पुणा International School
Shree Swaminarayan Gurukul, Zundal

Class -XI

Physics Practical

Year- 2020-21

INDEX

Experiment – 1

Aim

To measure internal diameter and depth of a beaker/calorimeter using vernier calipers and hence find its volume.

Materials Required

1. Vernier calipers
2. A cylindrical object like a beaker
3. Magnifying glass

Theory

What is least count?

The least count is defined as the smallest change in the measured quantity which can be resolved on an instrument's scale.

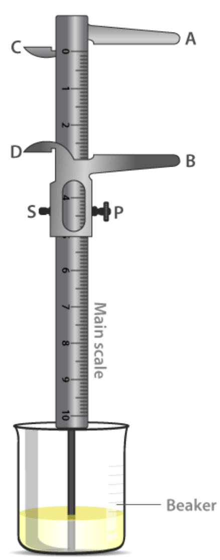
How to calculate least count?

The least count of vernier caliper = Least count of vernier caliper
= fracmagnitudeofthesmallestdivisiononthemainscaletotalnumberofsmalldivisionsonthevernierscale
The formula used to calculate the volume of beaker/calorimeter = internal area of cross-section × depth

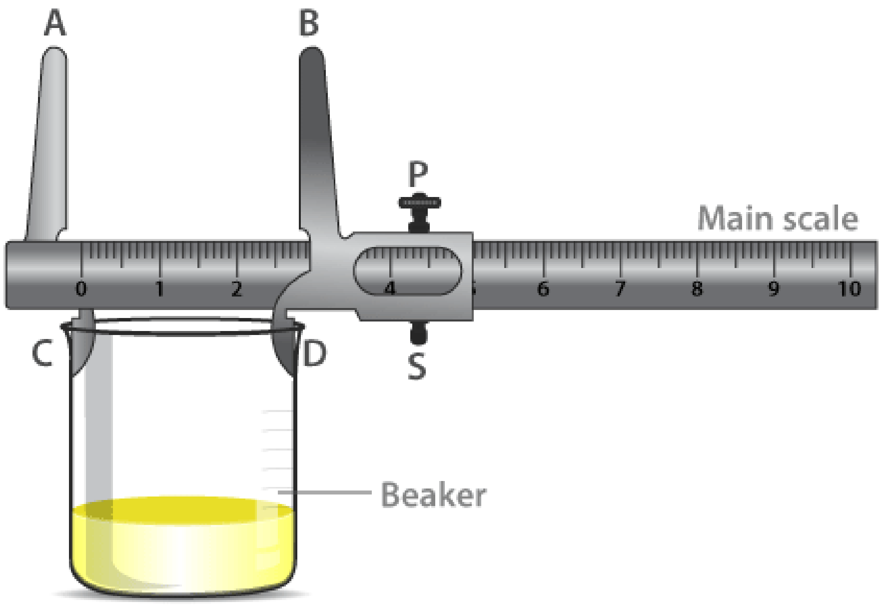
$$V=(D2)2.d$$

Where,

- D is the internal diameter of the beaker/calorimeter
- d is the depth of the beaker/calorimeter



Depth of beaker



Internal diameter of beaker

Procedure

1. Determine and record the least count of the vernier caliper which is also known as the vernier constant.
2. To find the zero error, bring the movable jaw BD in contact with the fixed jaw AC. Repeat and record this three times. If there is no zero error, then record zero error as nil.
3. Now put the jaws C and D inside the beaker and open till they make contact with the inner wall of the beaker without any pressure. Tighten the screw without putting too much of pressure.
4. On the main scale, record the zero mark of the vernier scale. Just before the zero mark of the vernier scale, record the main scale reading which is known as main scale reading (M.S.R).
5. Let n be the number of the vernier scale division which coincides with the main scale division.
6. Rotate the vernier caliper 90° and repeat the steps 4 and 5 for measuring the internal diameter in perpendicular direction.
7. To measure the depth, find the total reading and zero correction.
8. The edge of the main scale of vernier caliper should be placed on the peripheral edge. Care should be taken to make the strip go freely inside the beaker along with its depth.
9. Once the moving jaw of the vernier caliper touches the bottom of the beaker perpendicularly, the screw of the vernier caliper should be tightened.
10. For four different positions along the circumference of the beaker, repeat steps 4 and 5.
11. Find the total reading and also zero correction.
12. For internal diameter, take two different mean values and for depth, take four different values.
13. Calculate the volume using the proper formula and record the same in the result with units.

Observations

1. Determination of the least count of vernier caliper1 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
   The least count of vernier caliper (V.C) = 1 M.S.D – 1 V.S.D = (1-0.9) mm = 0.1 mm = 0.01 cm
2. Zero error = (i)…. cm (ii)…. cm (iii)…..cmMean zero error (e) = …..cm
   Mean zero correction © = -(e) = …….cm
3. Table for internal diameter (D)

Sl. no	Main scale	Vernier scale reading		Total reading	
		No.of vernier division coinciding (n)	Value [n×(V.C)]	Observed D_0=N+n×V.C	Corrected D=D_0+c
1.					D_1=
2.					D_2=
3.					D_3=
4.					D_4=

4. Table for the depth (d)

Sl. no	Position	Main scale reading (N in cm)	Vernier scale reading		Total reading	
			No.of vernier division coinciding (n)	Value [n×(V.C)]	Observed d_0=N+n × (V.C)	Corrected d=d_0+c
1.	at A					d_1=
2.	at B					d_2=
3.	at C					d_3=
4.	at D					d_4=

Calculations

Mean corrected internal diameter,

D=D_1(a)+D_1(b)2=…..cm

Mean corrected depth,

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

Volume of the beaker,

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

Result

The volume of the beaker is …….cm^3.

Precautions

1. Apply machine oil or grease to make the vernier scale slide smoothly over the main scale.
2. To avoid the damage to threads, do not exert more pressure on the vernier screw.
3. To avoid errors due to parallax, keep the eye directly over the division mark.
4. The significant figures and units used in observations must be correct.

Sources of Error

1. Not accounting for the zero error in the instrument.
2. Avoid gaps and undue pressure with respect to the placing of vernier calipers.

Experiment – 2

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

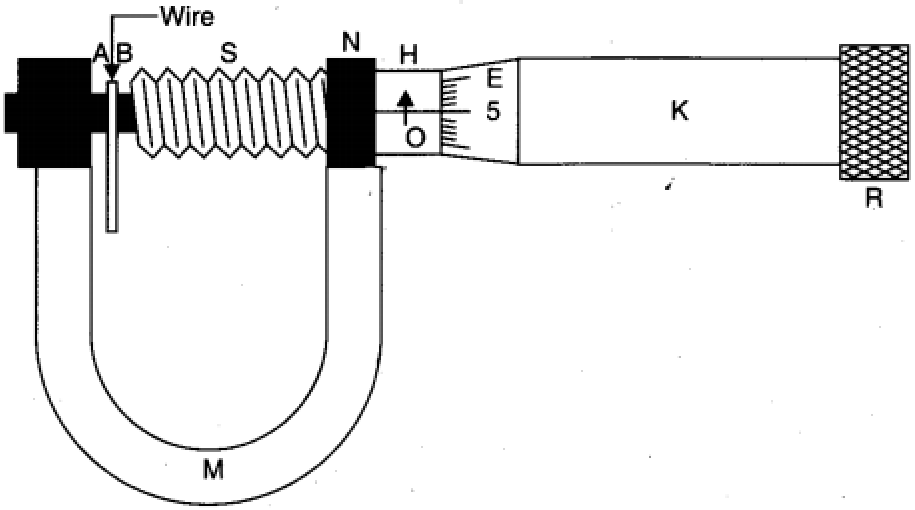


Fig. Screw gauge measuring diameter of the wire.

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.
2. Zero Error. (i)…….mm,(ii)…… mm, (iii)…….mm.
   Mean zero error (e) =……..mm
   Mean zero correction (c) = – e =……mm.
3. Table for diameter (D)

Serial No. of Observations	*Linear Scale Reading (N) (mm)*	*Circular Scale Reading*		*Total Reading*	
		No. of Circular Scale division on reference line (n)	*Value $[n \times (L.C.)]$ (mm)*	*Observed $D_0 = N + n \times (L.C.)$ (mm)*	*Corrected $D = D_0 + c$ (mm)*
1 (a) A Θ B					$D_1(a) =$
1 (b) ①					$D_1(b) =$
2 (a) A Θ B					$D_2(a) =$
2 (b) ①					$D_2(b) =$
3 (a) A Θ B					$D_3(a) =$
3 (b) ①					$D_3(b) =$

Calculations

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

Mean diameter of the wire,

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

Mean length of the wire,

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

Volume of the wire,

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

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 – 3

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

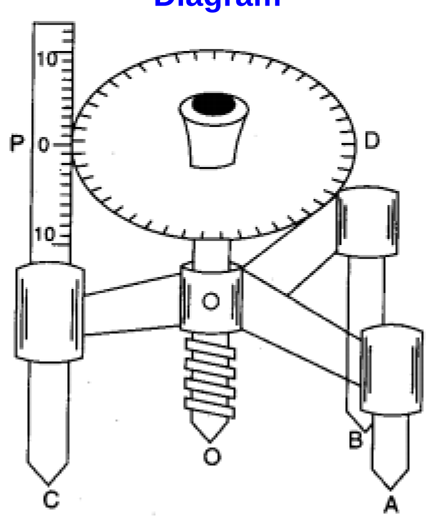


Fig. 2.14. Spherometer.

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

$$AB = \text{.......} \text{ cm}$$
$$BC = \text{......} \text{ cm}$$
$$AC = \text{......} \text{ cm}$$

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

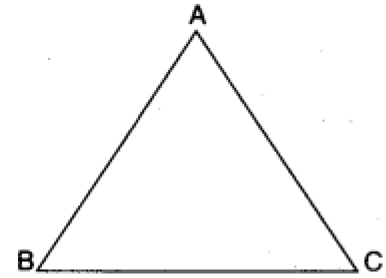


Fig. Distance between the two legs of the spherometer.

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, $p = \dfrac{5 \text{ mm}}{5} = 1 \text{ mm}$

Number of divisions on circular (disc) scale = 100

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

$= 0.01$ mm

$= 0.001$ cm.

3. Table for Sagitta (h)

Serial No. of Obser-vations	*Circular (Disc) Scale Reading*		*Number of complete rotations on plane glass sheet (n_1)*	*No. of Disc scale divisions in incomplete rotation $x = (a - b)$ or $(100 + a) - b$*	*Total Reading $h = n_1 \times p + x \times (L.C.)$ (mm)*
	On convex surface Initial (a)	*On plane glass sheet Final (b)*			
1. 2. 3.					$h_1 =$ $h_2 =$ $h_3 =$

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

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

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

3. Calculate

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

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

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 – 4

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

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

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

Diagram

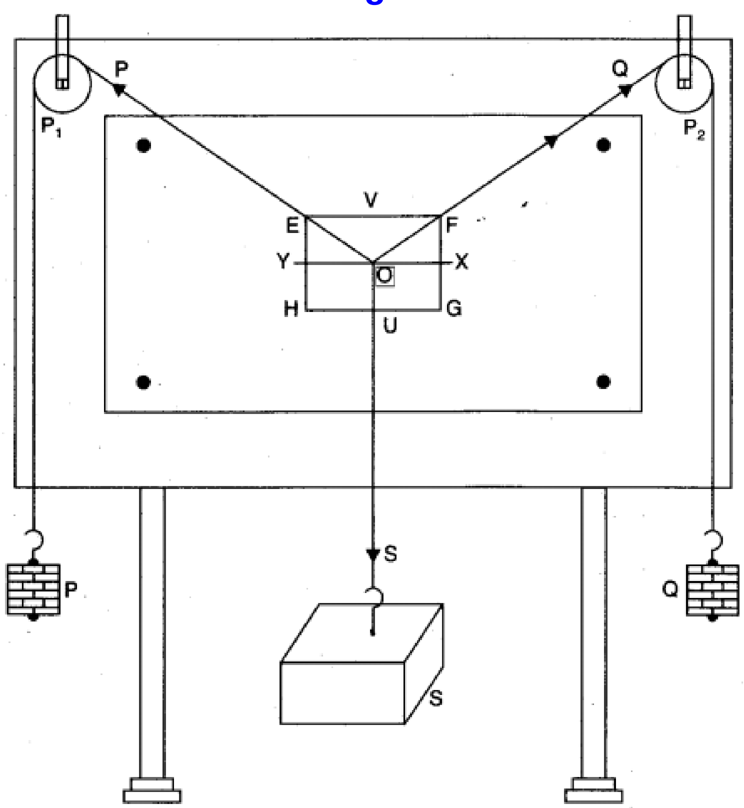


Fig. Gravesand's apparatus.

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.

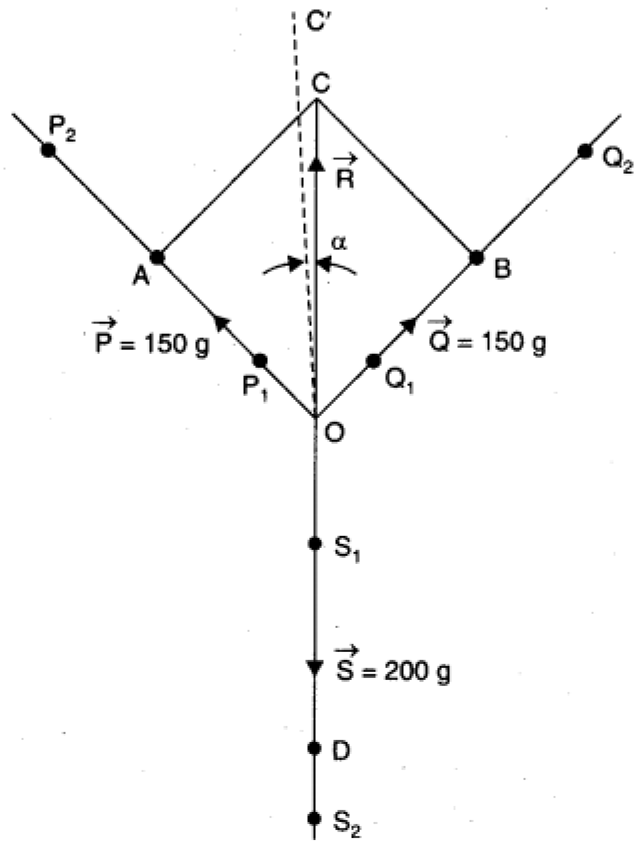


Fig. Determination of weight of a wooden block.

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.

Experiment – 5

Aim

To study variation of time period of a simple pendulum of a given length by taking bobs of same size but different masses and interpret the result.

Apparatus

A clamp with stand, a split cork, thread, vernier callipers, stop clock/stopwatch, metre scale and pendulum bobs of different masses.

Theory

1. Simple Pendulum:
2. Length of Simple Pendulum:
3. The time period is given by the formula,

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

For the given value of length of simple pendulum (as explained above) and gravitational acceleration at the place of experiment, the time period of the simple pendulum can be calculated by the above formula.

4. Time period of simple pendulum is independent of its mass. The time period of simple pendulum is given by the above formula. It clearly indicates that $T \propto \sqrt{l}$ and $T \propto \frac{1}{\sqrt{g}}$ but it is independent of mass of the simple pendulum i.e., for the same value of l and g, the time period for two bobs of different masses will be same.

Procedure

To check the effect of bobs of different masses on time period

(i) Choose any three bobs of known masses and determine their radii as in Experiment 1A

(ii) Now, arrange the experiment set up for first bob (say mass m_1) with any effective length of simple pendulum (say 100.00 cm) as explained in Experiment 7

(iii) Obtain the average time taken for 20 oscillations by the simple pendulum by performing the steps 12 to 18 as explained in Experiment 7

(iv) Repeat the steps (ii) and (iii) for second bob (say mass m_2) with the same effective length 100.00 cm [Note: Here you should adjust the length of the thread to set effective length 100.00 cm because of change in radius of the new bob as compared to the first bob].

(v) Now, finally repeat the steps (ii) and (iii) for third bob (say mas m_3) with the same effective length

100.00 cm.

(vi) Calculate the time periods for each bob and mention them in the table given below.

Observations

S. No.	Bob No.	Radius of bob	Effective length of simple pendulum $l = (i + h + r)$ cm	Time taken for 20 oscillation, t(s)				Period of oscillation $T = t/20$ (in second)
				t_1 (second)	t_2 (second)	t_3 (second)	Average t (second)	
1	First bob with mass $m_1 = \ldots$ gram	$r_1 = \ldots$ cm		39.7	40.5	39.8	40.0	2.00
2	Second bob with mass $m_2 = \ldots$ gram	$r_2 = \ldots$ cm	100.00*	40.4	40.2	39.4	40.0	2.00
3	Third bob with mass $m_3 = \ldots$ gram	$r_3 = \ldots$ cm		39.6	40.4	40.0	40.0	2.00

Calculations

Average time for 20 vibrations may be calculated as:

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

Then calculate the time period T = t/20 second and finally write in the table.

Experiment – 6

Aim

To study the relationship between force of limiting friction and normal reaction and to find the co-efficient of friction between a block and a horizontal surface.

Apparatus

Wooden block (with a hook on one side), 50 g or 20 g weights, horizontal plane (table top) fitted with a friction less pulley at one end, pan, spring balance, thread, spirit level.

Theory

Sliding friction. It is the friction between two surfaces of the bodies in sliding motion. Force of sliding friction. It is the least force required to make a body start sliding over a surface.

Force of friction $F \propto R$

$$F = \mu R$$

where μ = co-efficient of friction, R is the normal reaction.

At equilibrium, $F = P + p$

and $R = W + w$

Diagram

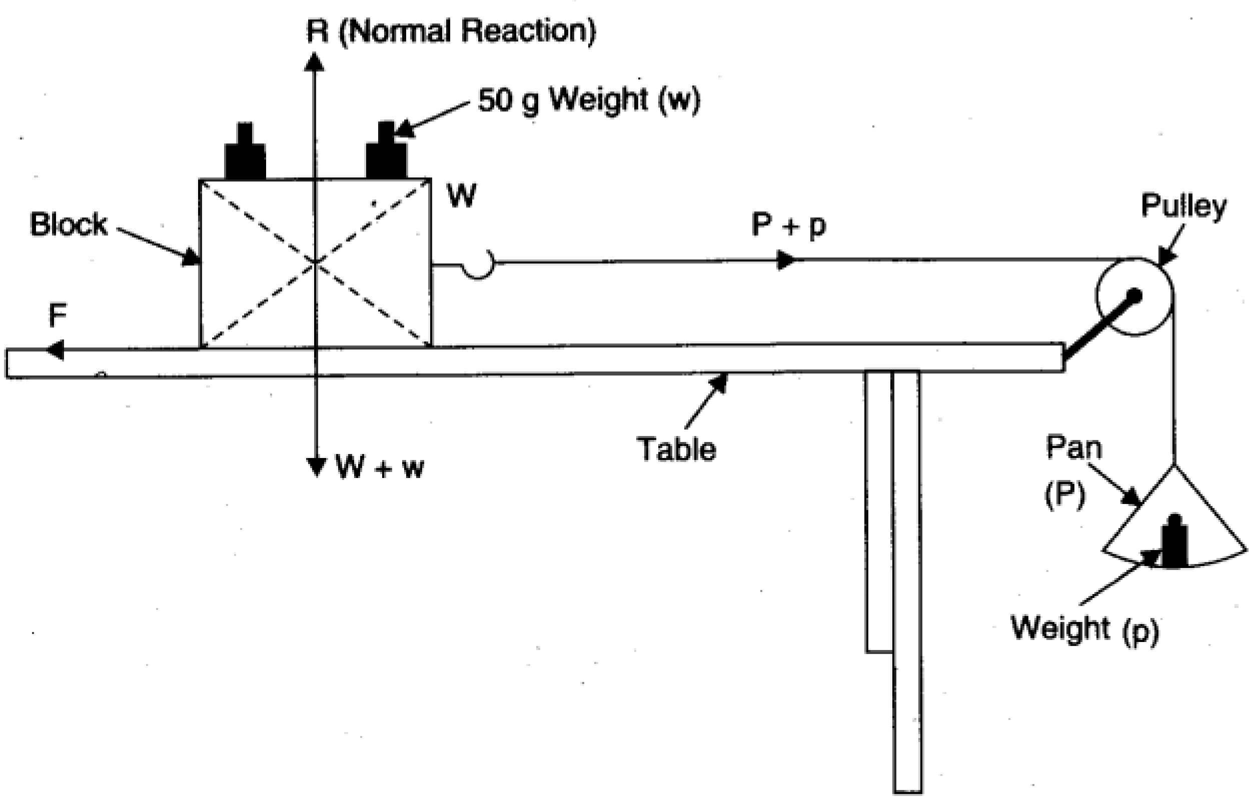


Fig. Study for force of sliding friction.

Procedure

1. Clean the horizontal table top and check the pulley to see that it is friction less (oil if necessary).
2. Weigh the wooden block and put it on the table top. (Check horizontality of table top by spirit level.)
3. Tie one end of a thread with the hook of the wooden block and pass it over the pulley. (The thread must be horizontal).
4. Find the weight of the pan.
5. Tie other free end of the thread with the pan and let the pan hang vertical. (The pan will pull the wooden block horizontally by a force equal to its weight).
6. Since the pan itself does not pull the block, put some weights in the pan (from weight box).
7. Tap the table top to make the block just slide.
8. Increase weights in pan little by little, till the block just starts sliding on tapping the table top.
9. Note the total weights put in the pan then record them in observation table (sum of weight of pan and weights in pan gives the force of sliding friction.)
10. Put one 50 g or 20 g weight over the wooden block and repeat steps 8 and 9.
11. Repeat steps 8, 9, 10, six times. Every time increase weight by 50 g or 20 g.
12. Record the observations in tabular form as given ahead.

Observations

Weight of wooden block, W = ………….gwt

Weight of pan, P = …………g wt.

Table for additional weights

Serial No. of Obs.	*Weights on wooden block (w) (g wt)*	*Total weight being pulled (W + w) (g wt) = Normal reaction (R) (g wt)*	*Weight on pan (p) (g wt)*	*Total weight (force) pulling the block and weights (P + p) (g wt) = Limiting friction (F) (g wt)*
1.	...	...	...	...
2.	...	...	...	...
3.	...	...	...	...
4.	...	...	...	...
5.	...	...	...	...
6.	...	...	...	...
7.	...	...	...	...

Calculations

Total weight (force) pulling the block and weights gives the value of force of sliding friction.

On horizontal surface, total weights being pulled give normal reaction R. Total weight (force) pulling these weights gives dynamic friction F.

Plot a graph between normal reaction R and limiting friction F, taking R along X-axis and F along Y-axis.

The graph comes to be a straight line as shown below.

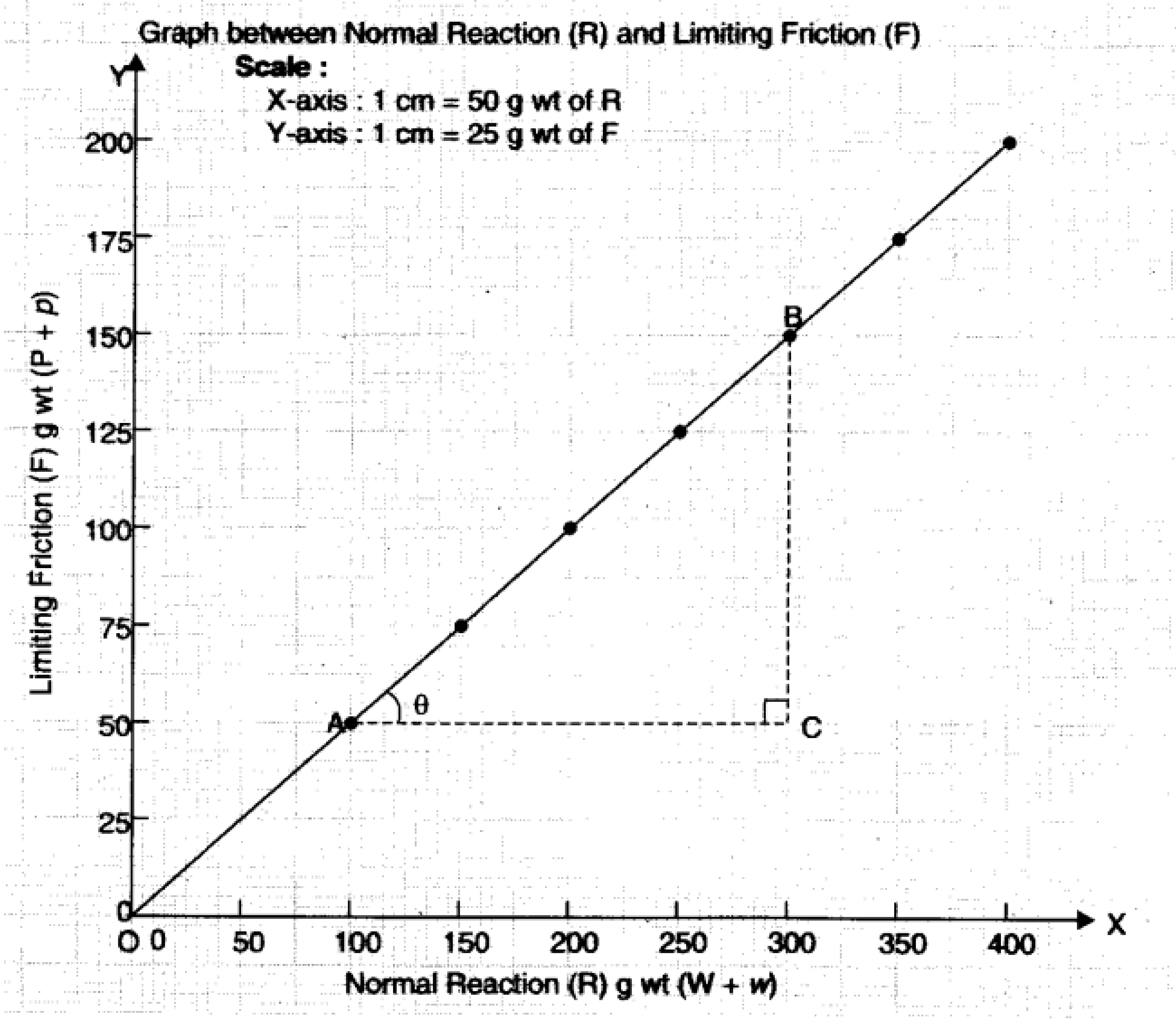


Fig. Graph between R and F.

Result

It is found that as the total weight pulled increases, force of limiting friction also in-creases. The increase is in direct proportion.

The graph shows that limiting friction F is directly proportional to the normal reaction R. It is an agreement with law of limiting friction. (This experiment may be taken as a verification of the law).

The constant ratio FIR, is called coefficient of friction (p). It can be calculated by finding slope of the graph.

In ΔABC

Slope of straight line $AB = \tan\theta = \frac{BC}{AC} = \frac{F}{R} = \frac{150-50}{300-100}$

$$\tan\theta = \frac{F}{R} = \frac{100}{200} = \frac{1}{2} = 0.5$$

But, $F = \mu R$

$$\frac{F}{R} = \mu$$

From equation (1) and (2)

$$\mu = \tan\theta = 0.5$$

$$\mu = 0.5.$$

Precautions

1. The surface (table top) should be horizontal.
2. The thread part between block and pulley should be horizontal.
3. Weight in pan should be increased in small steps and pan should not oscillate or rotate.
4. Table top should be tapped gently each time.
5. Pulley should be friction less.

Sources of error

1. The table top may not be horizontal.
2. The thread part between block and pulley may not be horizontal.
3. Pulley may not be friction less

Experiment – 7

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

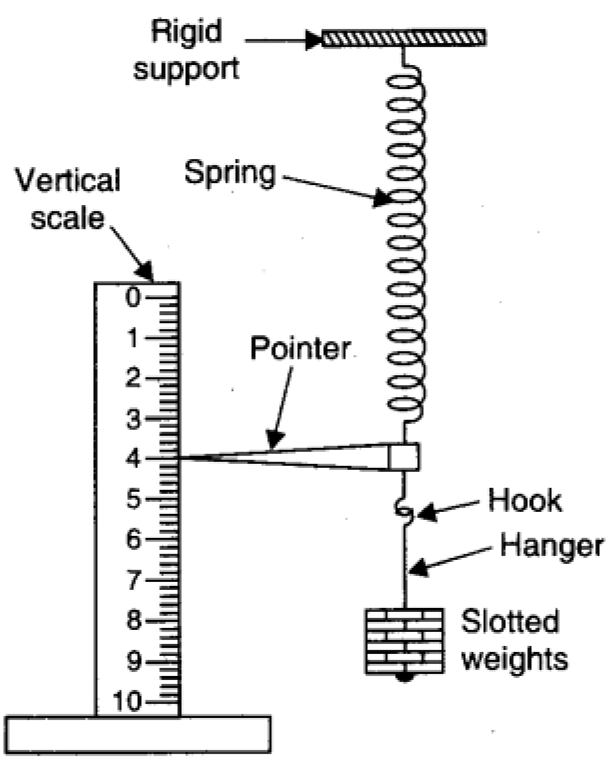


Fig. Extension of spring.

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.

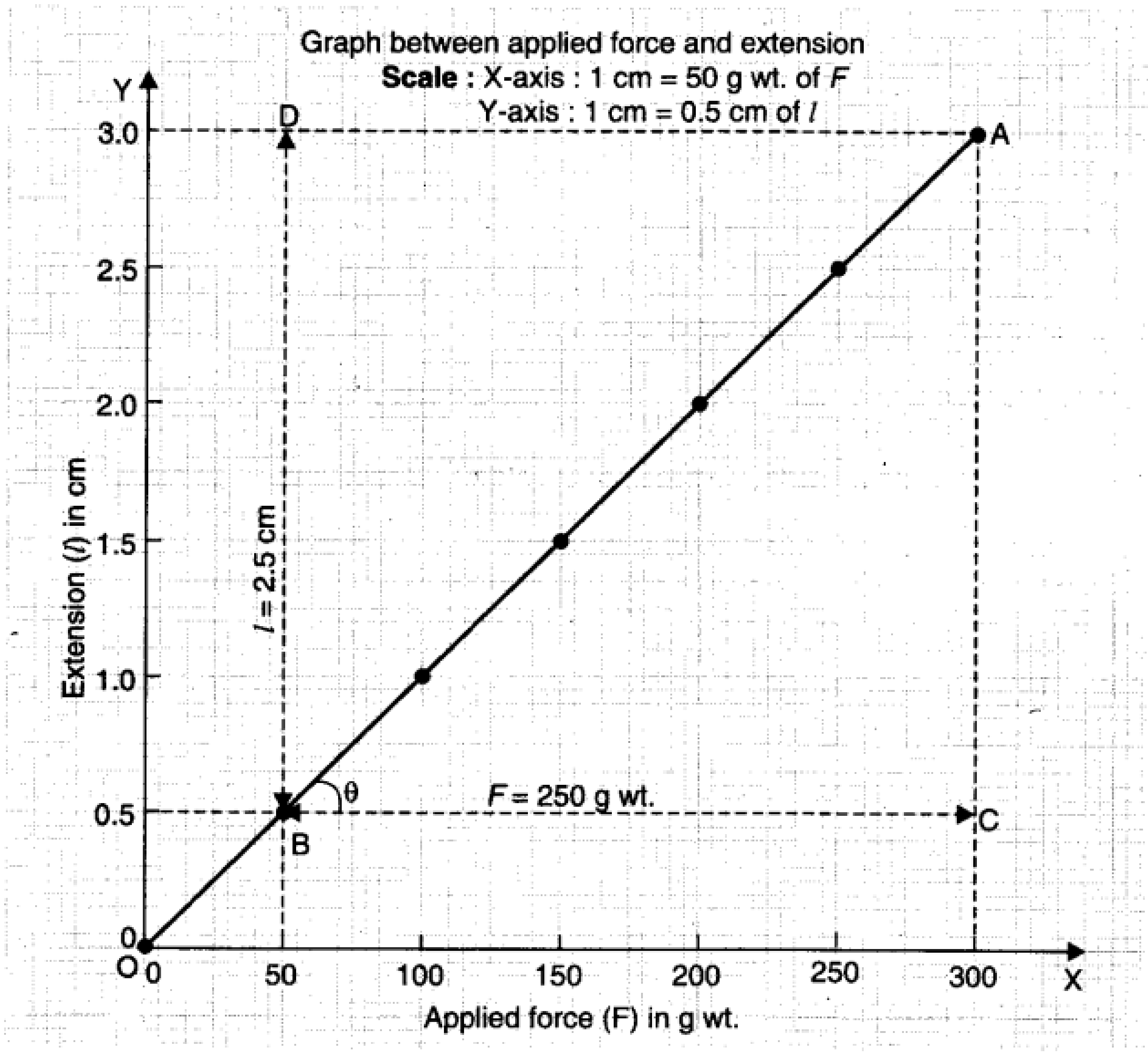


Fig. Graph between F and l. It is a straight line.

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 – 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

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

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

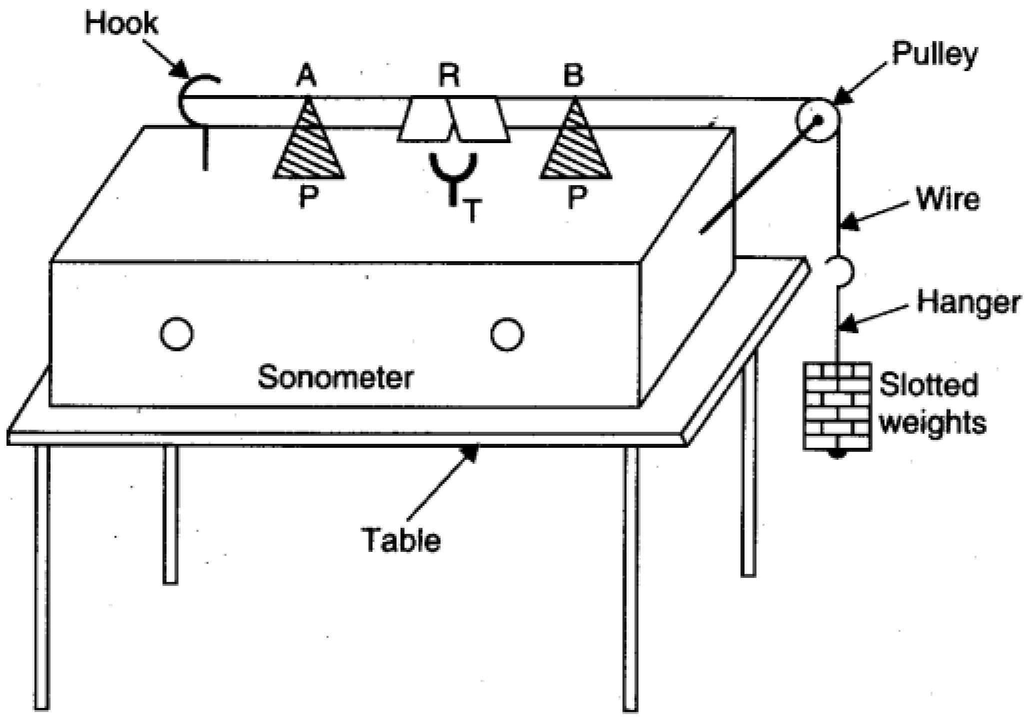


Fig. Sonometer in experimental set up.

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.

Table for frequency and length

Serial No. of Obs.	Frequency of tuning fork used v (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				

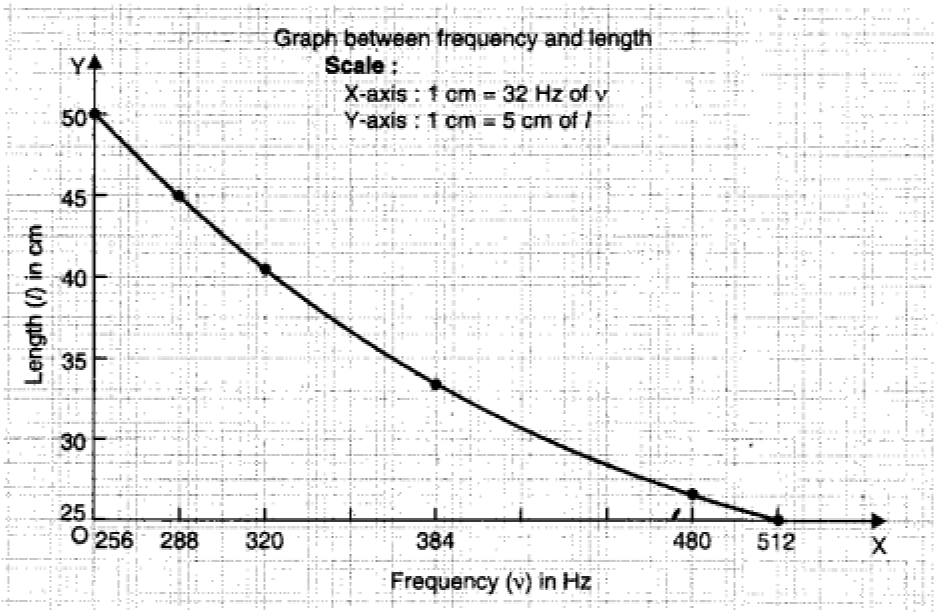
(**Note.** *Observation 1 is as sample*)

Calculations

1. Find mean length l.

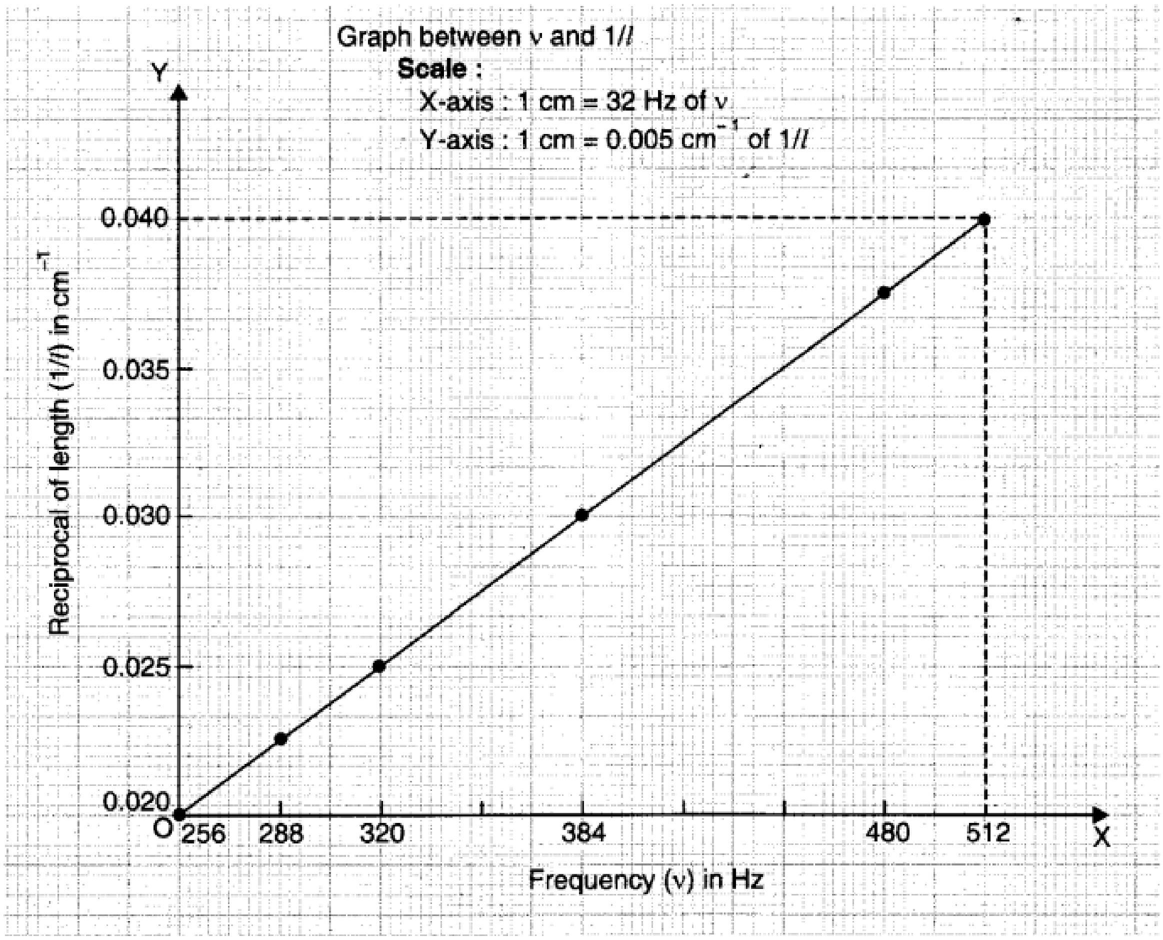
2. Find $\frac{1}{l}$.

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 νl = constant and $\nu \propto \frac{1}{l}$.

This verifies law of length of transverse vibrations of strings.