

Practical Notebook

Physics

Grade IX

Web Version of PCTB Textbook

giz



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Learning Outcomes of Practical Work

Students are required to carry out practical work as an integral part of the course. They are advised to maintain a practical notebook in which they record, for all their practical work, the experimental arrangements used, the observations made and the analysis of these observations. Through experimental work the students are expected to develop the following skills:

1. Techniques

- i. Reading to the maximum accuracy of linear and angular scales; use of vernier scales, timing by stopwatch or stopclock etc.
- ii. Accurate focusing and location of images.
- iii. Connecting up and checking electrical circuits from a circuit diagram, drawing a circuit diagram for a given simple circuit, already connected up.
- iv. Recognize and respond to hazards.

2. Information Handling

- i. Search, select and interpret scientific information from a variety of sources.
- ii. Display of results in tabular and graphical form.
- iii. Translate information between graphical, numerical, algebraic and verbal forms.
- iv. Accurate plotting of graphs with suitable choice of scales and interpret information from them.
- v. For linear graph, determine the slope, intercept and intersection.
- vi. Choose, by inspection, a straight line which will serve as the best straight line through a set of data points presented graphically.

Note: Use of centimetre graph be made compulsory.

3. Experimental and investigative skills

- i. Become acquainted with the use of scientific instruments of appropriate resolution and apparatus, including techniques of operation, essential precautions and safety aspects.
- ii. Make and record observations, measurements and estimates with due regard to precision, accuracy and units.
- iii. Analyze and interpret information and result obtained in scientific investigation and practical work, identify patterns and trends, and draw valid conclusions.

4. Attitudes

- i. Share the responsibility for accomplishing the group task.
- ii. Show concern for the maximum possible involvement of each group member.
- iii. Display respect for evidence, rationality and intellectual honesty during investigation tasks.
- iv. Concern for accuracy and precisions in investigations and practical work.

General Safety Procedures

Before you begin.....

1. Keep your work table neat and clean. Make sure that it has no unnecessary things such as school bag, files, clothes and books etc.
2. Read carefully all the instructions in your practical manual / book before you do anything.
3. Look out for possible safety precautions.
4. Be sure that equipment and glassware are cleaned before use.

While you are doing the experiment....

1. Follow the directions in the practical notebook precisely.
2. Do not wander around and do not endanger people around you.
3. Wear or use protective devices that are provided to you. These protective devices include goggles, gloves, apron and safety tongs.
4. Use wire gauze or sand bath for heating. Never leave heating apparatus unattended. Turn off Bunsen burner or spirit lamp when you have to leave your work table for a while or when you have finished your experiment.
5. Handle the apparatus and other instruments particularly sharp objects carefully to avoid damage and loss.
6. If you have broken any glassware (beakers, test-tubes and thermometers etc.) or spilt anything, report to your teacher at once so that it may be cleaned up.
7. Be aware of where fire extinguishers, fire blankets and first aid box are located in the laboratory.
8. Do not eat or drink anything in the laboratory.

After you have finished....

1. Turn off water and gas, disconnect electrical connections and return your apparatus to Lab. staff.
2. Do not dispose of material in the sink unless you are instructed to do so.
3. Wash your hands thoroughly.

The best preventive measure is to always be careful and alert. Take care of yourself and people working around you.

Skills Build-up: Displaying Data on Graphs

Introduction

1. Drawing & interpreting graphs is one of the important skills applied not only in mathematics and sciences but also in all other disciplines of social sciences, commerce, business studies etc.
2. Graphs make visual display of data and other numerical information readable easily.

Graphs in Physics Measurements

1. A graph is plotted to know the relationship between two quantities. It gives a visual picture of results and information regarding relationship between them.
2. It can be used to find an average value from a set of readings.
3. It can be used to find the value of a quantity which is not actually observed experimentally.
4. It helps to discover error in the experimental observations.

Plotting a Graph

- | | |
|--|--|
| (a) Give a title to graph | On top of the sheet such as “Load against extension” (Fig. 1). |
| (b) Mark axes | Fixing origin at left bottom corner or somewhere at the middle part as appropriate (Fig. 1). |
| (c) Axes to be labelled prominently | Normally cause (independent variable) on x-axis and the effect (dependent variable) on y-axis but it is not essential. Write clearly the name of each variable giving its unit (Fig. 1). |
| (d) Use a suitable scale | Do not condense the graph into a small area but draw a graph as large as the available space allows (Fig. 1). Scale should have 0,1,2,3..... or 0,2,4,8 or 0,5,10,15 sequence. Odd sequence such as 0,3,6,9 or 0,7,14 etc. should not be used. |
| (e) Selected scale to be mentioned | Scale should be mentioned along with the graph. Same scale on both axes not essential. Even zero of the scale not necessarily to lie on the origin. |

- (f) **Graduation**
- (g) **Points to be marked**
- (h) **Drawing a straight line or curve**
- (i) **Best straight line or a smooth curve**

Mark scale on each axis and not the actual number.

Crosses (x or +) or with dot and circle ($\odot$) (Fig. 2).

Do not attempt to join all points on the graph. Use a transparent ruler to help you draw a best fit straight line. If the points do not seem to lie on a straight line, draw a freehand smooth curve passing evenly through most of the points (Fig. 3 & 4).

The best straight line (or smooth curve) passes through as many of plotted points as possible or which leaves an equal distribution of points on either side (Fig. 3 & 4).

Caution

The graph line must be thin and clear. Thick, heavy point to point and kinked lines are not acceptable.

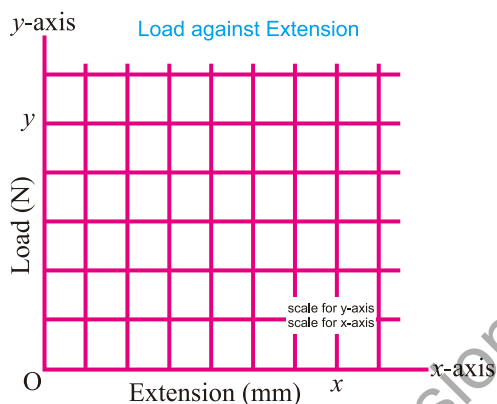


Fig. 1: Title, Labels, Units and Scales for Graph

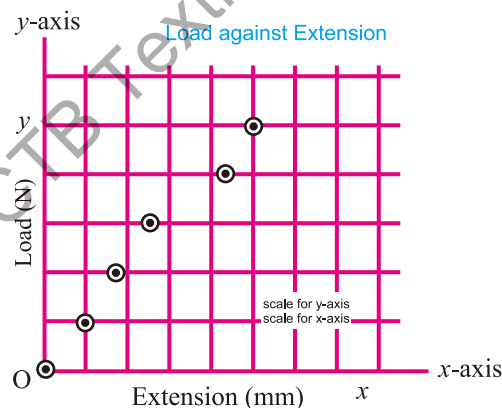


Fig. 2: Plotting Points

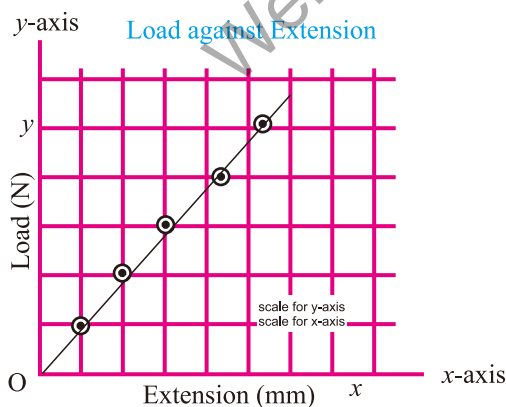


Fig. 3: A straight line graph which shows that y is directly proportional to x .

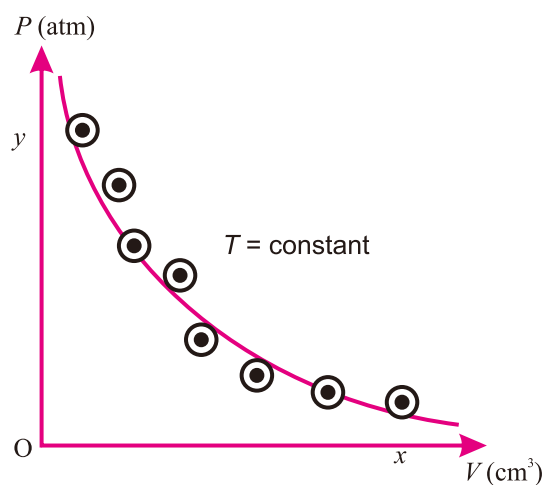


Fig. 4: A smooth curve of Pressure – Volume graph of a gas which shows that y is inversely proportional to x .

Straight Line Graph

It is often useful to plot experimental data in such a way that a straight line graph results.

From Fig. 5

$$\tan \theta = \frac{AM}{OM} = \frac{y}{x}$$

Let $\tan \theta = m$ (Slope or gradient of the line)

$$\text{Then } \tan \theta = m = \frac{y}{x}$$

Or $y = mx$ is the equation of a straight line through the origin. It means y is directly proportional to x , where m is constant.

If straight line does not pass through the origin then $y = mx + c$ where c is the intercept on y -axis.

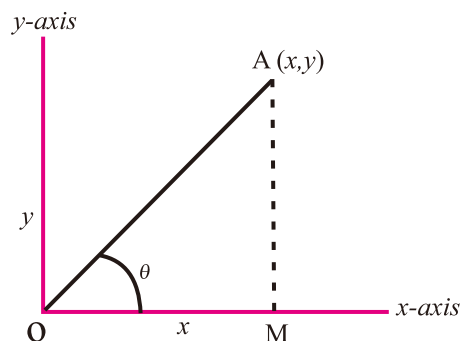


Fig. 5

Measurement of Gradient and Intercept

- (a) Gradient (slope) of a straight line is the tangent of the angle θ which the line makes with the horizontal. In case of potential difference (P.d.) and current ' I ' the slope of the line gives the resistance (Fig.6).

The slope m in the above equation is the ratio of vertical change to the horizontal change. For that purpose, select two points A and B, as far apart as possible on the graph line. The vertical change Δy is the difference between the vertical values of A and B. The horizontal change Δx is the difference between horizontal of A & B. The Slope $m = \Delta y / \Delta x$

- (b) Evidence of how a reading is obtained from a graph must be shown

- e.g. (i) the triangle for calculation of gradient.
(ii) reference lines (in broken lines) to find a point on the horizontal axis corresponding to a point on the vertical axis or vice-versa.

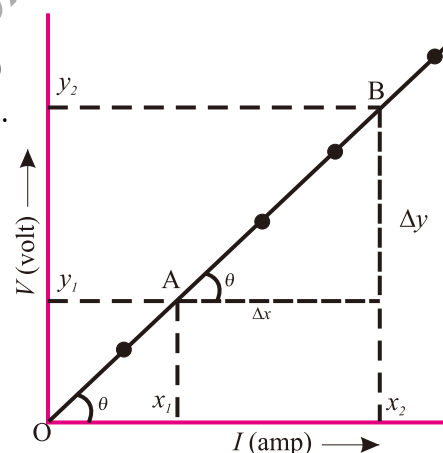


Fig. 6

Intercept

It is the point at which graph line crosses y axis known as y - intercept. The y -intercept must be read from an axis where $x = 0$

Direct Relationship

1. A graph in which data points lie on a straight line is a graph of linear relationship (Fig. 3).
2. A linear relationship can be expressed by the equations $y = mx + c$
3. The slope ' m ' of the straight line graph is a vertical change divided by the horizontal change.

Inverse Relationship

The graph of an inverse relationship between x & y is represented by curve $y = a/x$ and this curve is called hyperbola (Fig. 4).

Quadratic Relationship

Sometimes a quantity varies as the square of some other such as $y = ax^2$. The equation of this type is known as a quadratic equation and its graph is a parabola (Fig. 7).

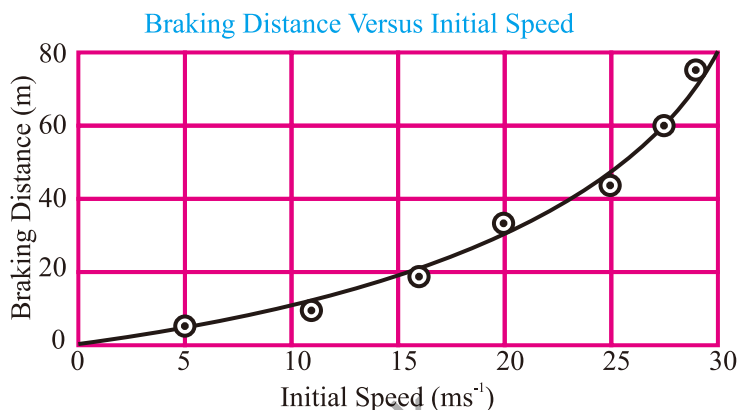


Fig. 7

Exercise

1. Make a list of direct relationship and inverse relationship between various physical quantities.
2. Use a metre rule to measure the diameter of four circular objects and a string to measure their circumference.

Materials required: Metre rule, string, four circular objects, graph paper.

- i. Record your data in a tabular form.

- ii. Make graph, the circumference versus the diameter.

- iii. What type of relation is shown by the graph between circumference and diameter?

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- iv. Find the slope of the graph.

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- v. What does the slope represent?

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Some Useful Data

Speed of sound in air at $0^{\circ}\text{C} = 331 \text{ ms}^{-1}$

Speed of light in vacuum = $3 \times 10^8 \text{ ms}^{-1}$

$$\pi = \frac{22}{7} = 3.142$$

Gravitational field strength near Earth surface = $9.8 \text{ N kg}^{-1} \approx 10 \text{ N kg}^{-1}$

Acceleration due to gravity near Earth surface = $9.8 \text{ ms}^{-2} \approx 10 \text{ ms}^{-2}$

Some Formulae

1. Area of a circle = Area of cross -section = $\pi \times (\text{radius})^2$
2. Circumference of a circle = $2\pi \times \text{radius}$
3. Surface area of a sphere = $4\pi \times (\text{radius})^2$
4. Volume of a sphere = $\frac{4}{3}\pi \times (\text{radius})^3$
5. Volume of a cylinder = $\pi \times (\text{radius})^2 \times \text{length (height) of the cylinder.}$

Densities of Some Solids and Liquids (in g cm^{-3})

Solid	Density	Liquid	Density
Cork	0.2 to 0.3	Water (at 4°C)	1.00
Glass	2.4 to 2.6	Milk	1.85
Marble	2.5 to 2.8	Kerosene oil	0.81
Iron	7.2	Petrol	0.7 – 0.8
Gold	19.2	Turpentine oil	0.87
Ice	0.92	Glycerin	1.26
Nickel	8.9	Benzene	0.85
Tin	7.3	Sulphuric acid	1.3
Brass	8.1 to 8.5	Mercury (at 0°C)	13.6
Aluminium	2.7	Sea water	1.03 – 1.05
Lead	11.3	Ethanol	0.81
Silver	10.5		
Copper	9.2		
Pinewood	0.4 – 0.7		
Oakwood	0.6 – 0.9		
Balsa wood	0.15		
Ice at 0°C	0.92		

Note: For conversion of g cm^{-3} in kg m^{-3} , multiply above values by 1000.

Approximate Co-efficient of Sliding Friction

Objective (Dry surface)	Co-efficient of friction
Between wood and wood	0.25 – 0.5
Between wood and stone	0.4
Between metal and metal	0.2
Between wood and leather	0.4
Between ice and ice	0.028
Rubber tyres on hard road	0.5 – 0.7

Specific Heat Capacity of Some Substances

Substance	$\text{J kg}^{-1} \text{K}^{-1}$	Substance	$\text{J kg}^{-1} \text{K}^{-1}$
Water	4200	Copper	385
Ethanol	2500	Aluminium	913
Turpentine oil	1760	Lead	126
Hydrogen	14300	Iron	106
Air	993	Steel	420
Helium	5240	Granite	820
Oxygen	913	Marble	900
Carbon dioxide	1000	Concrete	3350

Specific Latent Heat of Fusion of Some Substances

Substance	kJ kg^{-1}
Water	335
Aluminium	390
Iron	270
Copper	210
Mercury	1.3

Specific Latent Heat of Vapourization of Some Substances

Substance	kJ kg^{-1}
Water	2260
Ethanol	850
Ether	350
Turpentine	270



Measure the area of cross - section of a solid cylinder by measuring its diameter with vernier callipers

Date _____



Vernier callipers is a device which is generally used to measure length as small as 1/10th of a millimeter (0.1 mm). It has two scales (i) Main Scale (MS) (ii) Vernier Scale (VS).

Least Count of the instrument

$$\begin{aligned} \text{Least count} &= \frac{\text{Value of smallest division on the main scale (MS)}}{\text{Number of divisions on the vernier scale (VS)}} \\ LC &= 1 \text{ mm} / 10 = 0.1 \text{ mm} = 0.01 \text{ cm} \end{aligned}$$

Zero Error

If zero of the main scale does not coincide with the zero of the vernier scale, when the jaws are closed there is **zero error** in the instrument. This error may be positive or negative.



Fig. 1.1.1 (No Zero Error)



Fig. 1.1.2 (Positive Zero Error)



Fig. 1.1.3 (Negative Zero Error)

Positive Zero Error

If zero of the vernier scale is on the right side of the main scale zero, there is positive zero error. For example, in Fig. 1.1.2 zero of VS is on the right side of MS zero and 3rd division of the vernier scale coincides with one of the main scale division. Multiply this number with the least count to obtain value of zero error.

$$\begin{aligned} \text{Positive zero error} &= 3 \times LC \\ &= 3 \times 0.01 \text{ cm} = 0.03 \text{ cm} \end{aligned}$$

Negative Zero Error

If zero of the vernier scale is on the left side of the main scale zero, then zero error is negative. For example, in Fig 1.1.3 zero error is negative and 4th division of the vernier scale coincides with any division of the main scale. Subtract this number from the total number of divisions on vernier scale (10–4=6). Multiply the resultant number with least count to obtain the value of negative zero error.

$$\begin{aligned} \text{Negative zero error} &= 6 \times LC \\ &= 6 \times 0.01 \text{ cm} = 0.06 \text{ cm} \end{aligned}$$

Zero Correction

When the zero error is negative, it is added to the observed reading and is called

positive zero correction. For Fig 1.1.3,

Positive zero correction = +0.06 cm

When the zero error is positive, it is subtracted from the observed reading to obtain the correct value and is called negative zero correction. For Fig 1.1.2

Negative zero correction = -0.03 cm

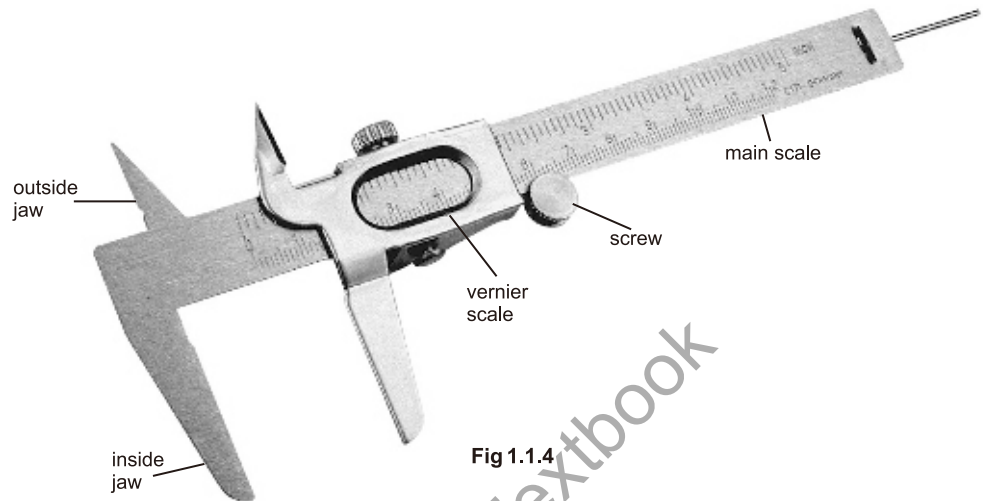
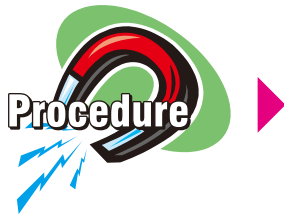


Fig 1.1.4

Vernier callipers, solid cylinder.



DO YOU KNOW?

Vernier Callipers is used by the lathe mechanic for making metallic cylinders of various sizes or measuring bores in the engine blocks. Aluminium and Steel window makers and plumbers also use vernier callipers.

- ❶ Find the Least Count. Close the jaws to check the Zero error and calculate the Zero Correction.
- ❷ Hold the Cylinder (Cross-section wise) between the two jaws of the vernier callipers. Tighten the jaws gently.
- ❸ Note the main scale division which is either coinciding or is on the left of vernier scale zero.
- ❹ Record this value as main scale reading (M).
- ❺ Note the vernier division (n) which exactly coincides with any one division of the main scale.
- ❻ Multiply this " n " with the least count and calculate the value of fraction (X) which is to be added in the main scale reading

$$X = (n \times LC)$$
- ❼ Add the values ' M ' & ' X ' to obtain observed value (Y) of diameter.

$$Y = M + X$$
- ❽ Apply zero correction to obtain correct diameter (D).

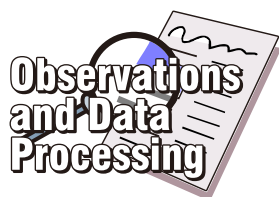
$$D = Y \pm ZC$$
- ❾ Take at least two more readings by inserting the cylinder cross-section wise between the jaws and get the average diameter.
- ❿ Calculate the radius of the cylinder.

Think

Why are the jaws closed gently?

Think

Why is the number (n) multiplied with the least count?



Observations and Data Processing

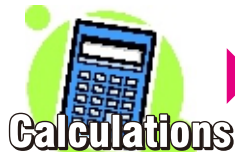
Least count (LC) =mm =cm

Zero error = cm

Zero correction (ZC) = ($\pm$)..... cm

Mean diameter = D = cm

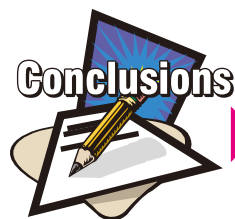
Radius of the cylinder = $r = D/2$ = cm



Calculations

Area of cross section of solid cylinder = $\pi(\text{radius of cylinder})^2$

$$A = \pi r^2$$



Conclusions

Area of cross section of solid cylinder = cm^2

! CAUTIONS

- Jaws of vernier callipers should be closed gently.
- Zero correction should be applied.
- Both jaws should touch the cylinder.



Post Lab Activities

1. Vernier callipers is used to measure some quantity of the given beaker as shown in Figure 1.1.5.
 - (i) Name the quantity to be measured.

 - (ii) Which parts of vernier callipers have been used?

 - (iii) What is the reading shown in the figure?

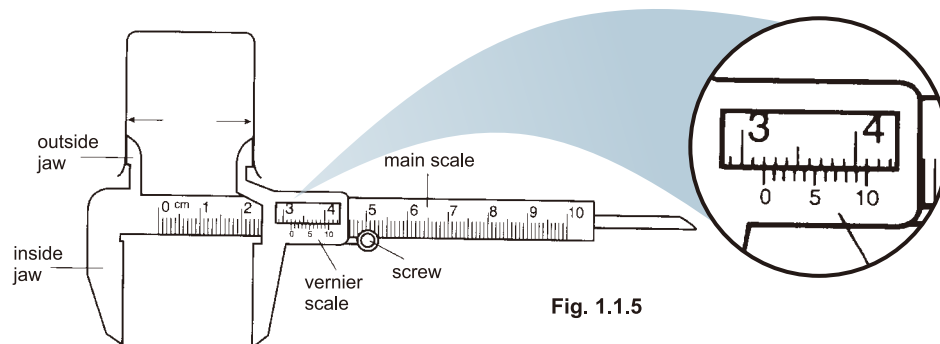


Fig. 1.1.5

2. Why is it necessary to take more than one readings and then to find the average reading?
_____.
3. What difficulties will you face by using a metre rod to measure the;
 - a. External diameter of a beaker? _____.
 - b. Internal diameter of a beaker? _____.
 - c. Internal depth of a beaker? _____.
4. What is the advantage of using vernier callipers for taking the above measurements?
_____.
5. How is the vernier scale related to main scale? _____.



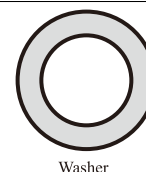
BRAIN TEASER

A student performed an experiment to measure the breadth of a washer as shown. She tabulated her observations as below:

S. No.	External diameter (D) in (cm)	Internal diameter (d) in (cm)
1	4.18	2.96
2	4.20	2.94
3	4.17	2.95

She is puzzled now. Help her to

- i) Establish a formula for breadth.
- ii) Calculate the breadth.

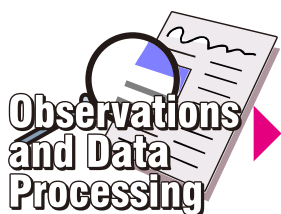


Washer

Experiment 1.2

Determine the volume of a solid cylinder by measuring its length and diameter with vernier callipers.

Date _____



DO YOU KNOW?

The accuracy of vernier callipers can be enhanced by increasing the number of divisions on the vernier scale.

- 1 Measure the length of the solid cylinder at least three times using vernier callipers as given in experiment 1.1. Calculate the average length.
- 2 Similarly, measure the diameter of the cylinder at least three times and calculate the average diameter.
- 3 Record the readings and calculate the volume of the cylinder by using formula $\pi r^2 L$.

CAUTIONS

- Jaws of vernier callipers should be closed gently.
- Zero correction should be applied.
- Both jaws should touch the cylinder.

Least count (LC) =mm =cm

Zero error = cm

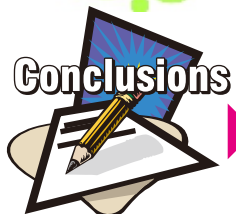
Zero correction (ZC) = ($\pm$)..... cm

Quantity	No. of Obs.	Main scale reading M	No. of vernier division coinciding with the MS division n	Fraction to be added $X = n \times LC$ (cm)	Observed value $Y = M + X$ (cm)	Corrected value $= Y \pm ZC$ (cm)
Length L	1					$L_1 =$
	2					$L_2 =$
	3					$L_3 =$
Diameter D	1					$D_1 =$
	2					$D_2 =$
	3					$D_3 =$

$$\text{Mean length} = L = \frac{L_1 + L_2 + L_3}{3} = \text{..... cm}$$

$$\text{Mean diameter} = D = \frac{D_1 + D_2 + D_3}{3} = \text{..... cm}$$

$$\text{Radius of the cylinder} = r = \frac{D}{2} = \text{..... cm}$$



Volume of solid cylinder = $\pi (\text{Radius of cylinder})^2 \times (\text{Length of cylinder})$
 $V = \pi r^2 L$

Volume of solid cylinder = cm³

1. Following figures are of the same vernier callipers. Fig. 1.1.6 shows the reading when the jaws are closed while Fig. 1.1.7 shows the reading when a cylinder is placed between the jaws. Determine the accurate length of the cylinder?

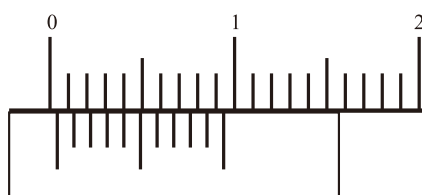


Fig. 1.1.6

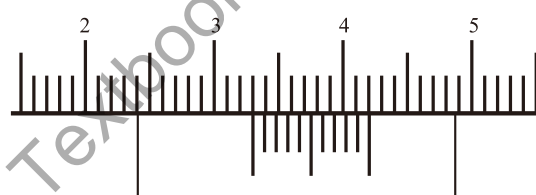


Fig. 1.1.7

2. A student performed an experiment using different vernier callipers. Complete the table shown as under.

Diagram	Reading with no zero error	Instrument has zero error	
		Zero of vernier scale lies at right of MS zero and 2nd division of VS coincides with a division on MS.	Zero of vernier scale lies at left of MS zero and 3rd division of VS coincides with a division on MS.

3. i) Place five identical pencils side by side and measure their total width using a metre rule.

ii) Calculate the thickness of one pencil. _____

iii) Now find the thickness of a pencil using vernier callipers. _____

iv) Compare and comment on the two results. _____

4. What is the least count of a clock if it has

i) Hours-hand, minute-hand and seconds-hand _____

ii) Hours-hand and minute-hand _____



BRAIN TEASER

Can you measure the diameter of a round marble by using metre rule with the same accuracy as that of vernier callipers? If yes, how?

Experiment 1.3

Measure the thickness of a metal strip or a wire by using a Screw Gauge.

Date _____

Background Information

Screw gauge is a device used to measure length as small as 1/100th of millimetre (0.01 mm).

Screw Gauge has two scales

- Main Scale
- Circular Scale or Thimble scale

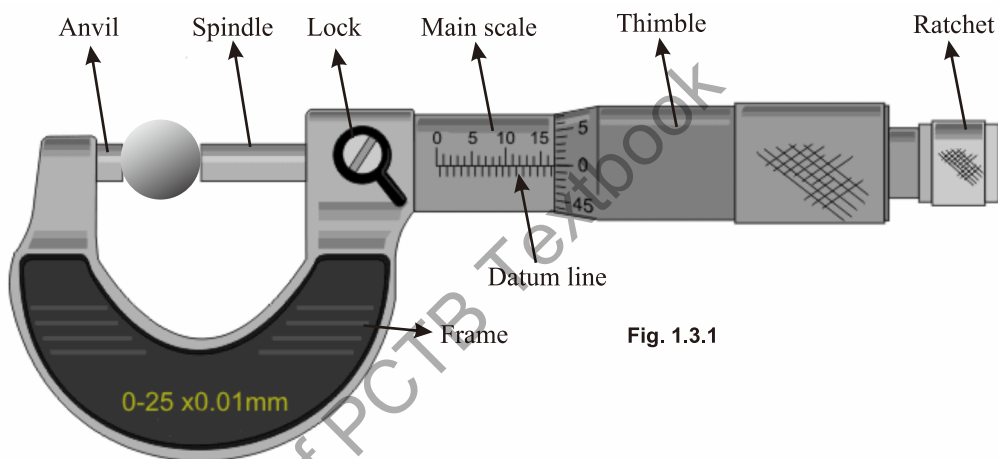


Fig. 1.3.1

Pitch of Screw Gauge

The distance moved on the main scale by giving one rotation to the circular scale is called pitch. Usually it is 0.5 mm for 50 divisions on circular scale.

Least Count

$$\text{Least Count} = \frac{\text{Pitch}}{\text{Number of divisions on the circular scale}}$$

$$LC = \frac{0.5\text{mm}}{50} = 0.01 \text{ mm}$$

Zero Error

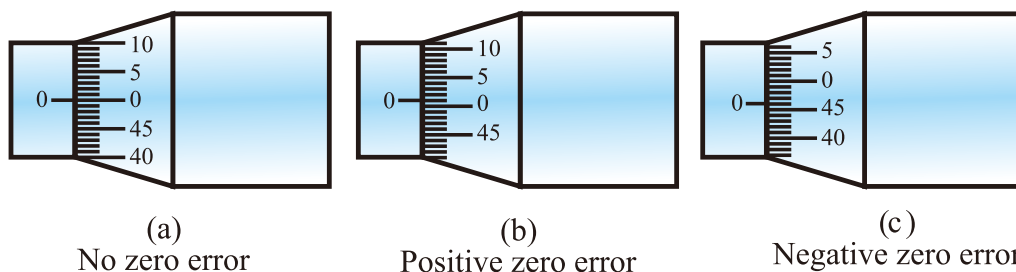


Fig. 1.3.2

Positive Zero Error

If the zero of circular scale is below the datum line, there is positive zero error. In Fig 1.3.2(b), zero error is positive where 2nd division of the circular scale coincides with the datum line. Multiply this number with the least count to obtain value of zero error.

$$\text{Positive zero error} = 2 \times LC = 2 \times 0.01 \text{ mm} = 0.02 \text{ mm}$$



DO YOU KNOW?

Screw gauge works on the principle of screw and nut. When the screw is turned through one revolution, it advances by one pitch length.

Negative Zero Error

If the zero of the circular scale is above the datum line, there is negative zero error. In Fig 1.3.2(c) zero error is negative where 46th division of the circular scale is in front of the datum line. Subtract this number from total number of divisions on circular scale ($50 - 46 = 4$). Multiply resultant number with the least count to obtain value of negative zero error.

$$\text{Negative zero error} = 4 \times LC = 4 \times 0.01 \text{ mm} = 0.04 \text{ mm}$$

Zero Correction

When the zero error is negative, the zero correction is positive.

$$\text{Positive zero correction} = +0.04 \text{ mm}$$

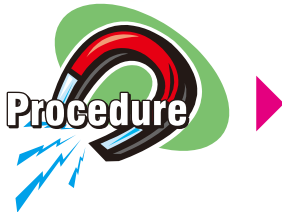
When zero error is positive, the zero correction is negative.

$$\text{Negative zero correction} = -0.02 \text{ mm}$$



Materials Required

Screw gauge, flat metal strip or kink free wire.



Procedure

CAUTIONS

- Add or subtract the zero correction as condition demands.
- Take the diameter of the wire from different places.
- Do not press the jaws of the screw gauge very hard.
- Do not rotate thimble unnecessarily in backward or forward direction.
- Rotate the screw gently using the ratchet.

- 1 Find the Least Count.
- 2 Close the anvil & spindle by rotating the ratchet till it clicks freely.
- 3 Check the zero error and hence calculate the zero correction.
- 4 Hold the metal strip between the anvil & spindle.
- 5 Tighten it gently by the ratchet till it clicks.
- 6 Note the main scale reading (M) which is just under or before the sleeve of the circular scale.
- 7 Note the division (n) on the circular scale which coincides with the datum line.
- 8 Multiply this number with the least count and calculate the fractional value as (X)
$$X = n \times LC$$
- 9 Add the values ' M ' and ' X ' to obtain the thickness of the strip (or diameter of wire).
- 10 Apply zero correction to determine the correct value of thickness $t = Y \pm ZC$
- 11 Take two more readings at different positions and find the average thickness.

Think

What is the purpose of ratchet?

Think

Why the metal strip should be flat or wire be kink free?

Observations and Data Processing



DO YOU KNOW?

Micrometer is commonly used to measure thickness of metallic sheets and wires to check their standard gauges.

Least count (LC) =mm

Zero error =mm

Zero correction (ZC) = ($\pm$).....mm

No. of Obs.	Main scale Reading M (mm)	Division of CS coinciding with the datum line n	Fraction to be added $X = n \times LC$ (mm)	Observed thickness $Y = M + X$ (mm)	Corrected thickness $t = Y \pm ZC$ (mm)
1.					$t_1 =$
2.					$t_2 =$
3.					$t_3 =$

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

Result



Thickness of the metal strip is _____ mm.

Post Lab. Activities



1. A student uses a screw gauge to determine the thickness of a sheet of paper. The student folds the paper three times and measures the total thickness of the folded sheet. Assume that there is no zero error in the screw gauge. The reading of screw gauge is shown in Fig 1.3.3. Find the thickness of the sheet. Show your working clearly.

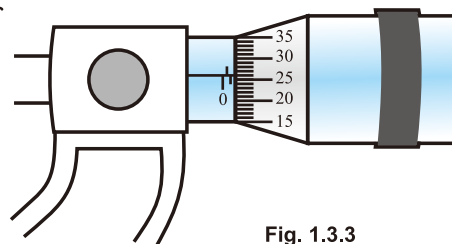


Fig. 1.3.3

2. Some modern screw gauges are digital, as shown in Fig 1.3.4.
- Suggest one advantage of a digital screw gauge.
 - Suggest one disadvantage of a digital screw gauge.

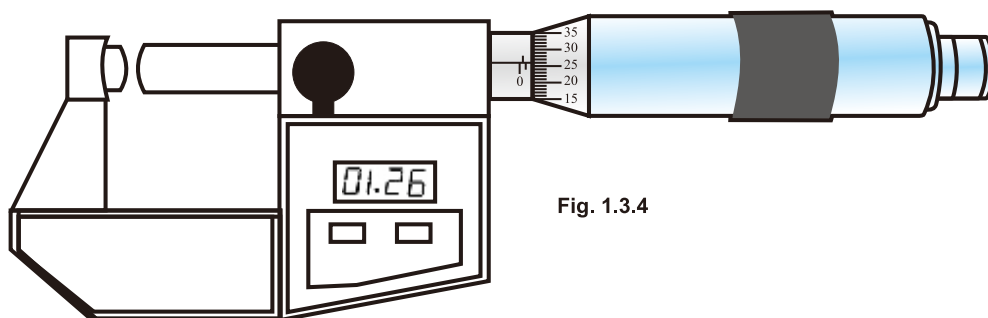


Fig. 1.3.4

3. The approximate diameter of a flexible thin wire can be determined by the apparatus shown in Fig. 1.3.5. Describe how would you use this apparatus to obtain a reasonably accurate value for average diameter (d) of the flexible wire.

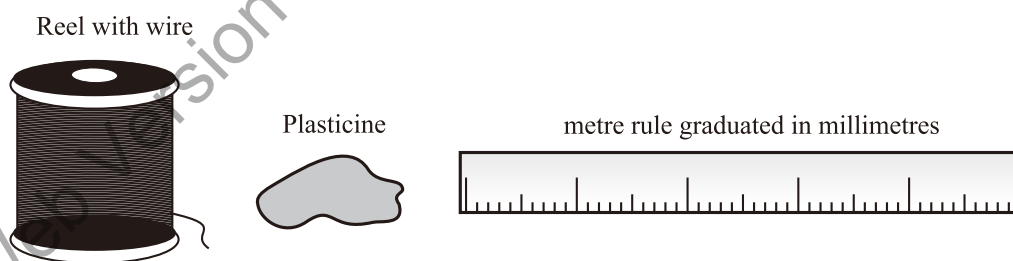


Fig. 1.3.5

4. Can you use a screw gauge to measure the exact thickness of a 10 rupee note?
5. (a) Place ten similar coins one above the other and find their total height by using a ruler.
- (b) Determine average thickness of a coin.

(c) Find the thickness of a coin using screw gauge.

(d) Compare and comment on the two results.

6. State a similarity and a difference between screw gauge and vernier callipers.



BRAIN TEASER

How would be the readings differ if the screw gauge is used instead of vernier callipers to measure the thickness of a glass plate?

Experiment 2.1

Find the acceleration of a ball rolling down an inclined angle iron by drawing a graph between $2S$ and t^2

Date _____

Background Information

In this experiment the motion of a body along an inclined plane is observed.

- The initial velocity ' v_i ' of the ball at the time of release is zero.
- The acceleration ' a ' during this motion is considered as uniform and is obtained from equation of motion

$$S = v_i t + \frac{1}{2} a t^2$$

Since $v_i = 0$

$$\text{then } a = \frac{2S}{t^2}$$

If a graph is drawn between $2S$ and t^2 then the slope $\frac{2S}{t^2}$ will be equal to acceleration ' a ' of the ball.

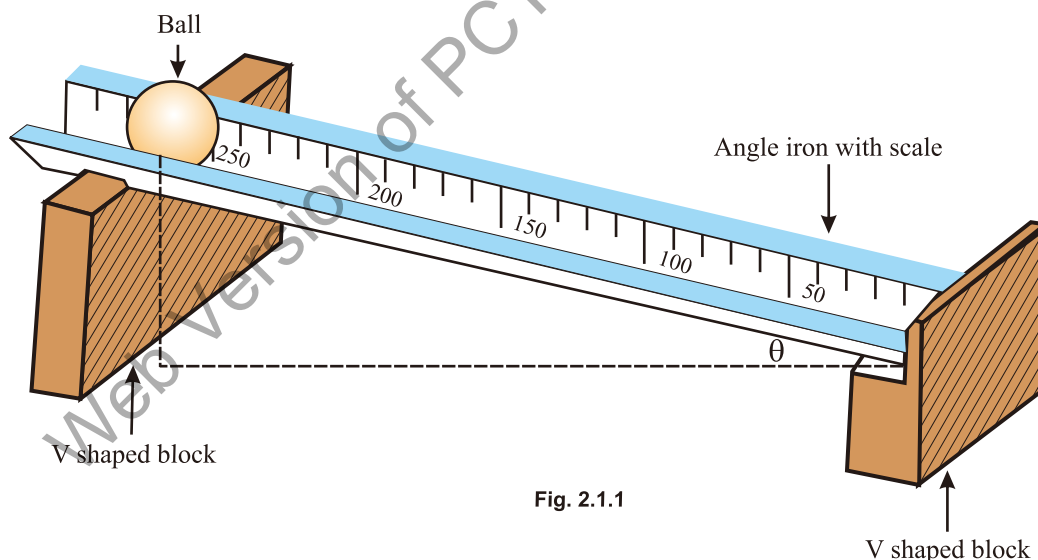


Fig. 2.1.1

Materials Required

Angle iron (2m long) with a fixed stopper at the lower end, iron stand with V-shaped groove to hold the angle iron in position, metre-rod, set square, steel ball, stopwatch, graph paper.

Procedure

- 1 Clean the inner surface of graduated angle iron and iron ball.

Think

What is the purpose to clean the inner surface of angle iron?

Think

Why the angle of inclination is kept small?



DO YOU KNOW?

When we drive a vehicle down a hill we always use brakes to control the speed of the vehicle to counter acceleration.

- 2 Set the apparatus according to Fig. 2.1.1. Keep the angle of inclination small (not more than 15°).
- 3 Place the iron ball on the inclined plane at higher end, e.g., 200cm or 250 cm.
- 4 Hold the ball with set square such that the front of the ball coincides with the position mark.
- 5 Release the ball gently and start the stopwatch simultaneously. Stop the watch when the ball just hits the stopper plate at the lower end. Note time taken as ' t_1 '.
- 6 Repeat step 5 and note the time as ' t_2 '.
- 7 Find the average time ' t '.

$$t = \frac{t_1 + t_2}{2}$$

- 8 Repeat the experiment by changing the release position of the ball in regular intervals.
- 9 Take six readings in all.
- 10 Calculate $2S$ and t^2 .
- 11 Plot the graph between $2S$ (along y-axis) and t^2 (along x-axis).

Observations and Data Processing

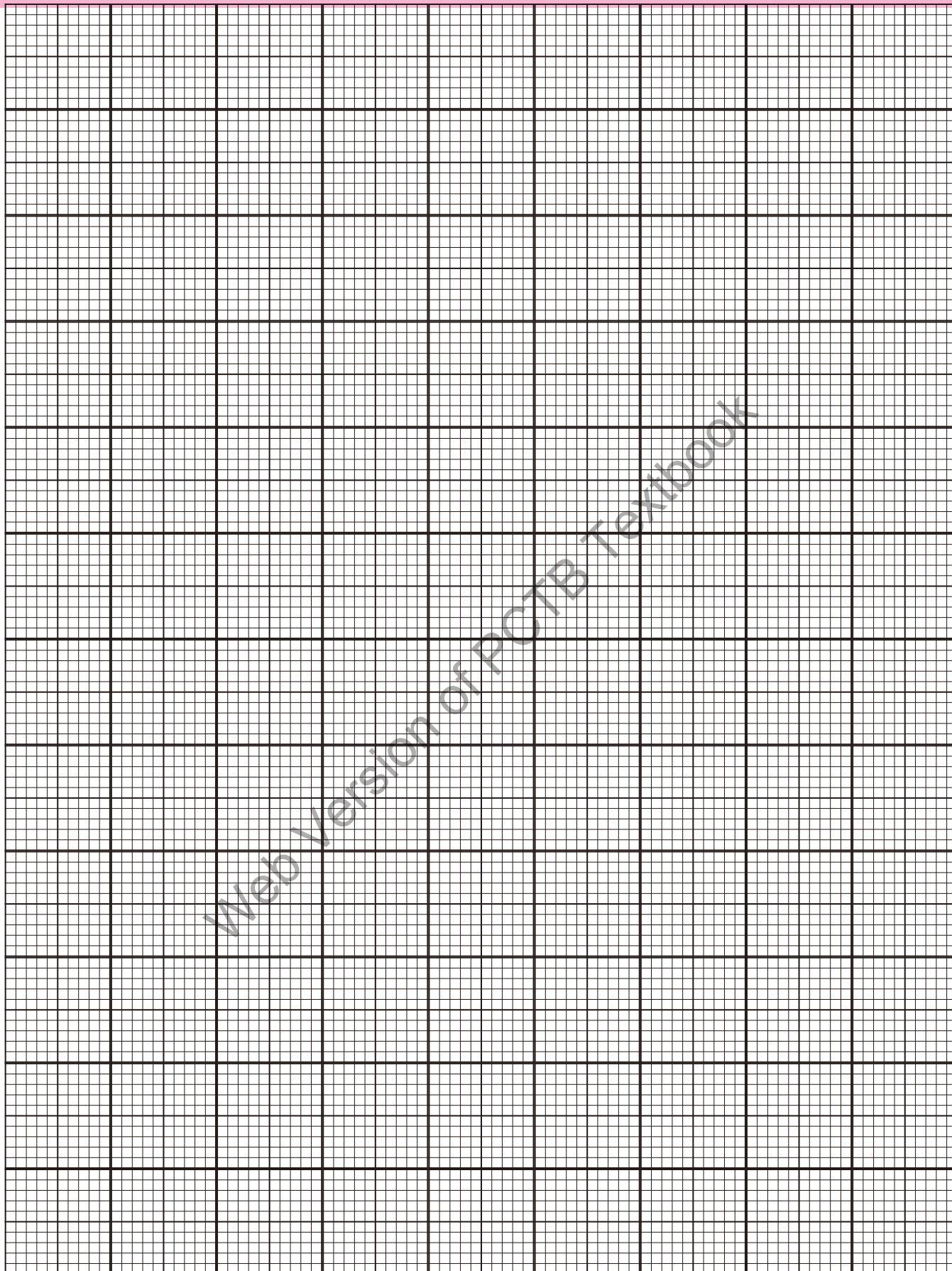
CAUTIONS

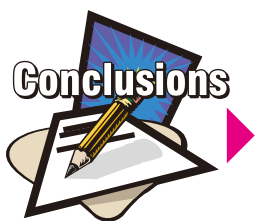
1. Preferably steel ball should have diameter about 3cm to 5cm.
2. Clean the inner surface of angle iron.
3. The angle of inclination should be small.
4. Keep the angle of inclination same throughout the experiment.
5. Release the ball gently using the set squares.

No. of obs.	Distance covered	Time taken			$2S$ (m)	t^2 (s ²)
	S (cm)	t_1 (s)	t_2 (s)	$t = \frac{t_1 + t_2}{2}$ (s)		
1						
2						
3						
4						
5						
6						

Plotting a graph

1. Select suitable scale for both axes.
2. Draw a best fit straight line.
3. Find the slope of the line by selecting any two point on the graph line.





Conclusions

Conclusion is drawn from the graph.

Result from the Graph

$$a = \frac{2S}{t^2}$$

$$a = \text{---} \text{ cm s}^{-2}$$

$$a = \text{---} \text{ m s}^{-2}$$

Investigation

Take three balls of different masses/sizes and investigate their speeds at the bottom of the ramp with reference to their masses for the same slope.



Post Lab Activities

1. For an inclined plane $a = g \sin \theta$, find value of 'g' from the calculated value of 'a'. Comment upon your result.

2. A ramp is made at the main entrance of a house. How does it help in raising the objects such as motorbike and car etc?

3. What force accelerates you down a hill on free wheels? Draw a sketch to show all the forces acting on you.

4. If angle of inclination is reduced to zero, what will be its effect on the rolling ball?



BRAIN TEASERS

1. If angle of inclination is increased, how will it affect the shape of the graph?
2. If two balls are released at the same time, one from the top and the other from a mark 50 cm below the top. Will the balls get close or further apart as they roll down the ramp?
3. A vehicle requires more force to climb up a hill. Why?

Experiment 2.2

Find the value of g by free fall method.

Date _____

Background Information

A metal bob and a bar pendulum are tied together with the help of a thread as shown in Fig. 2.2.1. When the thread is burnt, the bob and the bar are released simultaneously. The bob falls freely from rest, such that the bar makes exactly a quarter of an oscillation during the time of free fall. Thus, the time of free fall is equal to one fourth of the time period T . We can find the value of g by finding the time taken by the bob as it falls through height ' h ' from rest to hit the bar. The formula for finding the value of g is

$$h = v_i t + \frac{1}{2} g t^2$$

as the bob falls from rest, so its initial velocity $v_i = 0$

$$\text{then } g = \frac{2h}{t^2} \quad \text{as } t = \frac{T}{4}, \quad g = \frac{32h}{T^2}$$

Materials Required

Free fall apparatus, metre rod, stop watch, string, candle, metallic bob, match box.

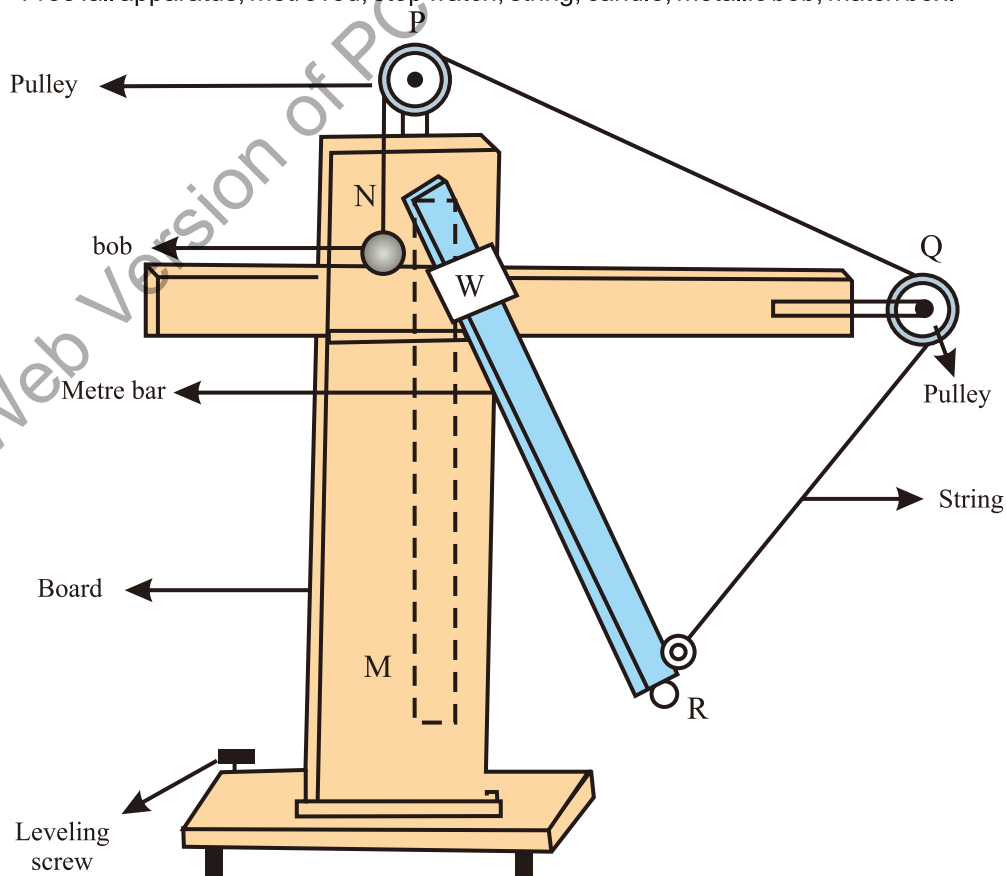
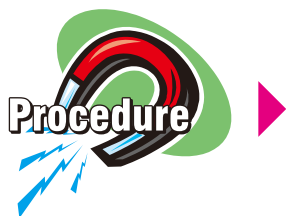


Fig 2.2.1



- ❶ Tie one end of the string, passing over two pulleys, with the bob and the other end with the hook near the end of the bar.
- ❷ Note the initial position (h_1) of the centre of the bob. The initial position of the bob is kept a few centimetres lower from the hinge of the oscillating bar.
- ❸ Blacken the bob with soot of a candle, and remove any mark already present on the side of the bar.
- ❹ Release the bob by burning thread between the two pulleys.
- ❺ Note the position (h_2) of black mark caused by the bob when it strikes the bar.
- ❻ Repeat the above procedure two times more.
- ❼ Set the bar to oscillate and note the time for 10 oscillations with the help of a stop watch. Repeat this step three times and find average time t_o .
- ❽ Calculate the time period T .

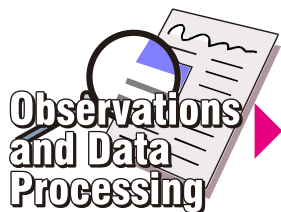
Think

Why is scissors or blade not used to cut the string?



DO YOU KNOW?

A satellite orbiting the Earth is in fact a freely falling body.



No. of obs.	Initial position of bob (h_1) (cm)	Position of Black mark (h_2) (cm)	height $h = h_2 - h_1$ (cm)
1			
2			
3			

Time for 10 vibrations

(i) -----

(ii) -----

(iii) -----

Mean time $t_o =$ ----- s

Time period of the bob $= T = \frac{t_o}{10}$ ----- s

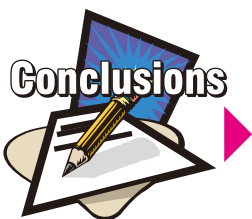
Time for free fall $= t = \frac{T}{4}$ ----- s

Value of $g = \frac{2h}{t^2} =$ cm s^{-2}

$g =$ cm s^{-2}

! CAUTIONS

- The oscillating bar should be made vertical by leveling screws at the base.
- The bar should move freely without touching the board.
- The amplitude of oscillation should be small.



Conclusions

The value of free fall acceleration g is cm^2



Post Lab Activities

1. Why time of free fall is taken as $t = \frac{T}{4}$

2. A student drops two identical marbles from different heights on sandy ground. Which marble would penetrate more?

3. The emergency food supplies fall with the parachute attached as shown. What is the acceleration of the food supplies? When
- i. They remain attached to the falling parachute.

- ii. They are released (detached) from the parachute.



BRAIN TEASERS

- Two stones of different masses m_1 and m_2 are dropped from the same height. Which stone will hit the ground first and why?
- The velocity of a freely falling steel ball is plotted against time. What would be the shape of the velocity-time graph? Give reason.
- A skydiver of weight 800 N jumps out of an aeroplane. After he has been falling for sometime, he is travelling at a constant speed. How big is the force of air resistance acting on him?



Investigate the relation between force of limiting friction and normal reaction to find the co-efficient of sliding friction between a wooden block and a horizontal surface.

Date _____



Friction is the resistance that an object encounters in moving over a surface. It is easier to drag an object over a glass than on a sandpaper. The reason for this is that the sandpaper exerts more friction as compared to glass. The friction increases with the increase of the normal force acting on the body. It attains its maximum value just before the object moves. This maximum frictional force is called the maximum static friction $f_s(\text{max})$ or limiting friction and is given by the formula:

$$f_s(\text{max}) = \mu_s R$$

Where μ_s is the coefficient of static friction and R is the normal reaction force. The frictional force $f_s(\text{max})$ acts parallel to the surfaces in contact and in a direction opposite to the motion of the object.



Wooden block, plane wooden surface with pulley, weight box, string, spring balance and a pan.



DO YOU KNOW?

The tread of a tyre has a grooved pattern on its surface which is in contact with the road. Grooves are designed in such a way that if there is some water in between the tyre and the road, it is swept within the grooves and hence friction between the tyre and the road does not reduce much due to the presence of water.

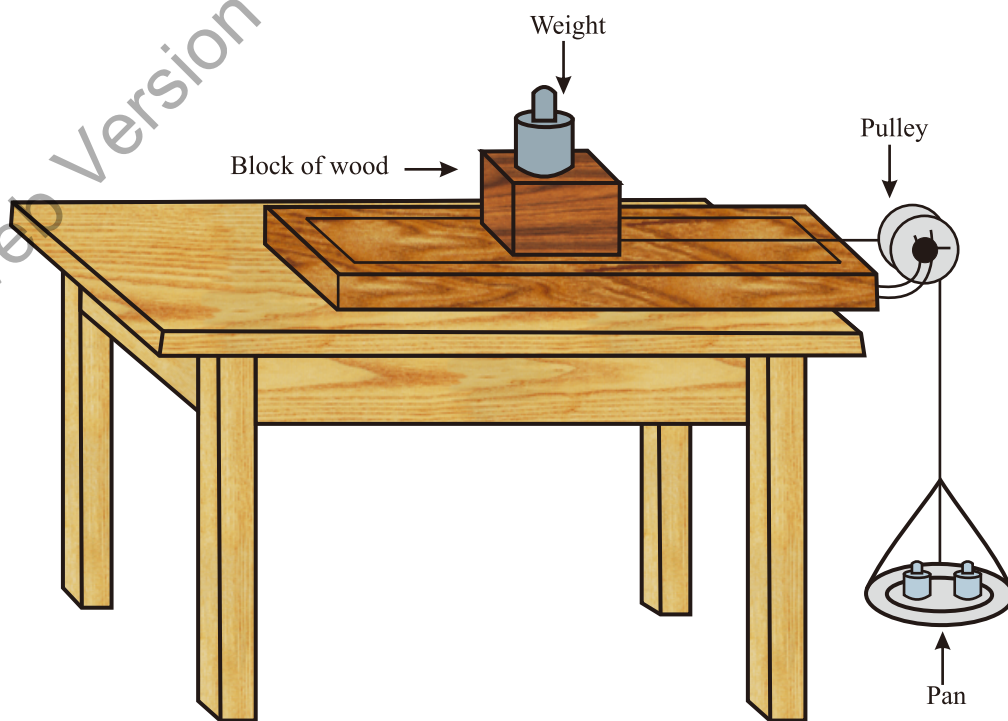
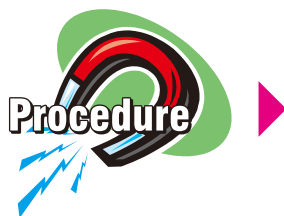


Fig 3.1.1



CAUTIONS

1. The plane should be smooth and cleaned well.
2. The pulley should move freely.
3. The string should be parallel to the table surface from pulley to the block.
4. Tap the table gently with finger.

1. Find the weight of the wooden block and also of the pan by a spring balance.
2. Tie the block and the pan to the ends of a string. Pass the string over a freely moving pulley which is clamped with the edge of the horizontal plane. The string between the pulley and the block should be horizontal. It should not touch the table.
3. Put a weight in pan and tap the surface. Now gradually add more weights in the pan one by one and tap the surface each time. When the block just begins to slide, note the total weight.
4. Repeat the experiment by putting a weight on the block.
5. Record data in tabular form. Take 100g equal to 1N.

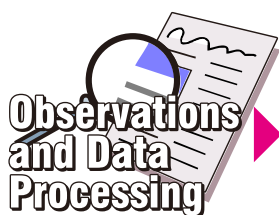
Think

Why there was no motion before adding the last weight in the pan?

Think

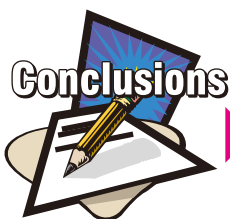
What factor affects the coefficient of friction?

Weight of the pan = w_3 = N



No. of obs.	Weight of the block w_1 (N)	Weight placed on the block w_2 (N)	Normal Reaction $R = w_1 + w_2$ (N)	Weight placed in the Pan w_4 (N)	Friction force $f_s = w_3 + w_4$ (N)	Coefficient of friction $\mu_s = \frac{f_s}{R}$
1						
2						
3						

Average μ_s =



The average value of co-efficient of static friction is -----.

Investigation

Investigate the dependence of co-efficient of friction on surface area and state your conclusion.



1. Using different surfaces in the above experiment, compare the coefficient of friction between wood and glass & glass and rubber.

2. Why a maglev train can achieve a speed which is unattainable by an ordinary train?



Design an experiment to find the co-efficient of friction of a wooden block using a variable inclined plane.



BRAIN TEASERS

1. Explain why is skating only possible on ice surface not on roads?
2. How does the lighting of a matchstick become possible?

Experiment 3.2

Find force of limiting friction by rolling a roller on a horizontal surface.

Date _____

Background Information

When a cylinder rolls on a surface, the force resisting its motion is termed as rolling friction. Rolling friction is considerably less than sliding friction. The limiting friction of a roller is equal to the applied force with which the roller just starts moving.

Materials Required

Horizontal plane, plastic or paper pan, weight box, pulley, string, spirit level.



DO YOU KNOW?

Wide tyres of soft rubber are ideal for gripping the roads. Have you ever seen the use of such tyres? Where?

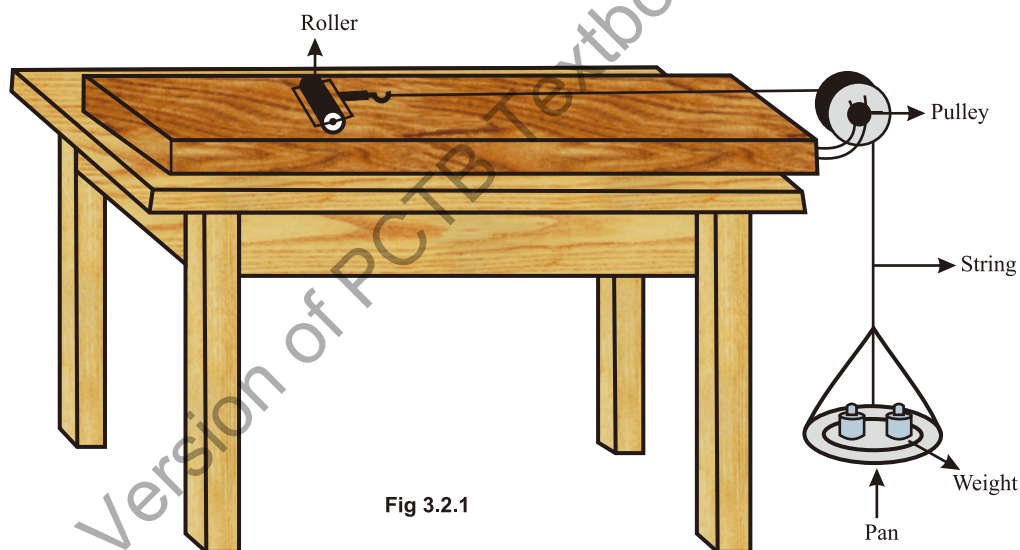


Fig 3.2.1

Procedure

- 1 Weigh the pan by a physical balance or electronic balance.
- 2 Level the horizontal wooden or glass surface with the help of a spirit level.
- 3 Oil the pulley attached with the horizontal surface to reduce friction.
- 4 Tie one end of the string with the hook of the roller and other end with the pan by passing the string over the pulley. The string between the hook and the pulley should be horizontal.
- 5 Put a small weight in the pan and observe the roller. Add more small weights gradually till the roller begins to move slowly.
- 6 Note the total mass in the pan and multiply it with 'g' to find the weight.
- 7 Repeat the experiment three times and find the average value of limiting friction

Think

Why is the rolling friction always less than the sliding friction?

Observations and Data Processing

Weight of the pan = m_1g = ----- N

Value of g = 10 ms^{-2}

No. of Obs.	weight placed in the pan m_2g (N)	Limiting friction = Total weight $m_1g + m_2g$ (N)
1		
2		
3		

CAUTIONS

1. The plane should be smooth and cleaned well.
2. The pulley should move freely.
3. The string should be parallel to the table surface from pulley to the block.

Average value of limiting friction = N

Conclusions

Value of limiting friction for the roller on the horizontal plane is N.

Post Lab. Activities

1. Identify the role of ball bearing in moving parts of a machine e.g., a bicycle.

2. Name some ways of reducing friction between surfaces in relative motion.



BRAIN TEASERS

1. Sometimes a car or a bus gets stuck in the deep mud. It is difficult to move it out of the mud. Explain why?
2. Why are the wheels of a TV trolley made spherical rather cylindrical?

Experiment 3.3

Determine the value of g by Atwood's Machine.

Date _____

Background Information

The Atwood Machine is a device which was used by George Atwood to measure acceleration of the moving objects due to the force of gravity. This machine consists of two masses connected with two ends of a string passing over a pulley as shown in Fig 3.3.1. Using second law of motion we can find acceleration " a " of the masses m_1 and m_2 .

Mathematical relation between the acceleration of the masses and gravitational acceleration g is given as

$$g = \frac{m_1 + m_2}{m_1 - m_2} a$$

In practice, the difference between the two masses should be small.

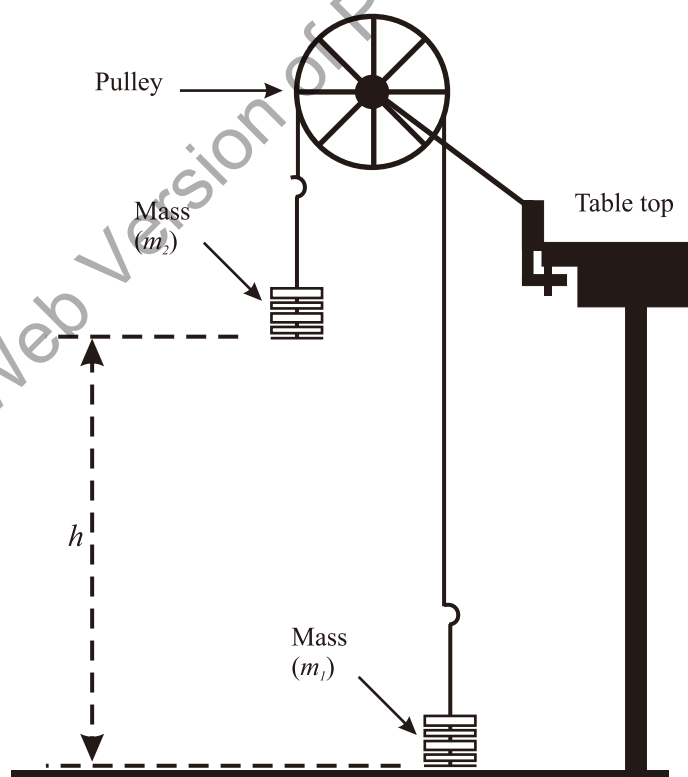
Materials Required

Atwood's machine apparatus, stop watch, metre rule, spirit level, slotted weights, light inextensible string of about 2.5 m long.



DO YOU KNOW?

Elevators in the tall buildings work on the principle of Atwood's machine. A heavy load moving down at one end of the steel rope lifts the elevator at the other end.



CAUTIONS

- Use a light ball bearing pulley.
- Lubricate the pulley to reduce its friction.
- Ensure a minimum fall of 1.0m for the experiment.
- Keep difference of masses small to keep acceleration small.

Fig 3.3.1



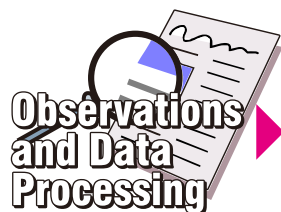
- ❶ Place the Atwood machine on horizontal surface. Check that the pulley moves freely, otherwise lubricate it.
- ❷ Attach two identical hangers to the both ends of a light and inextensible string.
- ❸ Pass the string over the pulley.
- ❹ Add slotted masses to the hangers such that m_1 is slightly greater than m_2 .
- ❺ Raise the mass m_1 upto to a certain height. Lock the pulley or otherwise hold the mass in this position
- ❻ Measure the height (h) of mass m_1 from ground.
- ❼ Release the mass and start the stopwatch at the same time.
- ❽ Observe the motion of both masses.
- ❾ Stop the watch when m_1 just hits the ground.
- ❿ Note the time (t_1).
- ⓫ Repeat the above procedure for the same h and masses m_1 and m_2 .
- ⓬ Repeat the experiment for different sets of masses.

Think

If the string has a significant mass how will it affect the experiment?

Think

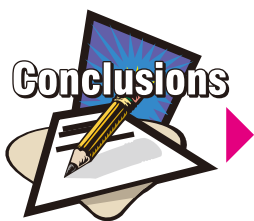
When the sum of masses remains constant but the net force increases, what happens to the acceleration?



Height of mass m_1 from the ground = $h = \text{----- cm} = \text{----- m}$

No. of Obs.	Large mass m_1 (g)	Small mass m_2 (g)	Time of fall of m_1		Average time $t = \frac{t_1 + t_2}{2}$ (s)	Acceleration $a = \frac{2h}{t^2}$ (cm s ⁻²)	$g = \frac{m_1 + m_2}{m_1 - m_2} a$ (cm s ⁻²)
			t_1 (s)	t_2 (s)			
1							
2							
3							

Average value of $g = \text{----- cm s}^{-2} = \text{----- m s}^{-2}$



Conclusions

The average value of g as found by using Atwood Machine is----- m s^{-2} .



Post Lab Activities

An x-ray machine is a heavy delicate equipment that has to be raised or lowered frequently during use by a single operator. Suggest how principle of Atwood machine can be used to achieve this?



BRAIN TEASERS

How does acceleration of masses change, when

1. Sum of masses remains the same but their difference changes?
2. Sum of masses changes but their difference remains the same?

CHAPTER

Turning Effect of Forces

4

Experiment 4.1

Determine the resultant of two forces graphically by using horizontal force table.

Date _____

Background Information

Materials Required

When the forces act in different directions they are added by head to tail rule method. The apparatus used for the addition of forces is horizontal force table. It has three strings knotted together which are passed over three frictionless pulleys mounted at the edges of the table. The other ends of the strings are attached with suitable masses such that knot stays near at the centre of the table. Usually the horizontal force table has a diameter about 40 cm and its height from the ground is 50cm.

A horizontal force table, strings, plane mirror strip, slotted weights with hangers, metre rule, geometry box, white paper sheet, thumb pins, spirit level and lead pencil.



DO YOU KNOW?

A sail boat can be made to travel even in a direction nearly opposite to wind by the suitable adjustment of the direction of its sails.

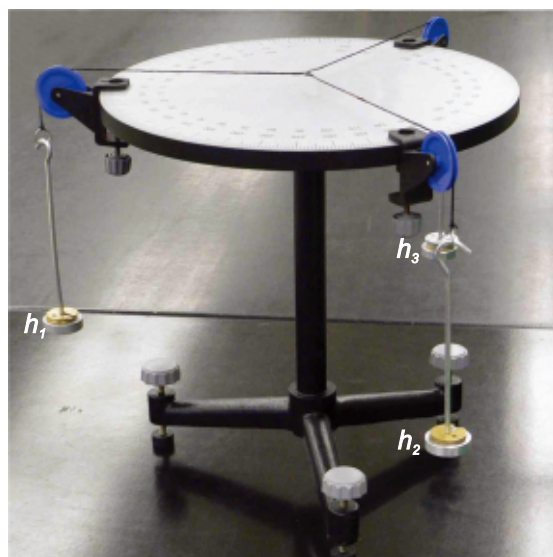
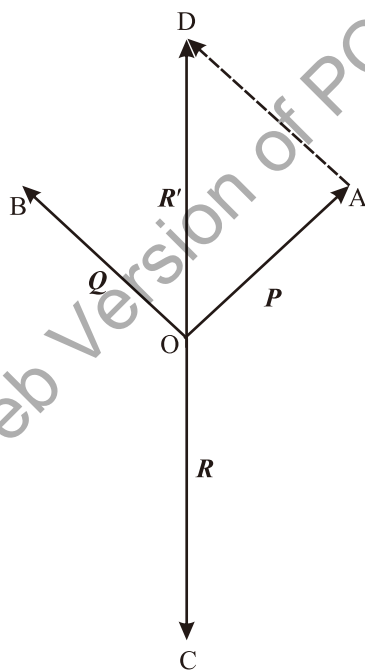


Fig 4.1.1

Procedure

- 1 Place horizontal force table on a smooth surface and level it with the help of screws at the base by using a spirit level.
- 2 Fix a white paper sheet of suitable size with the help of thumb pins at the middle of the table.
- 3 Take three pieces of string of proper length and knot them at one end.

- ④ Attach hangers h_1 , h_2 and h_3 at the other ends of the strings and hang them after passing over the pulleys. Note that pulleys should move freely, otherwise lubricate them.
- ⑤ Adjust the weights in the hangers in such a way that the knot is almost located in the middle of the sheet.
- ⑥ Tap the surface of the table slightly so that true equilibrium of the system can be found by overcoming the small friction in the system, if any.
- ⑦ Place the mirror strip length-wise under a string and mark two points on the paper where the string and its image coincides with each other. Repeat the procedure for other strings as well.
- ⑧ Note the weights in the three hangers and remove the hangers and strings from the pulleys.
- ⑨ Join the marked points with the help of a metre rule to get three lines OA, OB and OC meeting at point O.
- ⑩ Choose a suitable scale for the weights P , Q , R and take the length of the lines OA, OB with OC accordingly. These three lines represent forces P , Q and R respectively. Take 100g equal to 1N.
- ⑪ Apply head to tail rule to find out the resultant R' of P and Q .
- ⑫ Measure the length of the resultant and convert it to magnitude of the resultant force using the chosen scale.
- ⑬ Repeat this experiment using different weights and note the observations.

Think

How two forces are added if they are not concurrent but are acting in the same direction?

Think

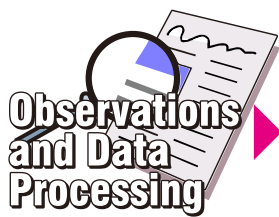
If the table is not tapped before taking readings, what will be the effect on the resultant?

Think

What causes the most uncertainty to your result? and how can it be improved?

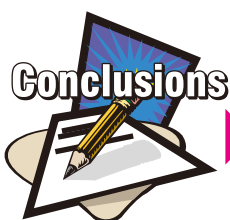
CAUTIONS

- Pulleys should move freely.
- Light and thin string should be used.
- Knot should be in the middle of the paper sheet.
- Use heavy weights.
- Use a mirror strip to mark the position of string.
- Suitable scale be chosen for representing forces.
- Direction of forces be shown by arrow heads.



Observations and Data Processing

No. of Obs.	Applied forces			Length			Resultant force	Difference
	P (N)	Q (N)	R (N)	OA (cm)	OB (cm)	OD (cm)	R' (OD) (N)	$R'-R$ (N)



Conclusions



Post Lab Activities

- Suppose a box is moved through three displacements of unequal magnitudes. Could the resultant displacement be zero? Support your answer with a diagram.

- A ping pong ball of weight w attached to one end of a 25cm long string is suspended to a rigid support. The force of horizontal air draught pushes the ball through 5cm. What will be the magnitude of the wind force acting on the ball in terms of its weight? Draw a vector diagram to show your working.



BRAIN TEASER

- What would be the effect on the resultant force by changing the positions of the pulleys?

Experiment 4.2

Find the weight of an object by using vector addition of forces.

Date _____

Materials Required

Horizontal force table fixed with three pulleys, plane mirror strip, unknown weight, two sets of slotted weights of 50 g with hangers, string, metre rule, protractor, compass, white sheet of paper, thumb pins and spirit level.

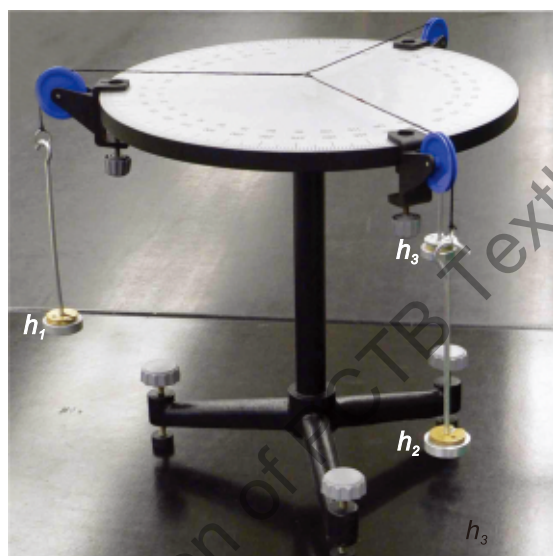
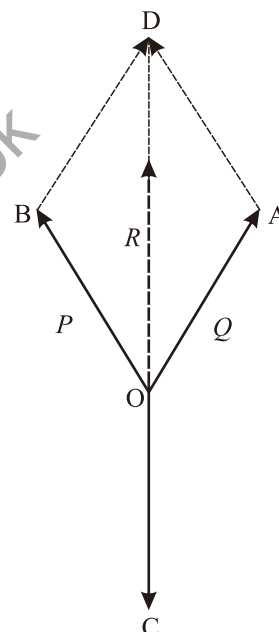


Fig. 4.2.1



Procedure

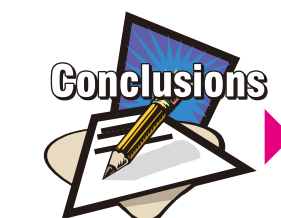
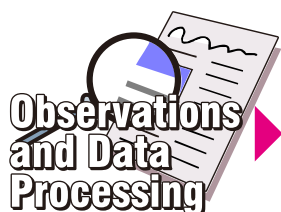
- 1 Place the horizontal force table on a smooth surface level it with the help of screws at the base. Fix a white sheet of paper at the centre of the board with thumb pins.
- 2 Take three pieces of string of suitable lengths and knot one end of each string together.
- 3 Hang two weights with hangers h_1 and h_2 and the unknown weight with the thread hanger h_3 and pass them over three freely moving pulleys mounted on the edge of force table.
- 4 Adjust the slotted weights in such a way that the knot is located almost in the middle of the sheet of paper.
- 5 Place the mirror strip length wise under a string and mark two points on the paper where the string and its image coincide with each other. Repeat the procedure for other strings as well.
- 6 Note the weights in two hangers. Remove the hangers, unknown weight and sheet of paper from the horizontal table.
- 7 Draw three lines by joining the encircled dots on the sheet of paper. These lines meet at a single point O.

Think

Why should the pulleys be moving freely?

DO YOU KNOW?

If the angle between the directions of two forces decreases, the magnitude of resultant increases.



BRAIN TEASER

A fishing boat has a maximum speed of 3ms^{-1} in still water. It is in a river that is flowing at 2ms^{-1} . What can be the maximum and minimum speeds of the boat with respect to the river bank?

- 8 Choose a suitable scale and cut OA and OB according to selected scale which indicates the forces P and Q respectively. Take 100g equal to 1N.
- 9 Apply head to tail rule to find the resultant R of the forces P and Q .
- 10 Measure the length of line OD.
- 11 Calculate the resultant force R from the length OD according to the chosen scale.
- 12 The resultant force R is equal in magnitude to the unknown weight.
- 13 Repeat the experiment two more times by changing the forces P and Q .

CAUTIONS

- Pulleys should move freely.
- Light and thin string should be used.
- Knot should be in the middle of the paper sheet.
- Use heavy weights.
- Use a mirror strip to mark the position of string.
- Suitable scale be chosen for representing forces.
- Direction of forces be shown by arrow heads.

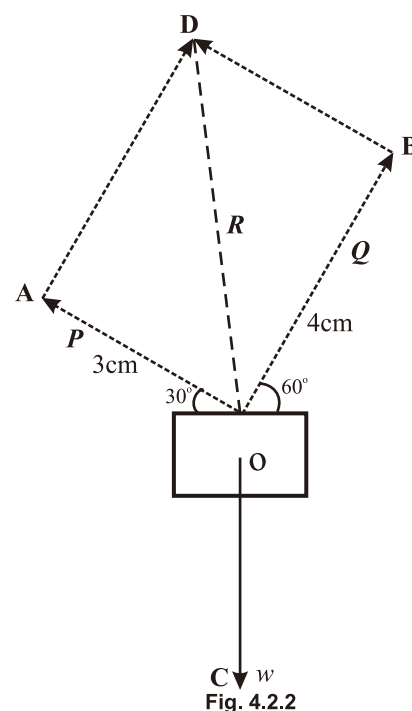
Scale _____ N = _____ cm

Acceleration due to gravity $g = 10 \text{ m s}^{-2}$

No. of Obs.	Forces		Length according to scale		Resultant force	Unknown weight
	P (N)	Q (N)	OA (cm)	OB (cm)	$R(OD)$ (cm)	$w = R$ (N)
1						
2						
3						

Mean unknown weight is N.

1. An object is supported by two forces P and Q of magnitude 30N and 40N in the directions shown by dotted lines in Fig.4.2.2. Using suitable scale, find the weight of the object by graphical method.



2. How is it possible to find out the unknown weight of an object if there are four pulleys instead of three on the horizontal force table?



Experiment 4.3

Verify the principle of moments by using a metre rule balanced on a wedge.

Date _____



Background Information

Moment of force = (Perpendicular distance from pivot to the point of application of force) $\times$ (force)

$$\tau = r F$$

According to principle of moments,

Sum of clockwise and anticlockwise moments acting on a body must be equal to zero to keep the body in rotational equilibrium.



Materials Required

Metre rule, wooden wedge, string, weight box



DO YOU KNOW?

A weighing scale measures accurate mass using the principle of moments.

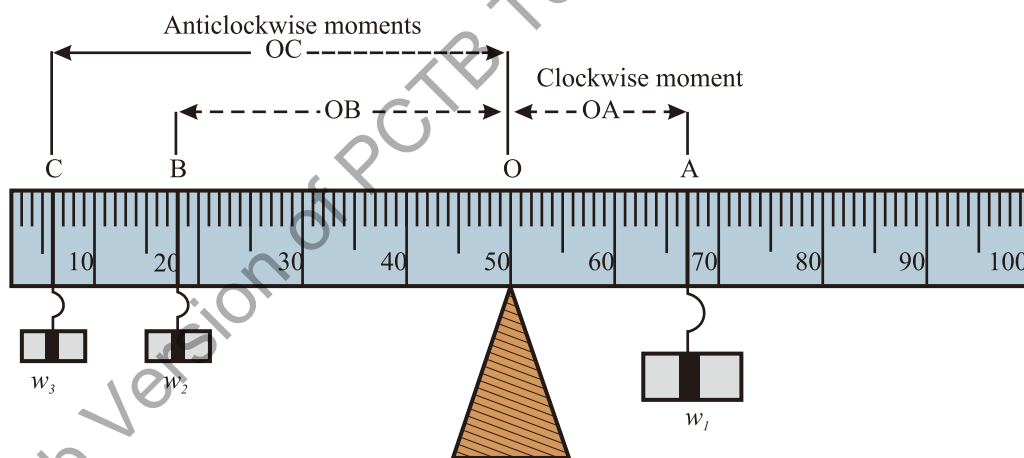
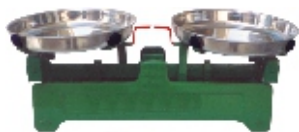


Fig. 4.3.1



Procedure



DO YOU KNOW?

The handle on a door is fixed near its edge away from the hinge to increase the moment arm. Do you know its benefit?

- 1 Balance the metre rule on the wedge preferably edge wise. Note the position 'O' of centre of gravity.
- 2 Suspend a weight w_1 by means of a loop of string on the metre rule to one side of the wedge.
- 3 Likewise, suspend two other weights w_2 and w_3 on the metre rule to the other side of the wedge. Note the values of weights taking 100g equal to 1N.
- 4 Adjust the positions of three weights w_1 , w_2 & w_3 to balance the metre rule again at its CG.

Think

Why should metre rule be balanced on the wedge edgewise?

Think

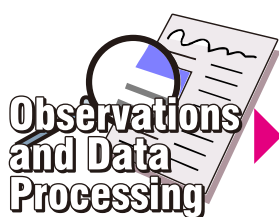
Why should suspended weights be kept away from centre of gravity?

- 5 Note the positions A, B and C of the weights w_1 , w_2 & w_3 respectively on the metre rule.
- 6 Measure the distances of points A, B and C from the centre of gravity 'O'.
- 7 Calculate the moments of each weight with respect to point 'O' using the formula given below.

$$\tau = r F$$
- 8 Repeat the experiment two times more by changing weights or positions of weights.

CAUTIONS

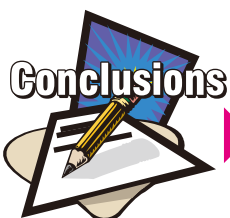
- Find precisely the centre of gravity of the metre rule.
- String loop should be vertical.
- All the distances should be measured from the centre of gravity.
- The weights should be suspended as far away as possible from the centre of gravity.



Position 'O' of center of gravity of metre rule = cm

No. of Obs.	Suspended Weights			Positions			Distance from the centre of gravity (moment arm)		
	w_1 (N)	w_2 (N)	w_3 (N)	A (cm)	B (cm)	C (cm)	OA (cm)	OB (cm)	OC (cm)
1									
2									
3									

No. of obs	Clockwise moment	Total anticlockwise moments	Difference of moments
	$\tau_1 = w_1 \times OA$ (N cm)	$\tau_2 = w_2 \times OB + w_3 \times OC$ (N cm)	$\tau_2 - \tau_1$ (N cm)
1			
2			
3			





1. Hold one end of the metre rule horizontally in your hand. Suspend a mass on it and move it away from your hand. You will have to apply more force to keep the metre rule in horizontal position now. Why?

2. How would a 30 kg son balance his father of 60 kg on a see-saw?

3. Use principle of moments to find out the weight of a metre rule.

4. Is a metre rule balanced edgewise on the wedge in stable equilibrium?



BRAIN TEASER

Why acrobats hold a long rod in their hands to balance themselves while walking on the rope?

Experiment 4.4

Find the unknown weight of an object by using principle of moments.

Date _____



Materials Required

Metre rule, wedge, weight box, thread, spring balance and unknown weight.

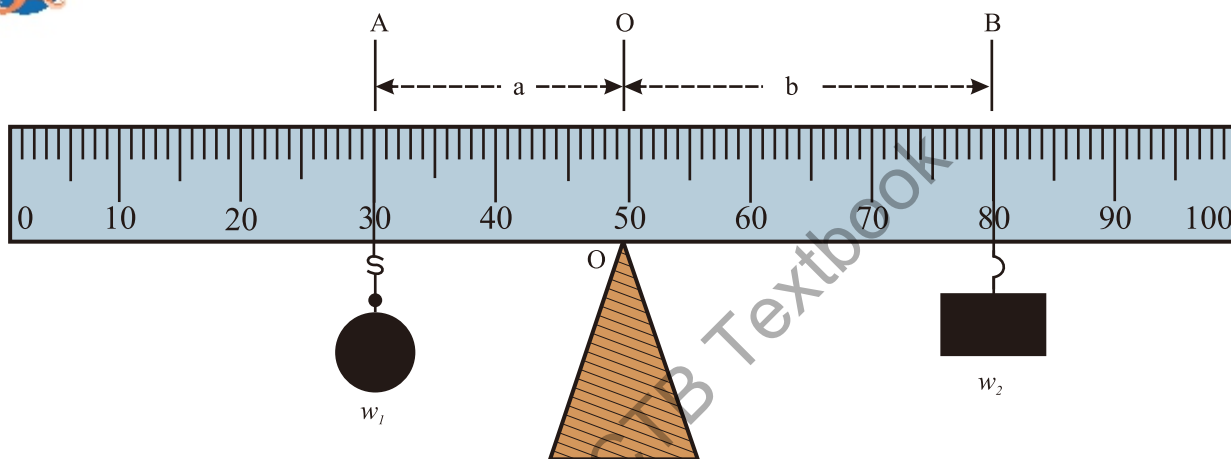


Fig. 4.4.1

Procedure



DO YOU KNOW?

According to principle of moments a counter weight is used to lift heavy loads in a simple crane.

- 1 Find the centre of gravity 'O' of metre rule by balancing it edgewise on the wedge.
- 2 Suspend unknown weight w_1 on one side of the wedge and known weight w_2 on the other side. Use weight of $100\text{g} = 1\text{N}$
- 3 Balance the metre rule on the wedge at its centre of gravity 'O' by adjusting the position of the weight w_2 on metre rule.
- 4 Note the position A of w_1 and position B of w_2 .
- 5 Find the distances OA and OB.
- 6 Find unknown weight w_1 using the following relation:

$$w_1 = w_2 \times \frac{b}{a}$$

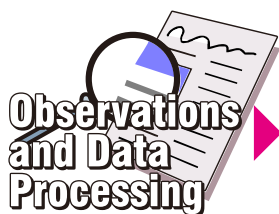
- 7 Repeat the experiment by changing the position of w_1 and w_2 two more times. Find the average value of w_1 .
- 8 Measure the weight of unknown object w_1' with a balance and compare it with your experimental result.

Think

Why should wedge be sharp?

CAUTIONS

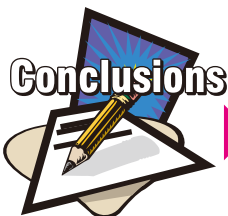
- Find precisely the centre of gravity of the metre rule using sharp wedge.
- Thread loops should be vertical.
- All the distances should be measured from the centre of gravity.
- The weights should be suspended as far away as possible from the centre of gravity.



Position of centre of gravity 'O' = _____ cm

Value of known weight w_2 = _____ N

No. of obs	Positions		Distance of unknown weight w_1 from 'O'	Distance of known weight w_2 from 'O'	Unknown weight of object
	w_1	w_2			
	A	B	a	b	$w_1 = w_2 \times \frac{b}{a}$
	cm	cm	cm	cm	
1					
2					
3					



Average value of weight w_1 = _____ N

Measured weight of the object w' = _____ N

Difference = $w_1 - w'$ = _____ N



1. Open the nut of a wheel with spanners of different lengths. Which spanner is best to open the nut of a wheel with minimum force? Explain.

2. How will you find the weight of metre rule by using the principle of moments?

3. In car parks the barrier usually has a counter balance. How does it work?

4. Explain why is it easier for a person to carry a ladder by holding it in the middle?



BRAIN TEASER

Why do we keep the length of crow bar long to lift a heavy object?

Experiment 4.5

Find the tension in the strings by balancing a metre rule on the stands.

Date _____

Background Information

1st condition of equilibrium

Sum of all the forces acting on a body is equal to zero for the body to be in translational equilibrium i.e.,

$$\sum F = 0$$

For a suspended metre rod with two spring balances we have

$$T_1 + T_2 - w = 0$$

$$T_2 = w - T_1 \dots\dots\dots (1)$$

2nd condition of equilibrium

Sum of all the torques acting on a body is equal to zero for the body to be in rotational equilibrium i.e.,

$$\sum \tau = 0 \quad \text{or} \quad \text{Clockwise torque} = \text{Anticlockwise torque}$$

$$\text{From Fig. 4.5.1} \quad T_1 \times a = w \times b$$

$$\text{or} \quad T_1 = w \left(\frac{b}{a} \right) \dots\dots\dots (2)$$

From equations (1) and (2)

$$T_2 = w \left(\frac{a-b}{a} \right)$$

Materials Required

Two iron stands, two spring balances, heavy metre rule, wooden wedge and thread.

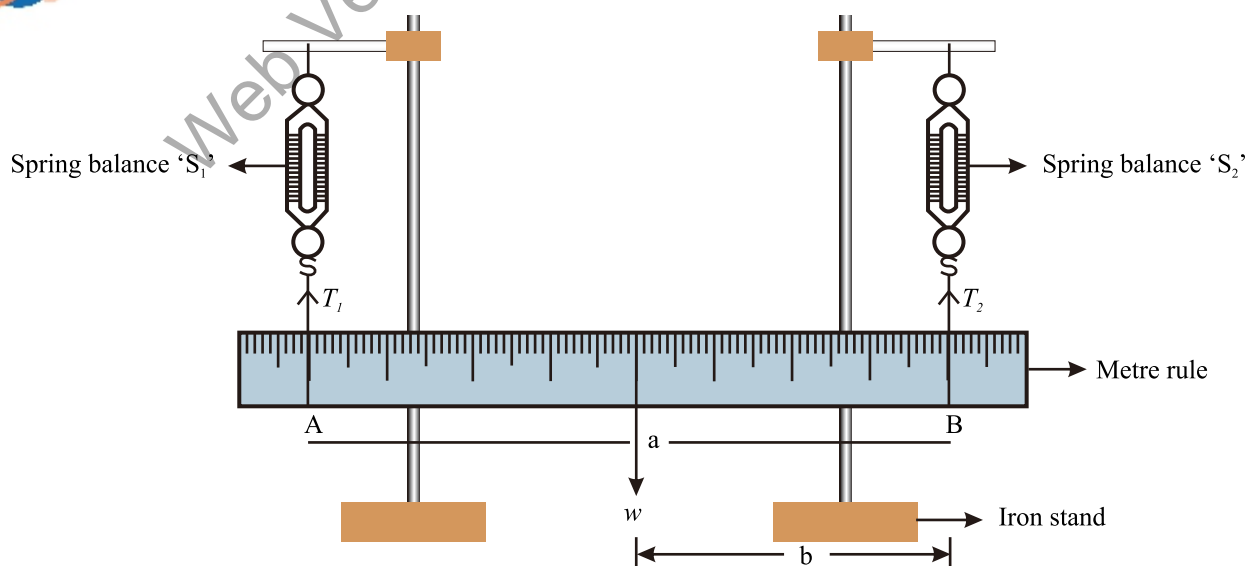
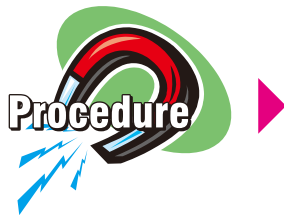
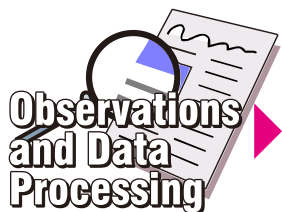


Fig. 4.5.1



DO YOU KNOW?

- A swing designed for children may break down when an adult tries to use it. It is due to increase in tension in the string or the rope holding the swing.
- Orthopedic surgeons use different tensions in the rope for the traction of broken bones.



- 1 Find the centre of gravity of the metre rule by balancing it on a wedge.
- 2 Take two iron stands and suspend spring balances from them as shown in Fig. 4.5.1.
- 3 Remove zero error in the spring balances, if any.
- 4 Suspend the metre rod edgewise with loops of thread attached to the spring balances.
- 5 Balance the metre rule by adjusting the clamps of iron stands such that it becomes horizontal.
- 6 Note the readings of two spring balances when pointers of spring balances are at rest. Add these readings to find the weight (w) of the metre rule.
- 7 Now calculate the theoretical value of tensions in the strings by applying second condition of equilibrium.
- 8 Compare the value of calculated tensions with the tensions shown by the spring balance.
- 9 Repeat the experiment two times more by changing the positions of spring balances.

Think

Why should not the readings of the spring balances be taken when pointers are oscillating?

! CAUTIONS

- Find precisely the centre of gravity of the metre rule.
- String loops should be vertical.
- All the distances should be measured from the centre of gravity.
- Spring balances should be as far away as possible from the centre of gravity.

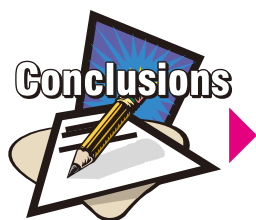
Position 'O' of CG = _____ cm

Weight of the metre rule w = _____ N

No. of obs.	Positions		Distance of S_2 from B	Distance of w from B
	A (cm)	B (cm)	$a=AB$ (cm)	$b=OB$ (cm)
1				
2				
3				

No. of obs.	Calculated Tension		Readings of spring balance		Difference	
	$T_1 = w \left(\frac{b}{a}\right)$ (N)	$T_2 = w \left(\frac{a-b}{a}\right)$ (N)	S_1 (N)	S_2 (N)	$T_1 - S_1$	$T_2 - S_2$
1						
2						
3						

Conclusions



Post Lab Activities



- How is tension produced in the string used for kite flying?

- Find the tension in the string using spring balance when an object of mass 100g is suspended with it.

- Would the result in the above experiment be affected if the metre rule was not horizontal when the readings were taken? Explain your answer.



BRAIN TEASER

Under what condition (s) will the two spring balances read the same?



Study the effect of length of a simple pendulum on its time period and hence, find the value of 'g'.

Date _____



A simple pendulum consists of a bob of mass m , attached to a rigid support by a light inextensible string of length ℓ . When the bob is displaced a few centimetres from its mean position and then released, it oscillates with time period T . The relationship between ℓ , T and g is given as

$$T = 2\pi \sqrt{\frac{\ell}{g}}$$

$$\ell = \text{constant} \times T^2 \quad \text{or} \quad \ell \propto T^2$$

Therefore, the length of simple pendulum is directly proportional to the square of its time period.

For value of g , squaring and rearranging the above formula we get

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



Metallic bob with a hook, stop watch, iron stand with heavy base, metre rule, cork (split in two halves), vernier callipers and inextensible string.

A simple pendulum

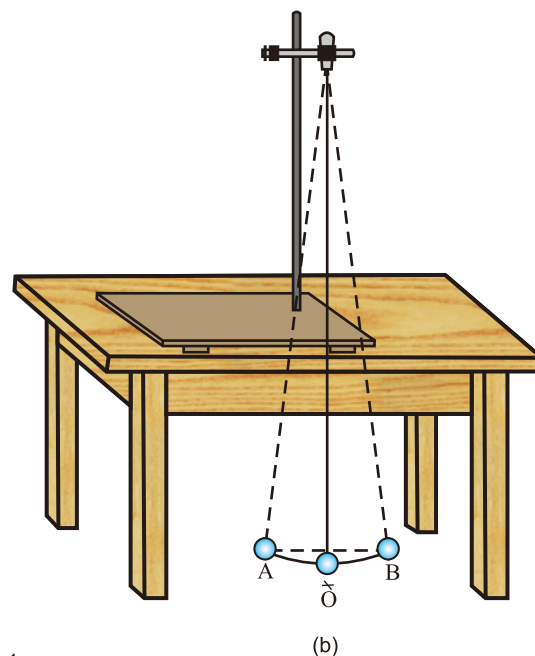
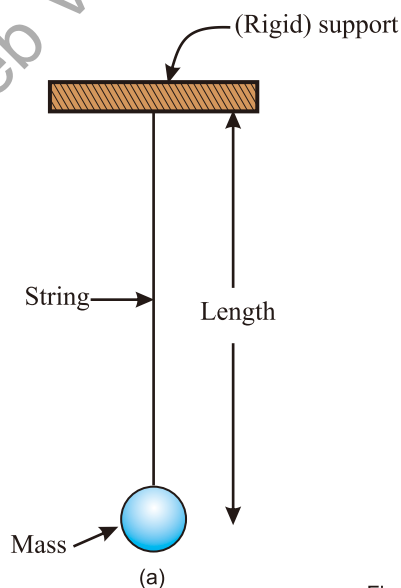


Fig. 5.1.1

Procedure



DO YOU KNOW?

A swing with longer ropes takes more time to complete its one round trip.

- Find the diameter D of the bob with the help of vernier callipers and calculate the radius r of the bob. (i.e. $r = \frac{D}{2}$)
- Take inextensible string and tie its one end with the hook of the bob.
- Place the other end of the string between the split cork.
- Clamp the cork in an iron-stand. The bob of the pendulum must be only a few cm above the ground.
- Measure the length ℓ_1 of the string including the hook. Total length of pendulum will be $\ell = \ell_1 + r$.
- Draw two mutually perpendicular lines with the help of chalk on the floor exactly below the hanging bob. Cut off about 5 cm on either side from the mean position 'O'. Points A and B show the extreme positions for the oscillating bob.
- Displace the bob from mean position to the position A and then release it gently. The oscillation of the bob should be along the straight line.
- Start the watch when the bob just passes point 'O' and at the same time start counting the number of oscillations from zero. Note the time t_1 for 20 complete oscillations.
- Repeat step 8 to obtain another value of time t_2 and find the mean time t .

$$t = \frac{t_1 + t_2}{2}$$
- Calculate the mean time period for one oscillation as

$$T = \frac{t}{20}$$
- Repeat the experiment by changing length of pendulum in steps of 10cm each.

Think

Why should the bob of simple pendulum be kept very near the floor?

Think

Why is it desirable to measure the time for at least 20 vibrations in order to get average value of t ?

CAUTIONS

- The bob of the pendulum should not be more than a few centimetre above the ground.
- The vibration of the bob should be linear.
- The amplitude of oscillation should be kept small.

Observations and Data Processing

Least count of vernier callipers = ----- cm

Zero error = ----- cm

Zero correction = ($\pm$) ----- cm

Corrected diameter of the bob = (1) ----- cm (2) ----- cm (3) ----- cm

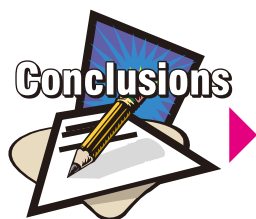
Mean diameter = D = ----- cm

Radius of bob = $r = \frac{D}{2} =$ ----- cm

No. of obs.	Length of string including hook ℓ_1	Total length of pendulum $\ell = \ell_1 + r$	Time for 20 oscillations			Time period $T = \frac{t}{20}$	T^2	$\frac{\ell}{T^2}$	$g = 4\pi^2 \frac{\ell}{T^2}$
			t_1	t_2	$t = \frac{t_1 + t_2}{2}$				
	cm	cm	s	s	s	s	s ²	cm s ⁻²	cm s ⁻²
1									
2									
3									

Mean value of $g =$ _____ cm s⁻²

Conclusions



Post Lab Activities



1. A student conducted an experiment to measure the acceleration due to gravity g by a simple pendulum. The data obtained is tabulated below:

Length of the pendulum (cm)	65	80	100	145	195
Time for 20 oscillations (s)	32.4	35.8	40.1	47.5	56.3

Using the relation $g = 4\pi^2 \frac{\ell}{T^2}$, find the value of g by plotting a suitable graph.

2. Do the following factors affect the period of the pendulum? Write down 'yes' or 'no'.
 - a. Length of the pendulum _____
 - b. Amplitude of oscillation _____
 - c. Mass of the bob _____
3. At what position during the oscillation does the bob move fastest?



BRAIN TEASERS

1. What effect would the temperature have on the time kept by a pendulum clock made of iron bar?
2. How would the time period of simple pendulum be affected if it were located on the moon instead of the Earth?

Web Version of PCTB Textbook

Experiment 5.2

Prove that time period of a simple pendulum is independent of mass of the pendulum.

Date _____



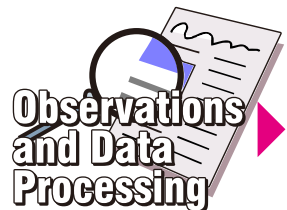
Materials Required

Three identical bobs of different metals such as aluminium, brass and lead with hooks, laboratory balance, stop watch, iron stand with heavy base, metre rule, cork (split in two halves), vernier callipers and inextensible string.



Procedure

Find the mass of each bob and then follow the procedure given in experiment 5.1. Measure the time period for three given bobs keeping the length and amplitude constant.



Observations and Data Processing

Least count of vernier callipers = cm

Zero error = cm

Zero correction = ($\pm$) cm

Corrected diameter of the bob

Aluminium bob = D_1 = cm

Lead bob = D_2 = cm

Brass bob = D_3 = cm

Average diameter of all the bobs = D = cm

Radius of the bob = $r = \frac{D}{2}$

Length of pendulum = $\ell = \ell_1 + r$ = cm

Think

Why should the bobs be of the same size?

CAUTIONS

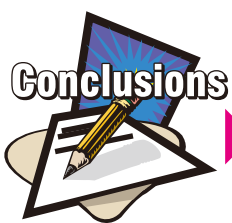
- The bob of the pendulum should not be more than a few centimetres above the ground.
- The vibration of the bob should be linear.
- The amplitude of oscillation should be kept small.



DO YOU KNOW?

Though Galileo did not have a time clock, he used his pulse and type of water-drop clock to measure time that was accurate enough for his experiments.

No. of obs.	Mass of the bob	Time for 20 oscillations			Time period $T = \frac{t}{20}$
		t_1	t_2	$t = \frac{t_1 + t_2}{2}$	
	(g)	(s)	(s)	(s)	(s)
1					
2					
3					



Conclusions



Post Lab. Activities

1. What would be the effect of replacing the bob of pendulum with a wooden ball, a lead ball, and a ping pong ball of the same size?

2. Explain, why is it not advisable to determine the period of vibrating pendulum by recording the time for one vibration only?



BRAIN TEASER

If the spherical bob is replaced by a cylinder of the same mass in a simple pendulum, how will the time period be affected provided that length of the pendulum is kept constant? Investigate.

Experiment 5.3

Prove that time period of a simple pendulum is independent of amplitude of the vibration.

Date _____



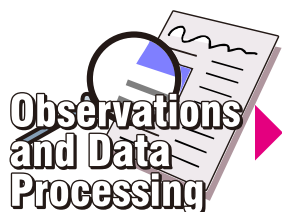
Materials Required

Metallic bob with a hook, stop watch, iron stand with heavy base, metre rule, cork (split in two halves) and inextensible string.



Procedure

There is no need to measure the diameter of the bob in this experiment. Follow the procedure given in experiment 5.1. Measure the time period T for different amplitudes i.e., 5 cm, 7 cm and 9 cm, keeping the length of simple pendulum constant.

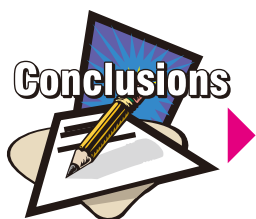


Observations and Data Processing

No. of obs.	Amplitude	Time for 20 oscillations			Time period $T = \frac{t}{20}$
		t_1	t_2	Average $t = \frac{t_1 + t_2}{2}$	
	(cm)	(s)	(s)	(s)	(s)
1					
2					
3					

CAUTIONS

- The bob of the pendulum should not be more than a few centimetre above the ground.
- The vibration of the bob should be linear.
- The amplitude of oscillation should be kept small.



Conclusions

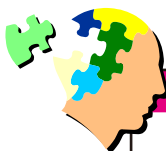
Investigation

May amplitude of the bob ever exceed the initial amplitude?



1. Perform the above experiment by making amplitude large, say 20cm and 30cm. What happens to the time period now?

2. Why do the oscillations of simple pendulum gradually diminish and eventually the bob stops?



BRAIN TEASERS

1. In the nursery rhyme "Hickory Dickory Dock" if the mouse actually runs up the pendulum of the grandfather pendulum clock, what would happen to its time period?
2. If the amplitude of a simple pendulum is 5cm, what is distance moved in one oscillation?

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CHAPTER Properties of Matter

7



Study the relationship between load and extension (Helical spring) by drawing a graph.

Date _____



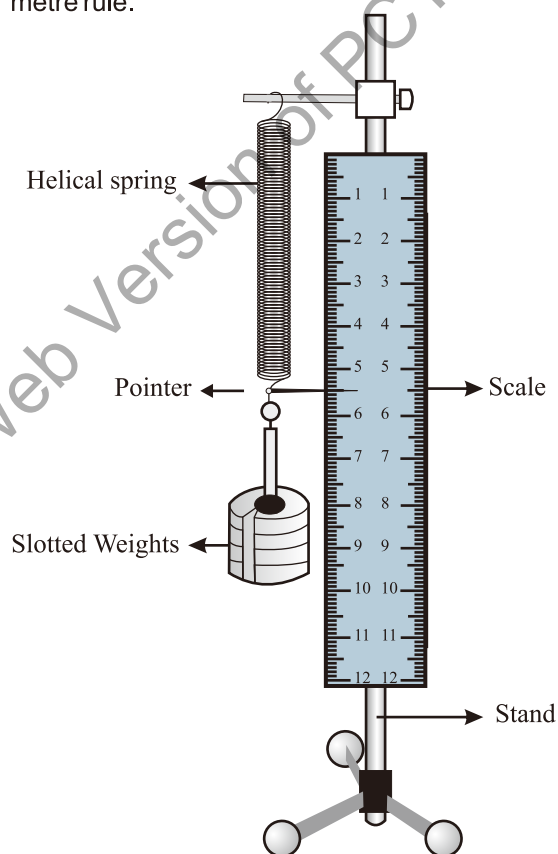
Hooke's law states that strain is directly proportional to stress. In case of a spring, the extension of the spring is in direct proportion with the load added to it as long as this load does not exceed the elastic limit.

Mathematically, $F = kx$

Where extension x is the length through which a load F attached to the spring is displaced from equilibrium position and k is the spring constant.



Helical spring with stand, hanger with pointer, slotted weights (50g×8=400 g) and half metre rule.



CAUTIONS

- The pointer should move on the scale freely.
- Note the reading when the pointer is completely stopped.
- While taking reading keep eye in level with the pointer.
- Put the weight gently in the hanger.
- Switch off fans at the time of experiment.
- Load should not exceed the elastic limit of the spring.

Fig. 7.1.1

Procedure



DO YOU KNOW?

In most of the physical exercise machines like chest expander, springs are used which expand or contract in proportion to applied force. A similar use of spring is in the shock absorber. Can you name some other uses of spring?

- 1 Suspend a helical spring with the stand and attach a hanger to its lower end.
- 2 Adjust the pointer in such a way that it does not touch the scale but moves up and down freely along the scale.
- 3 When the pointer comes to rest, note its position on the scale. This is the initial position P_0 of the pointer when no mass is added to the hanger. While noting the position of the pointer, keep your eye in level with the pointer to avoid parallax error.
- 4 Place a slotted weight in the hanger. The spring extends through a small distance. Note the reading of the pointer P_1 .
- 5 Repeat this process at least six times, each time by increasing the load in equal amount.
- 6 Unload the spring in the same steps and note the position P_2 of the pointer on the scale at each step.
- 7 Calculate the mean of the readings while loading and unloading for each load.
- 8 Draw a graph between load F (x -axis) and extension x (y -axis).

Think

Why is the load taken along y -axis and extension along x -axis?

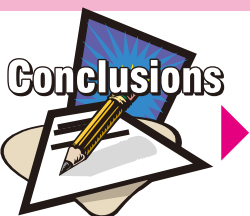
What does the graph show?

Observations and Data Processing

Initial position of the pointer with hanger = P_0 = ----- cm

Gravitational acceleration = g = 10 m s^{-2}

No. of obs.	Total mass of the slotted weights in the hanger m (g)	Load F $100\text{g}=1\text{N}$ (N)	Position of pointer			Extension $x = P - P_0$ (cm)
			loading	unloading	Mean	
			P_1 (cm)	P_2 (cm)	$P = \frac{P_1 + P_2}{2}$ (cm)	
1						
2						
3						
4						
5						
6						



Conclusions



Post Lab Activities

1. If spring used in above experiment is replaced by another stiffer spring (higher value of k), what will be the effect on the graph?

2. How can you find the value of unknown weight by using the above apparatus and the graph you have drawn?



BRAIN TEASERS

1. Springs are made of steel instead of iron. Why?

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Experiment 7.2

Find the density of an object heavier than water by Archimedes principle.

Date _____

Background Information

Archimedes principle states that when an object is immersed in a fluid, it experiences an upward force equal to the weight of the fluid displaced by the object. It is important to note that the upward force does not depend on the weight or shape of the submerged object, but depends only on the weight of the displaced fluid. If the density of the object is greater than that of the fluid, the object will sink. If the density of the object is lesser than that of the fluid, the object will float. Using Archimedes principle the unknown weight of an object can be found easily.

Materials Required

Physical balance, weight box, solid object such as glass stopper, beaker, thread, small wooden bench, water and half degree thermometer.



DO YOU KNOW?

In construction of a ship a lot of steel is used but it is designed to have plenty of empty space to make its overall density lesser than the water. This is why it floats in the water.

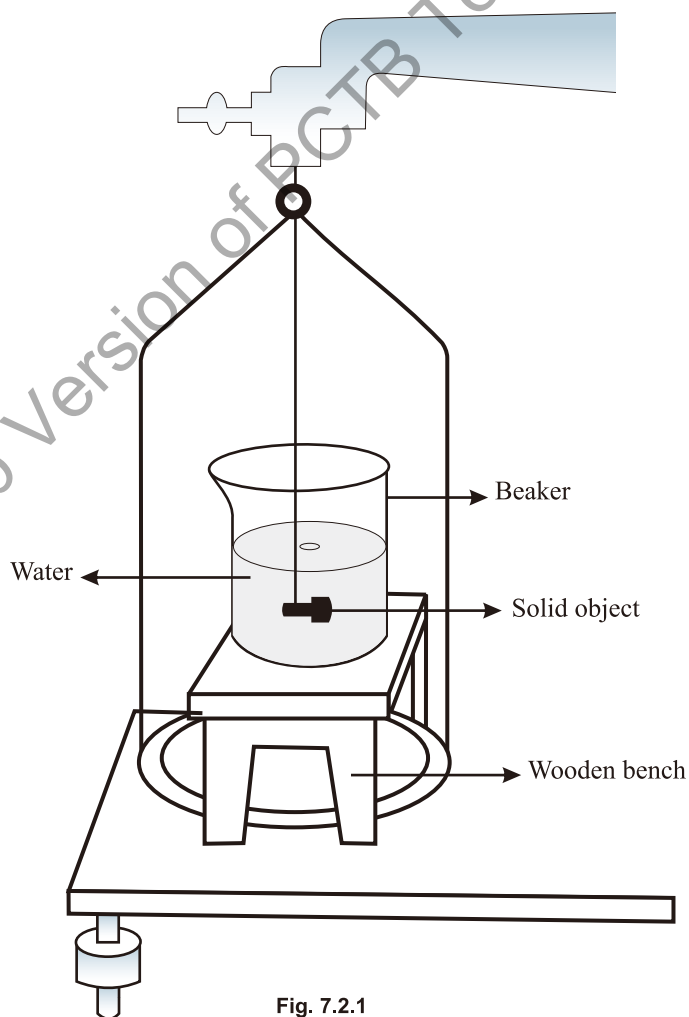


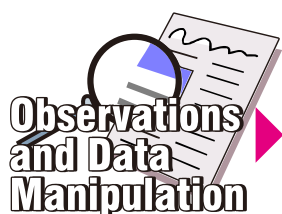
Fig. 7.2.1



- ➊ Note the room temperature with the help of a thermometer.
- ➋ Level the physical balance with the help of balancing screws.
- ➌ Measure the weight $w_1 = m_1 g$ of the given solid object in air.
- ➍ Place the wooden bench across the left pan of the balance.
- ➎ Fill $\frac{3}{4}$ th of beaker with water and put it on the bench.
- ➏ Suspend the solid with the hook of the balance such that the object is completely immersed in water in the beaker and does not touch its walls and bottom.
- ➐ Weigh it again and record the weight as w_2 .

Think

Why the object is completely immersed in liquid?



Room temperature = $\theta = \text{-----}^\circ\text{C}$

Weight of solid object in air = $w_1 = m_1 g = \text{----- N}$

Weight of solid object in water = $w_2 = m_2 g = \text{----- N}$

Decrease in weight of solid object in water = $w_1 - w_2 = \text{----- N}$

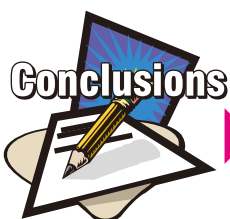
Density of water = 1000 kg m^{-3}

Using Archimedes principle

Density of solid object $\rho = \text{Density of water} \times \frac{w_1}{w_1 - w_2} = \text{----- kg m}^{-3}$

CAUTIONS

- The solid should not touch the walls and bottom of the beaker when dipped in water.
- Water drops should not fall in the pan
- Solid should be fully immersed in water.
- Pan should not touch the wooden bench.



The density of the given solid object is ---- kg m^{-3} .



1. Find the density of the above object by using spring balance and compare the result with that you have already found by physical balance.

2. How can the density of a body lighter than water (wood, cork, a piece of styrofoam) be determined?

3. How can a hot air balloon carrying a lot of load rise in the air?

4. Take two cans filled with soft drinks (1 diet and 1 regular) and put them in a tub containing water. Which one will sink and which one will float? Give reason.

5. Suppose you are asked to verify that the king's crown is made of pure Gold. How would you go about doing so without damaging the crown?



BRAIN TEASER

Why are Aluminium and Titanium used to build aircrafts?

Experiment 7.3

Find the density of a liquid using a disposable syringe.

Date _____

Background Information

Density ρ is defined as mass m per unit volume V of a substance. Knowing the mass of the given volume of a liquid, the density of the liquid can be calculated by using the following formula.

$$\text{i.e. } \rho = \frac{m}{V}$$

The units of density are gcm^{-3} or kg m^{-3} .

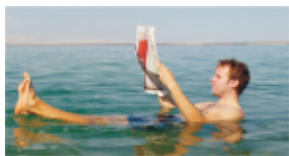
Materials Required

A disposable syringe (without needle), little amount of plasticine, liquid, physical balance, weight box and thermometer.



DO YOU KNOW?

A person can lie over the surface of Dead Sea because of high density of its water.



Procedure

- 1 Level the physical balance with the help of leveling screws.
- 2 Adjust the balancing screws on both ends of the beam such that the pointer moves equal distance on either side of the zero of the scale.
- 3 Close the nozzle of the empty syringe with a little amount of plasticine.
- 4 Measure the mass ' m_1 ' of empty syringe by using physical balance.
- 5 Remove the plasticine and fill the syringe with the given liquid exactly up to 5 mL mark with the help of its piston.
- 6 Close the nozzle again with the same piece of plasticine.
- 7 Measure the mass ' m_2 ' of the syringe containing liquid.
- 8 Repeat the procedure to measure the mass of 8 mL and 10 mL of the liquid.



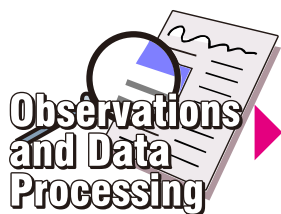
Fig. 7.3.1

Think

Why is it necessary to close the nozzle with plasticine?

Think

Why is the nozzle closed with the same piece of plasticine?

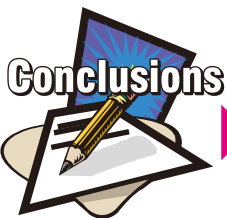


Room temperature $= \theta = \text{-----}^{\circ} \text{C}$

Mass of empty syringe $= m_1 = \text{-----} \text{g}$

No. of obs.	Volume of liquid V mL or (cm ³)	Mass of syringe with liquid m_2 (g)	Mass of liquid $m = m_2 - m_1$ (g)	Density of liquid $\rho = \frac{m}{V}$ (g cm ⁻³)
1.				
2.				
3.				

Average density $= \text{-----} \text{g cm}^{-3}$



Density of the given liquid is $\text{-----} \text{kg m}^{-3}$.



- How can the density of a metal ball having diameter less than the inner diameter of the syringe be determined?

- Take some water in a test tube. Pour some cooking oil into the tube. Fit a cork tightly to close the mouth of the tube. Shake the tube well and hold it for a while vertically. What do you observe? Give reason.

- Put an egg in water, it will sink to the bottom of the container. Add common salt gradually to water and stir it with a rod or a spoon. The egg will slowly rise to the surface of water. Give reason.



BRAIN TEASER

Why is it easier to swim in sea water than in fresh water lake?

CHAPTER

Thermal Properties of Matter

8

Experiment 8.1

Find the specific heat of given solid by the method of mixture using polystyrene cup.

Date _____

Background Information

The quantity of heat required to raise the temperature of one kilogram of a substance through 1K is called specific heat capacity of that substance. When two substances at different temperatures exchange heat such that they attain thermal equilibrium at a certain final temperature θ then, according to law of heat exchange.

Heat lost by one substance = Heat gained by the other substance

When a hot metallic bob of mass M_2 at temperature θ_2 is added to water of mass M_1 at temperature θ_1 , then knowing the specific heat capacity c_1 of water, the specific heat capacity c_2 of metal can be determined by the equation.

$$M_2 c_2 T_2 = M_1 c_1 T_1$$

where $T_2 = \theta_2 - \theta$ = fall in temperature of the metal bob
and $T_1 = \theta - \theta_1$ = rise in temperature of water

Materials Required

Polystyrene cup with lid, plastic stirrer, two half degree thermometers, heating arrangement, brass bob with a hook, physical balance, weight box, beaker and iron stand with clamp.

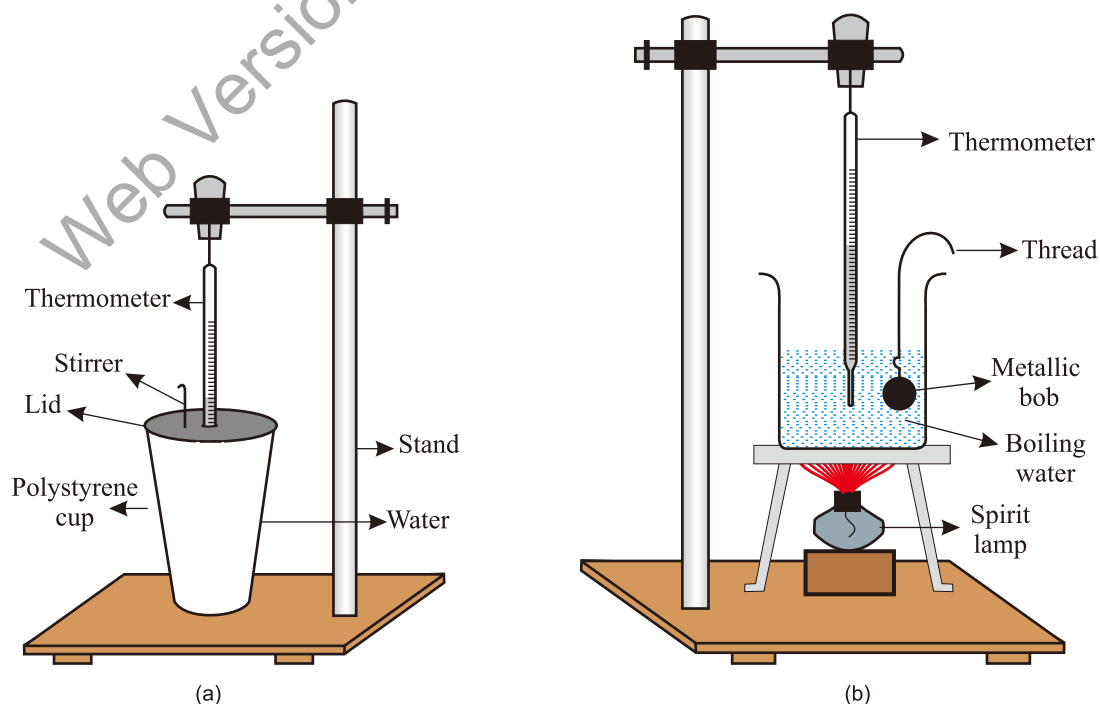


Fig. 8.1.1

Procedure

DO YOU KNOW?

Normally water is used as coolant in the radiators of vehicles to protect the engine from overheating due to high value of its specific heat.

FOR YOUR INFORMATION

The difference between any two temperatures is the same in centigrade and kelvin scale.

Observations and Data Processing

1. Take an empty polystyrene cup and measure its mass m_1 .
2. Add about 30 mL of water in the cup and weigh it again to find the mass m_2 of the cup with water.
3. Suspend the thermometer from the stand clamp and insert it in the water through the hole in the lid. Also insert the stirrer in the small hole on the other side of the lid.
4. Adjust the thermometer such that its bulb rests about 1 cm above the bottom of the cup.
5. Wait for a few minutes and then record the temperature θ_1 of water in the cup.
6. Take a brass bob. Tie the thread to its hook and find its mass M_2 by physical balance.
7. Take a beaker. Add about 150 mL of water in it and place the beaker on the heating arrangement.
8. When the water in the beaker begins to boil, place the bob in the boiling water for 10 minutes using a clamp.
9. Record the temperature of the boiling water. This is also the temperature θ_2 of the bob.
10. Carefully but quickly transfer the hot bob to the polystyrene cup containing water.
11. Immediately, replace the lid and thermometer assembly on the cup and stir the water gently.
12. Observe the rise in temperature until it becomes steady.
13. Note this steady temperature θ before it begins to decrease.

CAUTIONS

- Heat the solid to temperature where it remains constant for several minutes.
- Stir the mixture while noting its temperature.

Think

Why should the bob be kept in the boiling water for such a long time?

Think

- Why should water not be splashed from the polystyrene cup when the bob is added?
- How will the value of specific heat of the brass bob be affected if the hot bob is not quickly transferred to water?

Mass of empty polystyrene cup	$= m_1 = \text{-----g}$
Mass of polystyrene cup with water	$= m_2 = \text{-----g}$
Mass of water	$= M_1 = m_2 - m_1 = \text{-----g}$
Mass of bob	$= M_2 = \text{-----g}$
Initial temperature of water in the cup	$= \theta_1 = \text{-----}^\circ\text{C}$
Temperature of bob before adding it to water	$= \theta_2 = \text{-----}^\circ\text{C}$
Final temperature of mixture	$= \theta = \text{-----}^\circ\text{C}$
Increase in temperature of water in the cup	$= T_1 = \theta - \theta_1 = \text{-----K}$

Decrease in temperature of the bob

$$=T_2 - \theta_2 = \text{---- K}$$

Specific heat of water

$$=c_1 = 4.2 \text{ J g}^{-1} \text{ K}^{-1}$$

Specific heat of brass bob

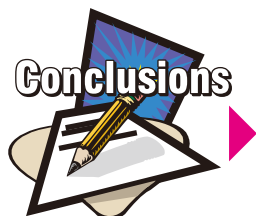
$$=c_2 = \text{----- J g}^{-1} \text{ K}^{-1}$$

Heat lost by the bob = Heat gained by the water

$$M_2 c_2 T_2 = M_1 c_1 T_1$$

$$c_2 = M_1 c_1 T_1 / M_2 T_2$$

Conclusions



Specific heat of brass bob $=c_2 = \text{----- J g}^{-1} \text{ K}^{-1} = \text{----- J kg}^{-1} \text{ K}^{-1}$

Post Lab Activities



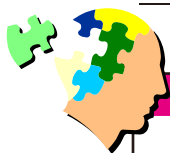
1. How can you find the high temperature of a metal piece of known mass and known specific heat by the method of mixture?

2. Why is polystyrene cup used in this experiment instead of a metallic calorimeter?

3. What effect is expected if instead of single cup, double cups (one into the other) are used and if the cup is covered by a lid of Styrofoam as well?

4. As soon as the hot solid is put in the cold water, it reaches the maximum temperature quickly. Give a reason for this.

5. If the same amount of heat is transferred to an equal mass of water or lead metal, which substance will be hotter?



BRAIN TEASERS

1. Why do the metal parts of a car get hotter than the plastic parts?
2. A piece of metal is broken up into two equal parts. What happens to its
i) specific heat capacity ii) thermal capacity
3. A lady takes a watermelon and a sandwich from the refrigerator and leaves them outside. After sometime she touches the watermelon and sandwich and feels that the watermelon is colder than the sandwich. Why does the watermelon stay cooler for a longer time than the sandwich even though both were taken out from the fridge at the same time?

Experiment 8.2

Draw a graph between temperature and time when ice is converted into water and then to steam by slow heating.

Date _____

Background Information

When the state of a substance changes from solid to liquid or from liquid to gas, heat is absorbed by the substance without any change in temperature. The heat absorbed or evolved during the change of state without change of temperature is called latent heat.

Materials Required

Ice chips, iron stand, beaker, gas burner or spirit lamp, stopwatch, thermometer, tripod stand, stirrer and graph paper.



DO YOU KNOW?

The liquid wax flowing down the sides of burning candle solidifies quickly due to its small value of specific latent heat.

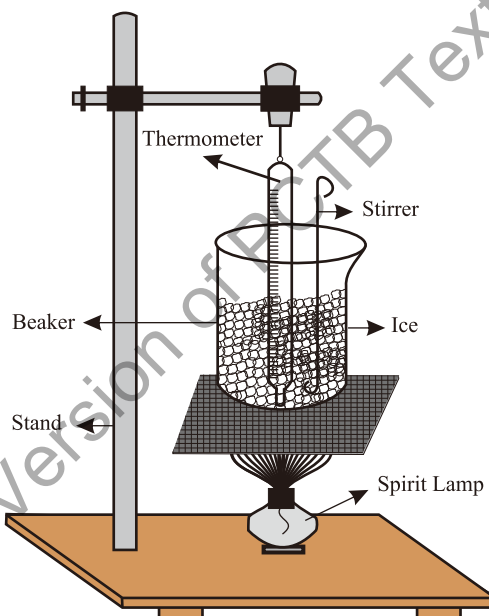


Fig. 8.2.1

CAUTIONS

- Time and temperature should be recorded simultaneously.
- Use small pieces of ice in a suitable quantity.
- Heat the ice with low flame.
- Use thermometer which can also record negative temperature.
- Stir the mixture when ice starts melting.

Procedure

- 1 Take some ice chips in a beaker.
- 2 Put wire gauze on a tripod stand and place the beaker on it.
- 3 Suspend the thermometer from the stand clamp and insert it in the water through the hole in the lid. Also insert the stirrer in the small hole on the other side of the lid.
- 4 Place a burner or spirit lamp under the beaker and heat it slowly.

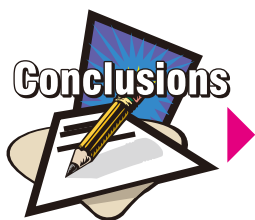
Think

Why should the ice be heated slowly?

- ⑤ Start the watch and note the temperature after every minute. During heating stir the ice continuously with the help of stirrer.
- ⑥ Keep on noting the temperature till all the ice chips melt and are converted into water.
- ⑦ Continue heating and record temperature of water after every minute till water starts boiling.
- ⑧ Turn off the burner immediately after completing the experiment.
- ⑨ Plot a graph taking temperature along y-axis and time along x-axis.



No. of obs.	Time	Temperature	No. of obs.	Time	Temperature
	min.	°C		min.	°C
1			11		
2			12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		



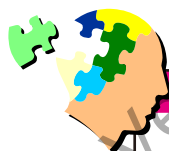


1. From the graph, find the melting point of ice. Describe energy changes during melting.

2. What is the boiling point as shown by the graph?

3. What will you observe if the water is further heated?

4. The same amount of water at hilly areas boils earlier as compared to plain areas. Why?



BRAIN TEASERS

1. Why steam at 100°C burns the skin more severely than water at 100°C ?
2. How will the graph of temperature versus time be changed if the mass of ice taken in the above experiment is increased.
3. Use dotted line on your graph for this experiment to predict what does the graph look like if the experiment is performed with only half as much ice?

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Experiment 8.3

Find the latent heat of fusion of ice.

Date _____

Background Information

The device used in this experiment is called a calorimeter. It is an insulated container that prevents heat exchange between the contents of the calorimeter and the outside surroundings.

The latent heat of fusion denoted as L_f is amount of heat required to convert 1 kg of ice into water without change of temperature.

When a piece of ice is added to warm water, heat is absorbed by ice for melting. Then heat is absorbed by melted water to raise its temperature from 0°C to the final temperature of the mixture as it mixes with the warm water in the calorimeter. In this process heat is lost by the calorimeter and the warm water in it, whereas heat is gained by the ice when it melts and the temperature of the melted ice rises to the final temperature. By law of heat exchange

$$\text{Total heat lost} = \text{Total heat gained}$$

If M_1 = mass of water, M_2 = mass of ice, m_1 = mass of calorimeter, c_1 = specific heat of water, c_2 = specific heat of copper, θ_1 = Temperature of warm water and θ = Final temperature of the mixture, then

Heat lost by + Heat lost by = Heat absorbed by + Heat absorbed by
warm water calorimeter ice to melt melted water

$$M_1 c_1 (\theta_1 - \theta) + m_1 c_2 (\theta_1 - \theta) = M_2 L_f + M_2 c_1 (\theta - 0)$$

or

$$L_f = \frac{M_1 c_1 (\theta_1 - \theta) + m_1 c_2 (\theta_1 - \theta) - M_2 c_1 (\theta - 0)}{M_2}$$

Materials Required

Copper or aluminium calorimeter with lid and lagging, thermometer, stirrer, physical balance, some cubes of ice, blotting paper and warm water.

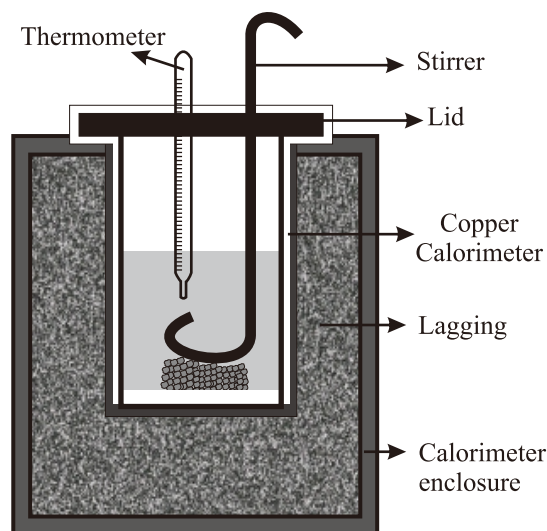


Fig. 8.3.1

CAUTIONS

Larger the change in temperature, the better is the precision with which it can be measured.



Procedure

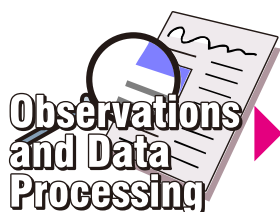
- ① Note the room temperature T before starting the experiment.
- ② Weigh the empty calorimeter and find its mass m_1 .
- ③ Put some warm water in the calorimeter. The temperature of water should be 5°C to 10°C higher than the room temperature.
- ④ Weigh the calorimeter with warm water as m_2 .
- ⑤ Place the calorimeter in its enclosure.
- ⑥ Put the lid with stirrer over the calorimeter and pass a thermometer through the hole in the lid such that its bulb is dipped in the water.
- ⑦ Note the temperature θ_1 of warm water.
- ⑧ Wrap up one piece of ice with blotting paper to dry it.
- ⑨ Drop the piece of dried ice gently in the calorimeter.
- ⑩ Replace the lid and stirrer gently.
- ⑪ Add another piece of ice into the water when the first one has been melted.
- ⑫ Keep on adding ice pieces one by one into the water until the temperature of the water becomes 5°C less than the room temperature. Note this temperature as θ .
- ⑬ Weigh the calorimeter with warm water and melted ice as m_3 .

Think

Why should be the temperature of water higher than the room temperature?

Think

Explain how would your result be affected if the ice had not been thoroughly dried before putting in water?



Observations and Data Processing



DO YOU KNOW?

Food scientists use calorimeter to measure energy values of foods. The energy given off when food item is burnt in a calorimeter is expressed in Calories. One food calorie is one kilocalorie and is equal to 4.2 kilojoule of energy.

Room temperature	$= T = \text{-----}^\circ\text{C}$
Mass of empty calorimeter	$= m_1 = \text{-----} \text{g}$
Mass of calorimeter + warm water	$= m_2 = \text{-----} \text{g}$
Mass of calorimeter + warm water + ice	$= m_3 = \text{-----} \text{g}$
Temperature of warm water	$= \theta_1 = \text{-----}^\circ\text{C}$
Final Temperature of the mixture	$= \theta = \text{-----}^\circ\text{C}$
Specific heat of water	$= c_1 = 4.20 \text{ J g}^{-1} \text{K}^{-1}$
Specific heat of copper	$= c_2 = 0.38 \text{ J g}^{-1} \text{K}^{-1}$

$$\text{Mass of warm water} = M_1 = m_2 - m_1 = \text{-----} \text{g}$$

$$\text{Mass of ice} = M_2 = m_3 - m_2 = \text{-----} \text{g}$$

$$\text{Difference of temperature} = \theta_1 - \theta = \text{-----}^\circ\text{C}$$

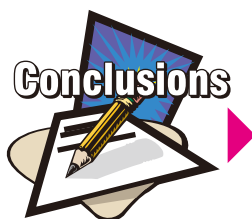
By using the formula

$$L_f = \frac{M_1 c_1 (\theta_1 - \theta) + m_1 c_2 (\theta_1 - \theta) - M_2 c_1 (\theta - 0)}{M_2}$$



DO YOU KNOW?

A piece of Gallium metal melts even when placed on the hand palm. It is because of its low melting point and low specific heat capacity.



Conclusions

$$L_f = \text{-----} \text{ J g}^{-1} = \text{-----} \text{ J kg}^{-1}$$



Post Lab Activities

1. Why does a large block of ice take longer time to melt?

2. Why is the latent heat of vaporization much larger than latent heat of fusion?

3. In melting and boiling there is no change in temperature even though a large amount of heat energy is absorbed. Where does the heat energy go?

4. Ice packed in saw dust does not melt quickly. Why?



BRAIN TEASER

Why is it better to put ice rather than an equal amount of icy water into a drink you want to chill?