

ENGINEERING SCIENCE LAB

PHYSICS

LAB MANUAL



Govt. Polytechnic College, Perumbavoor

General Department

COURSE CODE : C207 [2007]

COURSE NAME : ENGINEERING SCIENCE LAB

www.gptcperumbavoor.ac.in

VISION AND MISSION

Government Polytechnic College, Perumbavoor vision and mission

Vision

Excel as a centre of skill education moulding professionals who sincerely strive for the betterment of society.

Mission

- To impart state of the art knowledge and skill to the graduate and moulding them to be competent, committed and responsible for the wellbeing of society.
- To apply technology in the traditional skills, thereby enhancing the living standard of the community.

LIST OF EXPERIMENTS

Experiment	Aim
1. Screw Gauge I	Determine volume of the given sphere
2. Vernier Caliper I	Find out volume of given cylinder by measuring its length and diameter
3. Moment Bar I	Determine mass of the moment bar
4. Helical spring	Determine the spring constant. Calculate the mass of a body by measuring the extension
5. Parallelogram law	Find the mass of a body by Lami's theorem
6. Simple Pendulum	Determine the acceleration due to gravity g
7. Screw Gauge II	Measure thickness of glass plate and calculate its volume
8. Vernier Caliper II	Find the volume and surface area of rectangular block
9. Moment Bar II	Determine mass of the given body



SAFETY INSTRUCTIONS



Follow directions. Come to lab prepared to perform the experiment. Follow all written and verbal instructions. When in doubt, ask.

Be alert and attentive at all times. Act like an adult.

Report all accidents, injuries or breakage to the instructor immediately. Also, report any equipment that you suspect is malfunctioning.

Use equipment with care for the purpose for which it is intended.

Do not perform unauthorized experiments. Get the instructor's permission before you try something original.

Return all equipment, clean and in good condition, to the designated location at the end of the lab period.

Leave your lab area cleaner than you found it.



SAFETY INSTRUCTIONS



Follow stipulated dress code while entering the lab.

Keep safely your belongings other than essentials for doing Experiments outside the laboratory.

No individual work is allowed in the lab.

Laboratory in charge is responsible for the arrangements of your laboratory activities; Listen carefully and follow his/her instructions.

Inform the laboratory in charge about dangerous conditions and faults in the lab or nearby environment.

Strict discipline should be maintained in the laboratory.

Turn off cell phones before entering the lab.

Do not do any action that may harm people or equipments in the lab.

Do not misuse any of the tools or instruments belong to the lab.



ELECTRICAL SAFETY

The lab equipment is powered from electrical sockets installed on the tables. Do not use damaged sockets, damaged power cables or improperly assembles plugs for powering equipments.

Do not repair or disassemble electrical equipment including replacement of fuses installed in the equipment without proper consultation.

Do not open the main fuse or MCB box, unless it is an emergency and you need to switch off main circuit breaker.

The laboratory has circuit breakers, which is located in the main panel. Identify the place. In an emergency condition, switch off circuit breakers immediately.

Make sure you have a reliable ground point available near the table.

Do not wear clothing which generates static electric charges every time you move.

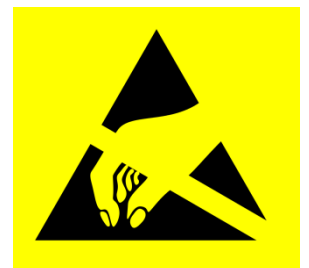
Do not handle static generating objects while working on electronics.

Store all chips and other components in appropriate anti-static containers.

Keep all ESD sensitive components and spares in anti-static envelopes for storage.

Be sure to turn off the power and remove the power plug from all equipment before working repairing or assembling.

Do not plug in or remove equipments while the power is on.



Screw Gauge I

Aim:

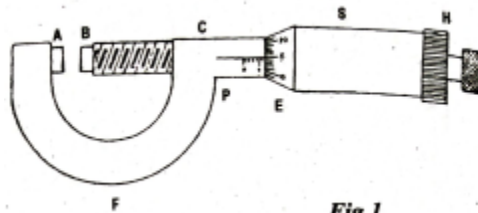
To determine the volume of the given sphere

Apparatus:

Screw gauge, small sphere etc.

Principle:

The screw gauge works on the principle of micrometer screw. It consists of a U shaped frame F with a cylindrical tube P attached to one end of it. Screw threads are cut inside this cylindrical tube and a screw works inside it. A sleeve S attached to the head of the screw has a beveled edge E and moves over the cylindrical tube which is graduated into 100 equal divisions. It is called the head scale. The tip B of the screw is plane. Directly opposite to the tip of the screw, there is a stud A with its plane face parallel to the tip of the screw.



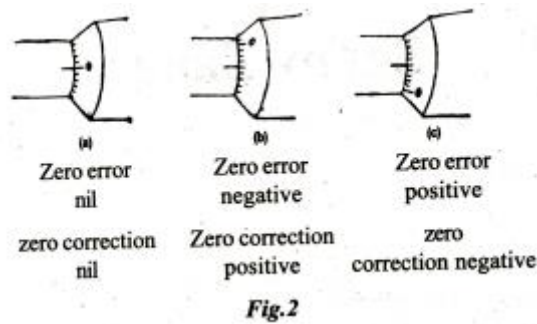
The least measurement which can be obtained accurately by an instrument is called its least count (LC)

$$\text{Least Count (LC)} = \frac{\text{Pitch}}{\text{Number of divisions on the headscale}} = \frac{P}{n}$$

Pitch is the distance moved by the tip of the screw gauge for one rotation of the head scale. The measured value using screw gauge is given by,

$$\text{Total reading} = \text{PSR} + (\text{Corrected HSR} \times \text{LC})$$

Here, PSR is the pitch scale reading and HSR is the head scale reading. When the fixed stud A and the movable stud B are brought in contact without applying any under pressure, and the zero of the head scale does not coincide with the reference line, there is a zero error. Based on the location of zero of the head scale with respect to reference line, zero errors are further as positive or negative zero error, so while doing calculations, in order to minimize the errors caused by the instrumental error, the positive or negative error is calculated by counting the number of divisions ahead or backward from the reference line and they are added or subtracted from the actual reading. Thus we can obtain the corrected HSR.



Volume of the sphere = $\frac{4}{3}\pi r^3$ and Surface area of the sphere = $4\pi r^2$.

Procedure:

To find the zero correction (z):- The head scale is rotated by holding the milled head, till the tip of the studs A and B gently touching each other. If the head scale zero coincides with the reference line on the pitch scale, there is no zero error. If the zero on the head scale is above the reference line, zero correction is positive and if the zero is below the reference line, zero correction is negative.

To find the volume and surface area of the sphere:- The given sphere is gripped between the studs of the screw gauge forward. Note that, the screw gauge tip advances by 1 mm (i.e., pitch increases by 1mm) only when the head scale makes one complete rotation. The PSR and the coinciding head scale division are noted. The division on the head scale while coincides with the reference line is the observed HSR.

$$\text{Corrected HSR} = \text{Observed HSR} + z$$

$$\text{Diameter of the sphere} = \text{PSR} + (\text{Corrected HSR} \times \text{LC})$$

The experiment is repeated for different positions of the sphere. The mean diameter and radius are determined. The volume of the sphere is calculated using the formula $V = \frac{4}{3}\pi r^3$ and surface area by $4\pi r^2$

Result:

Volume of the sphere = m³

Surface area of the sphere = m²

Observations and calculations:

To find least count:

Distance moved in 10 rotations =

$$\text{Pitch of the screw (P)} = \frac{\text{Distance moved}}{\text{Number of rotations}} =$$

Number of divisions on the head scale (n) =

$$\text{Least Count (LC)} = \frac{\text{Pitch}}{\text{Number of divisions on the headscale}} = \frac{P}{n}$$

Zero coincidence =

Zero error =

Zero correction =

Dimension	Sl. No.	PSR (mm)	Observed HSR divisions	Corrected HSR divisions (HSR+z)	Corrected HSR×LC	Total reading PSR+ (Corrected HSR×LC)
Diameter of the sphere (d)	1					
	2					
	3					
	4					
	5					

Mean diameter of the sphere (d) = mm

Radius of the sphere (r) = d/2 = m

Volume of the sphere = $V = \frac{4}{3}\pi r^3 = \dots\dots\dots m^3$

Surface area of the sphere = $4\pi r^2 = \dots\dots\dots m^2$

Vernier calipers I

Aim:

- To find the volume of the cylinder by measuring the length and diameter.
- To find the area of the cylinder.

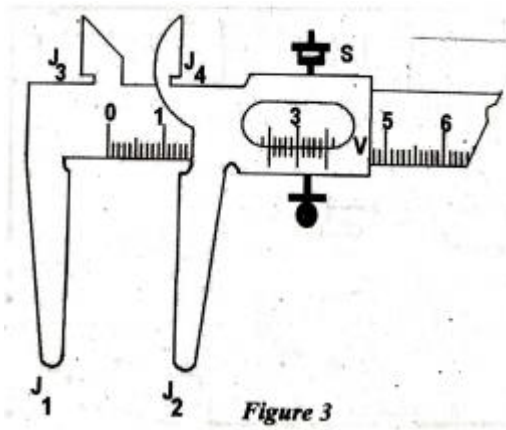
Apparatus:

Vernier calipers, cylinder

Principle:

Least count of an instrument is the least measurement that can be accurately made with it.

$$\text{Least Count (LC)} = \frac{\text{Magnitude of main scale divisions}}{\text{Number of vernier scale divisions}}$$



$$\text{Vernier caliper reading} = \text{MSR} + (\text{VSR} \times \text{LC})$$

Volume of the cylinder $= \pi r^2 l$ where r is the radius and l is the length of the cylinder

$$\text{Area of the cylinder} = 2\pi r(r + l)$$

Procedure:

The least count (LC) of the vernier caliper is determined by dividing the value of main scale division by the number of divisions on the vernier scale.

The least count (LC) of the vernier caliper is determined by dividing the value of main scale division by the number of divisions on the vernier scale.

To measure the length of the cylinder, it is gripped between the jaws J_1 and J_2 length wise and main scale reading (MSR) is found. It is the reading on the main scale up to the zero of the vernier. Then number of vernier divisions (VSR) that coincided with any of the main scale division is noted. The length of the cylinder is given by $\text{MSR} + (\text{VSR} \times \text{LC})$. The experiment is repeated by clamping vernier calipers at various points, of the cylinder and average length (l) is found. The mean diameter (d) is determined in the same procedure. Then radius, $r = d/2$.

Volume of the cylinder $V = \pi r^2 l$ and area of the cylinder $A = 2\pi r(r + l)$ is calculated.

Result:

Volume of the cylinder = m^3

Surface area of the cylinder = m^2

Observations and calculations:

Magnitude of one main scale division = mm

Number of vernier scale divisions =

$$\text{Least Count (LC)} = \frac{\text{Magnitude of main scale divisions}}{\text{Number of vernier scale divisions}} =$$

To find the volume of the cylinder

Dimension	Sl. No.	MSR (mm)	VSR divisions	VSR×LC (mm)	Total reading (mm) MSR+ (VSR×LC)	Mean (mm)
Diameter of the cylinder (d)	1					
	2					
	3					
	4					
	5					
Length of the cylinder (l)	1					
	2					
	3					
	4					
	5					

Diameter of the cylinder (d) = m

Radius of the cylinder (r) = d/2 = m

Length of the cylinder (l) = m

Volume of the cylinder = $V = \pi r^2 l = \dots\dots\dots m^3$

Surface area of the cylinder = $A = 2\pi r(r + l) = \dots\dots\dots m^2$

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Moment Bar I

Aim:

To determine the mass of the moment bar

Apparatus:

Moment bar (meter scale), slotted weight hanger, thread etc.

Principle:

A moment bar is a uniform bar suspended by a thread or supported on knife edge. Its center of gravity lies at its midpoint. The principle of moments states that an object is in equilibrium if the sum of all anticlockwise moments about the pivot is equal to the sum of all clockwise moments about the same pivot. If the moment bar is balanced horizontally at any point, this means that the clockwise moments and anticlockwise moments must be equal. In such case, weight of mass providing anticlockwise moment \times distance between mass and pivot = weight of mass providing clockwise moment \times distance between mass and pivot. This can be rewritten as

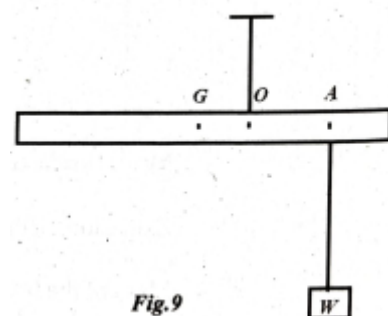
$$m_1 \times d_1 = m_2 \times d_2$$

Where m_1 is the mass of the moment bar, m_2 is the mass hanging from the moment bar, d_1 is the distance between the pivot and the center of gravity of the moment bar and d_2 is the distance between the hanging mass and the pivot.

This can be rearranged to give $m_1 = (m_2 \times d_2) / d_1$

Procedure:

The center of gravity G is determined first. For finding out the position of G, the moment bar is supported on a knife edge and balanced properly. The position of center of gravity is located and marked on the moment bar. Then it is suspended at a point O on one side of G as shown in figure 9. The weight of moment bar acts vertically downwards through the point G. A known weight W is suspended from



a point A on the bar and the position of W is adjusted until the moment bar remains horizontal. Since there is no translational or rotational motion for the moment bar at this position, for equilibrium

$$M \times GO = W \times OA$$

Here M is the weight of the moment bar which acts at the point G. From the above relation,

$$M = \frac{W \times OA}{GO}$$

The experiment is repeated. Mean value of the given mass is calculated.

Result:

Mass of the moment bar = kg

Observations and calculations:

Center of gravity of the given bar is at cm

Trial No.	Known weight (W)	Distance (GO)	Distance (OA)	$M = \frac{W \times OA}{GO}$
1				
2				
3				
4				
5				

Mean value = g

= kg

Helical spring

Aim:

- (a). To determine the spring constant of the helical spring by load-extension method
- (b). To determine the unknown mass of the given body.

Apparatus:

Helical spring apparatus, weight hanger with slotted weights, unknown mass etc.

Principle:

According to Hook's law, $F=kx$. Therefore $k = \frac{\text{Force}}{\text{extension}}$. Spring constant is given by $k = \frac{m}{x}g$; where x is the extension produced by mass m. Unknown mass $m=kL$, where L is the extension produced by the unknown mass m.

Procedure:

A suitable mass (dead load, m_0) is suspended from the spring using the weight hanger. Usually weight hanger itself acts as the dead load. The spring is brought to elastic mode by loading it and unloading it. Now the reading of the pointer (r_0) with dead load is taken from the scale.

Slotted weights are added one by one to the weight hanger, each time noting the scale reading. Then the slotted weights are unloaded one by one and each time the reading of the pointer is noted. The mean of the readings (r) corresponding to loading and unloading is calculated. The corresponding extension $x=r-r_0$, for 'm' values 50g, 100g, 150g etc. is determined by subtracting the extension for dead load from each reading. The value of m/x is found in each case, it is a constant. The spring constant calculated.

The unknown mass 'M' is suspended from the weight hanger along with the dead load. The extension produced, $L = R-r_0$ is found out and unknown mass is calculated.

Result:

Spring constant of the spring by calculation = g/mm

Mass of the given body = g

= kg

Parallelogram law of forces

Aim:

To find the weight of a given body using parallelogram law of vector addition

Apparatus:

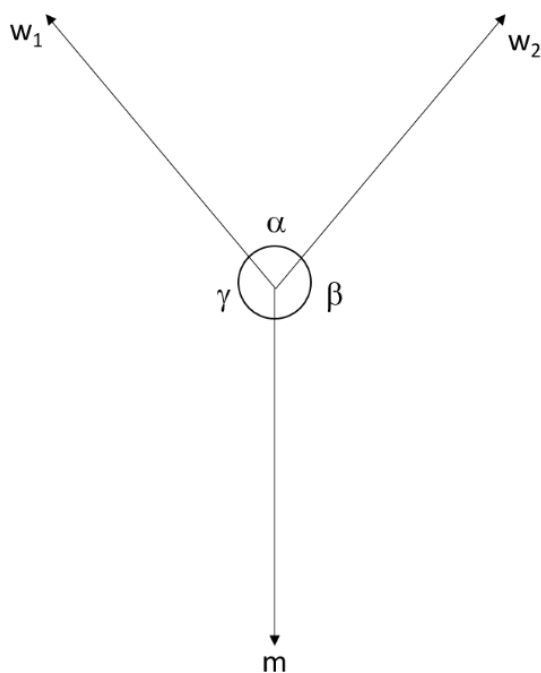
Parallelogram law apparatus, slotted weights, given body, paper, pins etc.

Principle:

Parallelogram law of vectors:-

If two forces acting at a point are represented by the adjacent sides of a parallelogram, then the diagonal starting from the common point represent their resultant. The unknown mass of the body m can be calculated using $\frac{m}{\sin \alpha} = \frac{w_1}{\sin \beta} = \frac{w_2}{\sin \gamma}$

Procedure:



A sheet of paper is fixed on the board using drawing pins. Suitable weights w_1 and w_2 are tied at the end of 2 strings passing over pulleys. The other end of the string are connected together and from this common point, its third string (unknown body) m is suspended.

Putting dot marks the direction of the 3 factors for us and the common knot are marked on the sheet of paper. The sheet of paper is taken out and the force vectors are drawn. Then calculating the angles between the three strings (forces) and find out the mean mass of the unknown body by repeating the experiment by

changing the weights w_1 and w_2 in steps of 50g weight. The mean value of m is found.

Result:

Mass of the given body = kg

Observations and calculations:

Trial No.	P (g)	Q(g)	α	β	γ	$\frac{P \sin \gamma}{\sin \alpha}$	$\frac{Q \sin \gamma}{\sin \beta}$	W (g)
1								
2								
3								
4								
5								

Mean W = g

Simple pendulum

Aim:

To determine the acceleration due to gravity g .

Apparatus:

Simple pendulum, stop clock and meter scale.

Principle:

For small amplitudes, time period of oscillation of a simple pendulum is $= 2\pi\sqrt{\frac{l}{g}}$. Therefore the acceleration due to gravity at the place $g = 4\pi^2 \frac{l}{t^2}$. i.e., $\frac{l}{t^2} = \text{constant}$, where l is the length of the pendulum.

Procedure:

The radius (r) of the bob is determined by measuring the diameter using vernier calipers. The length of the pendulum, l , is made. For this, the length of the string is so adjusted that, the distance between the point of suspension and the top of the bob is $l-r$.

A chalk mark is made on the table to indicate the equilibrium position. The bob is displaced to one side by a small distance and released to execute to and fro motion. The time taken for 20 oscillations is noted using the stop clock. This is repeated and mean time (t) for 20 oscillations is found out. Hence the time for one oscillation, $T = \frac{t}{20}$ is calculated.

The experiment is repeated by increasing the length of the pendulum l and in each case $\frac{l}{t^2}$ is calculated. It is found that $\frac{l}{t^2}$ is a constant. g can be calculated using this value.

Result:

The acceleration due to gravity at the place = m/s^2

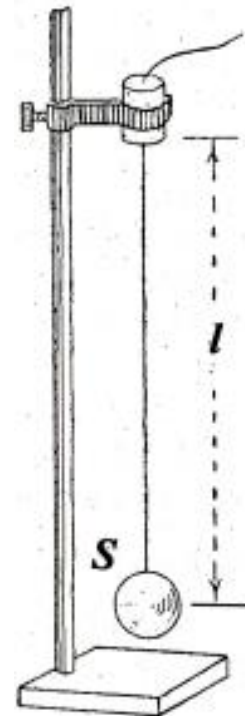


Figure 7

Observations and calculations:

Trial No.	Length l (m)	Time t for 20 oscillations (s)	Period T (s)	T^2 (s ²)	l/T^2 (m/s ²)
1					
2					
3					
4					
5					

Mean value of $(l/T^2) = \dots\dots\dots$ m/s²

$g = \dots\dots\dots$ m/s²

Screw Gauge II

Aim:

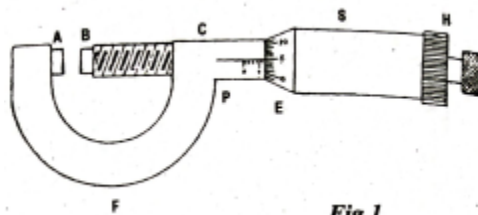
To determine the volume of the glass plate

Apparatus:

Screw gauge, glass plate etc.

Principle:

The screw gauge works on the principle of micrometer screw. It consists of a U shaped frame F with a cylindrical tube P attached to one end of it. Screw threads are cut inside this cylindrical tube and a screw works inside it. A sleeve S attached to the head of the screw has a beveled edge E and moves over the cylindrical tube which is graduated into 100 equal divisions. It is called the head scale. The tip B of the screw is plane. Directly opposite to the tip of the screw, there is a stud A with its plane face parallel to the tip of the screw.



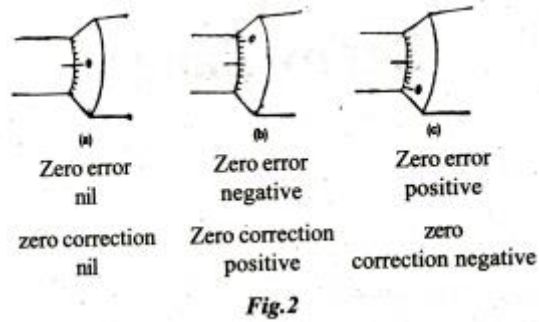
The least measurement which can be obtained accurately by an instrument is called its least count (LC)

$$\text{Least Count (LC)} = \frac{\text{Pitch}}{\text{Number of divisions on the headscale}} = \frac{P}{n}$$

Pitch is the distance moved by the tip of the screw gauge for one rotation of the head scale. The measured value using screw gauge is given by,

$$\text{Total reading} = \text{PSR} + (\text{Corrected HSR} \times \text{LC})$$

Here, PSR is the pitch scale reading and HSR is the head scale reading. When the fixed stud A and the movable stud B are brought in contact without applying any under pressure, and the zero of the head scale does not coincide with the reference line, there is a zero error. Based on the location of zero of the head scale with respect to reference line, zero errors are further as positive or negative zero error, so while doing calculations, in order to minimize the errors caused by the instrumental error, the positive or negative error is calculated by counting the number of divisions ahead or backward from the reference line and they are added or subtracted from the actual reading. Thus we can obtain the corrected HSR.



Volume of the glass plate = $A \times t$ where A is the area of the glass plate and t is the thickness of the glass plate.

Procedure:

To find the zero correction (z):- The head scale is rotated by holding the milled head, till the tip of the studs A and B gently touching each other. If the head scale zero coincides with the reference line on the pitch scale, there is no zero error. If the zero on the head scale is above the reference line, zero correction is positive and if the zero is below the reference line, zero correction is negative.

To find the volume of the glass plate:- The thickness (t) of the glass plate is measured by using screw gauge. The glass plate is placed on a graph paper and its outline is marked on the graph paper. The number (n) of 1 mm^2 columns in the glass plate area is counted. The $n \times 10^{-6}$ gives the surface area (A) of the glass plate. The volume of the glass plate $A \times t$ is calculated.

Result:

Volume of the glass plate = m^3

Observations and calculations:

To find least count:

Distance moved in 10 rotations =

$$\text{Pitch of the screw (P)} = \frac{\text{Distance moved}}{\text{Number of rotations}} =$$

Number of divisions on the head scale (n) =

$$\text{Least Count (LC)} = \frac{\text{Pitch}}{\text{Number of divisions on the headscale}} = \frac{P}{n}$$

Zero coincidence =

Zero error =

Zero correction =

Dimension	Sl. No.	PSR (mm)	Observed HSR divisions	Corrected HSR divisions (HSR+z)	Corrected HSR×LC	Total reading PSR+ (Corrected HSR×LC)
Thickness of glass plate (t)	1					
	2					
	3					
	4					
	5					

Mean diameter of the glass plate (t) = mm

No. of columns in the glass plate area (n) =

Area of the glass plate = $A = n \times 10^{-6} = \dots\dots\dots \text{m}^2$

Volume of the glass plate = $V = A \times t = \dots\dots\dots \text{m}^3$

Vernier calipers II

Aim:

To find the volume and surface area of the given rectangular block by measuring its dimensions.

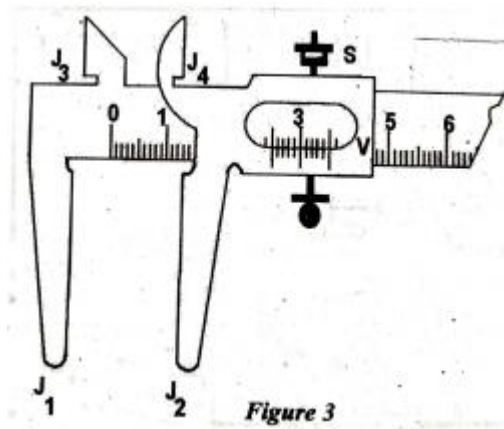
Apparatus:

Vernier calipers, rectangular block

Principle:

Least count of an instrument is the least measurement that can be accurately made with it.

$$\text{Least Count (LC)} = \frac{\text{Magnitude of main scale divisions}}{\text{Number of vernier scale divisions}}$$



$$\text{Vernier caliper reading} = \text{MSR} + (\text{VSR} \times \text{LC})$$

Volume of the rectangular block = lbh where l is the length, b is the breadth and h is the height of the rectangular block.

$$\text{Area of the rectangular block} = 2(lb + lh + bh)$$

Procedure:

The least count (LC) of the vernier caliper is determined by dividing the value of main scale division by the number of divisions on the vernier scale.

To measure the dimensions of the rectangular block, it is gripped between the jaws J_1 and J_2 and main scale reading (MSR) is found. It is the reading on the main scale up to the zero of the vernier. Then number of vernier divisions (VSR) that coincided with any of the main scale division is noted. The length (l), breadth (b) and height (h) of the rectangular block are measured as explained. The experiment is repeated by clamping vernier calipers at various

points, of the block and average value are found. Volume of the rectangular block $V = lbh$ and surface area $A = 2(lb + lh + bh)$ is calculated.

Result:

Volume of the rectangular block = m³

Surface area of the rectangular block = m²

Observations and calculations:

Magnitude of one main scale division = mm

Number of vernier scale divisions =

$$\text{Least Count (LC)} = \frac{\text{Magnitude of main scale divisions}}{\text{Number of vernier scale divisions}} =$$

To find the volume of the rectangular block

Dimension	Sl. No.	MSR (mm)	VSR divisions	VSR×LC (mm)	Total reading (mm) MSR+ (VSR×LC)	Mean (mm)
Length of the block (l)	1					
	2					
	3					
	4					
	5					
Breadth of the block (b)	1					
	2					
	3					
	4					
	5					
Thickness of the block (h)	1					
	2					
	3					
	4					
	5					

Length of the block (l) = m

Breadth of the block (b) = m

Thickness of the block (h) = m

Volume of the cylinder = $V = lbh = \dots\dots\dots m^3$

Surface area of the cylinder = $A = 2(lb + lh + bh) = \dots\dots\dots m^2$

Moment Bar II

Aim:

To determine the mass of given body using meter scale

Apparatus:

Moment bar (meter scale), slotted weight hanger, thread, a body of unknown mass etc.

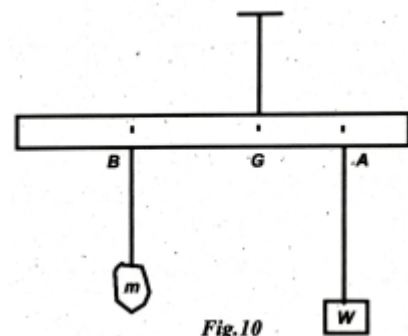
Principle:

A moment bar is a uniform bar suspended by a thread or supported on knife edge. Its center of gravity lies at its midpoint. The principle of moments states that an object is in equilibrium if the sum of all anticlockwise moments about the pivot is equal to the sum of all clockwise moments about the same pivot. If the moment bar is balanced horizontally at any point, this means that the clockwise moments and anticlockwise moments must be equal. In such case, weight of mass providing anticlockwise moment \times distance between mass and pivot = weight of mass providing clockwise moment \times distance between mass and pivot. At equilibrium, if x and x_1 are the distance of known mass m and unknown mass m_1 from the center of gravity of the moment bar, then

$$mgx - m_1gx_1 = 0 \text{ and hence } m_1 = (m \times x) / x_1$$

Procedure:

The meter scale is suspended from a stand using a loop of string so that it is horizontal. This position of the string is the center of gravity G of the scale. A known mass m is suspended from a fixed distance x (say 5cm) from G . Then the given body whose mass m_1 is suspended from the other end of the scale. The position m_1 is carefully adjusted till the scale remains horizontal. The distance x_1 from G to the position m_1 is noted. The unknown mass m_1 is calculated.



$$m \times x = m_1 \times x_1$$

$$m_1 = \frac{m \times x}{x_1}$$

The experiment is repeated by changing the value of m . In each case m_1 is calculated.

Result:

Mass of the given body = kg

