PART – A (Experiments 1 to 11 and Activities 1 to 7)

Experiment No. – 1

Aim of the Experiment: -

To measure the diameter of a small spherical/cylindrical body with a vernier calipers.

Theoretical Concept: -

A vernier caliper is a device used for the measurement of length, thickness and depth of the given solid bodies. It consists of two scales- the scale fixed at one end is called main scale while the other scale which is capable of moving is the vernier scale.

Parameters related to Vernier Callipers:

1. Vernier constant = 1 M.S.D (Main Scale Division) – 1 V.S.D (Vernier Scale Division)

2. Zero Error: If the zero of the vernier scale does not coincide with the zero of the main scale, the vernier caliper is said to have zero error. To calculate the zero error, note down the number (n) of vernier scale division that coincides with the main scale.

Zero Error = (n × Vernier Constant)

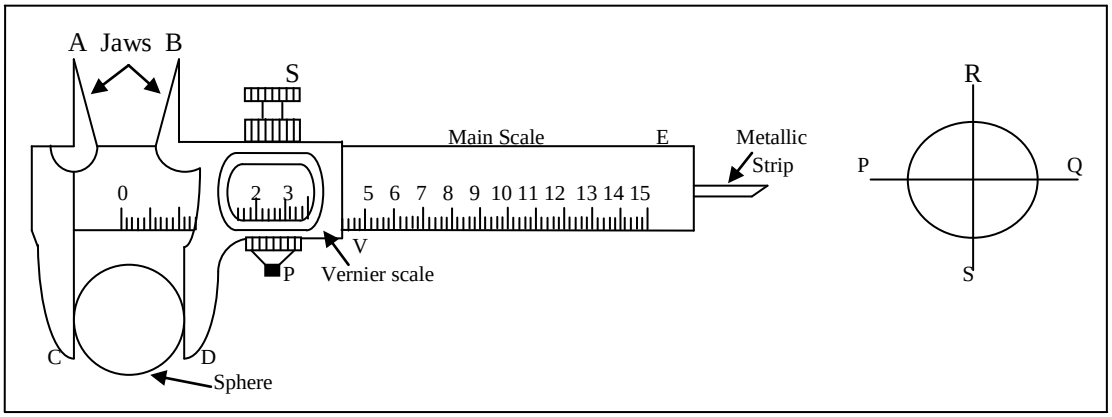
3. Zero Correction = - (Zero Error)

4. Final reading = x + n × Vernier Constant where 'x' is the main scale reading.

Apparatus & Material Required: -

Vernier Calliper, a solid sphere and a solid cylindrical body.

Circuit Diagram: -



Procedure: -

1) Calculate the least count (Vernier constant) of vernier calipers.
2) The method of calculating the least count / vernier constant is mentioned in the mathematical analysis and observation.
3) Find the zero error and note it down.
4) Place the given body diameter wise between the jaws of vernier calipers and adjust the movable scale to gently grip the body. Fix the screws of the vernier caliper in this position.
5) Note the main scale reading and the vernier scale division coinciding with the main scale readings.

Final Reading (y cms) = Main scale Reading (x cms) + No. of Division Coinciding (n) × V.C

6) Loosen the screws, remove the given body and place it again diameter wise but this time the direction should be perpendicular to the previous direction.
7) Repeat step No. 5 and again note down the readings.
8) Repeat the complete steps and find the diameter with zero error correction.

Mathematical Analysis & Observations: -

Let us suppose that (n-1) smallest main scale division coincide with 'n' smallest division of the vernier scale i.e.

$$n \text{ V.S.D} = (n-1) \text{ M.S.D}$$
$$1 \text{ V.S.D} = \left(\frac{n-1}{n}\right) \text{M.S.D}$$
$$\text{LC} = 1 \text{ M.S.D} - 1 \text{ V.S.D}$$
$$= \left[1 - \left(\frac{n-1}{n}\right)\right] \text{M.S.D}$$
$$\text{LC (Least Count) or VC (Vernier Constant)} = \frac{1}{n} \text{M.S.D}$$

Generally, for Vernier Callipers

$$10 \text{ V.S.D} = 9 \text{ M.S.D}$$
$$1 \text{ V.S.D} = \frac{9}{10} \text{M.S.D}$$
$$\text{LC} = 1 \text{ M.S.D} - 1 \text{ V.S.D} = \left(1 - \frac{9}{10}\right) \text{M.S.D} = \frac{1}{10} \text{M.S.D}$$
$$1 \text{ M.S.D} = 1\text{mm} = \frac{1}{10} \text{ cm}$$
$$\frac{VC}{LC} = \frac{1}{10} \times \frac{1}{10} \text{ cm} = 0.01 \text{ cm}$$

S. No.	First direction			Mutually perpendicular direction			Mean observed diameter (in cm) $\left(\frac{y+y'}{2}\right)$
	Main scale Reading (m)	No. of vernier division coinciding (n)	Observed diameter $y = m + n(V.C)$	Main scale Reading (m')	No. of vernier division Coinciding (n')	Observed diameter $y' = m' + n'(V.C)$	
1.							
2.							
3.							
4.							
5.							

Final mean observed diameter (d) = _____ cm.
Corrected diameter = D = d – (zero error with its proper sign)

Result: -

1) The diameter of a given spherical / cylindrical body = ____cm.

Precautions:-

1) The jaws should not be pressed too hard.

2) For measurement of diameter two mutually perpendicular directions should be used.
3) Apply the zero correction.
4) To avoid the parallax error, read the vernier calipers by keeping the eye vertically above it.

Experiment No. – 2

Aim of the experiment: -

To measure dimensions of a given rectangular body of known mass and hence fins its density.

Theoretical Concept: -

The concept and parameters for this experiment are same as we have discussed in the previous experiment. Some of the additional points are mentioned below:

1. Volume of rectangular block

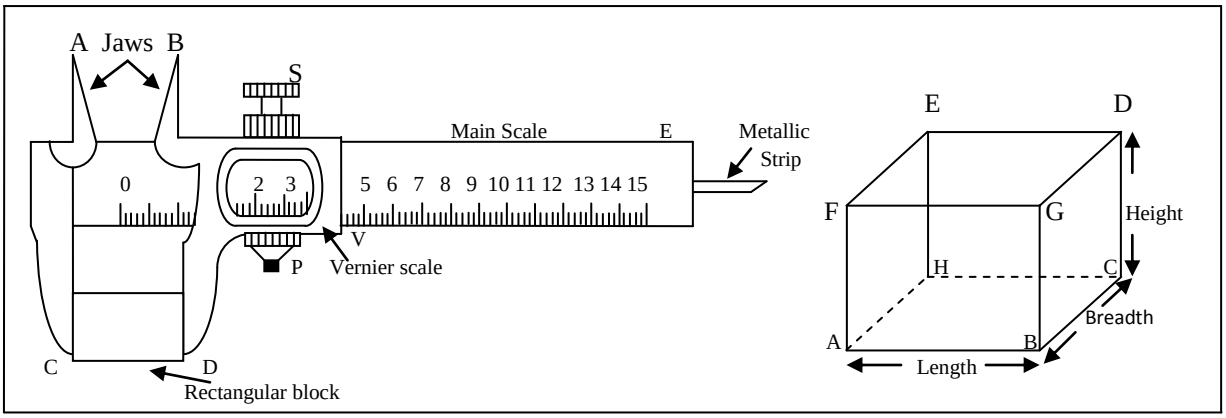
$$V = \text{length} \times \text{breadth} \times \text{height}$$

2. Density $= \frac{Mass}{Volume}$ $\quad \rho' = \frac{m}{V}$ where 'm' is mass and 'V' is volume

Apparatus and Material Required: -

Vernier calipers and a small rectangular block of known mass.

Circuit Diagram: -



Procedure: -

1) Calculate the least count and zero error of vernier calipers as we have done in the previous experiment.
2) Calculate the length, breadth and thickness (height) of the block by putting the block lengthwise, breadth wise and height wise between the jaws of the callipers as shown in the diagram.
3) Note down the readings of each dimension and apply zero correction.
4) Calculate the mean of each of the dimension.
5) Calculate the volume and finally the density of the block with the help of known mass.

Mathematical Analysis & Observations: -

1) Table for measurement of length.

S.No.	Side	Main scale reading N (cm)	Vernier scale reading (n×V.C)	Final Reading	
				Observed l = N + n × V.C	Corrected l'= l + e (e = zero error)
1.	AB				
2.	FG				
3.	ED				

2) Table for measurement of breadth

S.No.	Side	Main scale reading N (cm)	Vernier scale reading (n×V.C)	Final Reading	
				Observed b = N + n × V.C	Corrected b′= b + e (e = zero error)
1.	BC				
2.	GD				
3.	EF				

3) Table for measurement of thickness/ height

S.No.	Side	Main scale reading N (cm)	Vernier scale reading (n×V.C)	Final Reading	
				Observed h = N + n × V.C	Corrected h′= h + e (e = zero error)
1.	CD				
2.	BG				
3.	AF				

4) Mean corrected length of the block $l = \frac{l_1+l_2+l_3}{3}$ =_____ cms

5) Mean corrected breadth of the block $b = \frac{b_1+b_2+b_3}{3}$ =_____ cms

6) Mean corrected thickness of the block $h = \frac{h_1+h_2+h_3}{3}$ =_____ cms

7) Volume of the block, $V = l \times b \times h \ \ cm^3$, Volume = _____ cm^3

8) Density of the block $\rho = \frac{m}{V}$ =_____ g/cm^3

Result: -

The density of the given rectangular block comes out to be _____ g/cm^3

Precautions: -

1) The jaws should not be pressed too hard.
2) Apply the zero correction carefully.
3) The dimension to be measured should be held parallel to the main scale.

Experiment No. - 3

Aim of the Experiment: -

To measure the internal diameter and depth of a given beaker or calorimeter by using vernier callipers and find its volume.

Theoretical Concept: -

The parameters are same as we have discussed in the previous experiment. Whereas some additional parameters which are required are discussed below:

Volume of beaker / calorimeter

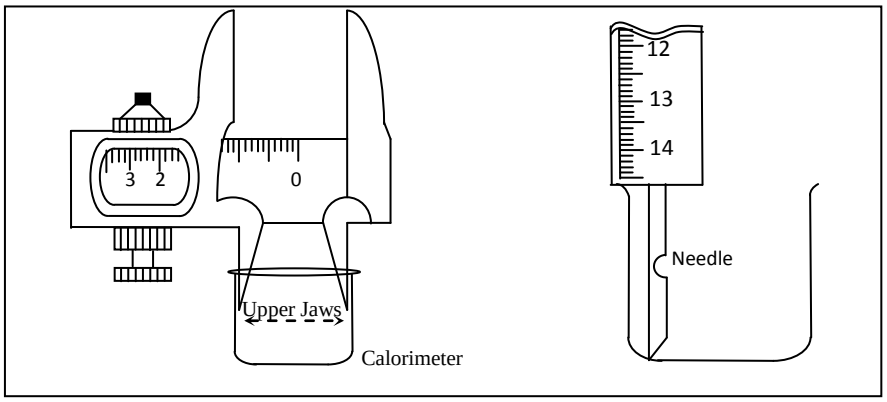
$$V = \pi \left(\frac{D}{2}\right)^2 \times 'd'$$

Where $'D'$ and $'d'$ are internal diameter and the depth of calorimeter.

Apparatus & Material Required: -

The beaker (or calorimeter) and a Vernier Calipers.

Circuit Diagram: -



Procedure: -

1) Calculate the least count (Vernier constant) of Vernier Callipers as discussed in the previous experiment alos calculate and note down the zero error.
2) To calculate the internal diameter of given beaker insert the pair of jaws (which are plane on outer side and curved on inner side as shown in fig) inside the beaker and adjust its position in a way to gently grip the beaker, fix the position of the screw at this point.
3) Note down the final reading of the vernier caliper and apply zero correction.
4) Repeat the same procedure for mutually perpendicular direction and take at least three observations of both the cases and calculate the mean value of the diameter.
5) To calculate the depth, place the smaller flat edge on the vertical wall of the calorimeter so that the thin rod goes inside it.
6) Move the jaw downwards and adjust the screws so that it touches the bottom of the calorimeter. Note down the final reading of the vernier callipers.
7) Repeat the above steps and take at least three readings for the depth and apply the zero correction.
8) Calculate the mean value (final) of the diameter and the internal depth of the beaker.

9) Finally calculate the volume of the beaker.

Mathematical Analysis & Observations: -

Generally, value of Vernier Constant = 0.01 cm

1) Table for internal diameter.

S.No.	Main scale reading (x cms)	No. of vernier division coinciding (n)	Final reading y= x +n (V.C)	Corrected reading y' = y + zero correction
1.				
2.				
3.				
4.				
5.				
6.				

Mean value of internal diameter,

$$D = \frac{y_1' + y_2' + y_3' + y_4' + y_5' + y_6'}{6} =$$_____ cm

2) Table for depth of the beaker.

S.No.	Main scale reading (x cms)	No. of vernier division coinciding (n)	Final reading y= x +n (V.C)	Corrected reading z = y + zero correction
1.				
2.				
3.				

Mean value of depth of the beaker,

$$d = \frac{z_1 + z_2 + z_3}{3} =$$_____ cm

Volume of beaker or calorimeter $= \frac{\pi D^2}{4} . d =$_____ cm^3

Result: -

The volume of beaker or calorimeter comes out to be _____ cm^3

Precautions: -

1) The thin rod should stand vertically in the beaker.
2) The jaws should not be pressed too hard.
3) While measuring the depth of the calorimeter, ensure that when the rod touches the bottom, the smaller edge should remain rested on the calorimeter.

Viva – Voce Questions

Q.1. What is a vernier calipers?
Ans. It is an instrument used to measure small lengths upto 0.01 cm or even smaller then this.
Q.2. Why is a vernier calipers called so?
Ans. It is named after the name of its inventor Pierre Vernier.
Q.3. Define vernier constant?
Ans. It is defined as the difference between one main scale division and one vernier scale division.

Q.4. What is zero error?

Ans. If the zero of the vernier scale doesn't coincide with the zero of the main scale, when the two jaws of the vernier calipers are brought in contact with each other, the vernier calipers is said to possess zero error.

Q.5. Can we measure thickness of piece of paper by using vernier calipers?

Ans. No, because its thickness is less than V.C of calipers.

Q.6. What is the utility of vernier scale?

Ans. It increases the accuracy of measurement.

Q.7. What is the cause of zero error in vernier caliper?

Ans. It is due to wear and tear after long use or is due to some manufacturing fault.

Q.8. What is the function of the jaws projecting on the other side in a vernier calipers?

Ans. These are provided to measure the internal diameter of a calorimeter, a glass tube, etc.

Q.9. What is zero correction? How is it applied?

Ans. The zero correction for an instrument has magnitude same but sign opposite to that of the zero error.
The zero correction is always algebraically added to the observed length.

Q.10. Design a vernier caliper with vernier constant equal to 0.01 cm, if 1 cm of its main scale is divided into 10 equal parts.

Ans. We know, vernier constant $= \frac{1\ M.S.D}{n}$

Or $$n = \frac{1\ M.S.D}{vernier\ constant}$$

Suppose that in the main scale of the vernier calipers, 1 cm has been divided into 10 equal parts i.e.

$$1\ \text{M.S.D} = 0.1\ \text{cm}$$

Since $\text{vernier constant} = 0.01\ \text{cm}$

$$n = \frac{0.1}{0.01} = 10$$

Thus, a vernier caliper, in which 10 vernier divisions coincide with 9 M.S.D and 1 M.S.D is equal to 0.1 cm, will have vernier constant equal to 0.01 cm.

Q.11. A student records a length measurement made by a meter rod as 10.67 cm. Is he correct in taking this observation? Give reasons.

Ans. The least count of a meter scale is 0.1 cm. In other words, a meter rod can measure only upto the first decimal place of a centimeter. Therefore, the student recording the length measurement with the metre rod as 10.67 cm is not correct in his measurement.

Q.12. Define density. Give its SI unit. Also give the density of water, ice and mercury in SI.

Ans. It is defined as mass per unit volume of a substance. SI unit is kg m^{-3}.
Density of water, ice and mercury are 1,000 kg m^{-3}, 930 kg m^{-3} and 13,600 kg m^{-3} respectively.

Q.13. Is there any difference between relative density and specific gravity of a substance?

Ans. Both relative density and specific gravity of a substance have the same meaning.

Q.14. Are the two terms- density and relative density of a substance have the same meanings?

Ans. No, the two terms are quite different in their meanings. The density of a substance is the mass of a substance per unit volume. It is a dimensional quantity and has units. On the other hand, the relative density of a substance gives the quantitative idea of how many times it is heavier than another given substance. It is dimensionless quantity and has no units.

Q.15. Is the value of density of a substance same in all the systems of units?

Ans. No, it is different in different systems of units. For, e.g density of water is 1 g cm^{-3} in c.g.s system and 1,000 kg m^{-3} in SI.

Experiment No. - 4

Aim of the Experiment: -

To measure the diameter of a given wire using a screw gauge and calculate its volume.

Theoretical Concept:-

Screw gauge is a 'U' shaped instrument that can measure length accurately upto $\frac{1}{100} th$ of a millimeter or even lesser depending upon the construction of the device.

Parameters related to screw gauge:

1) Pitch: It is defined as the linear distance moved by its screw, when one complete rotation is given to it.
Screw gauge consists of a reference line, circular scale shown in the diagram.

2) Least count: It is defined as the ratio of pitch of the screw to the total no. of divisions on the circular scale. Its value is generally 0.01 mm.

3) Zero error: If the zero of the main scale coincides with the zero of the circular scale then there will be no zero error, however if the zero of the circular scale is below the reference line then zero error is positive otherwise it is negative.

4) Zero correction: It is negative of the zero error.

$$\text{Pitch} = \frac{\text{distance moved by the screw}}{\text{number of rotations given to the screw}}$$

$$\text{Least Count} = \frac{\text{Pitch}}{\text{total number of divisions on circular scale}}$$

5) Final reading of the screw gauge:

$$D' = x + x \times least\ count$$

Where 'x' is the reading of main scale and 'n' is the number of division which is coinciding.

6) Volume of the wire: $V = \pi \left(\frac{D}{2}\right)^2 \times l$

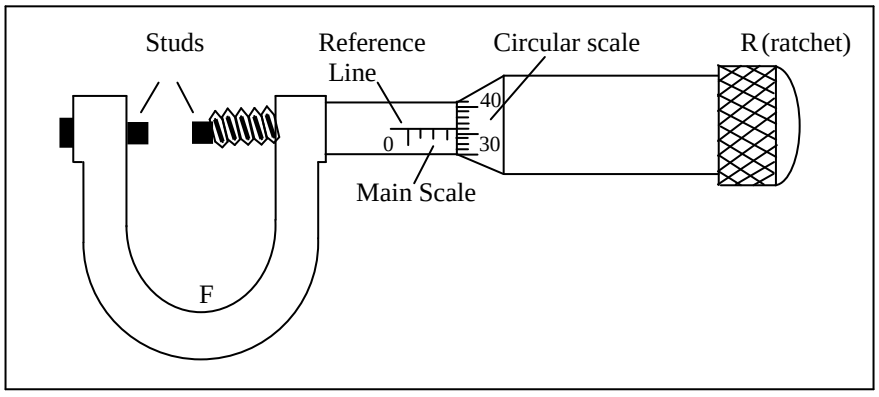
Where 'D' is the corrected diameter and 'l' is the final length of the wire.

7) Backlash error: This error is produced due to some play between the screw and the nut if the screw is not closely fit on the nut. To avoid this error, the screw should always be rotated in one direction.

Apparatus & Material Required: -

A screw gauge, piece of wire and a meter scale.

Circuit Diagram: -



Procedure: -

1) Calculate the value of least count and zero error as discussed in the theoretical concept. This can be done with the help ratchet arrangement (R) as shown in the diagram.
2) To measure the diameter of the wire, insert the wire between the two studs, turn the screw with the help of ratchet 'R' till the wire is gently placed between the two studs.
3) Note the main scale reading (x) and the number of the division (n) of the circular scale that coincides with the reference line.
4) Final reading $D' = x + n \times$(least count)
5) Rotate the wire through 90˚ and repeat the above listed steps.
6) Take at least 3-4 readings at different places for the wire and calculate the mean diameter.
7) Apply zero correction and measure the length of the wire and calculate its volume.

Mathematical Analysis & Observations: -

1) Pitch of the screw gauge $= \frac{\text{Distance moved on the main scale}}{\text{Number of full rotations}} =$_____mm.
2) Least count $= \frac{\text{Pitch of the screw gauge}}{\text{Total number of divisions on circular scale}} =$ _____ mm.

Table for measurement of diameter of wire.

S.No.	Main scale reading (x mm)	Circular scale reading (n)	Diameter D = x + n×L.C (mm)	Corrected Diameter D'= D + zero error (mm)
1.				
2.				
3.				
4.				
5.				

3) Mean diameter $(D') = \frac{D_1' + D_2' + D_3' + D_4' + D_5'}{5} =$_____mm.
4) Length of wire $l =$____ cm.
5) Volume of wire, V $= \frac{\pi D^2}{4} . l =$_____ cm^3.
6) Zero error =_____ mm.

Result: -

Diameter of the given wire = _____ cm.
Volume of wire, V = _____ cm^3.

Precautions: -

1) The screw should move freely without any friction.
2) Zero correction and Backlash error correction should be applied carefully.
3) The wire must be straight and free from kinks.
4) To avoid under pressure, the screw should be rotated with the help of ratchet.

Experiment No. - 5

Aim of the Experiment: -

To measure the thickness of a given sheet, by using screw gauge.

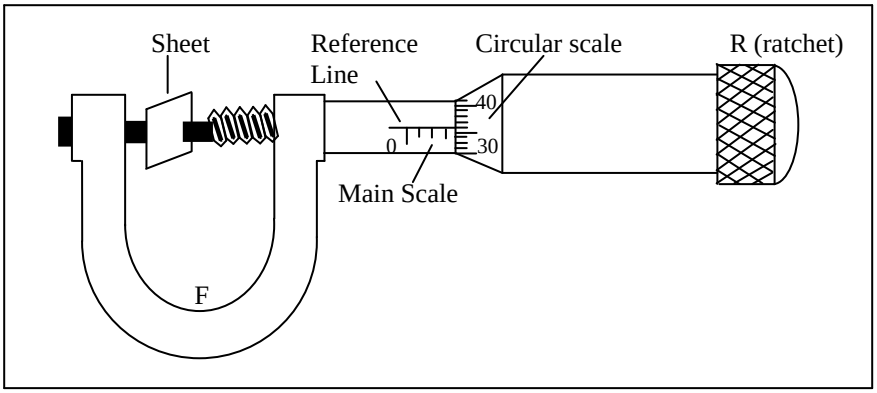
Theoretical Concept: -

All the parameters are same as we have discussed in the previous experiment. Here, we introduce a given solid sheet instead of a metallic wire in the gap between the studs.

Apparatus and Material Required: -

Screw gauge, a given solid sheet and a metre scale.

Circuit Diagram: -



Procedure: -

1) Calculate the pitch and least count of the screw gauge as we have done in the previous experiment.
2) Calculate the zero error and note it.
3) Hold the sheet between the stud and the screw and move the screw forward by rotating the ratchet till the sheet is gently gripped.
4) Note the main and circular scale reading.
5) Take at least four more readings at different points.
6) Apply zero correction and calculate the mean.

Mathematical Analysis & Observations: -

1) Pitch of the screw gauge $= \frac{\text{Distance moved on the main scale}}{\text{Number of full rotations}} =$_____mm.
2) Least count $= \frac{\text{Pitch of the screw gauge}}{\text{Total number of divisions on circular scale}} =$ _____ mm.
3) Zero error = _____ mm.

Table for measuring the thickness

S.No	Thickness of the sheet			Corrected Thickness
	Main scale reading (x mm)	Circular scale division (n)	Final thickness y = x + n × L.C (mm)	$Y' = y$ – zero error (mm)
1.				
2.				
3.				
4.				
5.				

Mean thickness of the sheet t $= \frac{y_1'+y_2'+y_3'+y_4'+y_5'}{5} =$ _____ mm.

Precautions: -

1) The movement of the screw should be done with the help of ratchet only.
2) The screw should be moved in one direction to avoid the backlash error.
3) The instrument (screw) should move freely without friction.

Result: -

The thickness of the given sheet comes out to be ____ mm.

Experiment No. - 6

Aim of the Experiment: -

To measure the volume of an irregular lamina.

Theoretical Concept: -

An irregular lamina is a body having no regular geometrical shape whose volume cannot be calculated by a known geometrical formula.

Its volume is calculated as:

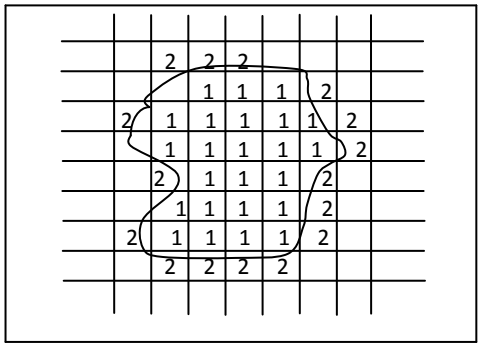
Volume = surface area × Thickness

Thickness can be measured with the help of screw gauge as we have discussed in the previous experiment.

Apparatus & Material Required: -

An irregular lamina, a screw gauge, graph paper, pencil and a metre scale.

Circuit Diagram: -



Procedure: -

1) To calculate the thickness, determine the pitch and least count of the screw gauge and then proceed as we have done in the previous experiment.
2) Apply the zero correction and calculate the mean value of thickness of the sheet.
3) To calculate the surface area, take a graph paper and place the lamina flat on the paper.
4) With the help of the pencil, mark the boundary of the lamina on the paper as shown in the diagram.
5) Now remove the lamina and count the number of full centimeter squares falling completely inside the boundary.
6) Mark the squares lying completely or more than half inside the boundary as 1 and those lying less than half in the boundary as 2 as shown in diagram.
7) The number of squares marked 1 gives the approximate area 'A' of the lamina in cm^2.
8) Volume of irregular lamina $= A \times t\ cm^3$.

Mathematical Analysis & Observations: -

1) Least count of screw gauge = _____ cm.
2) Pitch of the screw gauge = ____ cm.
3)

Table for calculation of thickness

S.No	Thickness of the sheet			Corrected Thickness
	Main scale reading (x mm)	Circular scale division (n)	Final thickness $y = x + n \times L.C$ (mm)	$Y' = y$ – zero error (mm)
1.				
2.				
3.				
4.				
5.				

4) Total number of square marked '1' = n.
5) Area of the lamina, A = _____ mm^2.
6) Volume of the lamina = A × t = _____ mm^3.

Result: -

The volume of the lamina comes out to be _____ mm^3.

Precautions: -

1) Calculate the number of squares accurately.
2) The movement of the screw should be done with the help of ratchet only.
3) The screw should be moved in one direction to avoid the backlash error.
4) The instrument (screw) should move freely without friction.

Viva – Voce Questions

Q.1. What is the principle of the screw?
Ans. It states that when a screw is rotated, the linear distance moved by the screw is always directly proportional to the number of rotations given to it.
Q.2. Define screw gauge.
Ans. A screw gauge is an instrument used to measure a very small thickness accurately upto 0.001 cm or even less than that. It is based on the principle of screw.
Q.3. What is the difference between a nail and a screw?
Ans. A nail possesses only linear motion, while a screw possesses both linear as well as the rotational motion.
Q.4. Define pitch and least count of a screw gauge.
Ans. Pitch: It is defined as the linear distance through which the screw moves, when one complete rotation is given to it.
Least count: It is defined as the linear distance through which the screw moves, when the circular cap of the screw gauge is rotated through one division on the circular scale.
Q.5. Which type of metal is used to make a screw gauge and why?
Ans. Gun metal, an alloy is used because it has very small wear and tear.
Q.6. Which is more accurate – a vernier calipers or a screw gauge.
Ans. A screw gauge is more accurate than vernier calipers as its least count is smaller than that of the vernier calipers.
Q.7. What is zero error in a screw gauge?
Ans. When the two studs of a screw gauge are brought in contact with each other, if the zero of the circular scale does not coincide with the reference line, the screw gauge is said to possess zero error.
Q.8. Why should the screw in a screw gauge be always moved in one direction?
Ans. In a screw gauge, the screw is always moved in one direction so as to avoid backlash error.
Q.9. What is backlash error?
Ans. Due to mechanical defect or due to its long use, there is always some play between the screw and its nut. If the screw is turned back after being rotated in one direction, it does not move back linearly for a while but the reading of the screw gauge undergoes a change. The error introduced in the screw gauge on this account is called the backlash error.
Q.10. How many types of zero errors are there?
Ans. There are two types of zero errors – positive and negative.
Q11. What is a ratchet and explain its use?
Ans. It is an arrangement inside the milled head (R) at the end of the screw. It prevents the screw from undue pressure.
Q12. What is a micrometer screw gauge?
Ans. The suffix 'micro' stands for $10^{-6.}$ A screw gauge capable of measuring a length as small as 10^{-6}m i.e. one millionth part of the metre is called a micrometer screw gauge or simply a micrometer.
Q13. Give least count of a metre scale, a vernier calipers and a screw gauge.
Ans. The least count of a metre scale, a vernier calipers and a screw gauge are 0.1 cm, 0.01 cm and 0.001 cm respectively.
Q14. How can you determine the thickness of paper by screw gauge?
Ans. We can determine the thickness of 100 sheets of paper. Then, calculate thickness of one sheet.

Experiment No. - 7

Aim of the Experiment: -

To measure the radius of curvature of a given spherical surface using a spherometer.

Theoretical Concept: -

Spherometer is an instrument designed to measure the radius of curvature of a given spherical surface. It consists of a circular scale, vertical scale and a screw as shown in the diagram.

$$\text{Least count of spherometer} = \frac{\text{Pitch}}{\text{Total no.of divisions on circular scale}}$$

$$\text{Pitch} = \frac{\text{Total distance moved}}{\text{Total no.of complete rotations}}$$

Final reading = x × pitch + y × L.C

x = no. of complete rotations.

y = Additional circular scale divisions.

L.C = Least count

The radius of curvature 'R' of the given spherical surface can be calculated by the formula.

$$\text{R (Radius of curvature)} = \frac{l^2}{6h} + \frac{h}{2}$$

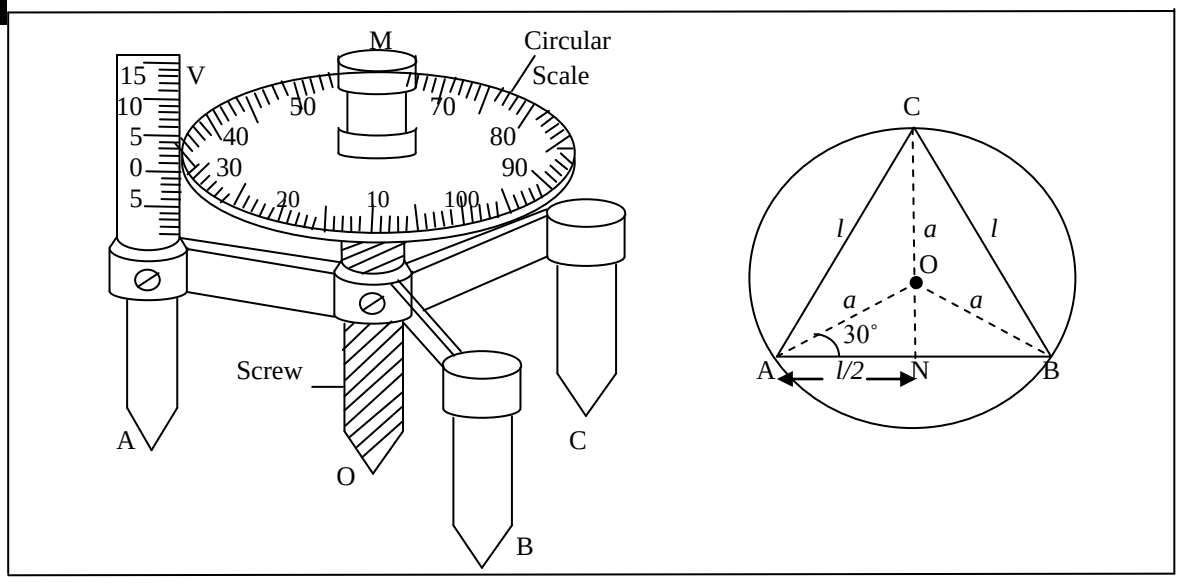
Where l = length of each side of the equilateral formed by joining the tips of the three outer legs.

h = height of the central screw.

Apparatus & Material Required: -

A spherometer, convex or concave surface, plane glass and a meter scale.

Circuit Diagram: -



Procedure: -

1) To calculate the least count of the spherometer, being the zero of the circular scale against any division on the vertical scale.
2) Give the circular scale five complete rotations and measure the distance moved by it along the vertical scale.

$$\text{Pitch} = \frac{\text{Total distance moved}}{\text{Total no.of complete rotations.}}$$

3) To calculate the least count use the formula:

$$\text{Least count} = \frac{\text{Pitch}}{\text{Total no.of divisions on circular scale}}$$

4) Note the values of pitch and the least count for the spherometer.
5) Raise the central screw of the spherometer and press the spherometer on the white paper sheet and mark the points as A, B and C as shown in the diagram.
6) Measure the distances AB, BC, AC and calculate the mean value of the length.
7) Place the spherometer on the given spherical surface (convex), adjust the central screw till it just touches the spherical surface. Note the circular scale reading.
8) Remove the (convex) spherical surface and place the spherometer on glass slab. Adjust the screw till it touches the spherical surface.
9) Note the number of complete rotations and the final reading of the circular scale.
10) If the spherical surface is concave, the initial reading should be taken with the help of a glass slab.
11) The difference between initial and final reading will give the value of height.
12) Repeat the above mentioned steps and take at least four more reading and calculate the mean value.

Mathematical Analysis & Observations: -

1) Pitch of the spherometer = ___ cm.
2) Least count of the spherometer = ___ cm.
3) Diameter between two legs of the spherometer
   AB = ___cm, AC= ____cm, BC = ____cm
4) Mean value (l) = $\frac{AB+BC+AC}{3}$ = ___cm.

Table for measurement of height

S.No.	Circular scale reading (cm) Initial (a)	Final (b)	No. of complete rotations (n)	Additional No. of circular scale divisions x = a- b or x = 100 + (a – b)	Final reading h = n ×pitch + x × L.C (mm)
1.					
2.					
3.					
4.					
5.					

5) Mean value of height = $\frac{h_1+h_2+h_3}{3}$ = ____ cm.
6) Radius R = $\left(\frac{l^2}{6h}+\frac{h}{2}\right)$ cm = _____cm.

Result: -

The reading of curvature of the given spherical surface is ____ cm.

Precautions: -

1) To avoid backlash error the screw should move in one direction only.
2) The tip of the screw should just touch the glass plate or spherical surface.
3) The length 'l' should be measured accurately.

Viva – Voce Questions

Q.1. What do you mean by spherometer?
Ans. It is an instrument based upon the principle of screw and is used to measure the radius of curvature of a spherical surface. It can also be used to measure small thickness as that of a sheet of paper.
Q.2. What is the principle of spherometer?
Ans. It is based upon the principle of screw as stated below:
When a screw is rotated, the linear distance moved by the screw is always directly proportional to the number of the rotations given to it.
Q.3. Why is spherometer provided three legs?
Ans. To make measurements with a spherometer, the distance of the tip of the central screw is measured relative to a horizontal plane. Since to determine a plane, at least three points are required, the spherometer is provided three legs.
Q.4. Define least count of a spherometer.
Ans. It is defined as the distance moved by the screw, when it is rotated through one division of the circular scale.
Q.5. What is common between the spherometer and the screw gauge?
Ans. Both of them make use of principle of a screw.
Q.6. Define radius of curvature.
Ans. Radius of curvature of a spherical surface is defined as the radius of the sphere of which spherical surface forms its part.
Q.7. How much is the radius of curvature of a flat surface?
Ans. It is an infinity.
Q.8. What is the order of accuracy in a spherometer?
Ans. The order of accuracy in a spherometer is equal to the minimum thickness, it can measure i.e equal to its least count. For an ordinary spherometer, it is equal to 0.01 mm or 10^{-5} m.
Q.9. Do you measure zero error in spherometer and why?
Ans. We do not measure zero error in spherometer because we are taking the difference of initial and final readings, hence effect of zero error is automatically eliminated.
Q.10. How can you still decrease the least count of a spherometer?
Ans. The least count of the spherometer can be decreased by increasing the number of divisions of the circular scale marked on the disc attached to the screw.
Q.11. Why don't we usually apply zero correction in spherometer?
Ans. The measurement of thickness of an object is made by taking the difference in two readings of the circular scale of the spherometer. As a result, the zero error (if any) cancels out.
Q.12. Define pitch of spherometer.
Ans. It is defined as the linear distance moved by the screw when the disc is moved through one complete rotation.
Q.13. What is the position of the screw w.r.t three outer legs?
Ans. The tips of the three legs from an equilateral triangle and the screw is equidistant from the verticies of the triangle.
Q14. Can you obtain the focal length of a concave or convex mirror by using spherometer?
Ans. Yes.
Q15. What is meant by spherometer constant?
Ans. It is distance between tip of any one of the spherometer feet and tip of the spherometer screw (feeler pin).

Experiment No. - 8

Aim of the Experiment: -

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

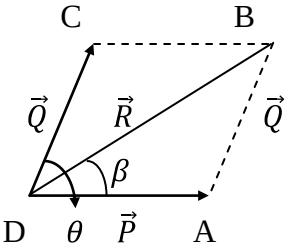
Theoretical Concept: -

According to parallelogram law, if two forces are represented in magnitude and direction by the two sides of a parallelogram, then their resultant is represented both in magnitude and direction by the diagonal of the parallelogram passing through the same point.

$$\vec{R} = \vec{P} + \vec{Q}$$

$$R = \sqrt{P^2 + Q^2 + 2PQ\,cos\theta}$$

$$\tan\beta = \frac{Q\sin\theta}{P + Q\cos\theta}$$



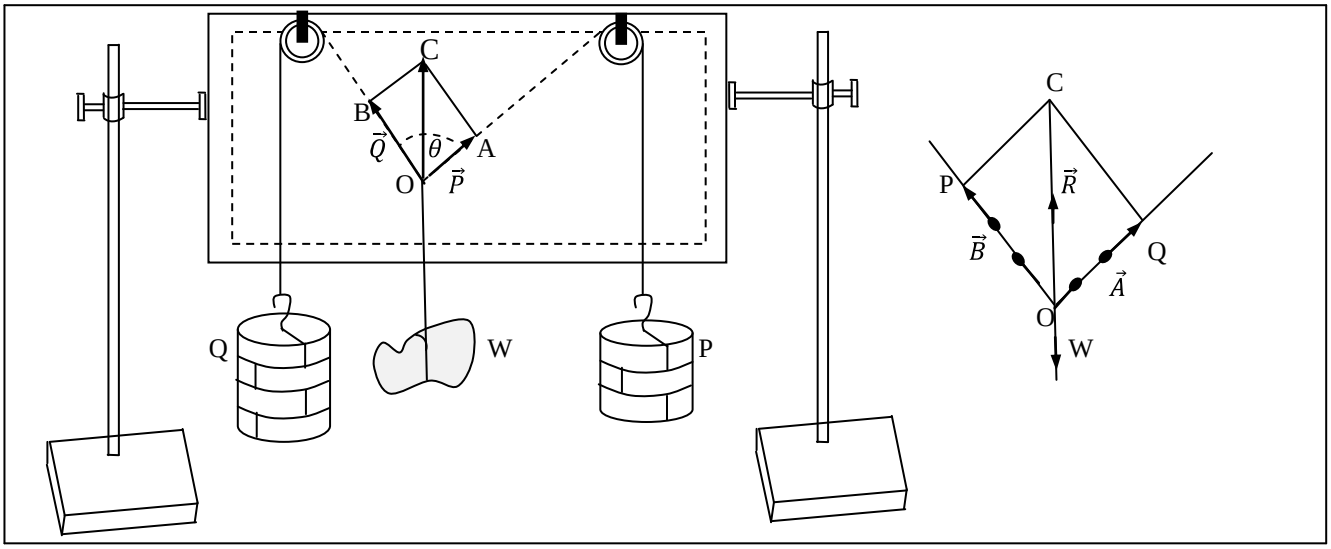
Here $'\theta'$ is the angle between $\vec{P}$ and $\vec{Q}$

Gravesand's Apparatus: It can be used to verify triangle law, parallelogram law and lami's theorem. It consists of a wooden board, two frictionless pulleys and two clamp stands as shown in the diagram.

Apparatus & Material Required: -

Gravesand's Apparatus, two hangers, slotted weights, a strip of plane mirror, a compass, a protractor, drawing pins, a plain white paper, pencil, unknown weight and a spring balance.

Analytical Diagram:-



Procedure: -

1) Place the gravesand's apparatus on the table and clamp it by using two clamp stands as shown in the diagram.
2) Check that the board is vertical and the pulleys are frictionless.
3) Tie the two hangers P and Q carrying slotted weights to the two ends of the string passing through two pulleys. At point 'O' (refer to the diagram), tie a piece of thread carrying unknown weight 'W'.

4) Adjust the slotted weights in such a way that the point 'O' lies in equilibrium condition (in the middle of the board). Make sure that none of the hanger touches the board.
5) If the system of the weights is steady, it means that point 'O' is in equilibrium positions under the action of three forces represented by $\vec{P}$, $\vec{Q}$ and $\vec{W}$.
6) Without distributing the threads and the hanger, place the strip of a mirror lengthwise under the thread in such a way that the thread exactly covers its mirror image. Keeping the eye at this position, mark the two points below the thread on the white paper (refer to the diagram).
7) Remove the paper from the board and draw the diagonal OC representing the resultant of $\vec{P}$ and $\vec{Q}$.
8) Calculate the force represented by OC.
9) Choose a suitable scale (e.g 50gf = 1 cm) to represent the weights P and Q by the lines OA and OB, evaluate the OC on the similar scale.
10) Repeat the above, mentioned steps and take at least four more observations.
11) Calculate the mean of the weights calculated to evaluate the final value of the weight.
12) The results can be verified by weighing the body with the help of a spring balance.

Mathematical Analysis & Observations: -

1) Weight taken in each hanger = ____ gm wt.
2) Scale choosen : ____ gm wt = 1 cm.

Table for weight of given body

S.No.	Forces		Length of diagonal OD (cm)	Weight represented by OD (gm wt)
	P (gm wt)	Q (gm wt)		
1.				
2.				
3.				
4.				
5.				

3) Mean weight of the body (W) = $\frac{W_1+W_2+W_3+W_4+W_5}{5}$ = ____ gm wt.
4) Weight of the body with the help of spring balance (W_0) = ΔW = ____ gm wt.
5) Percentage error = $\frac{W-W_0}{W} \times 100$ = ____%

Result: -

The unknown weight of the given body = _____gm wt.
The percentage error comes out to be _____%

Precautions: -

1) The hangers carrying the weights should not touch the board.
2) The thread should be inextensible and the pulleys should be frictionless.
3) The Gravesand's apparatus should be kept vertical.
4) The direction of forces should be marked with the help of a mirror strip.
5) The calculation of the percentage error should be accurate.

Viva – Voce Questions

Q.1. State the parallelogram law of addition of vectors.
Ans. If the two vectors can be represented in magnitude and direction by the two sides of a parallelogram draw feom a point, then their resultant is represented both in magnitude and direction by the diagonal of the parallelogram passing through the same point.
Q.2. What do you mean by composition of vectors?
Ans. The process of adding two or more vectors is known as the composition of the vectors.
Q.3. Which condition should be satisfied for vectors to be equal?
Ans. Two vectors are said to be equal, if they have same magnitude and same direction.
Q.4. Define the equilibrium force.
Ans. It is defined as the force equal and opposite to the resultant.
Q.5. Can any of the components of a given vector have greater magnitude than that of the vector itself?
Ans. Yes. It is possible, when the components are not rectangular.
Q.6. When does Lami's theorem hold good?
Ans. Lami's theorem holds good when three coplanar forces, acting at a point, are in equilibrium.
Q.7. What is the basis for the law of parallelogram of force?
Ans. The law of vector addition is the basis for the law of parallelogram of forces.
Q.8. What is the principle of a spring balance?
Ans. It is based on Hooke's law in elasticity, which states that the extension produced in a spring is directly proportional to the force applied, provided the spring is not loaded beyond the elastic limit.
Q.9. Can a scalar product of two vectors be negative?
Ans. Yes, when angle between the vectors is between 90˚ and 270˚.
Q.10. What are the main source of error in finding the weight of a body using Gravesand's apparatus?
Ans. 1. The pulleys may not be free from friction.
2. The weight of the thread cannot be neglected.
Q.11. Can the walking of man on the road be an example of resolution of vectors?
Ans. Yes, when a man walks on the road, he presses the road along oblique direction. The horizontal component of the reaction helps the man to walk on the road.
Q.12. In what way is the result of finding the weight of a body using a Gravesand's apparatus affected, if the pulleys have appreciable friction?
Ans. In case pulleys have appreciable friction, the effective weight of each hanger will be less than its actual weight. Hence, the experiment will give a lesser value of the weight of the body.
Q.13. When are the vectors said to be coplanar?
Ans. Vectors lying in same plane are called coplanar vectors.
Q.14. Which of the following is a scalar-force, velocity, displacement, mass?
Ans. Only mass is a scalar quantity, others are vectors.
Q.15. What do you mean by force?
Ans. It is push or pull which changes or tends to change the state of rest or the uniform motion of the body in straight line.

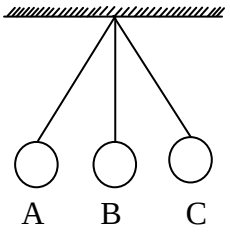
Experiment No. - 9

Aim of the Experiment: -

Using a simple pendulum, plot L - T and L - T^2 graphs. Hence find the effective length of second's pendulum using appropriate graph.

Theoretical Concept:-

A simple pendulum consists of a heavy point mass suspended by an inextensible thread which executes to and fro motion (oscillatory motion).'B' is the mean position of the particle. 'A' and 'C' are the extreme position of the particle.



For one oscillation to complete, the particle should move from point 'B' to point 'A' to point 'C' and finally to point 'B'. The time period 'T' of a simple pendulum is given by the relation as $T = 2\pi\sqrt{\frac{L}{g}}$ Where,

'L' is the length of pendulum

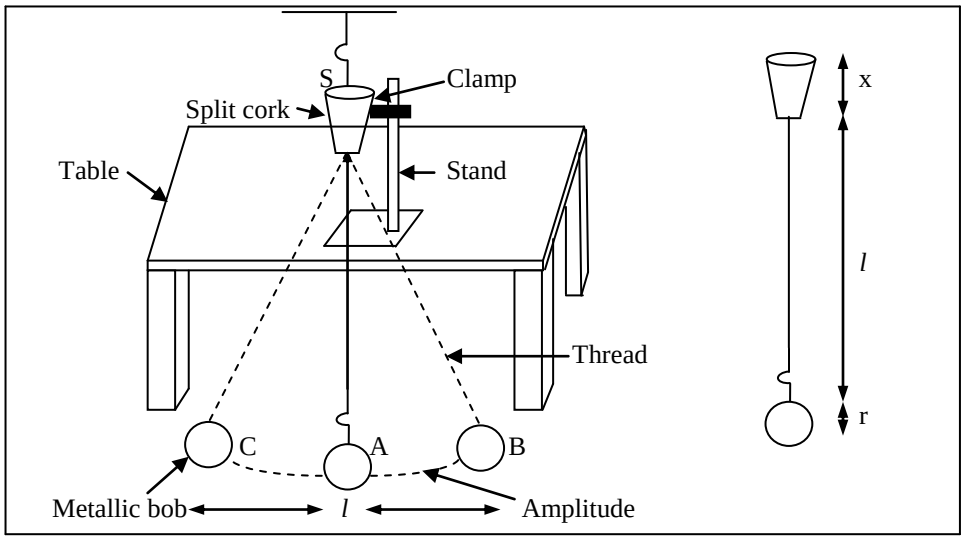
'g' is the acceleration due to gravity

$$T^2 = 4\pi^2 \frac{L}{g} \qquad L = \frac{T^2 g}{4\pi^2} \qquad g = 4\pi^2 \frac{L}{T^2}$$

Apparatus & Material Required: -

Spherical bob with a hook, a clamp stand, inextensible string, Vernier calipers, a metre scale and a stop watch.

Circuit Diagram: -



Procedure: -

1) Calculate the vernier constant and zero error of the vernier calipers, find out the diameter of the spherical bob as we have done in the Ist experiment.
2) Note the value of the diameter and calculate the radius of the bob.
3) The one end of the thread to the hook of the bob and pass the other end through the split cork as shown in the diagram.

4) Place the stand on the table in such a way that the bob is just (1 to 2 cm) above the ground.
5) Allow the pendulum to rest in its mean position.
6) Pull the bob to one side and release it so that it starts oscillations.
7) When the bob starts oscillating, start the stop watch as soon as the bob crosses its mean position.
8) Stop the stop watch when the bob completes 20 oscillations. Note the reading of stop watch; it gives us the time of 20 vibrations.
9) Repeat the above mentioned steps and take at least 5 readings.
10) Calculate the total length of the pendulum which is $L = x + l + r$. where 'x' is the length of the cork, 'l' is the length of string and 'r' is the radius of the bob.
11) Plot the graph between L vs T and L vs T^2.

Mathematical Analysis & Observations: -

1) Vernier constant = ____ cm.
2) Zero error = ____ cm , Zero Correction = ____ cm.
3) Diameter of the bob (D) = ____ cm.
4) Radius of the bob (R) = $\frac{D}{2}$ = ___ cm.

Table for measurement of L and T.

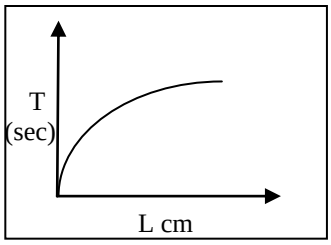
S.No.	Effective length L = x + l +r (cm)	Time for 20 vibrations (t)	Time period $T = \frac{t}{20}$ sec	T^2 $(sec)^2$
1.				
2.				
3.				
4.				
5.				

5) Mean value of T^2 = _____ sec^2.

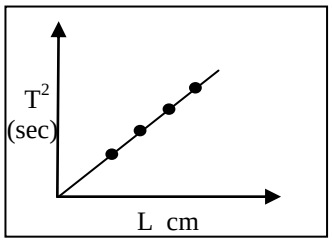
Time period of second's pendulum = 2 seconds.

Plot a graph of between 'L' (length of pendulum) and 'T' (time period of the pendulum) as shown in the figure.

Also plot a graph between 'L' and 'T^2'.



(A)



(B)

To calculate the length of second's pendulum, take a point on the y-axis with $T^2 = 4$, record the corresponding length 'L' (graph B) which will give the length of second's pendulum.

Result: -

1. The graph between 'L' and 'T' is a curved line.
2. The graph between 'L' and 'T^2' is a straight line.
3. From the graph, the length of the second's pendulum comes out to be ____ cm.

Precautions: -

1) The minimum length of pendulum should be 70 cm.
2) Note the time and number of vibrations carefully.
3) The stop watch should be accurate.
4) There should be no circular/ elliptical motion of the bob.
5) The thread should be strong and inextensible.
6) The amplitude of the oscillations should be small.

Viva – Voce Questions

Q1. What is simple harmonic motion?
Ans. It is a periodic motion, in which acceleration of the particle is directly proportional to its displacement from the mean position and is always directed towards it.
Q2. Why should the amplitude of vibration of a simple pendulum be kept small?
Ans. While deriving the formula

$T = 2\pi\sqrt{\frac{l}{g}}$, we make the approximation that $\sin\theta \approx \theta$. It is only then that the motion of the simple pendulum can be taken as S.H.M.

Q3. A pendulum clock is in a lift that descends at a constant velocity. Does it keep correct time?
Ans. Yes, because the acceleration of lift is zero.
Q4. What is meant by an isochronous motion?
Ans. A motion, which completes itself always in a fixed time irrespective of its amplitude, is called an isochronous motion.
Q5. Why does the bob go on swinging, if once disturbed?
Ans. The potential energy of the bob (at extreme positions) is converted into kinetic energy (at mean position) and vice versa.
Q6. Define one second in terms of the time of swing of a simple pendulum.
Ans. One second is defined as the time taken by a simple pendulum of length one metre (approximately) to swing from one extreme position to the other.
Q7. What will be the graph between L and T for simple pendulum?
Ans. A parabola.
Q8. If the brass bob is replaced by a wooden bob of same size, will the time period remain same?
Ans. With the wooden bob, the centre of gravity of the pendulum will rise. As a result of it, the length of the pendulum will decrease and hence its time period will also decrease.
Q9. What is the frequency of oscillation of simple pendulum mounted in a cabin that is free falling?
Ans. In the cabin falling, freely under gravity, the pendulum is in a state of weightlessness i.e., its weight becomes zero. The frequency of oscillation of the simple pendulum, $\nu = \frac{1}{2\pi}\sqrt{\frac{g}{L}} = \frac{1}{2\pi}\sqrt{\frac{mg}{mL}} = 0$ i.e, the frequency of oscillation is zero.
Q10. What will happen to the time period of the bob, if it is made to vibrate in water?
Ans. In this case, due to the up thrust of water, the effective weight of the bob and hence the value of g will decrease. Therefore, the time period will increase.

Experiment No. - 10

Aim of the Experiment: -

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

Theoretical Concept:-

The force which opposes the relative motion between two bodies is known as frictional force. The force of friction that comes into play between the surfaces of two bodies before the body actually starts moving is called 'Static friction'. The maximum value of static friction is 'limiting friction'. On applying the force greater than the limiting friction the body starts moving and the frictional force becomes 'kinetic'.

Laws of friction:

1) The value of the frictional force depends upon the nature of the two surfaces in contact.
2) The force of friction is directly proportional to the normal ion between the two surfaces.
3) The frictional force is independent of the area of contact of two surfaces.
4) The frictional force always opposes the relative motion between the two surfaces.

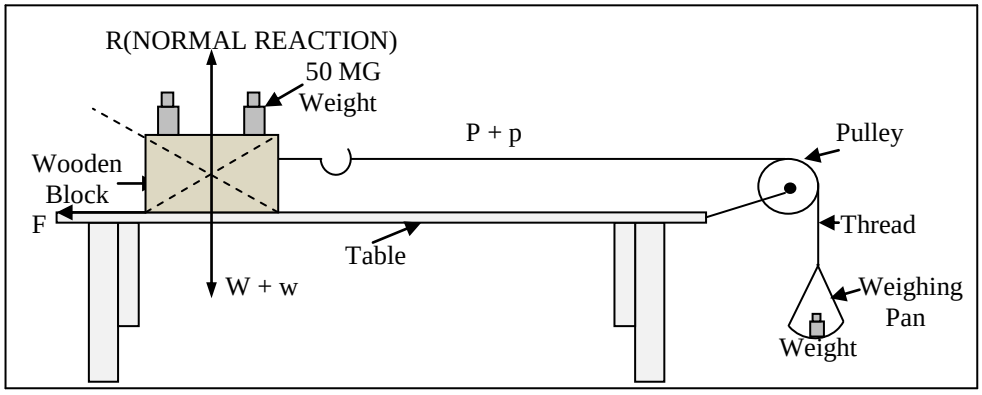
$F \propto R$

$F = \mu R \quad , \mu = \frac{F}{R}$ where $'\mu'$ is the coefficient of friction, 'F' is the force of limiting friction and 'R' is the normal reaction.

Apparatus & Material Required: -

A plane horizontal table with a pulley attached to one of its edges, wooden block with a hook, 50 gm or 100 gm weights, pan, spirit level, string and physical balance.

Circuit Diagram: -



Procedure: -

1) Check the leveling of the plane horizontal table with the help of spirit level.
2) Weigh the wooden block with the help of spring balance and place it on the table.
3) Attach one end of the wooden block to the weighing pan with the help of a thread through a pulley as shown in the diagram.
4) Make sure that the pulley used should be frictionless.
5) Make sure that the part of the thread from hook to the pulley is perfectly horizontal and the pan hangs freely.

6) Now place some weights from the box in the pan and gradually increase the value till the wooden block begins to slide. Note down the weights in the pan.
7) Place a weight of 50 grams on wooden block and add more weights in the pan till it begins to slide again. Note the weights placed in the pan.
8) In this way take at least five readings by increasing the weights placed on the wooden block in steps of 50 grams.
9) The weight of the wooden block and the added weight will give us the value of normal reaction.
10) The weight of the weighing pan and added weights will give us the value of frictional force.
11) Plot a graph between R (Normal reaction) and F (Frictional force).

Mathematical Analysis & Observations: -

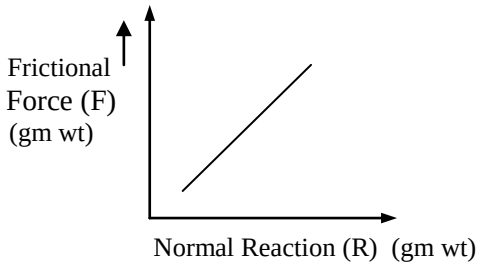
1) Weight of wooden block (W) = _____ gm wt.
2) Weight of the pan (P) = ____ gm wt.

Table for the calculation of coefficient of friction.

S.No.	Weights on wooden block W (g wt)	W+W (Normal reaction) R (g wt)	Weight on pan (P) (g wt)	(P+P) Gm wt (F)	$\mu = \frac{F}{R}$
1.	0				
2.	50				
3.	100				
4.	150				
5.	200				

3) Mean value of $\mu = \frac{F}{R}$ =_____.

Variation of F with R:



Result: -

The graph between 'F' and 'R' is a straight line, it shows that 'F' is directly proportional to 'R'.
The coefficient of friction (μ) = $\frac{F}{R}$ = _____.

Precautions: -

1) The pulley should have very low friction, i.e frictionless.
2) Weight on the pan should be increased in small steps.
3) Thread should not touch any part of the horizontal table.
4) The surface of the table should be horizontal and smooth; this can be checked using a spirit level.

Viva – Voce Questions

Q1. Define friction.

Ans. I t is defined as an opposing force that comes into play between two surfaces in contact. When a body moves or tends to move on another body.

Q2. On what factors does the force of friction depends?

Ans. It depends upon the nature and the state of polish (smoothness) of the two surfaces in contact.

Q3. What happens to limiting friction, when a wooden block is moved with increasing speed on a horizontal surface?

Ans. Limiting friction decreases as the wooden block is moved with increasing speed on the horizontal surface.

Q4. What is coefficient of friction?

Ans. It is the ratio of the limiting friction to the normal reaction for the two surfaces in contact.

Q5. What is the relation between downward force and angle of inclination of the plane?

Ans. $W = mg \sin \theta$.

Q6. How can you reduce the force of friction between two bodies?

Ans. By lubricating the moving parts and by polishing the surfaces in contact.

Q7. State any two practical application of force of friction.

Ans. (i) Without friction, it is impossible to walk.

(ii) It is not possible to light a match stick in absence of force of friction.

Q8. Why are tyres made of rubber and not of iron?

Ans. It is because; coefficient of friction between rubber and concrete (material of the road) is less than that between iron and the concrete.

Q9. Why do we slip on a rainy day?

Ans. On rainy day, the wet ground becomes very smooth. As a result, the coefficient of friction between our feet and the wet ground gets much reduced. Consequently, the force of friction ($F = \mu R$) between the feet and the ground becomes very small. As a result, it may cause us to slip.

Q10. Is a large brake on a bicycle wheel more effective than a small one?

Ans. Both the large and small brakes are equally effective. It is because, the force of limiting friction is independent of the area of the surfaces in contact, so long as the normal reaction remains the same.

Q11. Define dynamic friction.

Ans. The force of friction which comes into play between the surfaces of contact of two bodies, which one body in steady motion, over the other body is called dynamic friction.

Q12. A body is pulled over a surface with the help of a string attached to the body. The force applied along the string is gradually increased. What will be the nature of graph between applied force and force of static friction?

Ans. The nature of graph between applied force and force of static friction will be a straight line.

Q13. What is the essential cause of friction?

Ans. A surface cannot be perfectly smooth, thus due to interlocking of irregularities between two surfaces in contact, friction comes into play. Greater the roughness of the surface, greater is the force of friction. However, the basic reason of friction is electromagnetic in nature.

Q14. What is rolling friction?

Ans. When a body such as wheel, cylinder or a sphere rolls over a surface, the force of friction that comes into play is called rolling friction.

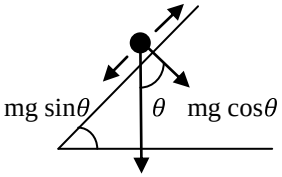
Experiment No. - 11

Aim of the Experiment: -

To find the downward force along an inclined plane acting on a roller due to gravitational pull of the earth and study its relationship with the angle of inclination by plotting graph between force and sin θ.

Theoretical Concept:-

The weight (w = mg) of the roller can be resolved into two components W$\sin\theta$ and W$\cos\theta$. The 'W$\cos\theta$' components is equal to the normal reaction and 'W$\sin\theta$' component will help the roller to move in downward direction.



In the first case, the weights are added to the pan (refer to the diagram), till the roller just begins to slide downwards,

$$W \sin\theta = p + P_{down} \quad \text{——————} \quad (1)$$

'P' – weight of the pan ,'P_{down}' – Added weights to the pan to assist the downward movement of the pan.

In the second case, the weights are added to the pan till the roller just begins to slide upwards,

$$W \sin\theta = p + P_{up} \quad \text{——————} \quad (2)$$

Where 'P_{up}' – added weights to assist the upward movement of the roller.

Adding (1) and (2) we get,

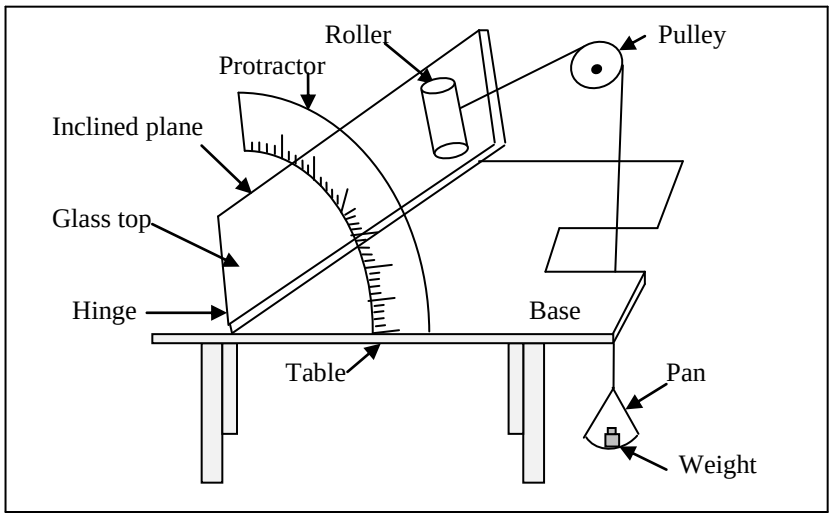
$$2W \sin\theta = (p + P_{down}) + (p + P_{up})$$

$$W \sin\theta = P + \frac{P_{down} + P_{up}}{2}$$

Apparatus & Material Required: -

Inclined plane with a pulley, a pan, metallic roller, weight box, thread, a metre scale, spring balance and a spirit level.

Circuit Diagram: -



Procedure: -

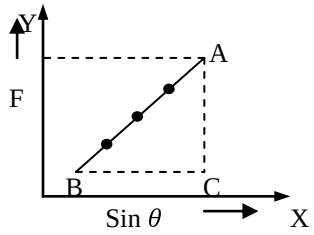
1) Calculate the weight of the roller and pan with the help of spring balance.
2) Place the inclined plane to horizontal position such that the angle of inclination is zero.
3) Now tie the one end of the pulley to the roller and other end to the weighing pan as shown in the diagram.
4) Raise the inclination angle of the inclined plane to 30˚.
5) Add the weigh on the pan and increase them till the roller just starts moving upwards.
6) Note the total weights of the pan.
7) Now remove the small weights till the roller just starts moving downwards.
8) Note the total weights in the pan.
9) Record all the observation and repeat the experiment for different angles of inclination.
10) Plot a graph between F and sinθ.

Mathematical Analysis & Observations: -

1) Weight of the pan (p) = _____ gm wt.
2) Weight of the roller (W) = ____ gm wt.

Table for the calculation of coefficient of friction.

S.No.	Angle of inclination (θ)	Weight in the pan when roller moves		Force on the roller due to gravitational pull $F = p + \frac{P_{down}+P_{up}}{2}$	sinθ	F/ sinθ
		Downward P_{down}	Upwards P_{up}			
1.	0					
2.	50					
3.	100					
4.	150					
5.	200					



Slope of the graph, $\frac{FC}{\sin\theta} = \frac{AC}{BC}$ = _____ gf.

Result: -

The graph between 'F' and 'sin θ' is a straight line, which proves that the force acting on the roller due to gravitational pull is directly proportional to the sin θ of the angle of inclination of the inclined plane.

Precautions: -

1) The pulley used should be free from friction.
2) Note the weight in the pan only when the roller moves upwards/ downwards slowly and with a constant speed.
3) The inclination angles of the inclined plane should be adjusted accurately with the help of a protractor.
4) The weighing pans should not touch the table.

Viva – Voce Questions

Q1. What is the component of the weight of the roller, which causes it to move along the inclined plane?
Ans. If θ is the inclination of the inclined plane with the horizontal, then the component W sin θ of the weight of the roller causes it to move along the inclined plane.
Q2. What is inclined plane?
Ans. Inclined plane is one of the simple machines which is used for raising heavy loads by applying less effort.
Q3. Which one is grater sliding or rolling friction?
Ans. Rolling friction is always less than sliding friction.
Q4. How are mass and weight related to each other?
Ans. The weight of a body of mass M is given by W = Mg, where g is acceleration due to gravity.
Q5. What is the direction of the force due to friction between the roller and the surface of the inclined plane, when the roller moves in (a) downward direction and (b) upward direction along the inclined plane?
Ans. Force due to friction always acts in a direction opposite to the direction of motion of the body.
(a) In upward direction along the inclined plane.
(b) In downward direction along the inclined plane.
Q6. Define mechanical advantage of an inclined plane.
Ans. It is defined as the ratio of load to the effort.
Q7. The downward force acting on the roller due to gravitational pull on it is found by finding the mean of the applied forces, when the roller just begins to move in downward direction and in upward direction. Why?
Ans. It is done in order to eliminate the effect of the force of friction between the roller and the surface of the inclined plane.
Q8. What is the component of the weight of the roller in a direction perpendicular to the inclined plane?
Ans. If θ is the inclination of the inclined plane with the horizontal, then the component of the weight of the roller in a direction perpendicular to the inclined plane is W cosθ.
Q9. State the work-energy theorem.
Ans. It states that the work done on the body by a resultant force is equal to the increase in the energy of the body.
Q10. Define energy.
Ans. energy is the capacity for doing work.

Activity No. - 1

Aim of the Activity: -

To make a paper scale of least count 0.2 cm.

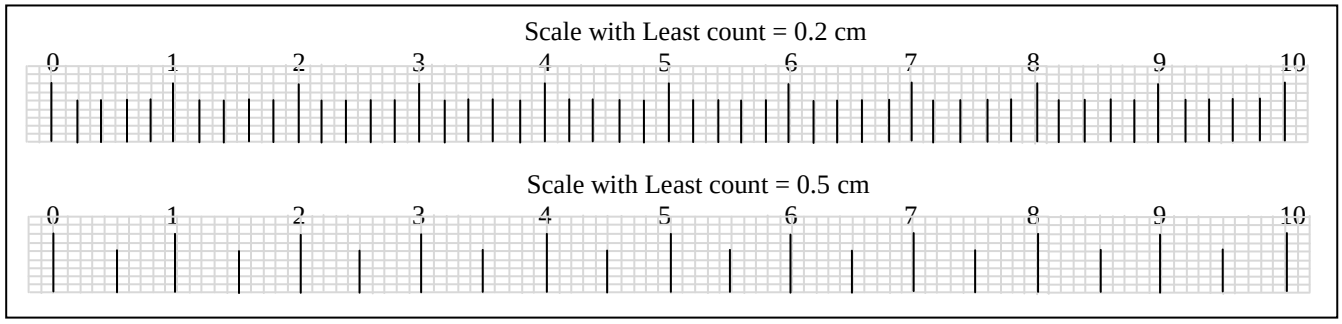
Theoretical Concept: -

The least count of a measuring instrument is defined as the minimum which can be measured accurately by the instrument.

Apparatus and Material Required: -

A thick sheet of white paper (cm graph paper), a flat wooden strip and gum.

Circuit Diagram: -



Procedure: -

1) Cut a strip (1 cm wide and 25 cm long) from the sheet of a cm graph paper.
2) On a cm graph paper the bold marks are at equal intervals of 1 cm and each cm is divided into 10 equal parts as shown in the diagram.
3) To prepare a scale of least count 0.2 cm, divide the 1 cm division into five equal parts, use a sharp pencil to draw the lines accurately.
4) Since 1 cm is divided into five equal divisions. So each division is of 0.2 cm.
5) Paste this paper strip on a flat wooden scale which will ultimately give us a scale with least count 0.2 cm.
6) If the 1 cm division is divided into two parts (each of 0.5 cm), that will lead to the formation of a scale with least count 0.5 cm.

Precautions: -

1) Making and cutting of the graph paper strip should be accurate.
2) The pencil should be sharp.
3) Thick line should be used for drawing the axis of reference.

Activity No. – 2

Aim of the Activity: -

To calculate the mass of the given body using a meter scale by principle of moments.

Theoretical Concept: -

According to the concept of principle of moments, if a body is in equilibrium under the action of a number of forces, then the sum of clockwise moments is equal to the sum of anticlockwise moments.

$M_1g \times ac + M_2g \times bc = Mg \times dc$ (refer to the diagram)

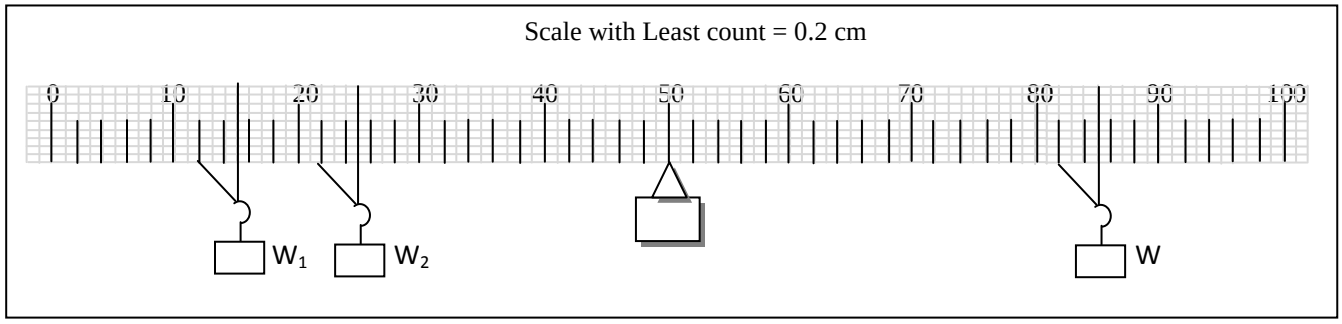
$M_1 \times ac + M_2 \times bc = M \times dc$

$$\frac{M1 \times ac + M2 \times bc}{dc} = M$$

Apparatus and Material Required: -

A meter scale, a body of unknown mass, a weight box, a broad wedge with sharp edges and a wooden block.

Circuit Diagram: -



Procedure: -

1) Place the metre scale on the wedge and calculate its centre of gravity.
2) Mark the point of centre of gravity as 'C'.
3) With the help of hangers, suspend the known weights on the left side of 'C', Mark those points as 'a' and 'b' as shown in the diagram.
4) Suspend the unknown weight to the right side of 'C', mark the point as 'd'.
5) Measure the distance ac, bc and cd, calculate the value of 'M' using the formula discussed in theoretical concept.
6) Repeat the above mentioned steps and record at least five observation by changing the distances.

Observations and Mathematical Analysis: -

1) Position of centre of gravity (point C) of the metre scale = _____ cm.

S.No.	Position of known masses		Value of Masses		Unknown mass
	ac (cm)	bc (cm)	M_1	M_2	$M = \frac{M1 \times ac + M2 \times bc}{dc}$
1.					
2.					
3.					

Mean value of mass, $M = \frac{M_1+M_2+M_3+M_4+M_5}{5}$ = _____ gms.

Result: -

The unknown mass of the given body M = _____ gms.

Precautions: -

1) The wedge should be having sharp edges.
2) Do not use too heavy weights, the metre scale should not bend under the weights suspended.
3) Centre of gravity of the metre scale should be calculated accurately.

Activity No. – 3

Aim of the Activity: -

To plot a graph for a given set of data with proper choice of scales and error bars.

Theoretical Concept: -

Following points should be considered while plotting a graph:

(1) Study the parameters and differentiate between the dependent and independent variable.

(2) Note down the minimum and maximum value of both types of variables, this will give you the range of physical variable.
(3) For plotting a graph, the minimum no. of observations taken should be 5.
(4) For plotting the graph, the different readings should be properly spaced.
(5) Every data has some uncertainty which is also called as error due to lack of precision in measurement of the physical quantities. These errors can be represented through the error bar in a line graph.
Data for the graph:

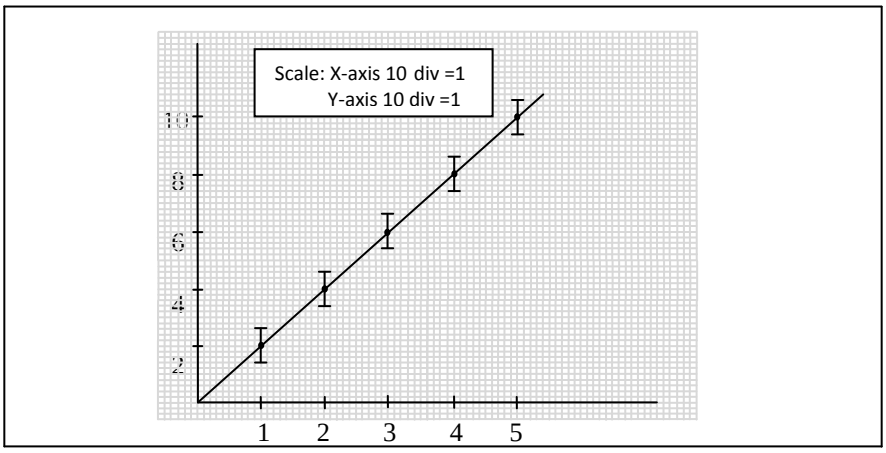
x	1	2	3	4	5
y	2	4	6	8	10

Here 'x' and 'y' are length in cms, the value of 'y' is calculated with an error of ± 0.02 cms.

Apparatus and Material Required: -

Graph paper and a sharp pencil.

Circuit Diagram: -



Procedure: -

1) Draw the co-ordinate axis on the graph paper; plot the value of 'x' on the 'X' axis.
2) Plot the value of 'y' on the 'Y' axis (refer to the graph).
3) The values of 'x' and 'y' should be plotted after the selection of the paper scale.
   Say 10 small divisions = 1 along 'X' axis.
   Say 10 small divisions = 2 along 'Y' axis.
4) Join the plotted points with the help of a meter scale; the error in 'y' can be represented with the help of error bars.
5) The graph between 'x' and 'y' is straight line.

Result: -

The graph between 'x' and 'y' is a straight line.

Precautions: -

1) The scale used should be convenient and should cover the maximum space of the graph paper.
2) The data points should be joined with a straight line.

Activity No. – 4

Aim of the Activity: -

To measure the force of limiting friction for rolling a roller on the horizontal plane.

Theoretical concept: -

There are two types of kinetic friction.

(a) Sliding friction: when a body slides over the surface of another body.

(b) Rolling friction: When a body rolls over the surface of another body.

The value of rolling friction is lesser as compared to that of sliding friction.

According to the laws of rolling friction: $F_r \propto R$

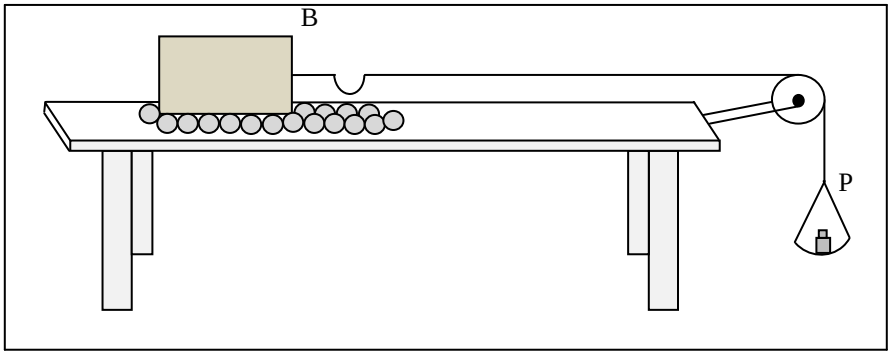
$$F_r = \mu_r R$$

Where 'μ_r' is the coefficient of rolling friction.

Apparatus and Material Required: -

A horizontal plane fitted with a pulley at one of its end, pulley, thread, a pan, a weight box with fractional weights, a spring balance $\vec{a}$ and spirit level.

Circuit Diagram: -



Procedure: -

1) Place the horizontal table and clean its surface, with the help of spirit level check that the top surface is perfectly horizontal.
2) Fix a pulley at one of its ends and check that it is functionless.
3) Place some ball bearings on the horizontal surface.
4) Place the wooden block on the ball bearings gently.
5) Tie one end of the thread to the wooden block and other end to the light pan P.
6) The thread should be tied through a pulley as shown in the diagram.
7) Add some fractional weights in the pan and adjust them such that the block just rolls over the ball bearings.
8) Note the weight placed in the pan, let it be P_2 and weight of the pan (P_1).
9) Then the force of limiting friction is $F_1 = (P_1 + P_2)$ gm wt.
10) Repeat the above mentioned steps and take at least five observations.

Observations and Mathematical Analysis: -

Weight of the pan (P_1) = ____ gms.

Table for calculating the force of limiting friction

S.No	Weights placed in the pan to just start the motion of roller P_2 (gm wt).	Force of limiting friction $F_1 = P_1 + P_2$
1.		
2.		
3.		
4.		
5.		

Result: -

The force of limiting friction for rolling comes out to be _____.

Precautions: -

1) The pulley should be frictionless.
2) The pan or the thread should not touch the horizontal table.
3) The weights in the pan should be taken carefully.

Activity No. – 5

Aim of the Activity: -

To study the variation in the range of a jet of water with angle of projection.

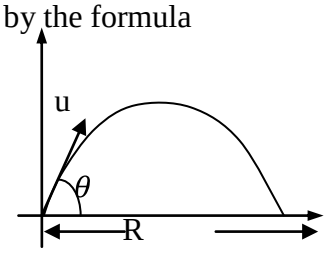
Theoretical Concept: -

The motion of an object in a plane with uniform acceleration in the vertical direction is called a projectile motion.

An object thrown with some velocity at angle with the horizontal direction is an example of projectile motion. The maximum horizontal distance covered by the projectile is the horizontal range given by the formula

$$R = \frac{u^2 \sin 2\theta}{a}$$

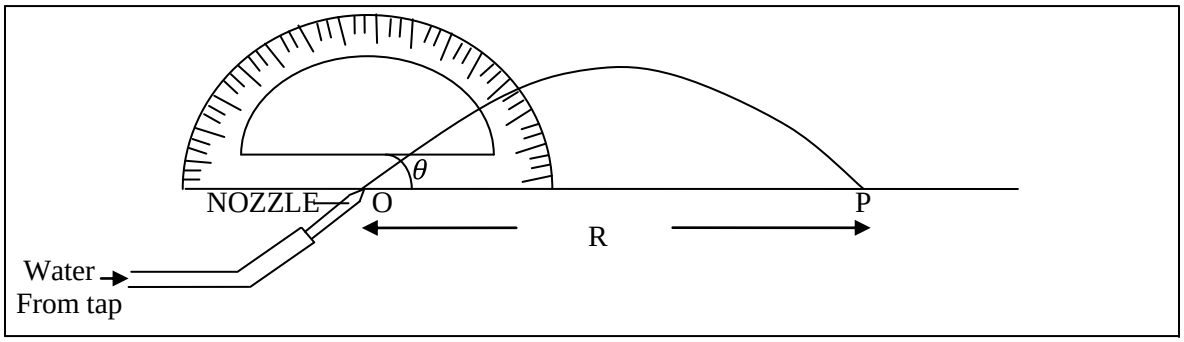
Where 'u' is the velocity with which the projectile is fired, 'θ' is the angle with the horizontal, 'R' is the range of the projectile and 'g' is the acceleration due to gravity.



Apparatus and Material Required: -

A water pipe with a nozzle, a large protractor of about 25 cm radius, a water tap connected to a overhead tank and a measuring tape.

Circuit Diagram: -



Procedure: -

1) Connect one end of the water pipe with the tank and insert a nozzle in the other end of the pipe.
2) Fix the protractor in a horizontal box to make its plane vertical, open the water tap and ensure that there is no leakage of water in the pipe.
3) Place the jet at centre 'O' of the protractor as shown in the diagram and direct the jet along 15˚ line on the protractor.
4) Note the horizontal distance covered by the jet.
5) Repeat the above mentioned steps for different angles of projection.
6) Record all the readings and make the table.
7) Plot the graph between range of water jet (R cm) and angle of projection (θ)

Mathematical Analysis and Observations: -

S.No.	Angle of projection of jet of water θ(degree)	Range of the water jet (cm)
1.	15˚	
2.	30˚	
3.	45˚	
4.	60˚	
5.	75˚	

Graphical Analysis: -

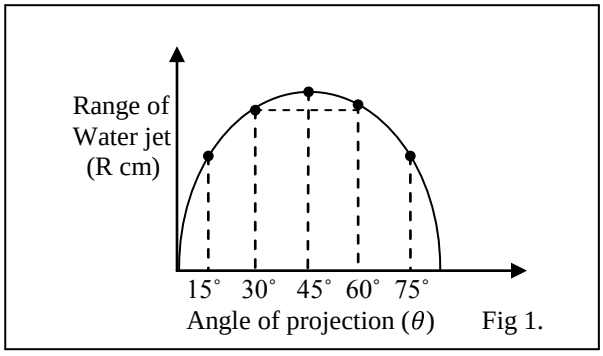


Fig 1.

Result: -

The graph between range of water jet and angle of projection (θ) is a parabola as shown in fig.1, The range becomes maximum at $\theta = 45^{\circ}$.

Precautions: -

1) The protractor should be placed in vertical direction.
2) The jet of water should be as sharp as possible.
3) The angle of projection should be noted carefully.

Activity No. – 6

Aim of the Activity: -

To study the conservation of energy of a ball rolling down on inclined plane (using a double inclined plane).

Theoretical Concept: -

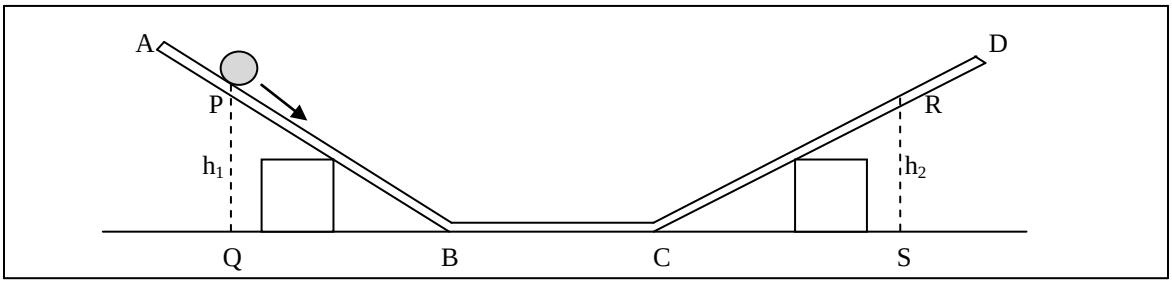
According to the law of conservation of energy, energy can neither be created nor be destroyed but can be converted from one form to another form i.e total energy remains constant.

When a solid ball is allowed to roll on an inclined plane as shown in the diagram, the final vertical height attained by the ball is same as the initial vertical height, at a height the ball possesses only potential energy, all this potential energy is converted to kinetic energy at the bottom and finally again to potential energy.

Apparatus and Material Required: -

Double inclined plane, metre scale, spirit level, a solid spherical base, stop watch and two weights of 1 kg each.

Circuit Diagram: -



Procedure: -

1) Take a horizontal table and check it using a spirit level.
2) Keep the double inclined plane on the table and make it stable with the help of wooden block as shown in the diagram.
3) Drop the ball from the point 'P', note down the height 'PQ' and mark it as 'h_1'.
4) Similarly note down the height 'RS' attained by the block and mark it as 'h_2'.
5) Repeat the above mentioned steps for different 'h_1' and take at least five observations.

Mathematical Analysis and Observations: -

S.No.	Position of point P on the plane (cm)	Position of point R on the plane (cm)	PQ h_1 (cm)	RS h_2 (cm)
1.				
2.				
3.				
4.				
5.				

Result: -

The vertical height covered by the ball i.e 'h_2' comes out to be approximately equal to the height 'h_1'. This proves the law of conservation of energy.

Precautions: -

1) The horizontal table should be properly checked with the help of spirit level.
2) The position of releasing as well as reaching the spherical ball should be properly noted.
3) The double inclined plane should be smooth.

Activity No. – 7

Aim of the Activity: -

To study dissipation of energy of a simple pendulum by plotting a graph between square of amplitude and time.

Theoretical Concept: -

There are two types of oscillations:

(i) Damped oscillations: The amplitude of the oscillations does not remain constant rather it decreases with time.

(ii) Undamped oscillations: The amplitude of the oscillation remains constant with time.

90% of the oscillations in nature are damped oscillations, there is same external agency required for undamped oscillations. For simple harmonic motion, the restoring force is given as $F_r = -kx$, where 'k' is the spring constant, and 'x' is the displacement at any time 't'.

The work done is equal to the potential energy 'u' of the particle at displacement 'x' i.e.

$$U = \frac{1}{2} kx^2 \quad \Rightarrow \quad k = mw^2$$

Where 'm' is the mass of the particle and 'w' is the angular frequency.

Kinetic energy = $\frac{1}{2} mv^2$, where $v = w\sqrt{t^2 - x^2}$, 'v' is the velocity of the particle, 'w' is the angular velocity, 'r' is the amplitude and 'x' is the displacement of the particle.

Total energy = kinetic energy + potential energy

$$= \frac{1}{2} mw^2 (r^2 - x^2) + \frac{1}{2} mw^2x^2$$

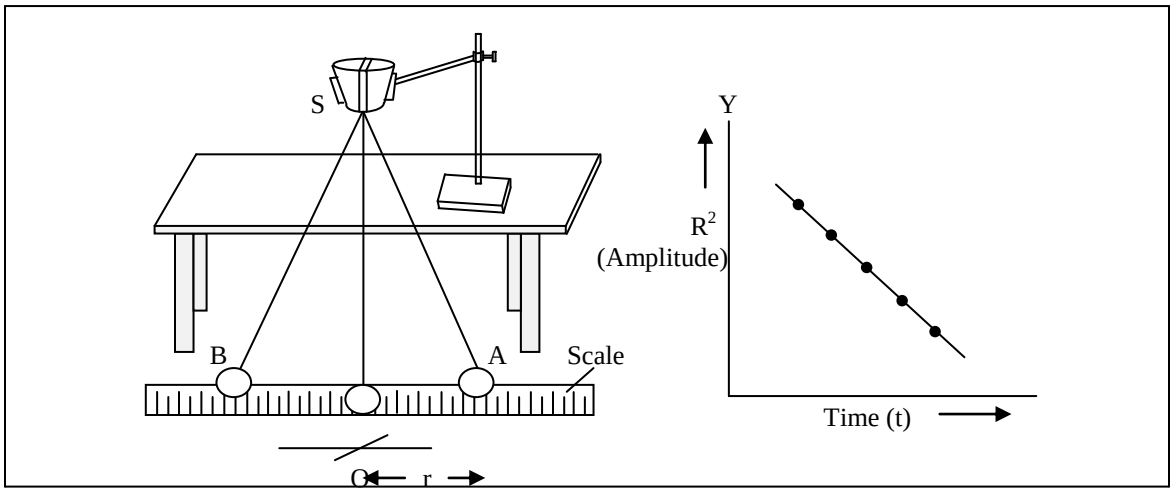
$$E = \frac{1}{2} mw^2r^2$$

The expression tells us that energy is directly proportional to square of the amplitude.

Apparatus and Material Required: -

A clamp stand, a split cork, a metallic bob with a hook, a piece of thread 1.5 my long, a stop watch and a metre scale.

Circuit Diagram: -



Procedure: -

1) The one end of the thread to the hook of the bob, tie the other end between the two halves of the cork and clamp it on the clamp stand.
2) Adjust the height of the stand such that the length of the pendulum is about 1 mt and the bob suspends just above the ground.
3) Calculate the least count of the stop watch.
4) Displace the bob through a small angle and release it.
5) When the bob reaches the right extreme position A, count zero and start the stop watch, when the bob just reaches the extreme position 'A' again, count one and so on, Note the amplitude of vibration of the bob and the time with the help of a stop watch when the bob completes 10, 20, 30, 40, 50 vibrations.
6) Record the readings and plot a graph between square of amplitude of vibration (r^2) and time (t).

Mathematical Analysis and Observations: -

Least count of the stop watch = _____ seconds.

S.No	Number of vibrations completed	Amplitude of vibration (r cm)	Time 't' seconds	Square of amplitude r^2 $(cm)^2$
1.	10			
2.	20			
3.	30			
4.	40			
5.	50			

Result: -

As the amplitude of vibration of the bob of the pendulum decreases with time, since energy is proportional to the square of amplitude to the energy also decreases with time.

Precautions: -

1) The thread should be small and inextensible.
2) The amplitude of the vibration should be small.
3) The amplitude and time of the oscillations should be noted carefully.