



PUNJA International School

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Term – II

Class – XI

Subject: Physics

Experiment (2021_22)

Exp. No	Aim
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.
Activities	
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 - 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

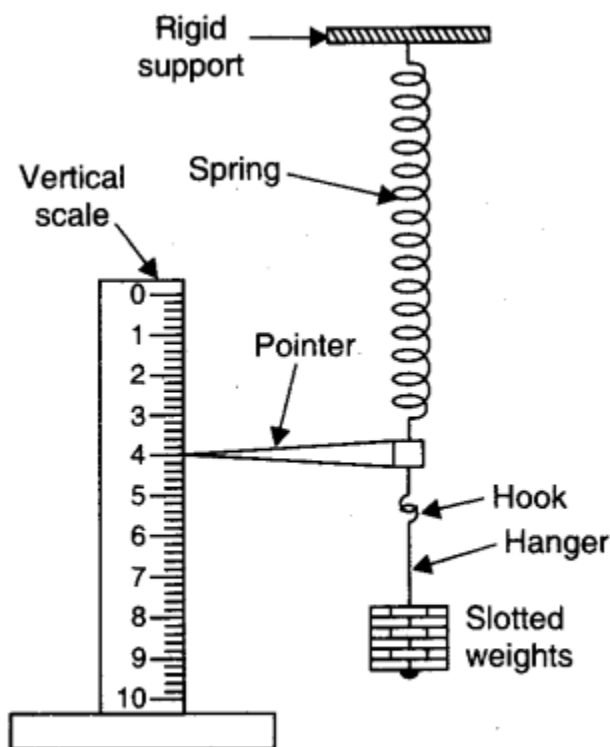


Fig. Extension of spring.

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.

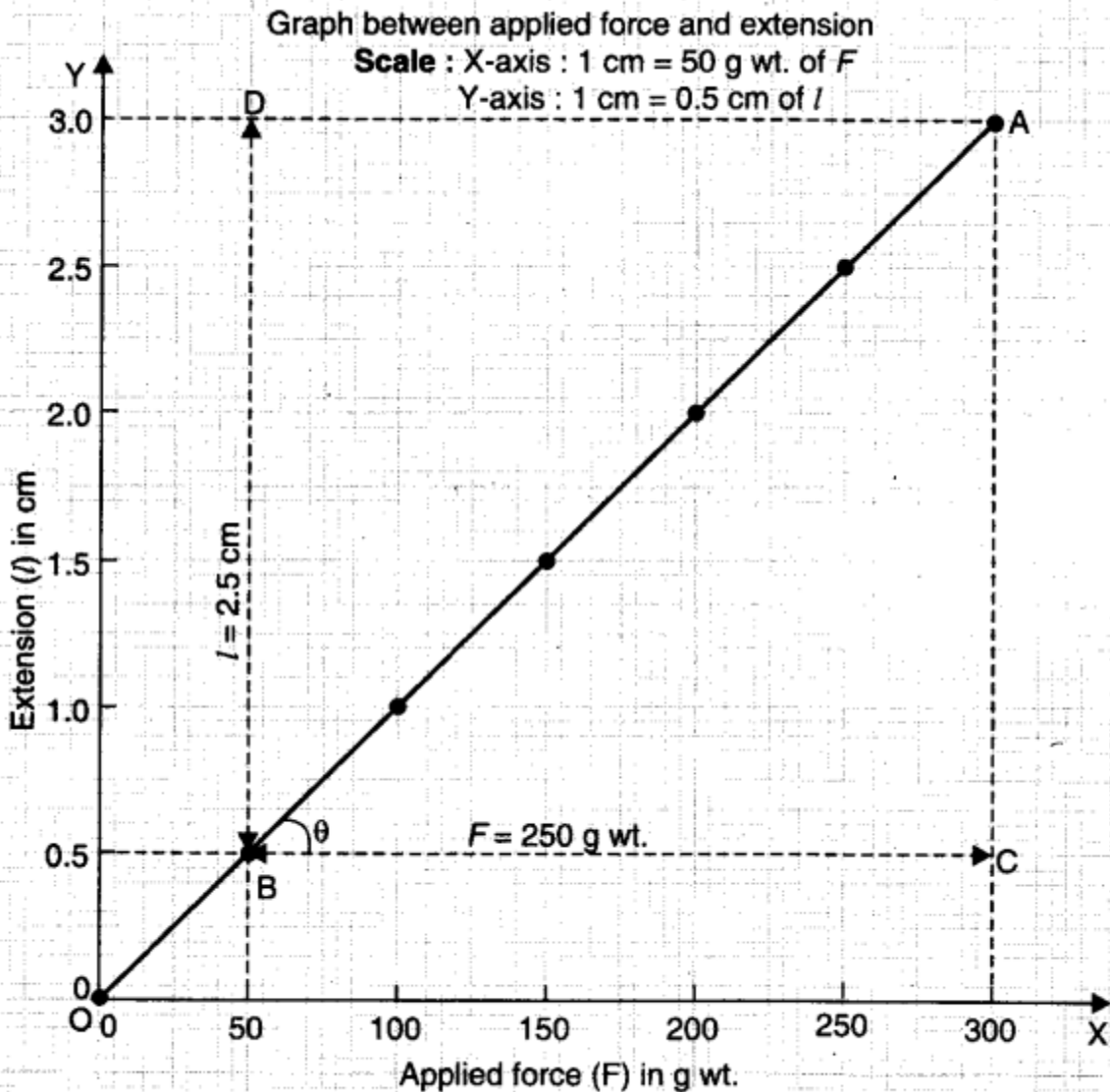


Fig. Graph between F and l . It is a straight line.

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

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

Diagram

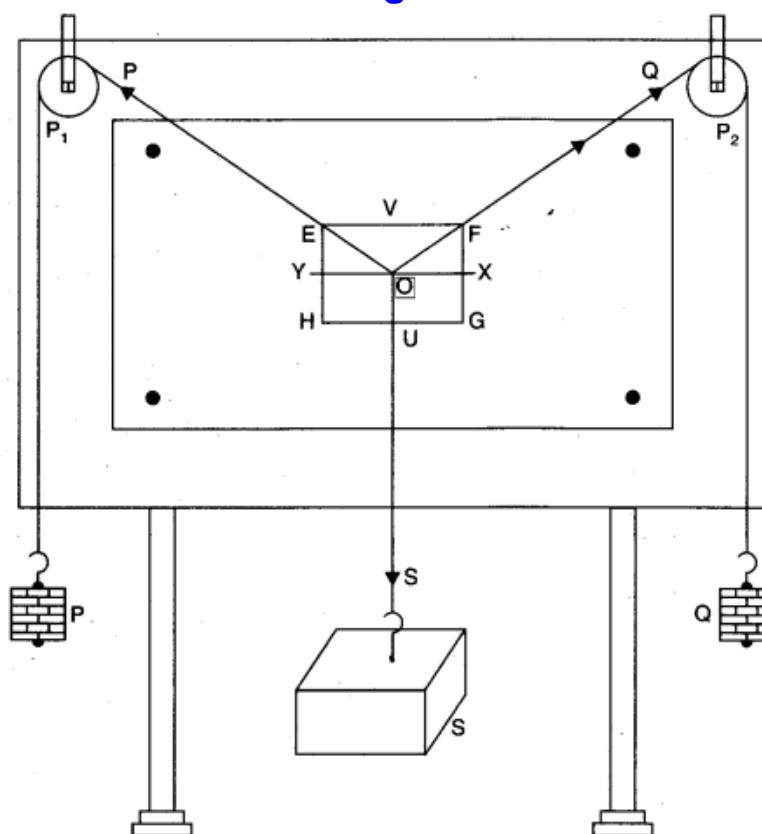


Fig. Gravesand's apparatus.

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.

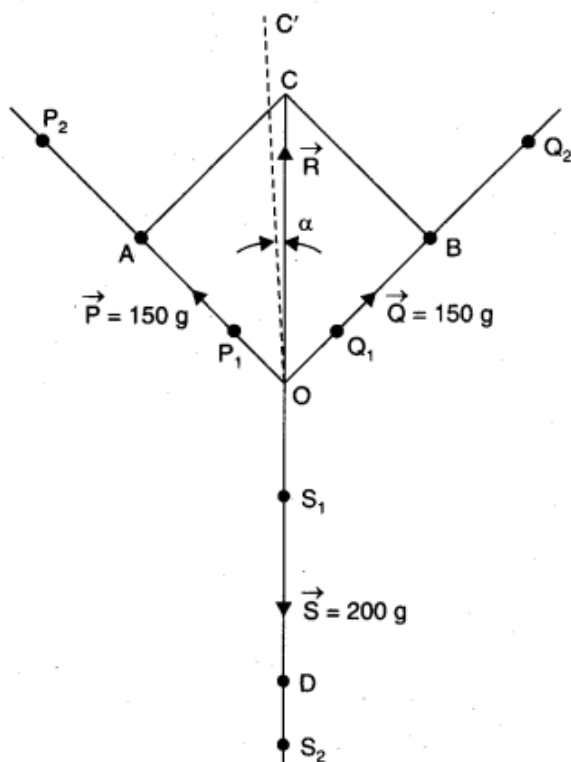


Fig. Determination of weight of a wooden block.

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

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

$$\text{Unknown weight } S = 195 \text{ g.}$$

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

$$\text{Weight by spring balance} = 200 \text{ g}$$

$$\text{Difference} = 5 \text{ g.}$$

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.

EXPERIMENT – 7

Aim

Using a simple pendulum, plot its L-T² 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

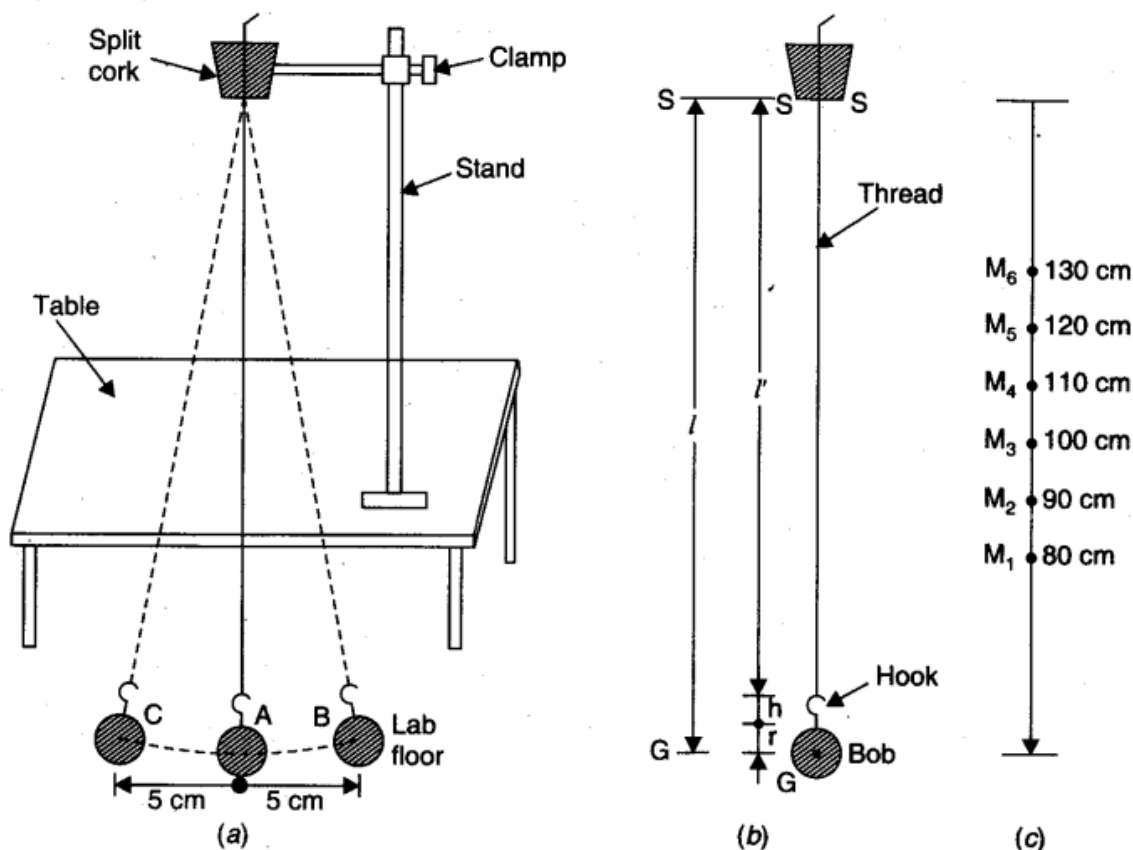


Fig. (a) Simple Pendulum.

(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 $g - 980 \text{ cm s}^{-2}$.

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 Pendulum		Time for 20 vibrations				Time period $T = \frac{t}{20}$	T^2
	l'	$l = l' + h + r$	t_1	t_2	t_3	Mean t		
	(cm)	(cm)	(s)	(s)	(s)	(s)	(s)	(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

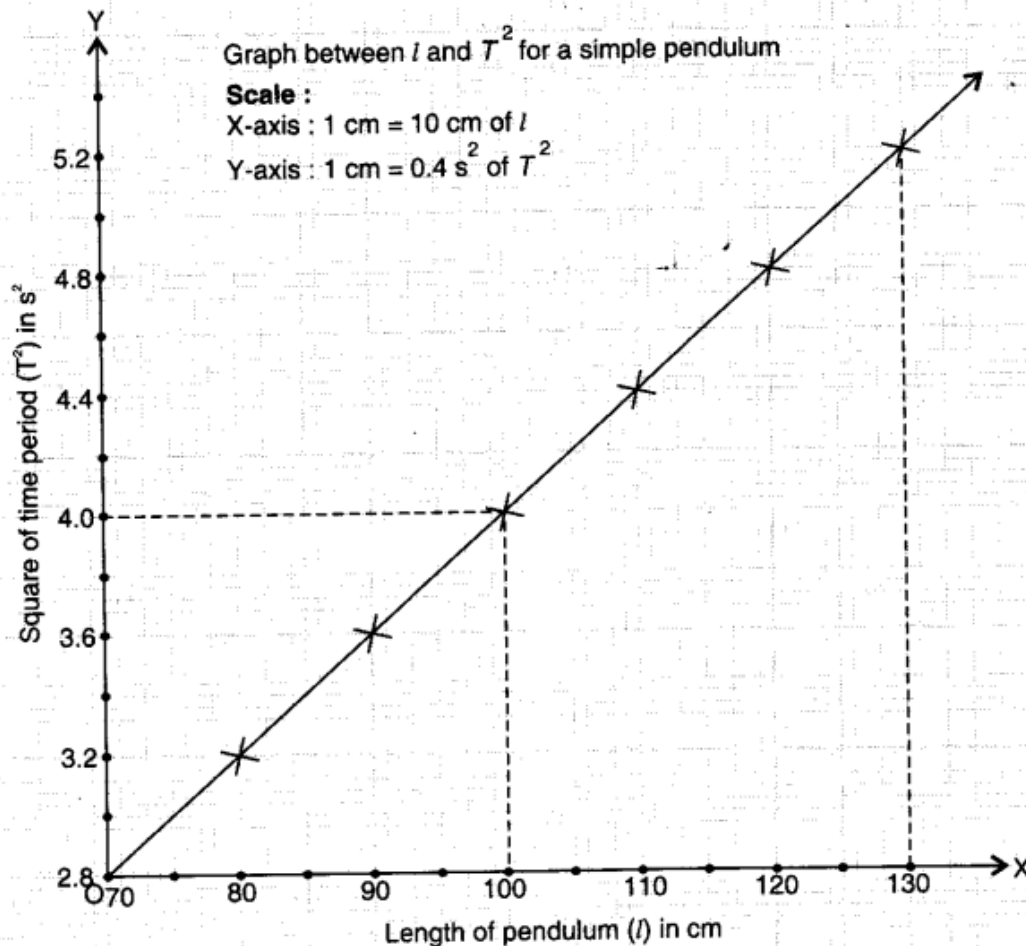


Fig. Graph between l and T^2 for a simple pendulum. It is a straight line.

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 = $0.6/99.4 \times 100 = 0.6\%$

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 $\sin \theta = \theta$. [when $\theta < 18^\circ$]
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 ν , then the string also has same frequency ν .

If the string has a length l , diameter D , material of density ρ and tension T , then

$$\nu = \frac{1}{lD} \sqrt{\frac{T}{\pi\rho}} \quad \dots(1)$$

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

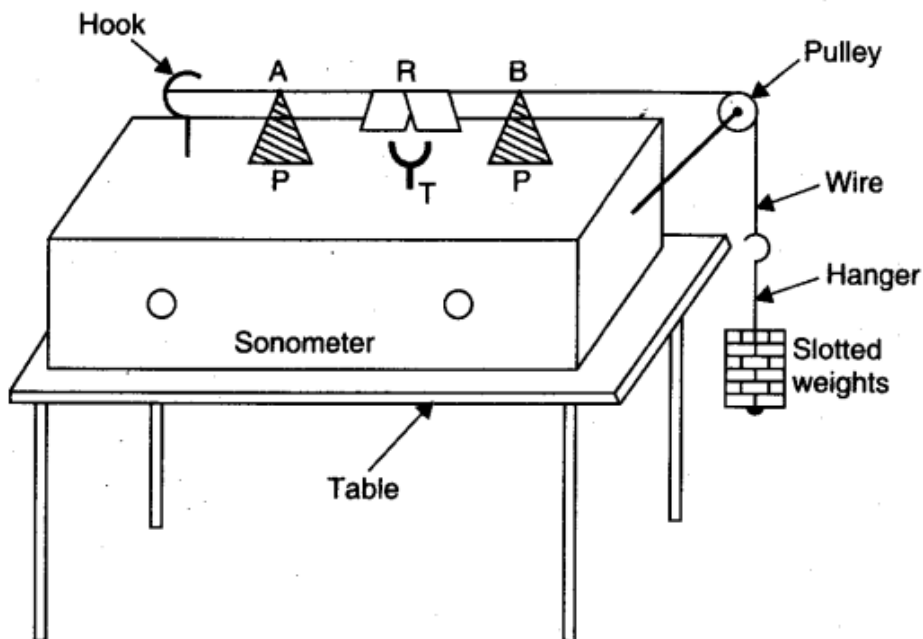


Fig. Sonometer in experimental set up.

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, $T = \dots\dots\dots$ kg.

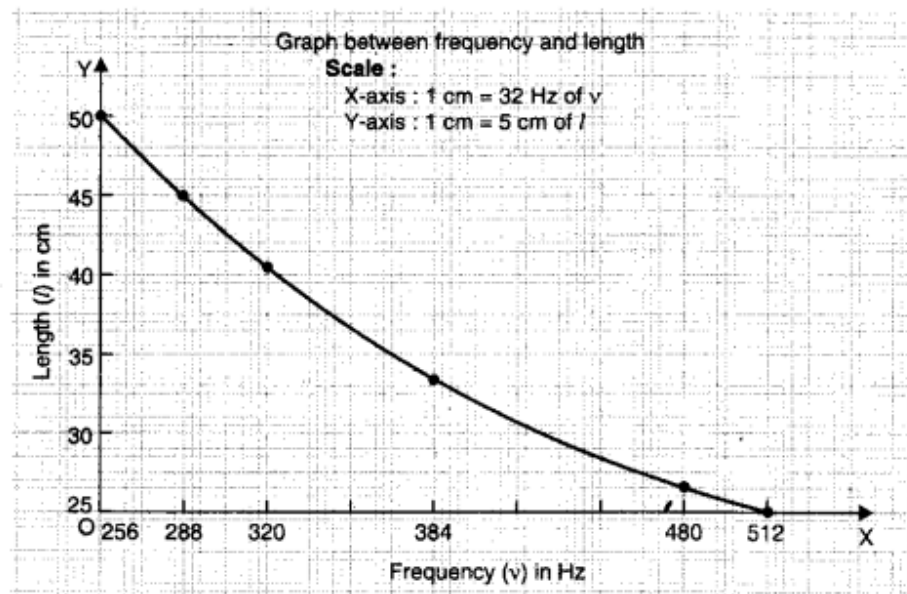
Table for frequency and length

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)

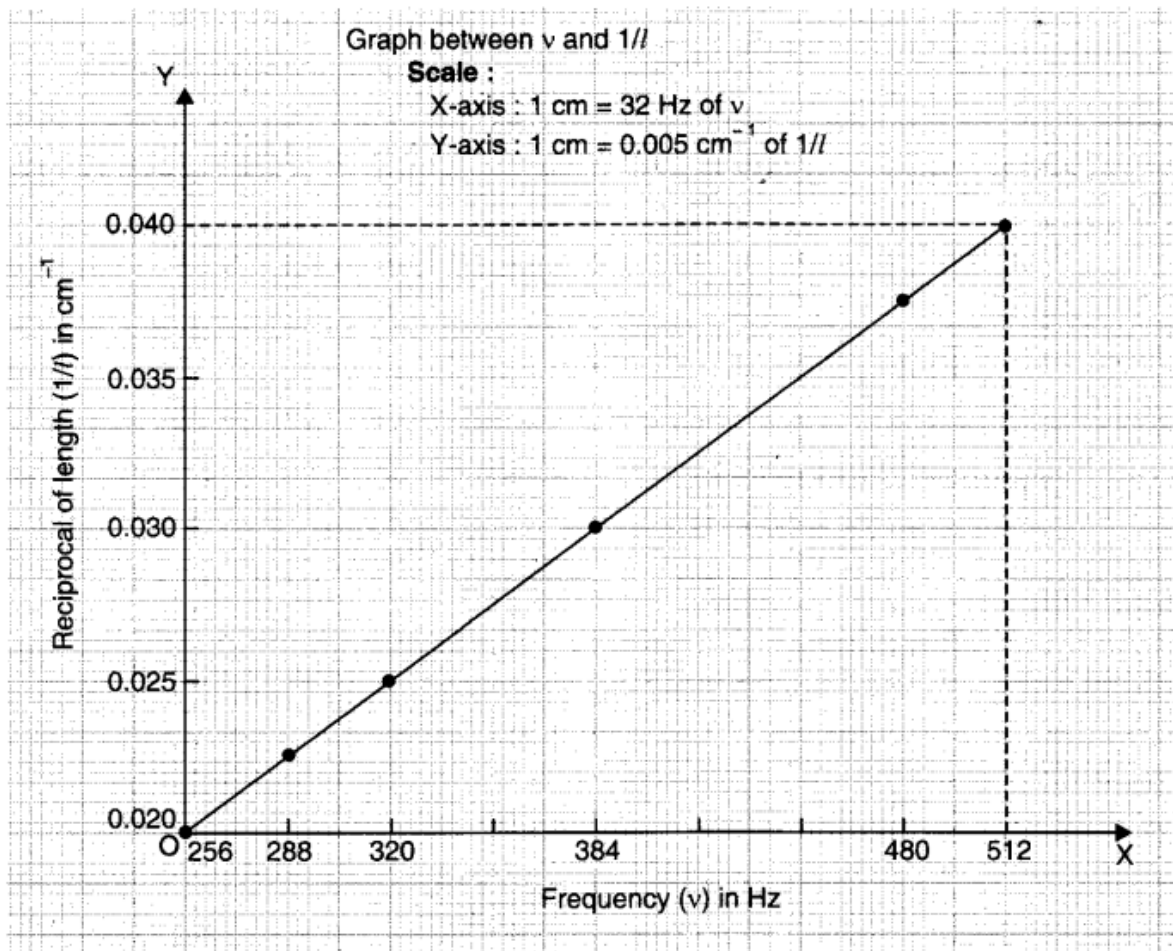
Calculations

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 $\nu l = \text{constant}$ 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 .

$$\delta = \frac{mgl^3}{4Ybd^3}$$

m = Total mass of slotted weights

Y = Young modulus

b = breadth

d = depth

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

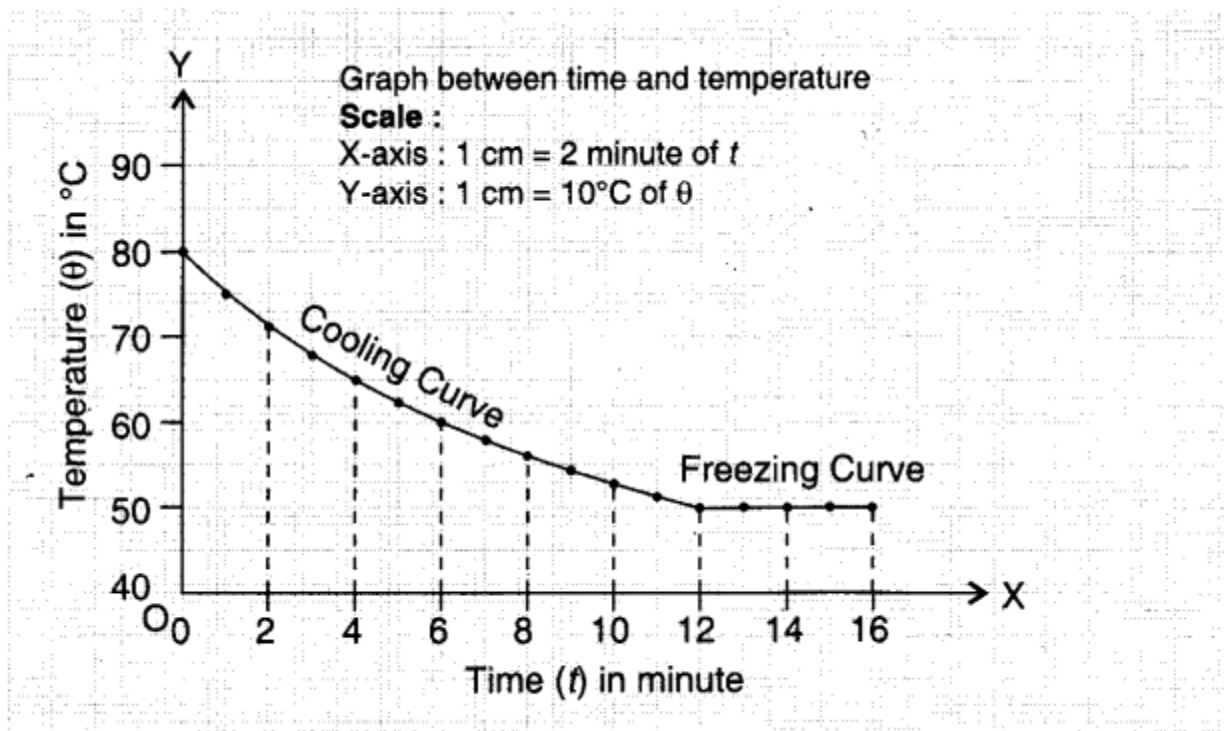
i.e., the depression produced is directly proportional to the load (weight) suspended from one end.

(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 $\theta (^{\circ}C)$
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 θ , taking t along X-axis and θ 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 $50^{\circ}C$ 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, its 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 affects conductivity through walls of the body).

Diagram

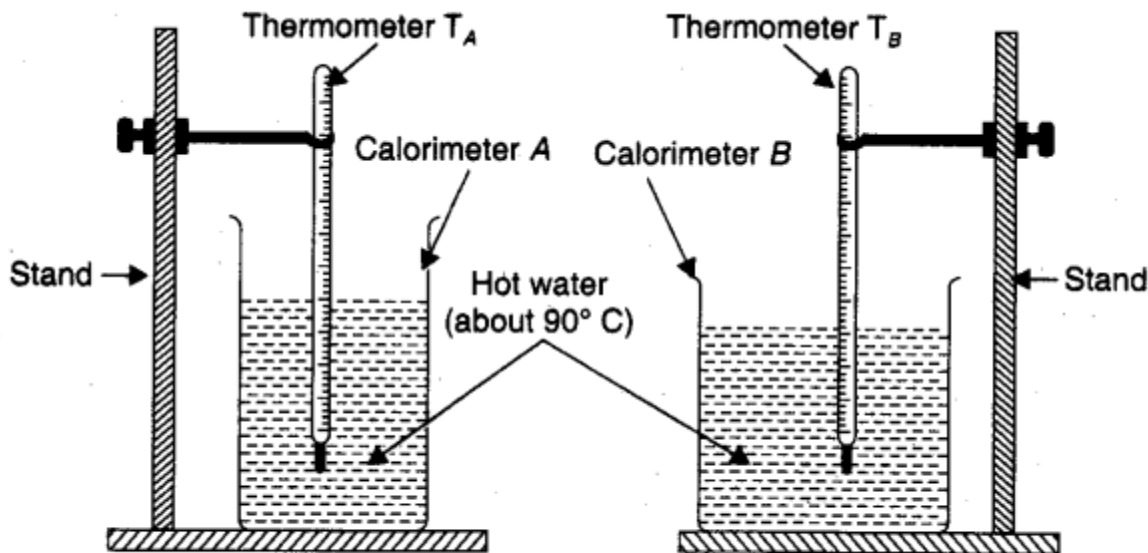


Fig. Studying the effect of area of surface losing heat.

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 (T_0) 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.

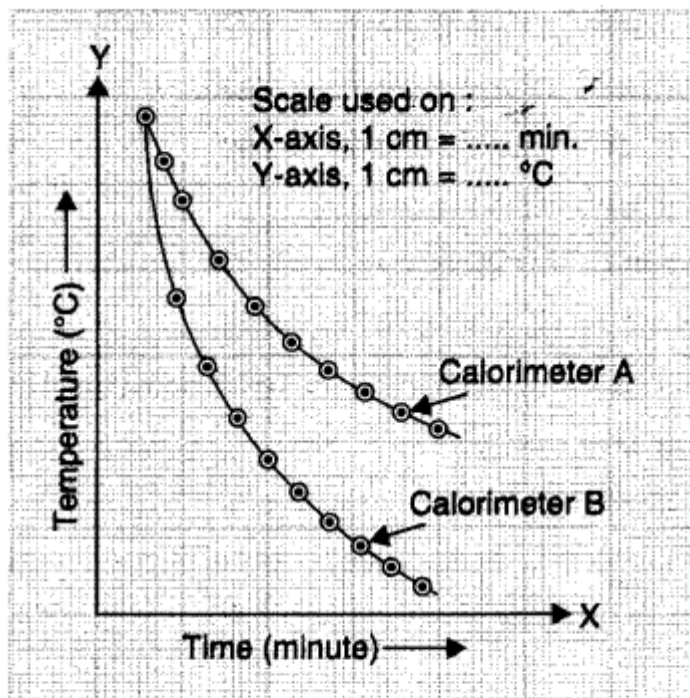
Least count of stop clock/watch =s.

Table for time and temperature

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

(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 rivetted at their ends. The strip is straight at room temperature.

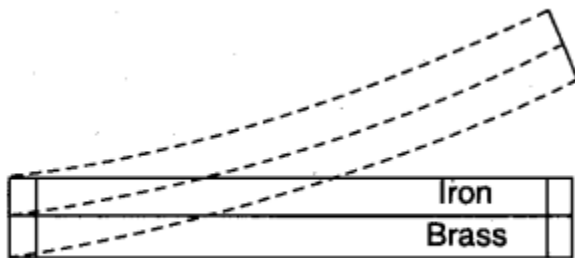


Fig. Bi-metallic strip.

When the bi-metallic strip is heated both bars expand differently. Since they are rivetted 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 $t_1^\circ\text{C}$ and L_2 be the length at $t_2^\circ\text{C}$, 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 $t_1^\circ\text{C}$, their length at higher temperature $t_2^\circ\text{C}$ 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

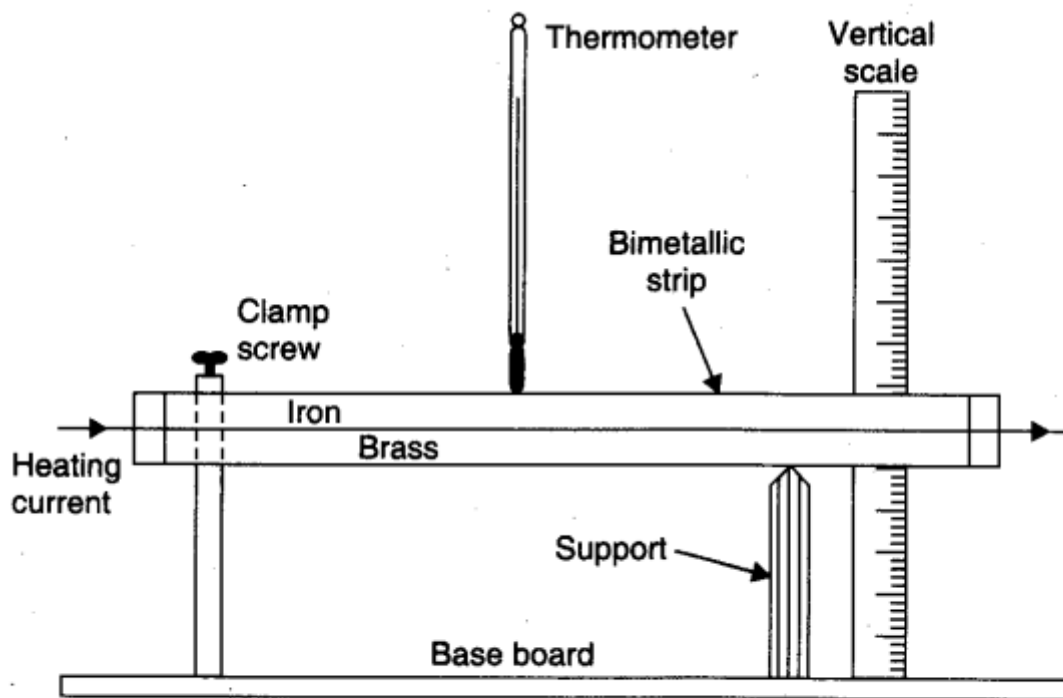


Fig. Bending of a bi-metallic strip.

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 \uparrow 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.