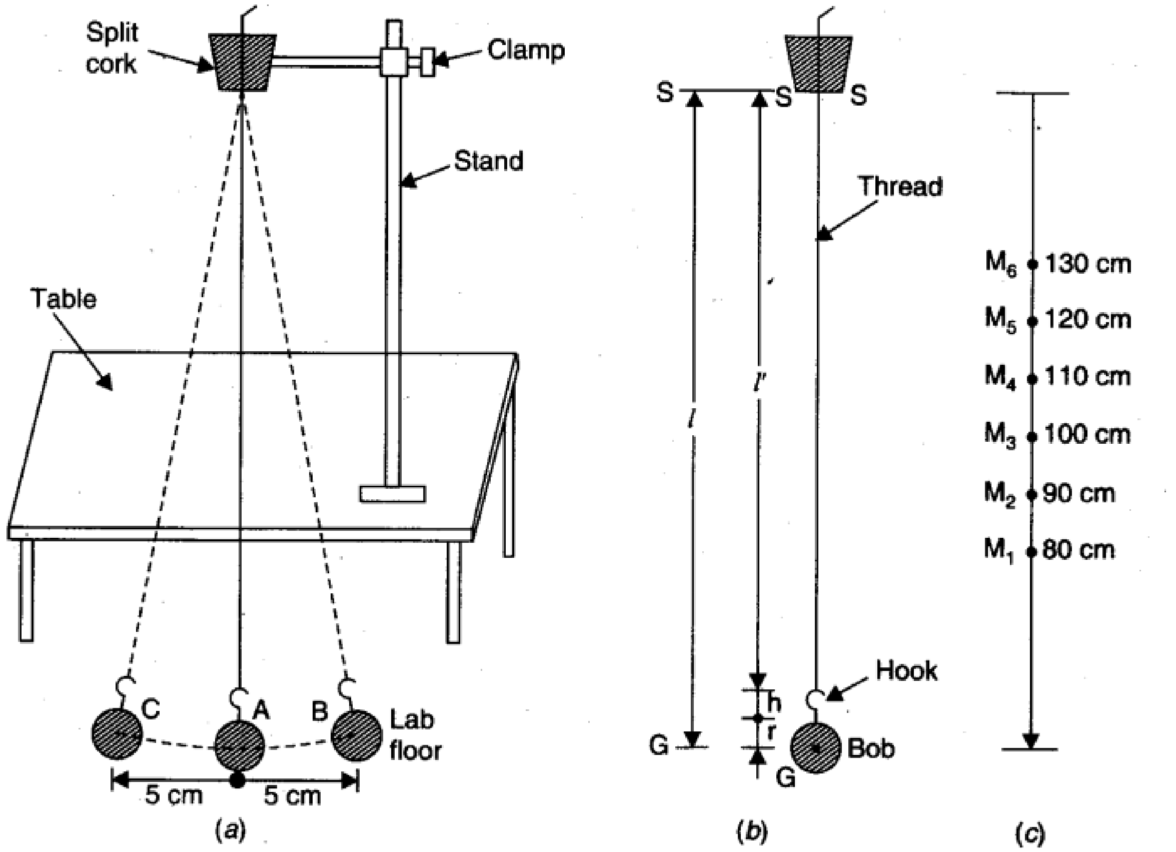


Fig. (*a*) Simple Pendulum.
(*b*) Effective length of simple pendulum, $l = l' + h + r$.
(*c*) Marks on thread.

Procedure

1. Find the vernier constant and zero error of the vernier callipers and record it (as in Experiment 1).
2. Determine the mean diameter of the spherical bob (as in Experiment 1A). Find the mean radius (r) of the bob.
3. Find the length h of the hook attached to the bob by metre scale and record it.
4. Take a cotton thread about 2 metres long and tie its one end with the hook.
5. Put ink marks, M_1, M_2, M_3, on the thread as distance of 80 cm, 90 cm, 100 cm, 110 cm, 120 cm, 130 cm, from the centre of gravity of the bob. These distances give effective length (l) of the simple pendulum.
6. Pass the thread through the two split parts of a cork with the thread coming out just from 80 cm mark.
7. Tight the two half cork pieces between the clamp.
8. Fix the clamp in a stand kept on a table at such a height that the bob is just 2 cm above the laboratory floor.
9. Mark a point A on the floor just below the position of bob at rest (mean position).

10. Draw a straight line CAB, 10 cm long in direction along which bob will move when oscillating. A is middle point of CB.
11. Find the least count and the zero error of the stop clock/watch. Bring its hands at zero position.
12. Move the bob by hand to over position B on the right of A and leave. See that the bob returns over line BC without spinning.
13. When the bob returns from C to A and starts moving to right of A, start the stop clock/ watch and count zero.
14. The bob goes towards B to right extreme, returns from right extreme and goes to-wards C to left extreme. When bob crosses A from towards C, count one.
15. In this way count up to 19. Become alert when bob starts the 20th vibration.
16. Just when 20th vibration is completed, count 20 and at once stop the stop clock/watch.
17. Find total time noting positions of both the hands of the clock/watch. This time is time for twenty vibrations.
18. Repeat steps 13 to 18 two times more for same length.
19. Move the clamp up by 10 cm.
20. Loose the cork pieces and pull the thread out to increase its length by 10 cm. Now effective length of pendulum becomes 90 cm. Bob will be again 2 cm above the laboratory floor.
21. Repeat steps 13 to 19 two times to take in all the two observations for this new length. Repeat step 20.
22. Repeat step 21 and then steps 13 to 19 to take two observations each for lengths 90 cm, 100 cm, 110 cm, 120 cm and 130 cm.
23. Record all the observations as given ahead.

Observations

1. Vernier constant of vernier callipers (V.C.) = cm.
Zero error of vernier callipers (e) :
(i)………cm, (ii)……..cm, (iii)… cm.
Mean zero error, (e) = cm
Mean zero correction (c) = – e = cm
Observed diameter of the bob :
(i)………cm, (ii)………cm, (iii)… cm.
Mean observed diameter, d_0 = cm
Mean corrected diameter, $d=d_0+c$= cm

Mean radius of the bob, r=d/2= cm

Length of hook of the bob, h= cm
Standard value of g- 980 cm s^{-2}.
2. Least count of stop clock/watch = s
Zero error of stop clock/watch = s

Zero correction of stop clock/watch = s.

3. Table for Length (l) and time (T)

S. No. of Obs.	Length of Thread l' (cm)	Length of Pendulum $l = l' + h + r$ (cm)	Time for 20 vibrations t_1 (s)	t_2 (s)	t_3 (s)	Mean t (s)	Time period $T = \frac{t}{20}$ (s)	T^2 $(s)^2$
1.	78.4	80.0	35	37	36	36	1.8	3.24
2.	88.4	90.0	38	38	38	38	1.9	3.61
3.	98.4	100.0	40	40	40	40	2.0	4.00
4.	108.4	110.0	41	42	42	42	2.1	4.41
5.	118.4	120.0	43	45	44	44	2.2	4.84
6.	128.4	130.0	47	45	46	46	2.28	5.20

(**Note.** *Observations are as sample. π^2 taken as 10*)

Calculations

(a) With the table

For each length, write mean time for 20 vibrations

$$t = \frac{t_1 + t_2 + t_3}{3} \text{ s}$$

Write mean values of t in column (3) of above table.

For each length, find time period T =t/20 s and write its value in column 4 and write value of T_2 in column 5 of the above table.

l-T_2 graph. Plot a graph between l (column, 2b) and T_2 (column 5) by taking Z along X- axis and T_2 along Y-axis. The graph comes to be a straight line

Graph

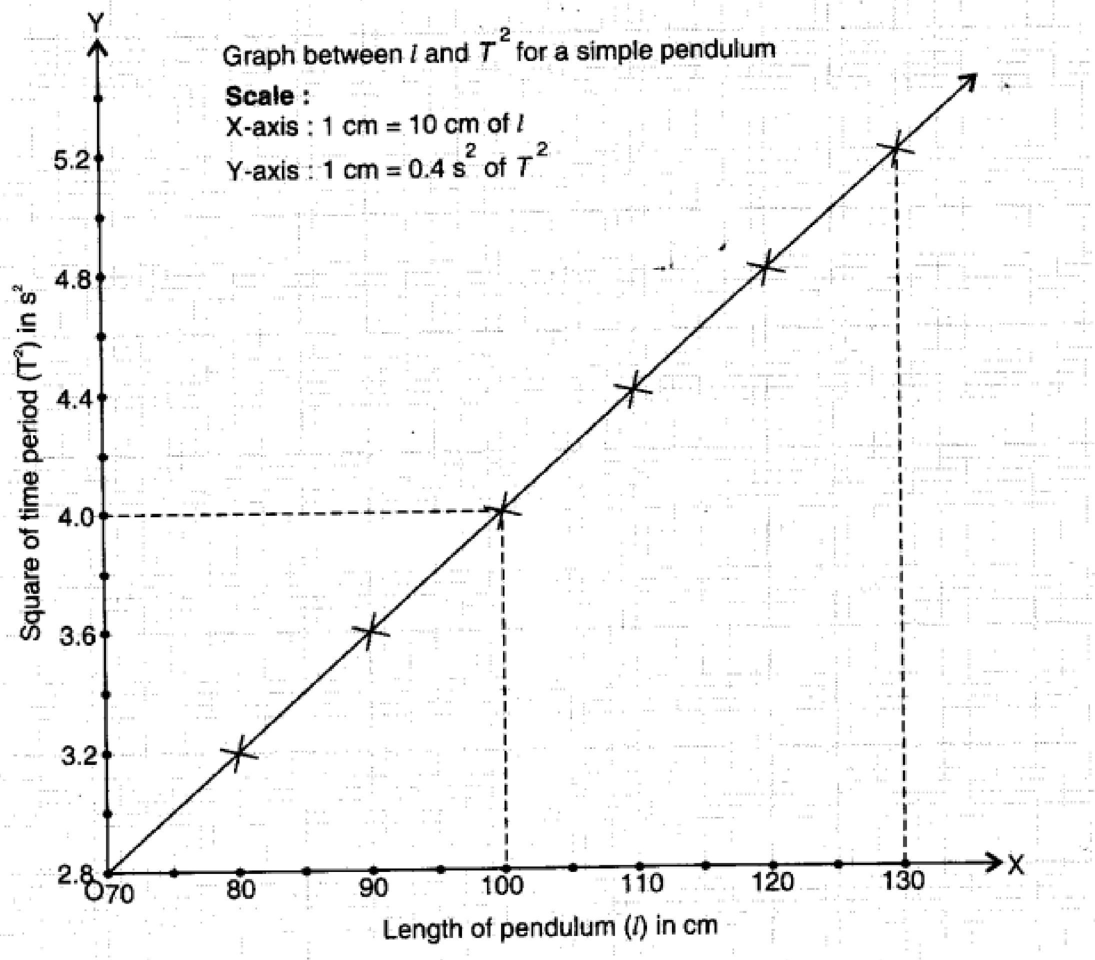


Fig. Graph between l and T^2 for a simple pendulum. It is a straight line.

The graph is a straight line because

$$T = 2\pi\sqrt{\frac{l}{g}} \text{ and } T^2 \propto l$$

From this graph, for T_2 = 4, l comes to be 100 cm.
Hence for seconds pendulum (T = 2 s) length comes to be 100 cm.

Result

Experimental length 100 cm Actual length = 99.4 cm Error = 0.6 cm
Percentage error = 0.6/99.4 x 100 = 0.6%
This error is within the limit of the experimental error.

Precautions

1. Thread should be strong, weightless and in extensible.
2. Point of suspension should be fixed in a rigid support.
3. Lower faces of split cork should be in same level.

4. Splitting should be perpendicular to the plane of vibration of the pendulum.
5. Amplitude should be small to have sin 0 = 0. [when 0 < 18°]
6. The bob should move along a straight line.
7. The bob should not spin during vibration.
8. Place of experiment should be free from disturbances of building vibrations or air current.
9. Laboratory fan should be switched off.
10. Length of pendulum should include length of hook and radius of bob.
11. Counting should be proper and started from zero.
12. Clock/watch should be accurate.
13. Length of pendulum should be increased in steps of 10 cm to bring appreciable change in time period.
14. Metre scale used should be accurate.

Sources of error

1. The string may not be weightless and in extensible.
2. Point of suspension may not be rigid.
3. The amplitude may not be small.
4. The bob may spin.
5. The air currents may disturb vibrations.
6. There may be an error in counting.
7. The stop clock/watch may be inaccurate.
8. There may be delay in starting and stopping the stop clock/watch.

EXPERIMENT – 8

Aim

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

Apparatus

A sonometer, a set of eight tuning forks, 1\2 kg hanger, seven 1\2 kg slotted weights, rubber pad, paper rider, metre scale, screw gauge.

Theory

If stretched wire (string) vibrates in resonance with a tuning fork of frequency v, then the string also has same frequency v.
If the string has a length l, diameter D, material of density p and tension T, then

$$\nu = \frac{1}{lD}\sqrt{\frac{T}{\pi\rho}} \qquad ...(1)$$

Relation between frequency (ν) and length (l). From Eq. (1) above, $\nu \propto \frac{1}{l}$

or $\nu l = \text{Constant.}$

A graph between ν and $\frac{1}{l}$ will be a straight line, while a graph between ν and l will be a hyperbola.

Relation between length (l) and tension (T). From Eq. (1) above,

$$\frac{\sqrt{T}}{l} = \text{Constant}$$

or $\sqrt{T} \propto l$

or $T \propto l^2$

A graph between T and l^2 will be a straight line.

Diagram

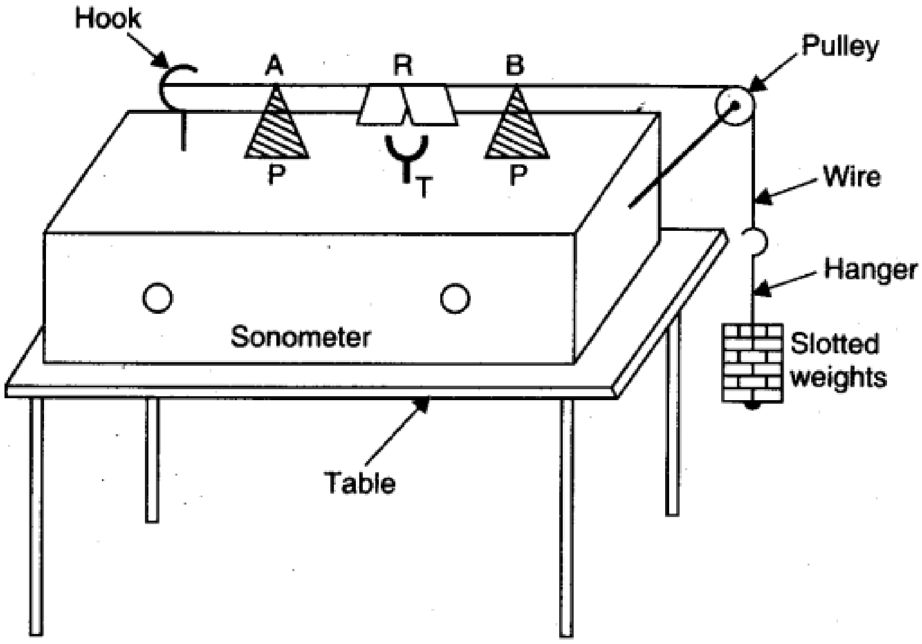


Fig. Sonometer in experimental set up.

Procedure (To find the relation between frequency and length)

1. Place the sonometer on the table as shown in Fig.
2. Test the pulley and make it frictionless by oiling (if necessary).
3. Put suitable maximum weight in the hanger.
4. Move wooden bridges P, outward to include maximum length of wire (AB) between them.
5. Take a tuning fork of least frequency from among the set. Strike its prong with a rubber pad to make it vibrate. Bring the tuning fork near your ear.
6. Pluck the wire AB from the middle and leave it to vibrate.
7. Listen sound produced by tuning fork and wire and judge which has less frequency (sound which is grave and has low pitch, has less frequency).
8. Since the long wire may have less frequency, decrease its length by moving the bridges inwardly. Check the frequencies again.
9. Go on decreasing the length till frequency of vibrating wire AB becomes equal to the frequency of the tuning fork.
10. Put an inverted V shape paper rider R on the wire AB in its middle. Vibrate the tuning fork and touch the lower end of its handle with sonometer board. The wire AB vibrates due to resonance and paper rider falls.
11. Note the length of the wire AB between the edges of the two bridges and record it in 'length decreasing' column.

12. Bring the two bridges closer and then adjust the length of the wire by increasing it little by little till rider falls.
13. Note the length of the wire and record it in 'length increasing' column.
14. Take the remaining five tuning forks, one by one, in order of increasing frequency and repeat steps 5 to 13.
15. Record your observations as given below.

Observations

Constant tension on the wires, T = kg.

Serial No. of Obs.	Frequency of tuning fork used ν (Hz)	Resonant length of wire			$\frac{1}{l}$ (cm^{-1})
		Length increasing l_1 (cm)	Length decreasing l_2 (cm)	Mean $= \frac{l_1 + l_2}{2}$ l (cm)	
1.	256	50.1	49.9	$= \frac{50.1 + 49.9}{2}$ = 50	0.02
2.	288				
3.	320				
4.	384				
5.	480				
6.	512				

(**Note.** *Observation 1 is as sample*)

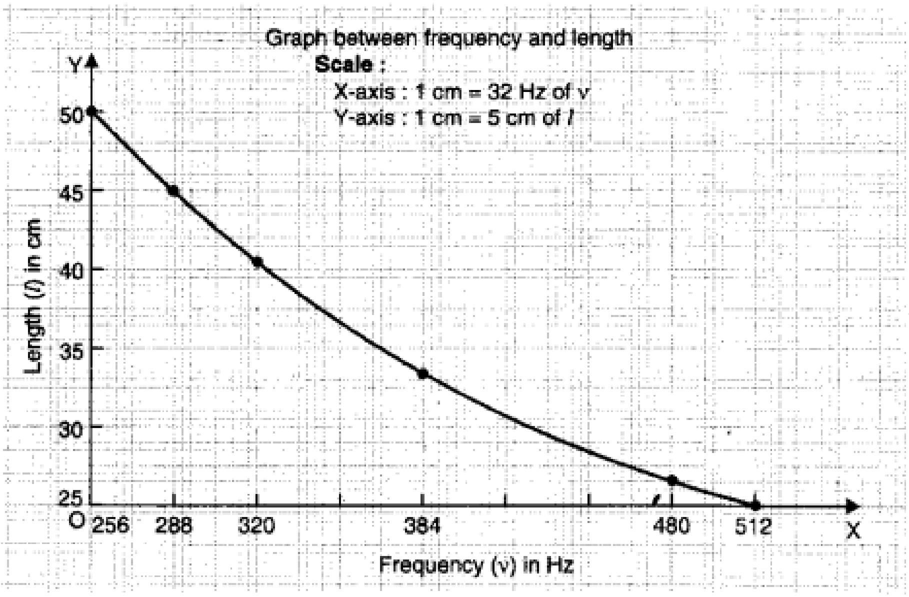
Table for frequency and length

Calculations

1. Find mean length l.

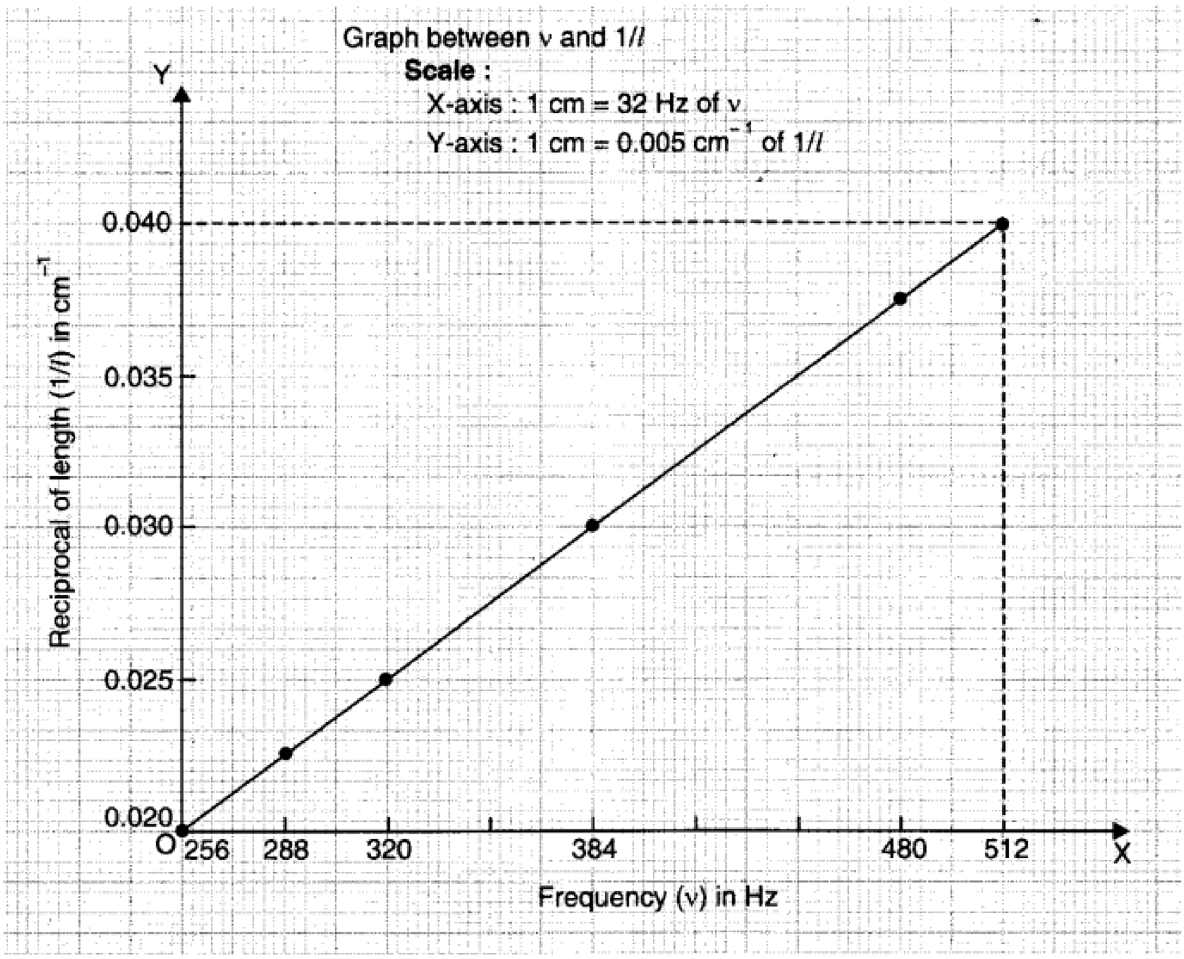
2. Find $\frac{1}{l}$.

3. Plot a graph between ν and l, taking ν along X-axis and l along Y-axis.



Graph between frequency (ν) and length l. It is a hyperbola.

4. Plot a graph between ν and $\frac{1}{l}$, taking ν along X-axis and $\frac{1}{l}$ along Y-axis. The graph comes to be a straight line as shown in below.



Graph between ν and 1/l. It is a straight line.

Result

From the graph, we conclude that νl = constant and $\nu \propto \frac{1}{l}$.

This verifies law of length of transverse vibrations of strings.

Activity – 4

Aim

To observe change of state and plot a cooling curve for molten wax.

Apparatus

A uniform straight wooden metre rod (scale). Two G clamp, pointer pin, thread, slotted weights of 50 g each, wax, vertical scale, clamp stand.

Theory

(a) For cooling

The depression (Buckling) δ produced in the wooden rod of length l.

$$\delta = \frac{mgl^3}{4Y\,bd^3}$$

m = Total mass of slotted weights

Y = Young modulus

b = breadth

d = depth

For a given rod, $\delta \propto mg$

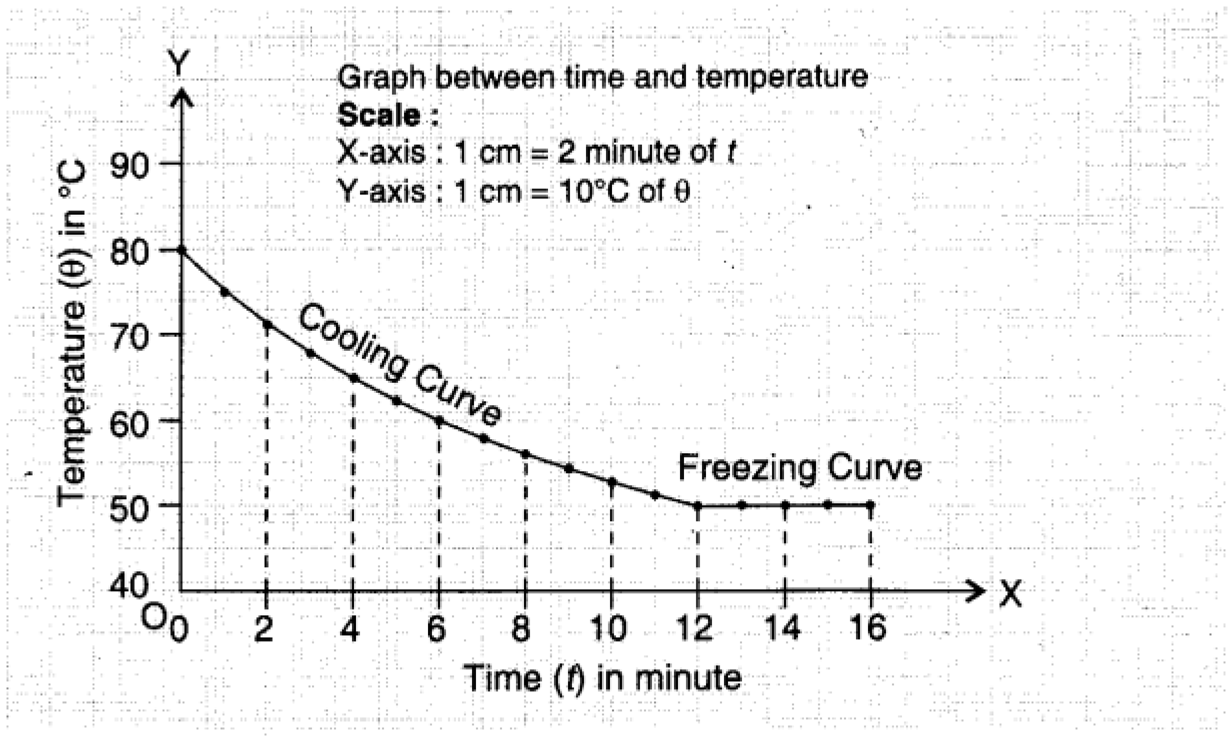
i.e., the depression produced is directly proportional to the load (weight) suspended from one end.

(b) For change of state

When molten wax cools down to its freezing point, it starts solidifying and the temperature becomes constant.

The curve becomes horizontal thereafter (parallel to time-axis) as shown in Graph.

Graph



Graph between time (t) and temperature (θ).

Procedure

Steps 1 to 8 of experiment 6 except step 2 in which calorimeter is filled two third by molten wax (in place of water)

9. When temperature of wax falls to about 80°C note it and start the stop clock.
10. Continue stirring and note temperature after every one minute.
11. Note enclosure water temperature after every five minutes.
12. When fall of temperature stops, remove the lid and note that the wax in calorimeter starts solidifying. Temperature remains same till all the wax in calorimeter solidifies.
13. Watch the constant temperature for some minutes.
14. Record your observations as given below.

Observations

Least count of enclosure thermometer = °C.

Constant temperature of enclosure, θ_0 = °C

Least count of calorimeter-wax thermometer = °C.

Least count of stop clock/watch = s.

Table for time and temperature

Serial No. of Obs.	*Time for cooling t(mt)*	*Temperature of wax in calorimeter* θ (°C)
1.	0	80
2.	1	76
3.	2	72
4.	3	69
5.	4	66
6.	5	63
7.	6	61
8.	7	59
9.	8	57
10.	9	55
11.	10	53
12.	12	50
13.	14	50
14.	16	50
15.	18	50
16.	20	50

(**Note.** *The ideal observations given above are as sample.*)

Plot a graph between time t and temperature 0, taking t along X-axis and 0 along Y-axis. The decreasing slope curve is called cooling curve of molten wax.

The horizontal straight line is called freezing curve of the wax.

Result

1. The temperature falls quickly in the beginning and then slowly.
2. When wax starts freezing, the temperature does not fall further. The freezing point comes to be 50°C as calculated from graph.

Precautions

1. The metre scale should be straight and uniform and clamped firmly.
2. The tip of pointer should not touch the vertical scale.
3. The scale should not be loaded beyond the elastic limit.
4. Reading on metre scale should be taken carefully.

Sources of error

1. The metre scale may be non-uniform.
2. The tip of pointer may not be very sharp.

Activity – 5

Aim

To study the factors affecting the rate of loss of heat of a liquid.

Apparatus

Two calorimeters A and B of different areas, two thermometers, two stands, stopwatch, wooden lids, burner and liquid (water).

Theory

According to Newton's Law of cooling, rate of cooling (i.e., heat lost per sec) of a body is directly proportional to the difference of temperature of the body and the surrounding.

$$\frac{dQ}{dt} = K(T - T_0)$$

where, T = temperature of hot liquid.

T_0 = temperature of surrounding (air).

K = constant, it value depends upon.

(i) Nature of surface.
(ii) Area of surface.

(iii) Nature of material of body.

Then, for same difference of temperature, rate of cooling also depends upon :
(i) Area of the surface of the body.

(ii) Nature of the surface of the body.

(iii) Material of the surface of the body (material effects conductivity through walls of the body).

Diagram

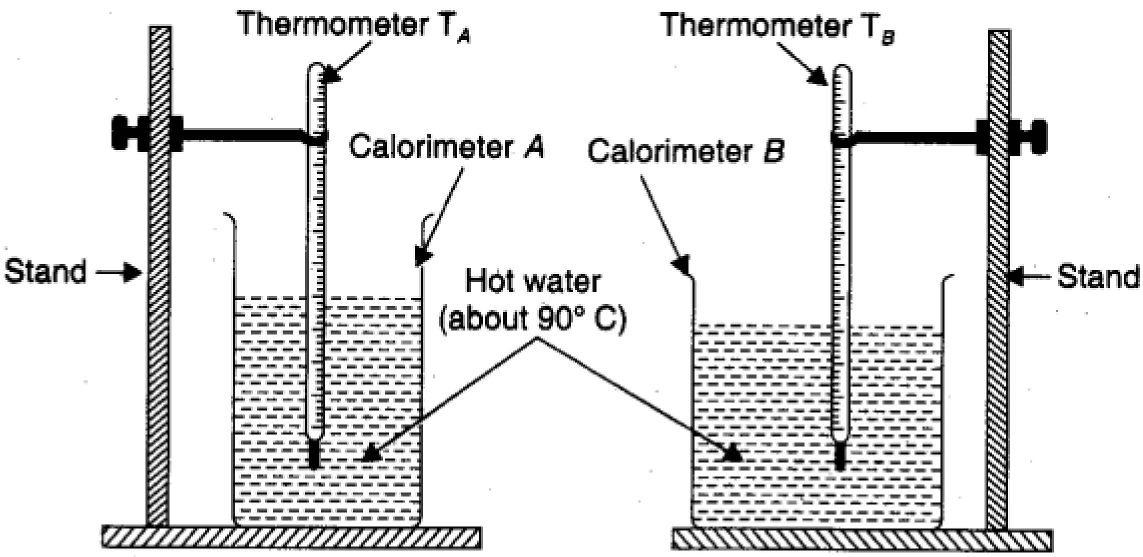


Fig. Studying the effect of area of surface losing heat.

Procedure

1. Fill the space between double wall of the enclosure with water and put the enclosure on a laboratory table.
2. Fill the calorimeter two-third with water heated to about 80°C.
3. Suspend the calorimeter inside the enclosure along with a stirrer in it. Cover it with a wooden lid having a hole in its middle.
4. Suspend from clamp and stand, one thermometer in enclosure water and the other in calorimeter water.
5. Note least count of the thermometers.

6. Set the stop clock/watch at zero and note its least count.

7. Note temperature (T0) of water in enclosure.

8. Start stirring the water in calorimeter to make it cool uniformly.

9. Just when calorimeter water has some convenient temperature reading (say 70°C), note it and start the stop clock/watch.
10. Continue stirring and note temperature after every one minute. The temperature falls quickly in the beginning.
11. Note enclosure water temperature after every five minutes.

12. When fall of temperature becomes slow note temperature at interval of two minutes for 10 minutes and then at interval of 5 minutes.
13. Stop when fall of temperature becomes very slow.

14. Record your observations as given ahead.

Case I. Take same volume of same liquid in calorimeters of small and large cross¬section (nature and material of surface same).

Case II. Take same volume of same liquid in similar calorimeters having black painted and polished outer surface (area and material of surface same).
Case III. Take same volume of same liquid in similar calorimeters of different materials (area and nature of surface same).

Observations

Least count of enclosure water thermometer = °C.

Least count of calorimeter water thermometer = °C.

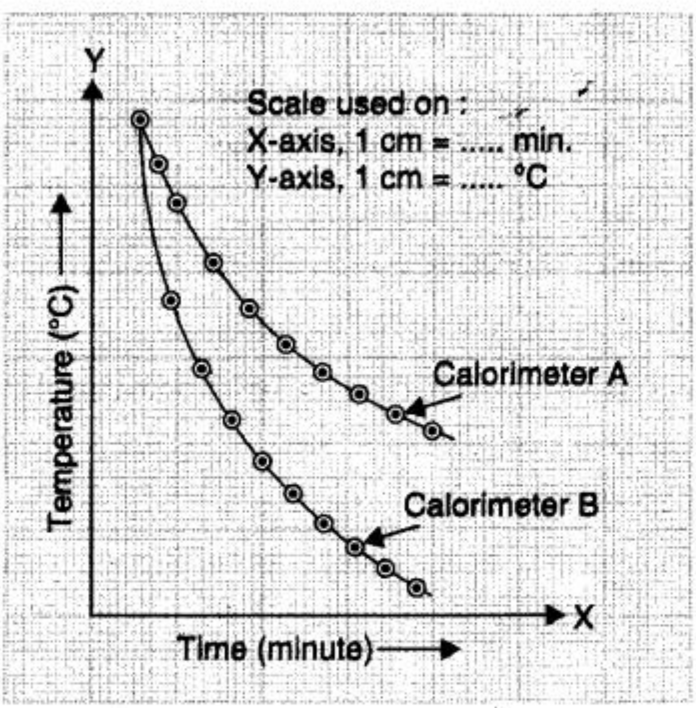
Least count of stop clock/watch = s.

Serial No. of Obs.	Time for cooling t(mt)	Temperature of water in calorimeter T (°C)	Temperature of water in enclosure T_0 (°C)	Difference of temperature $T - T_0$ (°C)
1.	0	70	30	40
2.	1	68		38
3.	2	66		36
4.	3	64		34
5.	4	62		32
6.	5	61	30	31
7.	6	60		30
8.	7	59		29
9.	8	58		28
10.	9	56		26

Table for time and temperature

(Note. The ideal observations given above are as sample.)

Graph



Temperature and time for calorimeter A, having small surface area and calorimeter B having large surface area.

Comparison of graphs

Case I. Cooling is fast from more surface area.
Cooling is slow from less surface area.
Case II. Cooling is fast from black painted surface and slow from polished surface of the calorimeter.
Case III. Cooling is fast from calorimeter having more conducting material and slow from calorimeter having less conducting material.

Result

Case I. Rate of cooling depends upon the area of the surface through which heat is lost. More area of surface causes higher rate of cooling.
Case II. Rate of cooling depends upon the nature of the surface through which heat is lost. Black painted surface causes higher rate of cooling.
Case III. Rate of cooling depends upon the material of the surface. More conducting surface causes higher rate of cooling.

Precautions

1. Double-walled enclosure should be used to maintain surrounding at a constant temperature.
2. Stirring should remain continuous for uniform cooling.
3. Same volume of same liquid should be taken in all cases.
4. Graphs of one case should be plotted on same graph paper on same scale.

Activity – 6

Aim

To observe and explain the effect of heating on a bi-metallic strip.

Apparatus

A bi-metallic strip (made of iron and brass bars), a board with clamp screw on one side and vertical scale on the other side, electric heating arrangement, or a burner thermometer.

Short Description of a Bi-metallic Strip

It is a strip made up of two bars of different metals but same dimensions, put together lengthwise and ripetted at their ends. The strip is straight at room temperature.

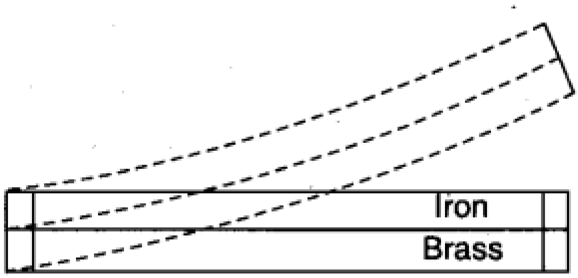


Fig. Bi-metallic strip.

When the bi-metallic strip is heated both bars expand differently. Since they are ripetted at their ends, their ends stay together. The bi-metallic strip bends keeping more expanding bar on its convex side. More is heating, more is the bending.

In case of an iron-brass bi-metallic strip, the bent strip will have brass bar on its convex side.

Theory

If L_1 be the length of a rod (bar) at temperature t_1°C and L_2 be the length at t_2°C, then

$$L_2 = L_1[1 + \alpha(t_2 - t_1)]$$

where α is the coefficient of linear expansion of the material of the rod (bar).

If two rods of different metals have same length L_1 at temperature t_1°C, their length at higher temperature t_2 °C will be different. The rod of a metal having more value of ' coefficient of linear expansion will have more length than the other rod.

Diagram

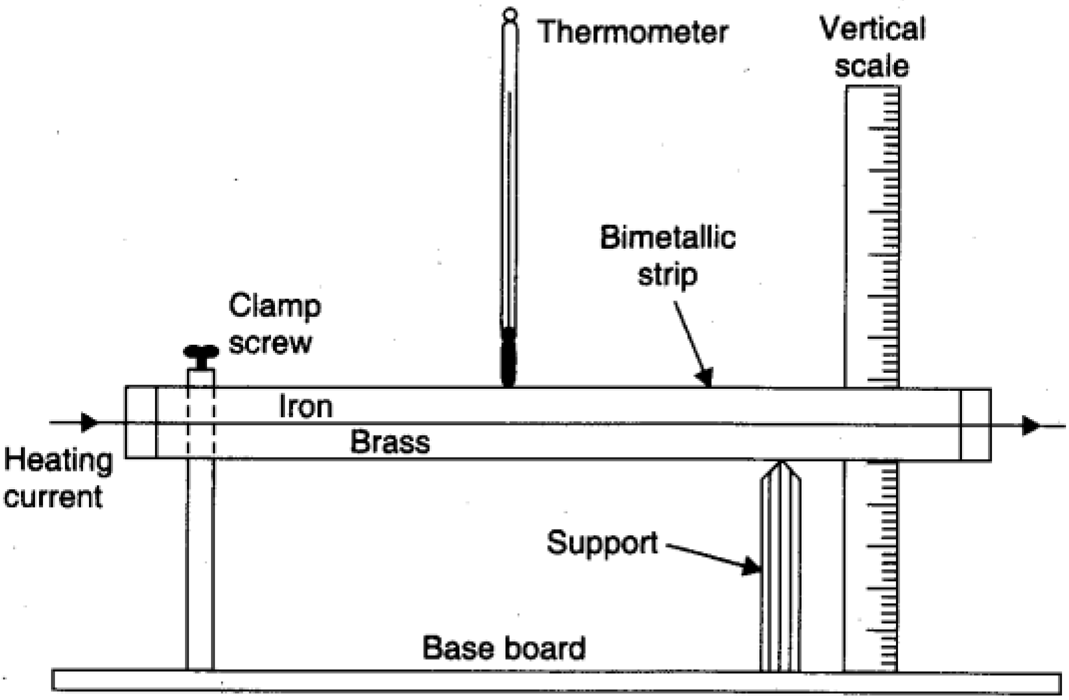


Fig. Bending of a bi-metallic strip.

Procedure

1. Clamp one end of the brass-iron bi-metallic strip, keeping brass bar on the lower side.
2. Keep the strip horizontal rested on a vertical support.
3. Fix a vertical scale near the free end of the bi-metallic strip.
4. Suspend a thermometer with its bulb touching the strip in the middle.
5. Note the initial temperature of the strip.
6. Note the vertical scale division coinciding with the upper edge of the strip.
7. Heat the strip by passing electric current through it or by using a burner. The thermometer will show a rise of temperature.
8. Watch the movement of the free end of the strip. The strip bends upwards (towards iron bar side) and position of upper edge of the strip changes.
9. Note the temperature after each rise of temperature by 2°C and also the position of the upper edge at that temperature.
10. Record your observations as given below.

Observations

Room temperature = 30°C (say)
Least count of vertical scale = 1 mm.
Table for temperature and vertical scale reading

Serial No. of Obs.	Temperature of bi-metallic strip t (°C)	Position of upper edge of bi-metallic strip x (mm)	Amount of bending upward (mm)
1.	30°C	$x_1 =$	$x_1 - x_1 =$
2.	32°C	$x_2 =$	$x_2 - x_1 =$
...	......	....	....
11.	50°C	$x_{11} =$	$x_{11} - x_1 =$

Calculations

1. Find the amount of bending by taking difference of position with initial position.
2. It is found that amount of bending increases as temperature rises.

Result

1. Bi-metallic strip bends more and more as its temperature rises.
2. Since brass bar is on convex side and iron bar on concave side of bent bi-metallic strip, brass bar expands more than the iron bar. Hence brass has larger linear expansion.

Precautions

1. The two bars should be firmly ripetted near their ends.
2. Brass bar should be kept on the lower side.
3. One end of the bi-metallic strip should be screw clamped.
4. Heating of whole bi-metallic strip should be uniform.

Sources of error

1. The ripettes may be loose.
2. Heating of strip may not be uniform.