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INTRODUCTION

Experiments play a crucial role in the progress of science. A large number of path breaking discoveries and inventions have been possible through investigations done usually in laboratories. The experimental work is, therefore, an essential component of any course in science. A course on practical work in science curricula in schools at the secondary stage is essentially designed to acquaint the learners with the basic tools and techniques used in a science laboratory. It also envisages developing problem-solving skills. These skills help the learner to acquire ability to identify a problem, to design and to set up the experiment, to collect and analyse data through experiment, and to interpret data to arrive at plausible solution in due course of time. These are, in fact, the long term objectives of laboratory work and become the nucleus of the philosophy of construction of knowledge by the learner.

A school science laboratory is a place where basic experimental skills are learnt by systematically performing a set of prescribed and suitably designed experiments. Performing experiments by one's own hands is not only a thrilling experience but is also important because it entails *learning by doing*. It also facilitates understanding the concepts of science. The experiments and project work suggested at the secondary stage intend to develop basic skills of measurement; handling of some common measuring instruments, equipment and chemicals; setting simple apparatus; handling microscope and preparing slides; making observations; collecting data and presenting it in appropriate format; interpreting and drawing conclusions; and preparation of report.

There are certain rules and regulations that every student must be familiar with before undertaking practical work in a laboratory. A student is required to be acquainted with the general facilities and the equipment available in the laboratory and follow the rules and regulations. Generally, in the beginning of the session, the teacher takes the students around the



laboratory to familiarise them with the general facilities available in the laboratory and informs them about certain do's and don'ts while performing the experiments in the laboratory.

Laboratory Manual in Science for Class IX is an exercise to familiarise pupil with the general facilities, equipment, measuring instruments, chemicals and glassware, specimen available in a school science laboratory. The precautions and measures for safety to be observed in a laboratory are also mentioned. The format adopted for description of experiments includes the aim of the experiment, theory or the principle involved in the experiment, list of materials required on the basis of method to perform the experiment, steps involved in performing the experiment, recording observations, the formula required for calculations and stating the results. An emphasis on drawing conclusions and initiating discussions is also made. Though the precautions that are necessary to be taken care of in performing the experiments are merged with the procedure itself, these along with the possible sources of errors are also mentioned separately with more reasoning. There could be some certain prerequisites for preparing the laboratory for performing an experiment, and additional information to teachers on a particular experiment. Such issues have been raised in almost all experiments in column titled Note for the Teacher. Authors have also used this column to communicate with teachers. It is hoped that teachers would find this column useful. The method used in the experiment may also be used to extend understanding in some applications. A column titled Applications has been added occasionally for addressing such issues. At the end of every experiment some thought provoking questions are also included. These questions are based on the procedures involved in the experiment. Many questions provoke pupil for relating their everyday life experiences with scientific principles. It is believed that such questions will be helpful in inculcating scientific temper and attitude among students. In these write-ups, it can be seen that the columns such as Materials Required and Note for the Teacher often address the issues related with the alternate materials and even alternate procedures that can be used for performing the experiment. It is however important to mention that the suggestions given for conducting the experiments are suggestive and may be modified depending on the facilities available in a particular situation. For example, if the material suggested for a particular experiment is not available, a suitable alternate material may be used. In addition to these experiments, a student may also conduct any other experiment of interest. However, it is important that every student of science must pay proper attention to the practical work and should try to acquire basic laboratory skills and develop a keen sense of observation and acquire a sound training in the reporting of the work done. Many experiments are so chosen that these can be performed using low cost and locally available materials without loosing the rigor

of science. The suggestions for maintaining the equipment have also been given wherever possible.

Questions at the end of each experiment may be dealt with meticulously and must be discussed with peers and teachers to arrive at appropriate and convincing answers.

1.1 GENERAL LABORATORY FACILITIES

In a science laboratory, we usually find working tables, some items of common utility and space for storing equipment, chemicals and glassware. The working tables in a science laboratory are usually provided with-

- Sinks with water taps for washing purposes and liquid waste disposal. It is expected that the students will use taps only when required and will not waste the water. A regular cleaning of sinks is essential.
- Reagent columns for keeping bottles of chemicals and reagents of frequent use. These reagent bottles are arranged in a definite order.
- Heating facilities provided in the form of gas taps fitted with a burner or spirit lamp. A gas tap should be opened only when the gas is required for lighting the burner. Leakage, if any, should be immediately brought to the notice of the teacher or other laboratory staff. Every laboratory must be equipped with a few fire extinguishers fixed at convenient places.
- In the science laboratory, the equipment and glassware of common use are stored separately in an almirah. They are generally issued to the students at the time of performing experiments.
- In some laboratories, equipment like balances and microscopes may be permanently placed in a place as these are used quite frequently. The type of balance used depends on how accurate the weighing must be and what to balance? At secondary stage, a physical balance is a good choice. Teachers are advised to train students appropriately to use a physical balance before they are asked to perform experiment that requires weighing measurements (Fig. 1). For weighing powders or solid materials, one must use weighing tubes or butter paper depending on the nature of the material. The pan of the balance must be kept clean. The microscopes (Fig. 2) must be placed near the window to ensure the availability of sufficient sunlight needed.
- A water distillation plant should also preferably be installed in the laboratory. However a proper arrangement for water supply and drainage should also be made close to the place of installation of distillation plant. Ensure the water supply through the plant before switching <u>ON</u> the electric power.
- Provision for fuming hood or exhaust may be made in the laboratory for gases.

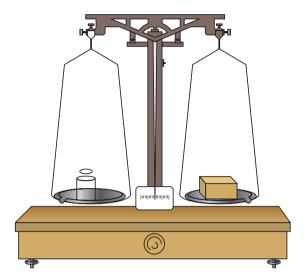
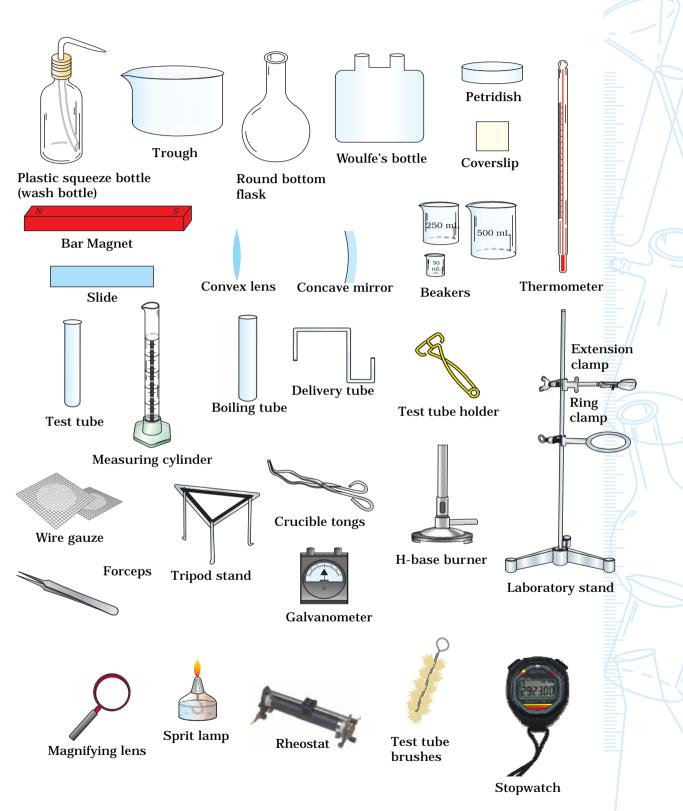


Fig. 1: A physical balance



Fig. 2: A compound microscope

- Electrical connections must be provided with all working tables for performing electricity and magnetism experiments.
- Utility items like soldering rod, hammer, drill machine with drill bits, pliers, hacksaw, cutter, screw driver set, spanners, torchlight etc. must be placed at a convenient place inside the laboratory. Common electrical measuring devices such as a multimeter may also be placed.
- A demonstration table is relevant for teacher demonstration.
- For the purpose of disposal of solid waste, a dustbin may be provided either near each working table or at a common place in the laboratory.



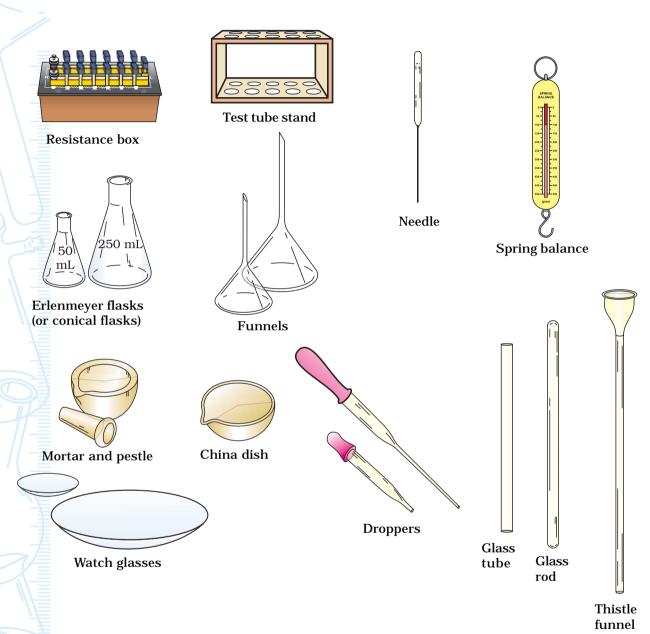


Fig. 3: Common laboratory equipment and glassware

• Equipment, glassware, and reagent bottles are kept at proper and specified place. Some of the common laboratory equipment and glassware are shown in Fig. 3.

1.2 Preparing Students for Laboratory Work

Students must be groomed for laboratory work and experience in order to benefit from them. Students must know why they are expected to participate in an activity and what they will derive from it. Science teachers are expected to facilitate students in arranging pre-laboratory discussion, giving directions, and post-laboratory discussions.

Pre-laboratory discussion must give students the clearest possible picture and understanding of what they are to do in the laboratory. This will help the students concentrate on what they are doing and make the experience more meaningful. If special equipment or difficult procedures are involved, the teacher should show the students how to use the equipment and procedures. Pre-laboratory discussions should be as concise but meaningful enough to thoroughly orient the students in the laboratory work. Sometimes these discussions are given a day before the laboratory period to give students plenty of time for the assigned laboratory activity.

The directions for laboratory exercises must be explicit and clear. They can be given orally or in written form or discussed during the pre-laboratory session. Sometimes it may also be helpful to summarise directions on the blackboard that have already been given.

Students should present and analyse their data during the postlaboratory discussion. Here the information can be analysed and related to the objectives of the experiment. The post-laboratory discussion is very helpful in broadening students' understanding the content and processes of science.

1.3 GENERAL LABORATORY RULES

In a science laboratory, the following rules are to be observed by all users-

- Students prepare in advance for the experiment they would perform in the laboratory.
- Students must accompany/carry their practical notebook, laboratory manual, geometry box, pencil, sharpener, and eraser to the practical class. They should also wear laboratory coat or apron, if available, while working in the laboratory.
- Students follow strictly the instructions given by the teacher and perform the experiments carefully at the allotted places. They should not move around unnecessarily in the laboratory. The teacher may be consulted for any help or guidance. Disposal of reagents must be done with care.
- All equipment such as microscope, physical balance, measuring items and glassware must be handled with care and after understanding their functions.
- Labels on the reagent bottles should be read carefully before using.
 The reagent bottles and chemicals must be kept back at their specified
 places after use. Cap the bottle with the stopper immediately after
 using a chemical reagent. To prevent contamination of reagents glass
 rods, filter papers, dropper should never be dipped directly into the

- reagent bottles. Partially used material should not be poured back into the reagent bottles.
- The mouth of the test tube should not be pointed towards any pupil including you while heating or adding a reagent (Fig. 4).

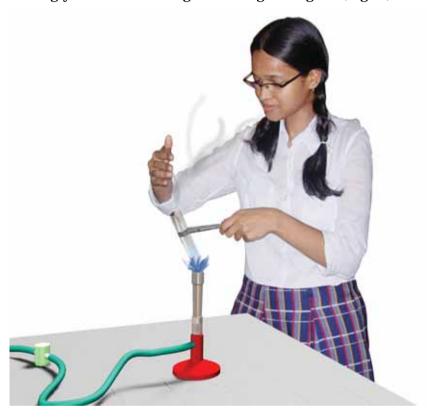


Fig.4: Correct method of heating a boiling tube and to know the smell (or odour)

• For smelling the vapours, fan the vapours gently with your hands towards the nose (Fig. 5). Avoid direct smelling of chemicals or vapours.

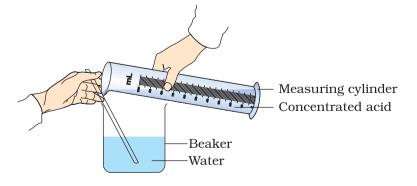


Fig.5: Correct way of adding acid to water for dilution

- Acid is diluted by adding water. Never add water to acid. (Fig. 5).
- Do not handle chemicals with hands and do not taste any chemical.
- Keep your working table and surroundings clean. Replace all laboratory equipment to its assigned place in the laboratory once the practical work is over.
- Do not eat or drink in the laboratory. Always wash your hands after the laboratory class.
- Be acquainted with the handling of first aid kit and fire extinguisher.
 In case of any accident or injury or breakage of apparatus, report to the teacher immediately.

1.4 FIRST AID TREATMENT

A first aid kit is an essential part of any science laboratory, which is placed at an easily accessible place. Accident occur in the science laboratory mostly due to the lack of attention. In such a case, first aid treatment must be provided immediately. The victim should be taken to the doctor, if required. Some common injuries caused due to accidents and their first aid treatments are given below.

BURNS

In the laboratory, burns can be caused due to steam, hot water, acids or alkali. The first aid treatment required for burns caused due to each one of them is different. The first treatment to be provided for some of them is as follows-

- For burns caused by steam or hot water, wash the affected part with cold running water. Do not use ice. Once the affected part is cool, dry it gently with clean cloth and then apply an antiseptic ointment.
- For an acid burn, wash the wounded part with water and apply a dilute solution of sodium hydrogen carbonate. Wash again with water. Dry gently with a clean cloth and apply an antiseptic ointment.
- For an alkali burn, wash with ample of water to remove all the alkali
 and then wash with dilute acetic acid. Dry the affected part with a
 clean cloth and apply an antiseptic ointment.

GLASS CUTS AND WOUNDS

Carefully remove all the visible pieces of glass from the wound. Protect the wound from dirt and dust. Wash with cold water to remove smaller pieces of glass sticking to the wound, if any. Control the bleeding by pressing a clean piece of cotton or cloth on the wound. Apply on antiseptic solution antiseptic cream. Take the victim to the doctor, if required.

EYE INJURIES

In case of injury to eyes, wash the eyes with cold water. Do not rub the eyes. Consult the doctor immediately.

FIRES

One should not run around if clothes catch fire. Immediately lie down on the floor and roll. If a container with inflammable liquid catches fire while heating, turn off the gas burner immediately, and take the container away from all reagents and chemicals. Cover the mouth of the container with a damp cloth. Fire extinguishers should be used if the fire goes out of control. In case the fire is because of the short-circuiting of electrical circuits, switch off the main switch of the electric supply and through soil in the affected area. Do not use water in such a case.

INHALATION OF GASES

If gases such as sulphur dioxide, chlorine or bromine are inhaled by any student, take the student at once to the open air and let the victim breathe deeply and then ammonia vapours. If the gas inhaled is ammonia, drink any fruit juice or lemon juice. Inhale dilute ammonium hydroxide if acid vapours are inhaled.

Report the accident to your teacher immediately to get the medical attention at the earliest.

1.5 RECORDING OF EXPERIMENT

Preparing a report on each practical performed in the laboratory and maintaining a record of the work done is an essential requirement. The report on each experiment should be such that it informs all steps involved in performing the experiment and the result obtained. It is therefore imperative that the report on an experiment should be presented under different headings so that it is easily understood. A format for presentation of report is suggested below.

AIM

It should explicitly state the objective of the experiment.

THEORY

It must explain the basic principle(s), laws or theories on which the experiment is based or which it is meant to verify. Wherever necessary, the

fundamental laws involved in the experiment should be supplemented with mathematical formulae or equations or with neat and labeled diagrams.

MATERIALS REQUIRED

List all equipment, measuring devices and other items or materials to be used for performing the experiment.

PROCEDURE

Various steps followed in carrying out the experiment should be mentioned sequentially under this heading. Labeled diagrams, if any, should be drawn to present a pictorial view of the experimental set up.

OBSERVATIONS

All observations taken while performing the experiment must be recorded as observed and properly. This may be in a tabular form, drawings, or statements or a combination of them depending on the nature of the observations. All measurements must be expressed with their proper units.

CALCULATIONS

In case, calculations based on the observations are required to obtain the result of an experiment, correct formulae and units must be used while substituting the data. All calculations must be carried out carefully. The result or the answer should be stated with proper SI units. In some experiments, drawing of graphs may also be required as a part of calculations.

RESULTS AND DISCUSSION

All results and findings of an experiment must be stated in clear and unambiguous language.

PRECAUTIONS AND SOURCES OF ERRORS

All the precautions taken or observed while performing an experiment should be noted and the same should be stated in the report. Although some of the precautions taken during some experiments may be common, these usually change from one experiment to another depending on the nature of the experiment, the available facilities and equipment. In addition Laboratory Manual – Science

to precautions, the possible sources of errors (that arise because of limitation of equipment, due to change in atmospheric conditions or any other reason) should also be stated.

The report on each experiment must begin from a fresh page and a proper index of the experiments performed should be made in the beginning of the practical notebook.

Materials

1



To study the different parts of a simple (dissecting) microscope.

THEORY 5



The human eye cannot distinguish objects smaller than 0.1 mm. Hence, we cannot observe cells, tissues, and minute organisms through naked eyes. Before the invention of microscope, biologists used lenses that could magnify minute objects only up to some extent. Subsequently scientists started using combination of lenses that led to the invention of microscope. Microscopes are instruments designed to produce magnified visuals of smaller objects.

The simple microscope, also known as dissecting microscope, has a single lens system through which the image of an object is seen. The simple microscope is infact a magnifying lens mounted on a metallic frame in such a way that lens can be mechanically moved up and down or sideways to get a magnified view of the object under observation. Its principle is not different from an ordinary lens used by a watch repairer.

MATERIALS REQUIRED



A simple (dissecting) microscope, permanent slides of plant (or animal) materials, parts of plants (or small insects), a slide, forceps, and a needle.

DESCRIPTION

A simple (dissecting) microscope (Fig. 1.1) consists of the following parts.

- 1. Base It is the basal part that is bifurcated and supports the weight of the microscope. It is generally horse-shoe shaped and is made of metal.
- 2. Stand It is a short, hollow cylindrical rod fixed to the base. Another small cylindrical rod called vertical limb fits into the stand, at the other end. The vertical limb can be moved up and down, with the help of an adjustment knob attached to the upper end of the stand.

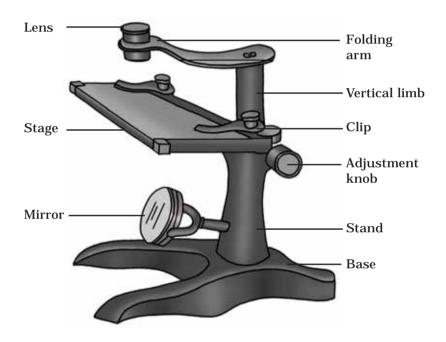


Fig. 1.1: A simple (dissecting) microscope

- 3. Folding arm To the upper end of vertical limb, a flat horizontal folding arm is attached. This can move sideways.
- 4. Stage It is a rectangular glass plate fitted with a pair of clips on its upper surface. The clips are used to hold the object or slide on the stage.
- 5. Mirror A movable plano-concave mirror is attached to the stand below the stage for reflecting light onto the stage.
- 6. Lens A simple convex lens (known as eye piece) is mounted on the folded arm. The magnification of a dissecting microscope depends on the magnification of the lens which is normally 5X, 10X or 20X. ('X' denotes the number of times a lens magnifies an object).

PROCEDURE



- 1. Clean the stage, lens and mirror with a soft and dry cloth or with a tissue paper.
- 2. Place a permanent slide or a slide with an object mounted on it on the stage.
- 3. Adjust the mirror to get maximum (reflected) light on to the object.
- 4. Align the microscope lens over the object under observation.
- 5. Rotate the adjustment knob to bring the object to clear focus.

PRECAUTIONS



- Keep the microscope in its box after use.
- Clean the lens and mirror with a lens cleaning solution. Always wipe the lens and mirror with a piece of silk cloth.
- Always carry the microscope in an upright position. Use both your hands to hold it.
- Clean the stage properly before placing the slide.
- Take care to prevent the microscope lens coming in contact with the slide or an object.

Note for the Teacher

- A dissecting microscope is used to observe whole mounts of small organisms, parts of plants or animals and for dissecting small organisms.
- It is important to acquaint the students with the precautions to be adhered to while handling a microscope before they proceed for using it.
- It is advised to mount a suitable material on a slide and demonstrate to students.

QUESTIONS

- What is the magnification of the simple microscope you have used?
- Why is a simple microscope also called a dissecting microscope?
- Which type of mirror is fitted in the simple microscope? What is its function?



To study the different parts of a compound microscope.

THEORY 💝

A compound microscope uses a combination of simple lenses in the objective and the eye piece. It offers a much higher magnification of an object than the simple microscope.

MATERIALS REQUIRED



A compound microscope and permanent slides.

DESCRIPTION

The compound microscope (Fig. 2.1) consists of the following parts-

- 1. Base It is the basal part that is bifurcated and supports the weight of the microscope. It is made of a metal.
- 2. Arm It is curved and supports the body tube, knobs for coarse and fine adjustments, stage and mirror. It is used for holding the microscope. The arm is attached to the base by an inclination joint.
- 3. Body tube It is a hollow tube attached to the upper end of the arm. It has the eye piece at the upper end and a circular, movable metallic ring called nose piece at the lower end. Objective lenses are screwed

- into the grooves present beneath the nose piece. Usually two objective lenses of 10X (low power) and 40X (high power) magnification are provided.
- 4. Stage It is a rectangular platform attached to the lower end of the arm. There is a hole at the centre of the stage which allows light from

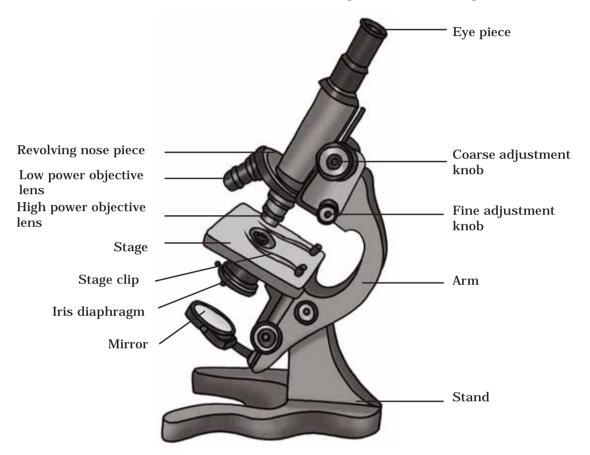


Fig. 2.1: A compound microscope

the mirror to pass through it and to fall on mounted slide. A pair of clips is provided to hold the slide firmly on the stage.

- 5. Diaphragm It is present below the stage and is used for adjusting the intensity of light.
- 6. Coarse adjustment knob It is attached to the arm and it moves the body tube up and down for focusing the object.
- 7. Fine adjustment knob It is attached to the arm and moves the body tube up and down very slowly. The fine adjustment is very essential for fine focusing of object, particularly in high power.
- 8. Mirror A plano-concave adjustable mirror is fitted below the stage to reflect light onto the objective.

PROCEDURE



- 1. The microscope should be placed safely on the working table with the arm facing yourself.
- 2. Clean the eye piece, objectives, and the mirror with a soft and dry silk cloth.
- 3. Rotate the nose-piece slowly till it clicks in position to bring the low power objective in line with the body tube.
- 4. Adjust the diaphragm for allowing optimum light to pass on to the stage.
- 5. Observe through the eye piece. Tilt and turn the mirror towards the light source and adjust its position till the microscopic field appears bright.
- 6. Place the slide on the stage and move it so as to view the object on the slide.
- 7. Move the body tube with the help of coarse adjustment knob until the image of the object is seen. Sharpen the focus with the help of fine adjustment knob.
- 8. For viewing the object under high power turn the nose piece to high power objective after the object is focused under low power. Using the fine adjustment knob, focus the object.

PRECAUTIONS



- While carrying the microscope, hold its arm with one hand and support the base with the other [see Fig. 2.2(a)].
- Place the microscope with its arm facing yourself [see Fig. 2.2(b)].
- Do not tilt the microscope, keep it in upright position [see Fig. 2.2(c)].
- Do not use coarse adjustment when viewing through high power objective [see Fig. 2.2(d)]. The slide may break.
- Use a tissue paper (or clean silk or muslin cloth) for cleaning lenses and mirror [Fig. 2.2(e)].
- Place the microscope gently on the working table about 15 cm away from the edge of the table to prevent its accidental fall [Fig. 2.2(f)].
- Do not allow direct sun-rays to strike the mirror. Use plane mirror for natural day light and concave mirror for artificial light.
- After use, lower the body tube and keep the microscope in its box.

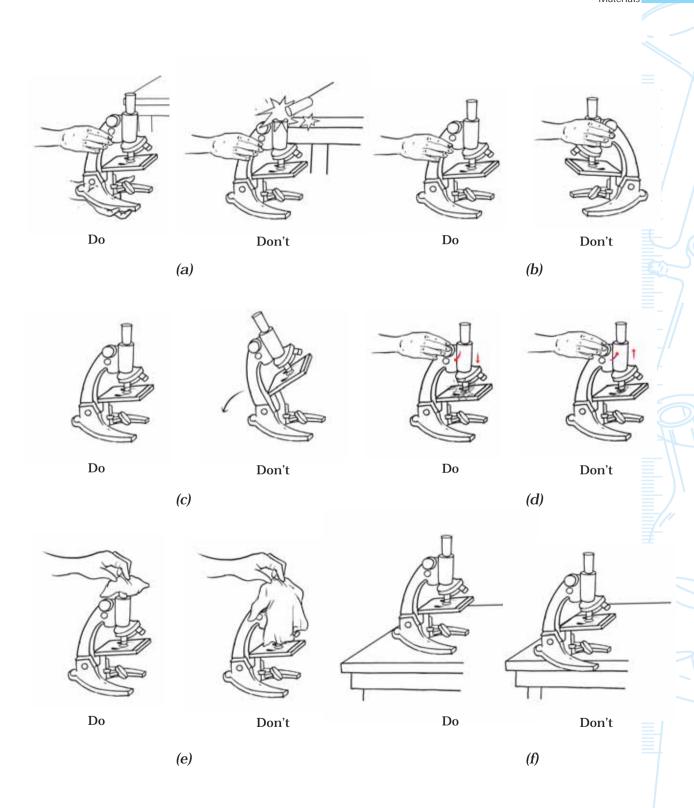


Fig. 2.2: Handling of a compound microscope

Note for the Teacher

- It is important to acquaint the students with the precautions to be followed for handling a microscope before they proceed to use it.
- Magnification of lenses is often written on the surface of the objectives and eye pieces. It denotes the number of times the object is magnified. In a compound microscope, generally an eye piece is 10X or 15X and an objective is 10X and 40X or 45X. The magnification (*M*) of a compound microscope is the product of magnification of eye piece lens and that of objective lens. For example, the magnification of a compound microscope with 10X eye piece and 40X objective is 10 × 40, that is 400.

QUESTIONS

- What will be the magnification of a microscope when 15X eye piece and 40X objective are used?
- Why is it suggested not to reflect the sunlight directly into the body tube of the microscope?
- What is the difference between a simple (dissecting) and compound microscope?
- What is the function of an adjustment knob in a microscope?
- Which of the following part supports the weight of microscope?
 (a) arm (b) stage (c) body tube (d) base.
- Name the part of a microscope with which objective lenses are fitted?
 - (a) nose piece (b) diaphragm (c) stage (d) arm.
- What holds the slide firmly on the stage of a microscope?
 - (a) diaphragm (b) clips (c) nose piece (d) objective.
- Which of the following regulates the intensity of illumination in a compound microscope.
 - (a) diaphragm (b) body tube (c) stage (d) mirror.



To determine the density of a liquid (other than water) by using a spring balance and a measuring cylinder.



The density (ρ) of a given substance is the mass of its unit volume. For a substance of mass M and volume V, the density is given by the ratio:

$$\rho = \frac{M}{V}$$

In this experiment the density of a liquid will be determined by finding the mass of its known volume.

MATERIALS REQUIRED



A spring balance (0 – 500 g), measuring cylinder (100 mL), polythene bag according to the size of the measuring cylinder, and the given liquid (kerosene, turpentine oil or any other).

PROCEDURE



1. Find the range and least count of the spring balance and the measuring cylinder. (**Hint:** To determine the least count of a spring balance or a

- measuring cylinder, note the value of the physical quantity measured by it between any of its two adjacent numerically marked divisions. Dividing this value by the number of smaller divisions between them gives the least count of the device.)
- 2. Hold the spring balance vertically and ensure that its pointer is at zero mark. Place the empty cylinder in a polythene bag and suspend it from the spring balance as shown in Fig. 3.1. Note the reading, M_1 of spring balance.
- 3. Place the measuring cylinder on a horizontal surface like a table. Pour the given liquid (whose density is to be determined) in the measuring cylinder. Note the volume, *V*, of the liquid (Fig. 3.2).
- 4. Put the liquid-filled cylinder in the polythene bag and again suspend it from the spring balance. Note the reading, M_2 , of the spring balance.



Fig. 3.1 : Measurement of mass of a measuring cylinder using a spring balance

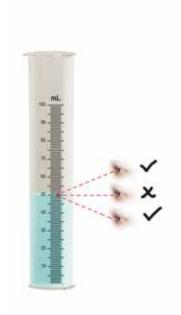


Fig. 3.2: Measurement of volume of given liquid

OBSERVATIONS



- (i) Range of the spring balance
- (ii) Least count of the spring balance
- (iii) Range of the measuring cylinder
- (iv) Least count of the measuring cylinder

= ____ g

= _____ g

= ____ mL

= ____ mL

- (v) Mass (*M*) of the given liquid:
 - (i) Mass of the empty cylinder in the polythene bag, $M_1 =$ _____ g
 - (ii) Mass of the liquid-filled cylinder (in the bag) $M_2 =$
 - (iii) Mass of the liquid, $M = M_2 M_1$ = ____ g
 - (vi) Volume of the given liquid, V = ____ mL

CALCULATIONS

Volume of the given liquid V =____ mI Mass of the given liquid M =___ g

Density of the liquid $\rho = \frac{M}{V}$ = _____ g/mL = ____ kg/m³ (1kg/m³ = 0.001 g/mL)

7

RESULTS AND DISCUSSION

The density of the given liquid is _____ kg/m³.

Find the standard value of density of the given liquid and compare it with the observed result (see Appendix – C).

PRECAUTIONS



- The measuring cylinder must be clean and dry.
- The measuring cylinder should be placed on a horizontal surface while measuring volume of the given liquid.
- While observing the liquid meniscus the line-of-sight should be at the same horizontal level as that of the lowest meniscus.
- There should be no air bubble in the liquid while measuring its volume.
- The spring balance should be held vertical while taking measurement.
- Before making use of spring balance it must be ensured that its pointer is at the zero mark.
- The readings of the spring balance should be noted only when its pointer comes to rest.

Sources of Error

- The graduations marked on the measuring cylinder and on spring balance may not be evenly spaced.
- A spring balance is primarily meant for measuring the weight (force) of a body. However in laboratories, a spring balance is often used to measure the mass of a body. It should be remembered that the

calibration of spring balance scale is done at the place of its manufacture and depends on the value of acceleration due to gravity (g) at that place. Therefore, if a spring balance is used to measure mass at any other place where the value of g is different, an error in the measurement of mass will appear.

QUESTIONS

- A spring balance calibrated in newton, reads 19.6 N. What will be its mass in grams at your place?
- You are given two measuring cylinders of least count 1.0 mL and 2.5 mL, respectively. Which one will you prefer to determine the density more accurately?
- Write two precautions that you will observe while measuring the volume of a liquid with the help of a measuring cylinder.
- Two bottles of equal volume are filled with glycerine and water respectively. Which of the bottle will be heavier? Give reason for your answer.
- Why is the density of water at 80 $^{\circ}$ C less than its density at 30 $^{\circ}$ C?



To determine the density of a non-porous solid (insoluble and denser than water) by using a spring balance and a measuring cylinder.

THEORY 💝

The density (ρ) of a given substance is the mass of its unit volume. For a substance of mass M and volume V, the density is given by the ratio:

$$\rho = \frac{M}{V}$$

MATERIALS REQUIRED



A spring balance (0 -500 g), measuring cylinder (100 or 200 mL), a piece of thread, water, and a small piece of experimental solid.

PROCEDURE



- 1. Find the range and least count of the spring balance and the measuring cylinder (Explained in Experiment 3).
- 2. For finding the mass of the given solid, suspend it from the spring balance with the help of thread (Fig. 4.1). Note the reading of the spring balance.

- 3. Place the measuring cylinder on a horizontal surface like a table-top and fill it with water, say, up to the half of its range. Note the reading of the water meniscus as the initial volume.
- 4. Tie the given solid with a thread and lower it slowly in water in the measuring cylinder. What happens to the level of water in the cylinder? Let the solid to immerse completely in the water. Next, note the reading of water meniscus as the final volume (Fig. 4.2).



Fig. 4.1: Measuring of mass of solid using spring balance

Fig. 4.2: Determination of volume of a non-porous solid

5. Take out the solid from the measuring cylinder. Dry it and repeat the activity by taking different initial volume of water in the cylinder. In each case note the initial and final readings of water meniscus.

OBSERVATIONS AND CALCULATIONS



- (i) Range of spring balance
- (ii) Least count of the spring balance
- (iii) Range of the measuring cylinder
- (iv) Least count of the measuring cylinder
- (v) Mass (M) of the given solid
- (vi) Volume (V) of the given solid-

, ,		_	
	_		•
	=		2

- g
- _ g
- = mLmL
- ___ g

Sl. No.	Initial Reading of water meniscus, V_1	Final Reading water meniscus, V_2	Volume of Solid $V=V_2-V_1$	Mean value of volume of solids
	(mL)	(mL)	(mL)	V (mL)
1.				
2.				
3.				
4.				

Density of the solid
$$(\rho = \frac{M}{V})$$
 = ____ g/mL= ___ kg/m³ (1 kg/m³ = 0.001g/mL.)

RESULTS AND DISCUSSION



The density (ρ) of the given solid is ____ kg/m³. Find the standard value of density of the given solid and compare it with the observed result (see Appendix – B).

PRECAUTIONS



- The measuring cylinder must be dry and clean.
- The measuring cylinder should be placed on a horizontal surface while reading the water meniscus.
- While observing the liquid meniscus the line-of-sight should be at the same horizontal level as that of the lowest meniscus.
- There should be no air bubble in the liquid while measuring its volume.
- The spring balance should be held verical while taking measurement.
- Before making use of spring balance it must be ensured that its pointer is at the zero mark.
- The readings of the spring balance should be noted only when its pointer comes to rest.
- The solid piece should be wiped with a dry cloth before repeating the activity.

Sources of Error

- The graduations marked on the measuring cylinder and on spring balance may not be uniform and evenly spaced.
- A spring balance is primarily meant for measuring the weight (force) of an object. However in laboratories, a spring balance is often used to measure the mass of an object. It should be remembered that the calibration of spring balance scale is done at the place of its manufacture and depends on the value of acceleration due to gravity (*g*) at that place. Therefore, if a spring balance is used to measure mass at any other place where the value of *g* is different, an error in the measurement of mass will appear.

Note for the Teacher

- The method describe above is useful for small solid objects. In case of larger objects, one should make use of an overflow can rather than measuring cylinder.
- This method is only useful for non-porous and water insoluble solid objects. Therefore it is advised to use a metallic solid.
- Some error in the measurement of volume of the solid piece may occur even if it has meagre porosity.
- The density of solid should be more than the density of water so that the solid can sink in water. If the density of solid is less than the density of water then a sinker can be used to perform the experiment.
- Earlier Experiment titled "To determine the density of a liquid (other than water) by using a spring balance and a measuring cylinder" also uses a spring balance. It is therefore advised that students may perorm the earlier experiment first to be aware of the instruments used in this experiment.

QUESTIONS

- Can you determine the density of a porous solid by using a spring balance and a measuring cylinder? Give reasons in support of your answer.
- How the presence of an air bubble in the liquid taken in the measuring cylinder can affect the volume of the solid?
- Density of sealing wax is 1.8 g/cm³. Express it in kg/m³.
- A metal cylinder is melted and the whole mass is cast in the shape of a cube. What happens to its density? Give reasons.
- At which temperature is the density of water maximum?



To show that gases are readily compressible and liquids are not.

THEORY 💝

The density of gases varies considerably with pressure but not for liquids. That is, gases are readily compressible while liquids are not. In this experiment we shall use a plastic syringe to demonstrate it.

MATERIALS REQUIRED



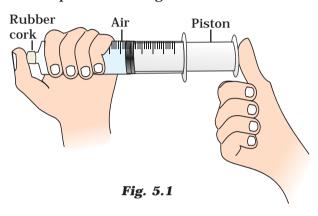
A plastic syringe of maximum available size (such as 25~mL or 50~mL) without needle, water, some other liquids such as mustard oil, kerosene, and fruit juice etc.

PROCEDURE



- 1. Hold the cylinder of a plastic syringe of maximum available size in one of your hand.
- 2. Insert the piston into the syringe cylinder and bring it to a certain level inside the syringe cylinder. In this situation air (gas) is inside the syringe. Note and record the reading of the piston in the syringe. This is your initial reading.
- 3. Close (or plug) the outlet nozzle of the syringe strongly by one of the finger of the same hand holding the syringe cylinder.

- 4. Apply a little force on the piston to push it in the syringe cylinder (that is to compress the air). Are you able to push it (Fig. 5.1)?
- 5. Keep on applying the force on the piston to push it further inside the syringe cylinder. Do you find that after some attempts, the piston stops pushing in further? Are you able to further compress the air inside the syringe? Note and record the reading of the piston in the syringe cylinder. This is the final piston reading.
- 6. Take out the piston from the syringe and unplug the nozzle.
- 7. Fill the syringe cylinder with water. Insert the piston into the syringe cylinder. Slowly push it inside the cylinder to allow the air pass through the nozzle of the syringe. Ensure that there is no air bubble



inside the cylinder. Note the reading of the piston in the syringe. This is your initial reading for water inside the syringe.

- 8. Again close (or plug) the nozzle of the syringe strongly.
- 9. Apply force on the piston to push it in (or to compress the water inside). What do you observe? Does the water compress? Note and record the final reading.
- 10. Repeat the experiment with other liquids. Record observations.

OBSERVATIONS



Sl. No.	Material	Initial reading of piston in syringe	Final reading of piston in syringe
1. 2. 3. 4.	Air Water Oil		

RESULTS AND DISCUSSION



Infer from your observations that the gases are readily compressible while liquids are not. This shows that gases have more vacant space between the constituent particles.

PRECAUTIONS AND SOURCES OF ERROR



- Use a cloth to safely and tightly close or plug the nozzle of the syringe cylinder.
- The motion of piston inside the syringe cylinder must be tight otherwise air (or liquid) may leak from the gas-piston boundary (or liquid-piston boundary).
- The needle of the syringe must not be used as it may hurt.

QUESTIONS

- What do you conclude about the inter-particle space in case of liquids and gases?
- Was it easy to compress gas (air)? What happened when you released pressure on the piston?
- What do you think which is present between the particles of air?
- Where do you come across the phenomenon of compressibility of gases and liquids in daily life?



To study the changes in state of sublimate solids on heating.



A change in state directly from solid to gas on heating without changing into liquid state, or vice-versa is called sublimation. That is,

$$Solid \xrightarrow{heat} Vapour (gas)$$

MATERIALS REQUIRED



Ammonium chloride (or camphor or naphthalene or iodine or any other sublimable solid), china dish, funnel, cotton plug, burner, tripod stand, and a wire gauge,

PROCEDURE



- 1. Take powdered sublimable solid in a china dish.
- 2. Put an inverted funnel over the china dish.
- 3. Insert a cotton plug on the stem of the funnel.
- 4. Put china dish over the wire gauge on the tripod stand.
- 5. Heat the china dish slowly with the help of a burner.

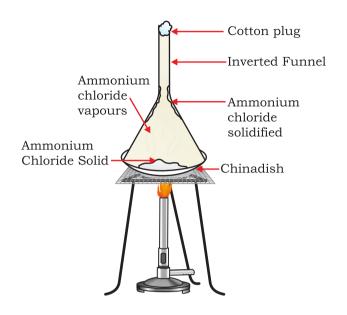


Fig. 6.1: Sublimation of ammonium chloride

6. Cover the outer surface of the funnel with wet cotton to sublime the vapours quickly.

OBSERVATIONS



A sublimable solid on heating directly get converted into vapours, that sublimes back on cooling directly into solid again on the walls of the funnel.

RESULTS AND DISCUSSION



A sublimable solid on heating directly converts into gaseous state. How? Is it because of the high vapour pressure of the liquid state of the solid. The liquid state is practically non-existant.

PRECAUTIONS



- Heat the sample carefully.
- Take care in plugging the stem of the funnel securely with cotton.
- The size of the mouth of the funnel and china dish should be comparable.
- Do not remove the funnel when hot.

Note for the Teacher

• Moth repellent balls are easily available which can be crushed and can also be used as a sample in this experiment.

- In your view, what could be the reason for direct conversion of some solids to vapours and vice-versa?
- In the above experiment, you have observed conversion of solid to vapours. Is this a physical or a chemical change?
- Could you think of some applications of this change in daily life?

7



To study the process of evaporation.

THEORY 📚

Particles of matter are always moving and are never at rest. At a given temperature in any gas, liquid or solid, there are particles with different amount of kinetic energies. In the case of liquids, a small fraction of particles at the surface, having higher kinetic energy than the bulk is able to break away from the forces of attraction of other particles and gets converted into vapour. This phenomenon of change of a liquid into vapours (gases) at any temperature below its boiling point is called evaporation.

MATERIALS REQUIRED



Water, china dish, tripod stand, burner, and spirit.



- 1. Take about 50 mL tap water in a china dish.
- 2. Heat the china dish slowly with the help of burner.
- 3. Observe how the contents in the china dish disappear with time.
- 4. Continue heating untill all the water evaporates.
- 5. Repeat the experiment taking spirit as a sample.



Fig. 7.1: Evaporation of water

- 6. Take about 10 to 15 mL spirit in a china dish and mark its level.
- 7. Keep it for some time. **Do not heat it**.
- 8. Observe the contents in the china dish and continue observing till all the spirit evaporates.

OBSERVATIONS



Water evaporates on heating whereas spirit evaporates at room temperature.

RESULTS AND DISCUSSION



Some solvents evaporate even at room temperature. The tendency of the liquid to vapourise depends on the nature of the liquid through the molecule-molecule (intermolecular) interaction in the bulk of the liquid.

NOTE FOR THE TEACHER

- A container containing spirit must never be heated directly on a flame. Instead a water bath may be used, if required.
- The solvents which evaporate fast at room temperature are called 'highly volatile' solvents. Examples of highly volatile solvents are ether, acetone, petroleum ether, benzene etc.

- How is the crystallisation of sugar from its solution related to the above phenomenon?
- How would the presence of sodium chloride in water effect its evaporation tendency?
- Do you think that the process of evaporation increases if the surface area of a container containing the solvent increases?
- Will an increase of temperature effect the rate of evaporation? Justify your answer.
- On a rainyday, the rate of evaporation decreases. Why?
- Amongst evaporation and condensation which process is more indisciplined? Justify your answer.



To determine the boiling point of water and melting point of ice.

THEORY



The temperature at which a solid changes into its liquid state is known as its melting point. Once a solid attains its melting temperature, the temperature remains same until the entire solid converts into liquid.

The temperature at which a liquid changes into its vapour state is known as its boiling point. Once a liquid attains its boiling point, the temperature remains same until all the liquid changes into its vapour.

MATERIALS REQUIRED



Round bottom flask (250 mL), a double bored cork, beaker (100 mL), thermometer (-10 °C – 110 °C), stop-watch (or a stop-clock), spirit lamp (or gas burner), tripod stand with wire gauze, spring balance, a glass tube, a polythene bag, laboratory stand, water, crushed ice, and thread.



- A. Determination of boiling point of water.
 - 1. Note the range and the least count of the thermometer.



Fig. 8.1: Determination of Boiling point of water

- 2. Take about 150 mL water in the round bottom flask and close its mouth with a two-holded stopper. Fix the thermometer through one of the holes in the cork and a glass tube through the other [Fig. 8.1]. Make sure that the bulb of thermometer hangs in air and is not in contact with water in the flask.
- 3. Place wire gauze on a tripod stand and keep the flask over it. Start heating the water with a spirit lamp or a gas burner.
- 4. Switch on the stop-watch (or stop-clock) and note the reading of the thermometer after fixed intervals of time, say after every two minutes. Once the temperature rises above 80 °C, the time interval to read the thermometer should be reduced, say to one minute.
- 5. Continue recording the thermometer readings for 4-5 minutes even after the water in the flask begins to boil.
- B. Determination of melting point of ice.
 - 1. Take a beaker and fill it up to half with crushed ice.
 - 2. Insert the bulb of the thermometer into the ice and let it stand in a vertical position (Fig. 8.2).
 - 3. Switch on the stop-watch or the stop-clock and note the reading of thermometer and the state of ice in the beaker after every one minute till the whole of ice melts.
 - 4. Continue recording the temperature till the temperature of the water so formed rises up to 2-3 °C.

OBSERVATIONS AND CALCULATIONS



Record your observations on heating of water in Table 1 and those on melting of ice in Table 2.

Fig. 8.2: Determination of melting point of ice

A. Table 1: Observations for Heating of Water

Sl.No.	Time (minute)	Temperature of water (°C)
1.		
3.		
 3. 		

B. Table 2: Observations for Melting of Ice

Sl.	State of the ice	Time (minute)	Temperature (°C)
No.	solid/partly solid/partly liquid/liquid		
1.			
2.			
3.			
0.			

RESULTS AND DISCUSSION



Study the observations recorded in Table 1 and find the temperature that remains constant even when the water begins to boil. Infer the boiling point of water. Study the observations recorded in Table 2 and find the temperature that remains constant as long as the ice gets converted into water. Infer the melting point of ice.

Precautions



- A. Determination of boiling point of water
 - Thermometer in the flask should be fixed in a manner that its bulb does not touch the water surface in the flask.
 - Recording of temperature and time should be done simultaneously.
- B. Determination of melting point of ice
 - The bulb of the thermometer should be completely inside the crushed ice.
 - The thermometer should not touch the wall of the beaker.
 - Recording of temperature and time should be done simultaneously.

Note for the teacher

- The boiling point of water under standard conditions is taken as 100°C.
 However, it may differ due to impurities in water and atmospheric pressure.
- The melting point of pure ice under standard conditions is taken as 0°C. However, it may change due to impurities in ice and atmospheric pressure.

- Why is the bulb of thermometer kept above the surface of water while determining the boiling point of water?
- Why does the temperature remain unchanged until the entire solid changes into liquid even if we are heating the solid?
- Why do we fix a two holed-cork in the round bottom flask while determining the boiling point of water?



To prepare a saturated solution of common salt in distilled water and to determine its solubility at room temperature.

THEORY 💝

A solution in which no more solute dissolves in the given solvent at a particular temperature is a saturated solution. The solubility of a substance in a saturated solution is defined as the mass of solute dissolved in 100 g of solvent. In this experiment we shall prepare a saturated solution of common salt in water at room temperature and then will determine its solubility.

MATERIALS REQUIRED



Common salt or sugar, distilled water, three beakers (250 mL), stirring rod, filter paper, funnel, china dish, watch glass, tripod stand, burner, spring balance (0 g – 250 g, preferably having least count of 1 g), a polythene bag, a measuring cylinder (100 mL), and a thermometer (–10 $^{\circ}$ C – 110 $^{\circ}$ C).

PROCEDURE



1. Hang the thermometer freely in the room. Note and record its reading to find the room temperature.

A. Preparation of saturated solution

- 1. Using a measuring cylinder take 100 mL distilled water in a 250 mL beaker. Dry the measuring cylinder after use.
- 2. Dissolve some common salt in distilled water with the help of a stirring rod.
- 3. Warm the solution slightly and keep on adding common salt in the solution with constant stirring till no more common salt dissolves in it.
- 4. Stop warming the solution and allow the beaker to cool till it comes to the room temperature.
- 5. Filter the solution into another beaker in order to separate undissolved salt, if any. The filtered solution is the saturated solution of sodium chloride (common salt) in distilled water at room temperature.

B. Determination of Solubility

(i) Density Method

- 1. Determine the mass of the third beaker of 250 mL. (See Experiment 3 for details), using a spring balance and a polythene bag.
- 2. Pour 100 mL of prepared saturated solution in the weighed beaker, using the measuring cylinder.
- 3. Determine the mass of the beaker containing saturated solution (using a spring balance and a polythene bag).
- 4. Find the mass of the 100 mL of saturated solution.

(ii) Evaporation Method

- 1. Determine the mass of the china dish, using a spring balance and a polythene bag.
- 2. Using the measuring cylinder, take 25 mL of prepared saturated solution in a china dish.
- 3. Heat the china dish until all the water (solvent) evaporates out. The dish will now contain only the solute (common salt).
- 4. Stop heating the china dish and allow it to cool.
- 5. Determine the mass of the china dish containing the solute, using the spring balance and polythene bag.
- 6. Find the mass of solute that was dissolved in 25 mL saturated solution.

OBSERVATIONS A	ND	CALCULATIONS	A	
Room temperature	=	$^{\circ}\mathbf{C}$	=	K

(i) Determination of solubility by Density Method

Mass of empty beaker, $m_1 = \underline{\hspace{1cm}} g$

Mass of the beaker containing $100\ mL$

of prepared saturated solution, $m_2 =$

Mass of 100 mL of saturated solution, $m_3 = \underline{\qquad} g$

$$(m_3 = m_2 - m_1)$$

Density of distilled water, ρ (given) = ____ 1 g/mL

Mass of 100 mL distilled water (= $\rho \times 100$ mL) = 100 g

Mass of the solute (common salt) in

100 mL of distilled water, $m = m_3 - 100 \text{ g}$ = ____ g

Solubility of common salt, *m* g per 100 g of distilled water = ____ g per 100 g of distilled water.

(ii) Determination of solubility by Evaporation Method

Mass of empty china dish, $m_1 = \underline{\qquad} g$

Mass of china dish and common salt, $m_2 =$ ____ g

Mass of salt in 25 mL of prepared saturated solution, $m_3 = (m_2 - m_1)$

= _____g

Density of distilled water, ρ (given) = 1 g/mL

Mass of 25 mL distilled water (= $\rho \times 25$ mL) = 25 g.

25 mL (or 25 g) of distilled water dissolves m_3 g of common salt to prepare a saturated solution. Thus the 100 mL (or 100 g) of distilled

water would require $\frac{m_3 \times 100}{25}$ g of common salt to get a saturated solution at room temperature.

Solubility of common salt, m g per 100 g of distilled water

$$= \frac{m_3 \times 100}{25}$$
 g per 100 g of distilled water

= ___ g per 100 g of distilled water.

RESULTS



Compare the solubility of common salt in distilled water to form a saturated solution at room temperature obtained by density and evaporation methods. Using density method the solubility of common salt in a saturated solution at room temperature (___ °C or ___ K) is ____ g per 100 g of distilled water.

Using evaporation method the solubility of common salt in a saturated solution at room temperature (___ °C or ___ K) is ____ g per 100 g of distilled water.

PRECAUTIONS AND SOURCES OF ERROR



- The spring balance should be held vertical while taking measurements.
- Before making use of the spring balance it must be ensured that its pointer is at zero mark. If not then ask your teacher to help.
- The readings of the spring balance should be noted only when its pointer comes to rest.
- The measuring cylinder should be placed on a horizontal surface while measuring the volume of the distilled water and solution.
- While preparing the saturated solution, the warming of the solution should be slow and to a temperature slightly (2 °C to 5 °C) more than the room temperature. Similarly the cooling of solution must also be slow.
- While performing evaporation method, heating of saturated solution must be stopped as soon as all the water evaporates from the solution.

NOTE FOR THE TEACHER

- In place of common salt, some students may be suggested to perform this experiment with sugar.
- Experiment 3 and 4 explains a simple method to find the mass of a measuring cylinder using a spring balance and a polythene bag. Since in this experiment too a beaker and a china dish (empty as well as filled) are to be weighed, it is therefore suggested that students may be asked to perform either of experiment 3 and 4 first.
- If the spring balance is not sufficiently sensitive, students may be suggested to use a physical balance. However a physical balance might be new equipment for them, it is advised to kindly guide them in making use of a physical balance to weigh the objects more accurately.
- In case, if distilled water is not available, the experiment may be performed with filtered water or drinking water. Its density may be assumed as 1 g/mL.
- If students find it lengthy to determine the solubility using both density and evaporation methods, suggest them to perform only one method.

- How does the solubility of a solute in solvent change with an increase in temperature?
- What is a supersaturated solution in your opinion?
- How can a supersaturated solution of salt in water be prepared?
- What will happen if a saturated salt solution prepared at high temperature is (i) cooled slowly? (ii) cooled suddenly?
- Would the solubility of sodium chloride (common salt) in water increase or decrease in presence of water sample containing magnesium/calcium chloride? Give explanation.



To prepare a solution of common salt of 10% composition by mass.

THEORY 💝

The concentration of a solution is the amount of solute present in a given amount (mass or volume) of the solution. Mass percent concentration is defined as a mass (g) of the solute per 100 g mass of the solution. A 10% solution by mass means, 10 g of solute dissolved in 90 g of solvent to result into 100 g of solution.

MATERIALS REQUIRED



Common salt, distilled water, watch glass, stirring rod, physical balance, measuring cylinder (100 mL), and a beaker (250 mL).



- 1. Calculate the volume of solvent (distilled water) and mass of solute (sodium chloride or common salt) required to prepare 100 g of 10% by mass solution. This may be done as follows-
 - 10 g solute is required for 100 g solution (distilled water + salt). Thus the amount of water required would be 100 g 10 g = 90 g. Since the density of distilled water is 1 g/mL, therefore the volume of distilled water (required to prepare 100 g of 10% by mass solution with 10 g of common salt) is 90 mL.

- 2. Weigh an empty watch glass on a physical balance. Also weigh 10 g of sodium chloride (common salt) on the watch glass now.
- 3. Take 90 mL (90 g) of distilled water in a 250 mL beaker with the help of a measuring cylinder.
- 4. Transfer 10 g of salt from the watch glass to the beaker containing 90 mL distilled water.
- 5. Stir the solution untill all the salt dissolve in it.

OBSERVATIONS AND CALCULATIONS



- (i) Mass of empty watch glass (m_i)
- (ii) Mass of watch glass + sodium chloride $(m_1 + 10 g)$ =
- (iii) Mass of sodium chloride (common salt)

= _____ ;

= 10 g.

RESULTS AND DISCUSSION



The concentration of prepared solution is 10% by mass of common salt in water. This way of expressing concentration is one amongst many.

PRECAUTIONS AND SOURCES OF ERROR



- Use of physical balance must be done with all precautions. Ask your teacher acquaint you with the working of a physical balance.
- The readings of the physical balance should be taken only when its pointer comes to rest.
- The measuring cylinder should be placed on a horizontal surface while measuring the volume of the distilled water and solution.

Note for the Teacher

- In place of common salt, some students may be suggested to perform this experiment with sugar.
- This experiments requires to use a physical balance to weigh 10 g of common salt or sugar using a watch glass. A physical balance is a sophisticated equipment. It is suggested to acquaint students with the working of a physical balance. They may be asked to practice with this balance before performing this experiment.
- In case, if distilled water is not available, the experiment may be performed with filtered water or drinking water. Its density may be assumed as 1 g/mL at the experimental temperature.

- Why should the density of a 10% common salt be more than the density of pure water at a specified temperature? Offer qualitative explanation.
- A student is asked to prepare 250 mL sugar solution 15% by mass concentration. How much amount of sugar and water should be taken for preparation of the solution?
- If 50 mL of water is added to the above solution. What will be the change in the mass percentage of the solute?
- 830 g of salt solution contains 50 g of common salt in it. Calculate its concentration in terms of mass percentage?



To separate the components of a mixture of sand, common salt and ammonium chloride.

THEORY \$\bigs\{\bigs\}

Sand, common salt, and ammonium chloride form a heterogeneous mixture and can be separated easily by physical methods of separation. By selecting the right order of methods of separation, the three can be easily separated:

- (i) ammonium chloride sublimes on heating;
- (ii) sand is insoluble in water; and
- (iii) common salt can be recovered by evaporation of its aqueous solution.

MATERIALS REQUIRED



A china dish, a funnel, a beaker (250 mL), a cotton plug, burner, tripod stand, wire gauge, sand, common salt, ammonium chloride, water, and filter paper.

PROCEDURE



1. Take mixture of ammonium chloride, sand and common salt in a china dish.

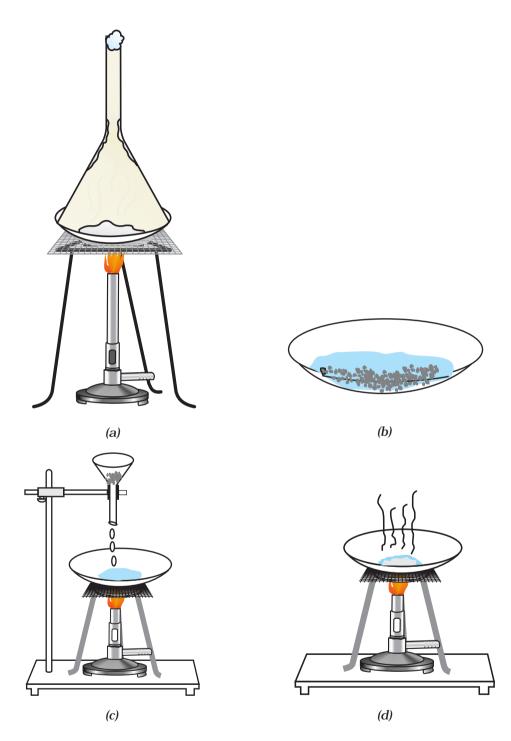


Fig. 11.1: Separation of components of a mixture of ammonium chloride, sand and common salt. (a) Separation of ammonium chloride by sublimation; (b) Residue containing sand and common salt dissolved in water; (c) Separation of sand by filtration; and (d) Obtaining common salt by evaporation

- 2. Set up a sublimation apparatus as shown in Fig. 11.1(a).
- 3. Heat the mixture. Ammonium chloride will be separated on the walls of the inverted funnel.
- 4. The residue left behind in the china dish contains sand and common salt.
- 5. Dissolve this residue mixture in water. Common salt will dissolve but sand will not [Fig. 11.1(b)].
- 6. Filter the sand from the mixture using a filter paper [Fig. 11.1(c)].
- 7. Sand is separated as residue and the filterate is salt solution in water.
- 8. Heat the filterate (salt solution) to evaporate the water and to get the dry sample of common salt [Fig. 11.1(d)].

RESULTS AND DISCUSSION



Using methods of separation sequentially, ammonium chloride, sand and common salt have been separated from their mixture.

PRECAUTIONS



- Sublimation process should be carried out carefully.
- Take care while filtering so that the filter paper does not tear off.

Note for the Teacher

- If soil is taken instead of sand for formation of mixture, it will form colloidal solution and clear filterate may not be obtained.
- As in the laboratory the sublimation apparatus is not air tight, recovery of ammonium chloride will not be 100%.
- The outer surface of funnel must be covered with wet cotton to separate sublimation product (ammonium chloride in this case) easily.
- To make the process of separation easily workable, it is desired that one water soluble component be separated by a process other than solubility and that is sublimation in this experiement.

- If in the first step the mixture had been dissolved in water what would have been the difficulty in separation.
- Instead of common salt if one component in the given mixture is sulphur, how would you carry out separation process then?
- Can the two components of a mixture that are soluble in water be separated by any technique? Justify your answer.



To prepare solutions of various substances and to identify them as true solutions and suspensions.

THEORY 💝

A true solution is a homogeneous mixture of two or more substances. The solute and solvent particles can not be observed by the naked eye as they are very small (of the order of 1nm). A suspension is a hetrogeneous mixture of two or more substances. The solute particles of a suspension are often visible by the naked eyes as the size of particles is more than 0.1 mm.

MATERIALS REQUIRED



Powder samples of sodium chloride (or common salt), sugar, baking soda, chalk powder, sand, and sulphur etc., a beaker (250 mL), water, and a glass stirrer rod.



- 1. Take a small amount of a solid sample as solute.
- 2. Dissolve it in 100 mL water taken in a beaker with the help of a glass stirrer rod. Stir the mixture for some time.
- 3. Allow it to stand for some time.

- 4. Observe and record whether the mixture formed is homogeneous or heterogeneous.
- 5. Repeat the experiment for different solid solutes.

OBSERVATIONS



Sl. No.	Solute	Homogenous or heterogeneous	Type of mixture formed (true solution or suspension)
1.			
2.			
3.			
4.			

RESULTS AND DISCUSSION



(a)	Samples	,, form tr	ue
	solution in water.	Which are homogeneous.	
(b)	Samples	form suspension in water	

NOTE FOR THE TEACHER

- Students may be provided fine powder samples.
- If a light beam from a torch is passed through suspensions, scattering of light may also be observed.

- Why are the particles of a true solution not visible to naked eye?
- What is the order of the size of a particle that can be seen by naked eyes?
- What different techniques of seperation can be employed for separation of components of homogeneous and heterogeneous mixture?
- What will be your observation, when a beam of light is passed through a true solution and through a suspension respectively?



To prepare a colloidal solution of sulphur and differentiate it from a true solution or from a suspension on the basis of transparency and filtration.

THEORY 💝

A collodial solution of sulphur in water can be obtained by the oxidation of hydrogen sulphide by nitric acid.

$$H_2S$$
 (aq) + 2HNO₃ (aq) \longrightarrow 2H₂O (l) + S (s) + 2NO₂ (g)

A true solution is homogenous and transparent. It can be completely filtered through a filter paper. It remains stable on standing.

A colloidol solution is heterogenous, it appears translucent. It can be filtered completely through filter paper. Here solute particles do not easily settle down on standing.

A suspension is heterogenous mixture. The particles of a suspension are visible to the naked eye. They settle down on standing and can be separated by filtration.

MATERIALS REQUIRED



Kipp's apparatus to get hydrogen sulphide gas, concentrated nitric acid, common salt, chalk powder, funnel, four boiling tubes, glass rod, test tube stand, and filter paper.

PROCEDURE



- (i) Preparation of Colloidal Solution of Sulphur
 - 1. Take about 20 mL distilled water in a boiling tube and pass H₂S gas through it for about 5 minutes. The solution would smell like a rotten egg.

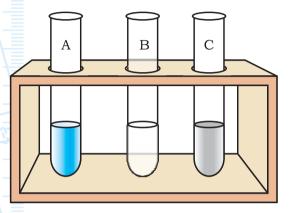


Fig. 13.1

- 2. Add few drops of concentrated nitric acid in it. Stir the solution. Continue adding few more drops of nitric acid untill solution becomes milky.
- 3. Transfer the contents into a another clean boiling tube. Label this boiling tube as tube A.
- (ii) Preparation of True Solution
 - 4. Take about 20 mL distilled water in a clean boiling tube.
 - 5. Add approximately 1- 2 g of sodium chloride (or common salt) into it.
 - 6. Stir the solution till it becomes clear. Label this boiling tube as tube B.
- (iii) Preparation of suspension
 - 7. Take about 20 mL of distilled water in another clean boiling tube.
 - 8. Add approximately 1-2 g of powdered chalk into it.
 - 9. Stir the mixture with the help of glass rod. Label this boiling tube as tube C.

OBSERVATIONS



Sl.No.	Experiment	Boiling tube	Inference
1.	Transparency	A	
	Observe the contents of	В	
	different boiling tubes	C	
2.	Filtration		
	Filter the contents of	A	
	different tubes through	В	
	an ordinary filter paper	C	

RESULTS AND DISCUSSION



Colloidal and suspension are heterogenous mixtures where as true solutions are homogenous mixtures. They differ form each other only on the basis of their particle size.

NOTE FOR THE TEACHER

- Arrangement for the preparation of H₂S gas may be done in advance in the laboratory using the Kipp's apparatus. It requires ferrous sulphide and conc. sulphuric acid.
- When sulphur is formed by an insitu reaction the particle size is in the colloidal range as particles of sulphur remain aggregate in water, forming a colloidal solution.
- Sulphur can form true solution in carbon tetrachloride or carbon disulphide solvent.
- A suspension of sulphur can be formed in water by mixing sulphur powder in distilled water.
- Colloidal solution of sulphur can also be obtained by adding dil. HCl or conc. H₂SO₄ to sodium thiosulphate solution

$$\begin{aligned} \text{Na}_2 \text{S}_2 \text{O}_3 + 2 \text{HCl} &\rightarrow 2 \text{NaCl} + \text{SO}_2 + \text{S} + \text{H}_2 \text{O} \\ \text{(sodium thiosulphate} & \text{(colloidal} \\ \text{or hypo solution)} & \text{sulphur)} \end{aligned}$$

- What will be the effect of passing light through colloidal solution of sulphur?
- What is the difference in the particle size of colloid, true solution and suspension.
- Classify the following as a true solution, as a suspension, or as a colloid: (i) milk; (ii) CuSO₄ solution; (iii) jam; (iv) gum; (v) soil in water; and (vi) sand in water



To study the process of separation of a mixture of two immiscible liquids.

THEORY



The separation of two immiscible liquids by a separating funnel depends on the difference in their densities. A less denser liquid floats over a liquid whose density is more.

MATERIALS REQUIRED



Separating funnel (250 mL)(with its stop-cock), two beakers (250 mL), and two immiscible liquids such as water and kerosene.



- 1. Take a mixture of two immiscible liquids (say water and kerosene) in a separating funnel (Fig. 14.1).
- 2. Allow it to stand for some time.
- 3. The mixture separates into two liquid layers according to their densities.
- 4. Collect the lower layer carefully in a beaker by opening the stop-cock of the separating funnel.
- 5. Similarly collect the upper layer in another beaker.

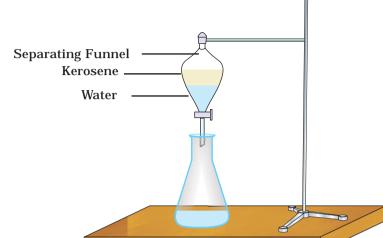


Fig. 14.1: Separation of immiscible liquids

RESULTS AND DISCUSSION



Water and kerosene are immiscible and can be separated by using separating funnel. Miscibility and immiscibility of liquid pairs depends upon the effectiveness of intermolecular interaction.

NOTE FOR THE TEACHER

- It is essential to remove the lid of the separating funnel while opening the stop cock of the separating funnel.
- In order to get the two components in pure form, it is advisable to discard a part of the mixture at the junction of the two layers.

- Arrange the two liquids used in the above experiment according to the increasing order of their densities?
- Think of a technique that you can use to separate the above immiscible liquids if separating funnel is not available?
- Is the mixture used in the above experiment heterogenous or homogenous in nature?
- Which of the two sea water or pure water has got higher density?
- Can there be any way of varifying that lower layer in the separating funnel is water layer. Explain either way.



To separate a mixture of two miscible liquids by simple distillation.

THEORY 💝

The separation of two miscible liquids (having at least a difference in their boiling points of 25 K) can be separated by a simple distillation method. Distillation depends on the difference in their boiling points. The liquid which has lower boiling point evaporates first and faster than the liquid which has a higher boiling point.

MATERIALS REQUIRED



Mixture of two miscible liquids (water and acetone), measuring cylinder, a round bottom flask (250 mL), thermometer (-10 °C - 110 °C), condenser, two beakers (250 mL), burner, tripod stand, and a wire gauge.



- 1. Take a mixture of 50 mL water and 50 mL acetone in a round bottom flask.
- 2. Arrange the apparatus as shown in the Fig. 15.1.
- 3. Heat the mixture of acetone and water slowly and carefully monitor the rise in temperature.

- 4. Observe and note the temperature at which the first component of the mixture distils out, that is, vapours get cooled and collected in a beaker kept at the other end of the condenser.
- 5. Continue heating and similarly observe and note the temperature at which the second component distills out.

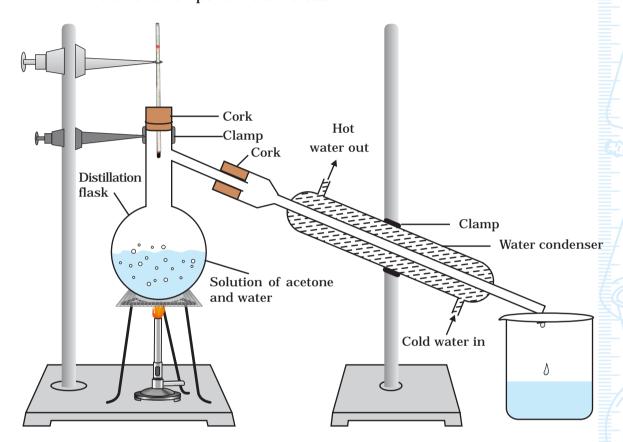


Fig. 15.1: Laboratory apparatus for distillation

OBSERVATIONS



	Component	Component
	I	II
Temperature Name of the component		

RESULTS AND DISCUSSION



The two components of the miscible liquids are separated by distillation. The difference in the boiling points of the liquids depend upon the attraction between the particles of the liquid.

NOTE FOR THE TEACHER

- The intermediate fraction may be rejected as it may contain both the components.
- For distillation, in place of round bottom flask and condenser, a distillation apparatus is easy to use.
- The process of distillation can be stopped after the separation of first component, as the second component of the mixture is left in the round bottomed flask.
- A discussion on the difference between bottled mineral water and distilled water may be initiated in the class room.

- In the above experiment you have found the boiling points of water and acetone. Use this information to arrange acetone and water in the order of (i) increasing force of attraction between the particles of water (water-water); particles of acetone (acetone-acetone); and (ii) increasing densities.
- You are provided with a mixture of methanol and ethanol having boiling points 61 °C and 78 °C respectively. Can you separate the two components by simple distillation method? Explain.
- You are given a sample of tap water, suggest a technique for obtaining pure and salt free water (distilled water) from it?
- What is the natural technique of obtaining distilled water from the nature?
- What is the utility of acetone in daily life?



To differentiate between a mixture (containing two components) and a pure compound.

THEORY 💝

The components of a mixture retain their individual properties. In a mixture these components can have any ratio while components of a mixture lose their individual properties once the compound is formed. Ratio of components in a compound is fixed. Merely mixing two components is a physical change and converting these into a compound is a chemical change.

MATERIALS REQUIRED



Sulphur powder, iron filings, dil. hydrochloric acid (or dil. sulphuric acid), lead acetate solution, carbon disulphide solvent, a bar magnet, two beaker (100 mL), three test tubes, china dish, watch glass, glass rod, filter paper, tripod stand, burner, wire gauge, splinter (or candle), and a mortor and pestle.

PROCEDURE



1. Take iron fillings (5.6 g) and sulphur powder (3.2 g) in a beaker. Mix them properly. Label this mixture as A.

- 2. Take half of this mixture A in a china dish and heat it slowly with constant stirring untill black mass is formed.
- 3. Cool the contents of china dish.
- 4. Grind the black mass with the help of mortar and pestle and put it in another beaker and mark it as B.
- 5. Perform various tests (as suggested in the table below) with samples A and B and record your observations.

OBSERVATIONS



Sl. No.	Experiment	Observation with sample	Inference
		A B	
1.	Magnet test Move a magnet over the sample A and powdered black mass in sample B several times.		
2.	Gas test Take a small amount of mixture from sample A in a test tube and add 5 mL dil. hydrochloric acid or dil. H ₂ SO ₄ carefully. Test the evolved gas by (a) bring a burning splinter or lighted candle near the mouth of the test tube; (b) bring a filter paper dipped in lead acetate solution near the mouth of the test tube. Repeat the same test with sample B.		
3.	Solubility test Take a pinch of A and B in test tubes. Add 5 mL carbon disulpide (CS ₂) and shake the mixture. Filter the solution.		

PRECAUTIONS



- Do not inhale hydrogen sulphide gas as it a poisonous gas.
- Carbon disulphide is inflammable, so keep it away form the flame.

Note for the Teacher

- In order to simplify the performance part of this experiment, it is suggested that 5.6 g of iron filings and 3.2 g of sulphur powder may be provided to the students.
- It is important to maintain the proper stoichiometry in the reaction of iron with sulphur. In case of excess iron the product will be attracted towards magnet.
- A mixture containing iron and sulphur shows the properties of both its contituents. Iron filings are attracted towards a bar magnet and react with dil. hydrochloric acid or dil. sulphuric acid to liberate hydrogen. Hydrogen burns with the pop sound at the mouth of the test tube. This reaction is highly exothermic and therefore, must be performed carefully.

2Fe (s) + 6HCl (aq)
$$\longrightarrow$$
 2FeCl₃ (aq) + 3H₂ (g);
2Fe (s) + 3H₂SO₄ (aq) \longrightarrow Fe₂(SO₄)₃ (aq) + 3H₂ (g);

Sulphur is soluble in non polar solvent like carbon disulphide (CS_2) . The compound iron sulphide (FeS) is formed on heating iron (Fe) and sulphur (S).

Fe (s) + S (s)
$$\xrightarrow{\text{heat}}$$
 FeS (s)

Iron sulphide reacts with dilute hydrochloric acid forms hydrogen sulphide (H_2S) gas which turns lead acetate paper into shiny black. Iron sulphide is insoluble in carbon disulphide solvent.

$$\begin{split} 2\text{FeS (s)} + 2\text{HCl (aq)} &\longrightarrow 2\text{FeCl}_2\,(\text{aq}) + \text{H}_2\text{S (g)}; \\ 2\text{FeS (s)} + \text{H}_2\text{SO}_4\,(\text{aq}) &\longrightarrow 2\text{FeSO}_4\,(\text{aq}) + \text{H}_2\text{S (g)}; \\ (\text{CH}_3\text{COO)}_2 \text{ Pb (aq)} + \text{H}_2\text{S (g)} &\longrightarrow \text{PbS (s)} + 2\text{CH}_3\text{COOH (aq)}. \\ & \text{(Black)} \end{split}$$

- How would you proceed to test that a mixture of NH_4Cl and $CuSO_4$ give test for NH_4^+, Cl^- , Cu^{2+} and SO_4^{2-} ions?
- Which one is the more appropriate statement amongst the following and Why? (i) Air is an oxidising agent; (ii) Oxygen of the air is an oxidising agent.
- Why does brass react with dilute hydrochloric acid and is corroded in rainy season to form CuCO₃. Cu(OH)₂?



To verify the law of conservation of mass in a chemical reaction.



Law of conservation of mass states that the mass remains conserved during a chemical reaction. In this experiment we shall verify the law of conservation of mass using a precipitation reaction. This reaction is considered as the simplest method to verify this law.

MATERIALS REQUIRED



Barium chloride (BaCl $_2$.2H $_2$ O), sodium sulphate (Na $_2$ SO $_4$.10H $_2$ O), distilled water, two beakers (150 mL), one beaker (250 mL), physical balance, spring balance (0 – 500 g) and a polythene bag, two watch glasses of known masses, and a glass stirrer.



- 1. Pour 100 mL distilled water in two beakers (150 mL).
- 2. Using the physical balance and a watch glass of known mass, weigh 7.2 g of BaCl₂.2H₂O and dissolve it in a beaker (150 mL) containing 100 mL distilled water.
- 3. Similarly, weigh 16.1 g of $\text{Na}_2\text{SO}_4.10\text{H}_2\text{O}$ in another watch glass of known mass and dissolve it in another beaker (150 mL) containing 100 mL distilled water.

- 4. Take the third beaker (250 mL) and weigh it using a spring balance and polythene bag (see Experiment no. 3 for details).
- 5. Mix both solutions of 150 mL beakers in the third beaker (250 mL). Mix the contents using a glass stirrer.
- 6. On mixing white precipitate of BaSO₄ appears due to precipitation reaction.
- 7. Weigh the beaker containing the reaction mixture again to determine the mass of the precipitation reaction products.
- 8. Compare the masses of before and after the chemical reaction.

OBSERVATIONS



(i)	Mass of 100 mL distilled water	= 100.0 g
	(The density of distilled water is 1 g/mL.)	

(ii)	Mass of BaCl ₂ .2H ₂ O	= 7.2 g
(iii)	Mass of BaCl ₂ solution	= 107.2 g
(iv)	Mass of Na ₂ SO ₄ .10H ₂ O	= 16.1 g
(v)	Mass of Na ₂ SO ₄ solution	= 116.1 g

- (vi) Total Mass of reactants = 223.3 g (solutions of BaCl₂ and Na₂SO₄)
- (vii) Mass of empty 250 mL beaker, $m_1 = ___ g$
- (viii) Initial mass of reaction mixture and empty beaker (before the precipitation), $m_2 = (m_1 + 223.3 \text{ g}) =$ _____ g
- (ix) Final mass of reaction mixture in the beaker after the precipitation, $m_3 = g$.

RESULTS AND DISCUSSION



Compare the initial mass (m_2) of the reaction mixture (before the precipitation) with the final mass (m_3) of the reaction mixture (after the precipitation). Are they same? If the two masses are same within the reasonable limits, then the law of conservation of mass stands verified. The verification of the law rests on accurate mass measurements in the laboratory.

The chemical reaction involved is

$$BaCl_2$$
 (aq) + Na_2SO_4 (aq) \longrightarrow $BaSO_4$ (s) + 2NaCl (aq)
White precipitate

and more precisely

$$Ba^{2+}(aq) + SO_4^{2-}(aq) \longrightarrow BaSO_4(s)$$

PRECAUTIONS



- The spring balance should be held vertical while taking measurements.
- Before making use of the spring balance it must be ensured that its pointer is at zero mark. If not then ask your teacher to help.
- The readings of the spring balance should be noted only when its pointer comes to rest.
- Mixing of barium chloride and sodium sulphate solutions be done slowly with constant stirring.

Note for the Teacher

A physical balance is a sophisticated equipment. It is advised that students may be trained to use a physical balance and they must be properly supervised while they use the physical balance. This experiment involves several weighings that may take lot of time. In case if the weighing measurements takes lot of time, the required quantities of barium chloride and sodium sulphate may be provided to the students on two separate watch glasses. This will facilitate students to concentrate on the reaction dynamics rather than on the weighing skills.

- What are the other precipitation reactions that can be conveniently studied in the laboratory to verify this law?
- How can the law be verified by studying combination reaction?
 Suggest a procedure for the same.

The World of Living

18



To prepare a stained, temporary mount of onion peel and to study its cells.

THEORY 📚

All living organisms are composed of cells. New cells arise by the division of pre-existing cells. Cell is the structural and functional unit of life. In plants, cells have an outermost rigid cell wall beneath which is a cell membrane. The cell membrane encloses cytoplasm, cell organelles, and a nucleus.

MATERIALS REQUIRED



An onion bulb, slides, cover slips, two watch glasses, needle, brush, forceps, razor blade, compound microscope, blotting paper, methylene blue (or safranin) solution, glycerine, and water.



- 1. Take one fleshy scale leaf of an onion. Break it into two and using a forcep pull out a thin membranous peel adhering to the inner surface of the leaf. This is the epidermal peel.
- 2. Place the peel in a watch glass containing water and cut it into small rectangular pieces.



Fig. 18.1: (a)
Method of
removing an
epidermal peel
from onion leaf

- 3. Mix 1 or 2 drops of methylene blue or safrarin in a small quantity of water taken in another watch glass and transfer the peels into it. Leave the peels for about 3 minutes. Dip the peel in water to remove excess stain.
- 4. Take a clean slide with a drop of glycerine in the middle and using a brush transfer the washed and stained peel on to it.
- 5. Place a cover slip over it by slowly lowering it with a needle. Avoid entry of air bubbles.
- 6. Remove excess glycerine from the edges of cover slip with the help of a piece of blotting paper.
- 7. Observe the slide under the microscope, first in low power and then in high power.
- 8. Draw a labelled diagram of the cells as seen under microscope.
- 9. Note the features listed in the observation table.

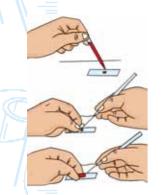


Fig. 18.1 : (b)
Staining and
mounting the
onion peel

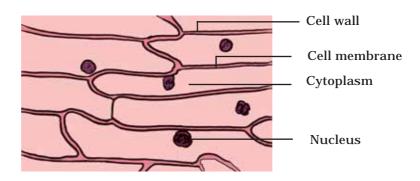


Fig. 18.2: Epidermal cells of an onion peel

OBSERVATION TABLE



Sl.No.	Feature	Observation
1.	Shape of cells	spherical/oval/rectangular/square
2.	Arrangement of cells	compact/loose
3.	Inter-cellular spaces	present/absent
4.	Nucleus	present/absent
5.	Cell wall	present/absent
6.	Stained portions of cell	cell wall/cytoplasm/nucleus
7.	Unstained portions of cell	cell wall/cytoplasm/vacuole

RESULTS AND DISCUSSION



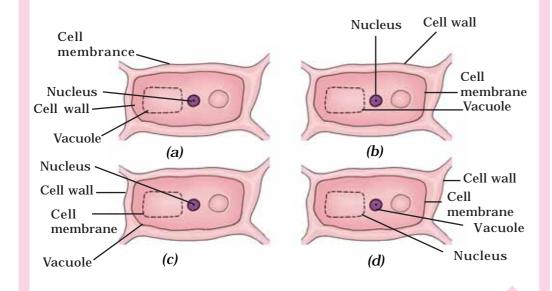
The cells that form the peel are rectangular in shape, compactly arranged and without any intercellular spaces. Each cell has a distinct cell wall, a prominent nucleus and a vacuole. The cells form the outer layer of the leaf known as epidermis.

PRECAUTIONS



- Staining of the peel must be appropriate. Excess stain can be removed by rinsing the peel with water taken in a watch glass.
- Use a brush to transfer the peel on to the slide.
- While placing the cover slip care should be taken to avoid air bubbles.

- What is the size of nucleus in relation to size of cell?
- Name the stained parts of the cell.
- Pick the odd one out. (a) plastids, (b) large vacuoles, (c) cell wall, (d) centrioles.
- Which of the following is a correctly labeled cell of an onion peel?







To prepare a temporary mount of human cheek epithelial cells, and to study its characteristics.

THEORY



Like plants, the body of all animals including humans is composed of cells. Unlike plant cells, animal cells do not have cell wall. The outermost covering of an animal cell is a cell membrane. The cytoplasm, nucleus and other cell organelles are enclosed in it. Epithelial tissue is the outermost covering of most organs and cavities of an animal body.

MATERIALS REQUIRED



Methylene blue stain, glycerine, a compound microscope, slide, cover slip, a clean spatula or a toothpick, a brush, a needle, and a piece of blotting paper.

PROCEDURE



- 1. Rinse your mouth with fresh water.
- 2. With the help of a clean spatula or a toothpick, gently scrap the inner side of your cheek.
- 3. Transfer the scrapped material into a drop of water taken on a clean slide.

- 4. With the help of a needle spread the material uniformly.
- 5. Add a drop of methylene blue stain. After about 3 minutes put a drop of glycerine over it.
- 6. Place a clean cover slip over the glycerine. Remove the excess glycerine from the edges of cover slip with the help of a piece of blotting paper.
- 7. Examine the slide under microscope, first under low power and then under high power.
- 8. Draw diagrams of cells as seen under the microscope. Observe and record the features.

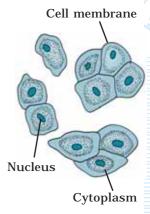


Fig. 19.1 : A few Cheek cells



Sl.No.	Feature	Observation
1.	Shape of cells	
2.	Arrangement	
3.	Intercellular space	
4.	Cell wall	present/absent
5.	Cell membrane	present/absent
6.	Cell contents	
7.	Vacuoles	

RESULTS AND DISCUSSION



Epithelial cells are small, polygonal in shape and compactly arranged to form a continuous layer. The cells are without cell wall. Cell membrane encloses a distinct nucleus and a vacuole. Epithelial tissue forms the outermost covering of almost all the organs and various cavities of animals and human.

PRECAUTIONS



- Cheeks should be scrapped gently to prevent injury.
- Spread the material on the slide so that it forms a thin uniform layer.
- Avoid over staining (or understaining) of the material.
- While mounting the cover slip, avoid entry of air bubbles.

NOTE FOR THE TEACHER

In such temporary preparations, cytoplasmic organelles are not visible because they are too small and are not stained by methylene blue.

- Arrange the following steps in correct sequence-
 - (i) Putting a drop of glycerine on the cheek cells on a slide,
 - (ii) Scrapping the inner side of cheek,
 - (iii) Adding methylene blue stain, and
 - (iv) Placing the cover slip over the material.
 - (a) i, ii, iii, iv; (b) ii, i, iv, iii; (c) iv, ii, iii, i; (d) ii, iii, i, iv.
- · Which one of the following is absent in animal cells-
 - (a) Cell membrane, (b) Nucleolus, (c) Cell wall, (d) Cytoplasm
- · Cheek epithelial cells are an example of
 - (a) squamous epithelial cells, (b) cuboidal epithelial cells,
 - (b) columnar epithelial cells, (d) all of these.
- Why are cheek epithelial cells always moist?
- Name two structures which you would see in cheek cells if you were using a very high magnifying power of microscope?

20



To study the phenomenon of osmosis.

THEORY



Every living cell has an extremely thin, elastic cell membrane, also called plasma membrane, which separates cell contents from the external environment. It is the outermost covering of animal cells. In plant cells, the membrane is present below the cell wall. It is selectively permeable as it allows solvent molecules and only selected solute molecules to pass through it. It differs from a permeable membrane which allows all types of molecules to pass through it. Movement of molecules of water or solvent from a region of its higher concentration to the region of its lower concentration across a selectively permeable membrane is called *osmosis*. It is of two types – endosmosis and exosmosis. Endosmosis is the entry of water into the cell while exosmosis is the movement of water out of the cell into the external solution. Endosmosis takes place, when the cell is placed in a hypotonic solution. Exosmosis takes place when the cell is placed in a hypertonic solution.

MATERIALS REQUIRED



Two raw eggs, dil. hydrochloric acid, a salt (or sugar) solution of about 25% concentration in water (dissolve about 25 g salt in 100 mL water), beakers and petri dishes.

PROCEDURE



- 1. Dissolve the shells of two eggs by placing them in two separate beakers containing dil. HCl. Hydrochloric acid dissolves the calcium chloride of the egg shells. The eggs will become de-shelled.
- 2. Carefully drain off the acid from the beakers and wash the eggs thoroughly with water while they are still in the beakers. Repeat this process several times till all traces of acid are completely removed.
- 3. Observe the de-shelled eggs.
- 4. Fill one beaker containing one de-shelled egg with water and the other beaker with another de-shelled egg with the concentrated salt (or sugar) solution.
- 5. Leave the set up for about four hours and observe the two deshelled eggs.

OBSERVATIONS



Observe the de-shelled eggs before and after placing them in water and concentrated salt (or sugar) solution respectively. And answer the following-

- (i) What has happened to the de-shelled egg placed in water?
- (ii) What has happened to the de-shelled egg placed in salt (or sugar) solution?

RESULTS AND DISCUSSION



The de-shelled egg when placed in water swells because the concentration of water molecules outside the egg is much higher than the concentration of water molecules inside the egg, as a result of which endosmosis takes place and water from the beaker enters into the egg. Exosmosis takes place when the de-shelled egg is placed in a sugar (or salt) solution. The water comes out from the de-shelled egg into the (or salt) sugar solution. The loss of water results in the shrinkage of the egg.

PRECAUTIONS



- While washing the de-shelled eggs, care should be taken to prevent the damage of egg membrane.
- Use dil. hydrochloric acid only lest the egg membrane gets damaged.

- What is the difference between endosmosis and exosmosis?
- What will happen if a de-shelled egg is placed in a solution with the same osmotic concentration as in the egg?
- Why did the egg swell when placed in water?
- Movement of water during osmosis takes place across—
 (a) cell wall, (b) cell membrane, (c) cytoplasm, (d) protoplasm.
- The plasma membrane which selectively allows solvent molecules and solute molecules to pass through it is-
 - (a) a permeable membrane, (b) a selectively permeable membrane,
 - (c) an impermeable membrane, (d) a semi-permeable membrane.





To study plasmolysis in leaf epidermal peels of *Rhoeo* or *Tradescantia*.

THEORY



Living cells generally contain plenty of water due to which they are turgid. Turgidity is an important attribute of cells as it gives shape to cells. When turgid cell is placed in salt (or sugar) solution, water moves out of the cell across its membrane into the external solution. As a result, the volume of protoplast decreases and the cell membrane withdraws from the cell wall creating an apparent colourless space within the cell. This shrinkage of protoplast inside a cell is termed plasmolysis.

MATERIALS REQUIRED



Compound microscope, fresh leaves of Rhoeo or Tradescantia, a sugar (or salt) solution of about 10 per cent concentration in water (dissolve about 10 g sugar in 100 mL water), a new razor blade, slide, cover slip, needle, forceps, brush, and a piece of blotting paper.

PROCEDURE



1. Using a new razor blade, take out three or four small peels from the lower epidermis of leaf of Rhoeo or Tradescantia.

- 2. Mount one peel in a drop of water taken on a slide. Place a cover slip and observe under the low power of microscope. Notice the compact arrangement of polygonal cells. Each cell contains pink coloured protoplast. Draw a neat diagram of few cells in your notebook and shade the regions covered by the protoplast.
- 3. Count about 25 cells and note down how many of them are turgid and how many are plasmolysed.
- 4. Remove the cover slip. Add about five drops of sugar (or salt) solution on the peel.
- 5. After five minutes place a cover slip on the peel, blot out the excess solution from the sides of the cover slip. Focus the cells under the low power of microscope and observe.
- 6. Note down your observations. Draw some cells and shade the extent of pink coloured region in them.
- 7. Again count about 25 cells and note down how many of them are turgid and how many are plasmolysed.

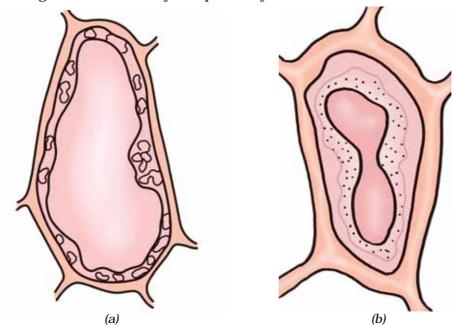


Fig. 21.1: (a) A normal cell and (b) a plasmolysed cell



	No. of cells counted	Number of turgid cells	Number of plasmolysed cells
Peel in water			
Peel kept in salt (or sugar) solution			

RESULTS AND DISCUSSION



Based on the observations, analyse and reason out the causes for plasmolysis.

PRECAUTIONS



- Perform the experiment using coloured leaf samples like those of *Rhoeo*, *Tradescantia*, *Coleus*, etc.
- Use concentrated sugar (or salt) solution.
- Ensure complete immersion of peels in the solution.

Note for the Teacher

In the experimental peel, water from the cells moves out into the external solution by a process called exosmosis. This happens due to the fact that the cell sap is a weaker solution as compared to the external (salt or sugar) solution. Consequently, it has more water molecules than that in external solution. Due to this difference in the concentration of water inside the cell and the external solution, a concentration gradient is established. Due to this gradient, water moves out of the cell into the external solution. This results in a reduction in volume of protoplasm inside the cell hence the pink region appears shrunk in these cells. The phenomenon of losing water from cells leading to shrinkage of protoplast is called plasmolysis.

- What moves out from the cells in this experiment? Why?
- Why pigments and other cell contents do not move out of the cells?
- Why are living cells always turgid?
- What will happen if the cells are kept for a very long time in the salt (or sugar) solution? Explain.
- Between the cell sap and solution (salt or sugar) in the experiment, which is the hypertonic solution?
- Will plasmolysis occur when cells are placed in isotonic solution?





To test the presence of starch in a given food sample and metanil yellow in pigeon pea.

THEORY



The presence of starch in a given food sample (say in potato) can be determined using iodine solution. Starch is a carbohydrate that produces blue colour when brought in contact with the iodine solution.

Food products are often adulterated for economic gains. For example, metanil yellow is used to adulterate pigeon pea (arhar dal). Metanil yellow turns into pink colour when it reacts with the concentrated hydrochloric acid. Whereas the pieces of unadultrated sample does not exhibit such a change.

MATERIALS REQUIRED



Potato, pieces of pigeon pea (arhar dal), iodine solution, concentrated hydrochloric acid, petridish, test tube, knife, and a dropper.

PROCEDURE



- A. To test the presence of starch in potato-
 - 1. Wash a potato alongwith its skin.
 - 2. Take a thin slice of potato in a petridish.

- 3. Add a few drops of iodine solution on the surface of the thin potato slice.
- 4. Observe the change in colour in the area of slice where iodine soluton was added.
- B. To test the presence of metanil yellow in pigeon pea-
 - 1. Take a few dry pieces of pigeon pea sample in a dry test tube.
 - 2. Add a few drops of conc. HCl to these dry pieces.
 - 3. Does the colour of the reaction mixture change?
 - 4. Conclude whether the sample under test is adulterated or not?



- (a) The colour of potato slice changes into _____ on addition of iodine solution.
- (b) The colour of reaction mixture of pigeon pea sample when reacted with conc. HCl changes into ______.

RESULTS AND DISCUSSION

On the basis of observations comment on (a) presence of starch in potato and (b) whether the pigeon pea sample is adulterated with metanil yellow or not.

NOTE FOR THE TEACHER

- The starch test may also be performed on samples of rice, wheat flour etc.
- The presence of metanil yellow can also be detected in other food samples such as turmeric powder.

- In what form the food is stored in plants?
- Which is the common adulterant of arhar dal?
- What are the efects of adulteration of food items.
- Why do the old stock of potato taste sweet?
- What are the different adulterants commonly used in foods?





To study parenchyma and sclerenchyma tissues in plants by preparing temporary slides.

THEORY



Flowering plants are structurally complex as they are made up of different parts like roots, stem, leaves, flowers, fruits, etc. Each part is in turn an assembly of different types of tissues. Each tissue type has specific structure and performs a particular function. Plant tissues are broadly classified into meristematic and permanent tissues. Permanent tissues may be simple, permanent tissues like parenchyma, collenchyma and sclerenchyma. Complex permanent tissues are xylem and phloem. The structural features of tissues like wall characteristics, cell size, lumen size, and cytoplasmic contents are different in different tissues.

MATERIALS REQUIRED



Tender stem of a herb (balsam/Tridax/Petunia/any cultivated ornamental herb or wild plant), safranin stain solution, dilute glycerine, chart of transverse section of stem, compound microscope, razor blade, slide, cover slip, brush, petri dish, and a piece of blotting paper.

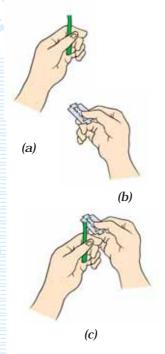


Fig. 23.1: (a) Correct way
of holding the
material;
(b) Correct way
of holding the
razor blade;
and
(c) cutting the

section

Procedure 1



A. Making a temporary slide

- 1. Cut a tender stem of any of the above-mentioned plants into bits of about 3 cm length and place them in water.
- 2. Hold a piece between the thumb and forefinger in your left hand as shown in Fig. 23.1 (a).
- 3. Pass a wet blade across the stem in quick motion so as to get a thin, unbroken, circular cross section of the material [Fig. 23.1 (b) and (c)].
- 4. Repeat the process to get about fifteen transverse sections of the material.
- 5. Transfer the sections to a petri dish containing water. Select a thin, transparent section and with a brush transfer it to a drop of water taken on a slide. Add three drops of dilute safranin stain solution to the section and leave it for about five minutes.
- 6. Blot the excess stain. Add three drops of dilute glycerine on the stained section. Place a cover slip on it. Focus it under the low power of microscope and observe the section.
- 7. Now focus the section under high power and observe again. Note and record your observations.
- 8. Starting from the outer most layer, locate the epidermis, cortex and vascular tissues [Fig. 23.2(a) and (b)]. compare the layers with the diagram in the chart.
- 9. In the layers of cells beginning from epidermis, observe the following features-

a. Cell wall thin/thick;

b. Arrangement compact/loose;

c. Shape of cell circular/oval/rectangular/polygonal;

d. Intercellular spaces present/absent;e. Lumen (cell cavity) small/large;f. Nucleus present/absent;

g. Staining of cell wall deeply stained/mildly stained/no

stain; and

h. Cytoplasm: present/absent

10. Record your observations in the given tabular column.

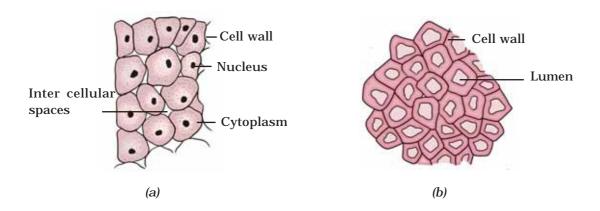


Fig. 23.2: (a) Parenchyma; and (b) sclerenchyma



	Features	Parenchyma	Sclerenchyma
a.	Cell wall		
b.	Arrangement		
c.	Shape of cell		
d.	Intercellular spaces		
e.	Lumen		
f.	Nucleus		
g.	Staining of wall		
h.	Cytoplasm		

RESULTS AND DISCUSSION



Parenchyma tissue is the most abundant type of tissue in plants. It forms the major bulk of stem, roots, leaves, fruits and seeds. The tissue is composed of living cells, with various shapes, sizes and functions. The cells provide mechanical support to the plant body. The parenchyma also acts as a storage tissue for food, air and water. Cells of sclerenchyma tissue are higly lignified with very thick cell walls and obliterated lumen. Cells are usually elongated and polygonal in shape in cross-section. The tissue provides the mechanical support and is found below the epidermis and around the vascular bundles.

PRECAUTIONS



- For sectioning, select soft, tender herbaceous stem only. Avoid stems that are hard and woody.
- Take care not to injure your finger while sectioning.
- Always keep the plant materials and sections in water.
- Use dilute safranin stain solution.
- The trachea and tracheids of xylem tissue appear to be very much similar to sclerenchyma and may be erroneously identified as sclerenchyma tissue. Xylem is always confined to the vascular bundle and is generally not seen in the cortex or pith.

NOTE FOR THE TEACHER

• Features of parenchyma and sclerenchyma are given below for purpose of their identification

Parenchyma

- Parenchyma constitutes the major type of tissue in plants.
- Parenchyma cells have very thin walls, may be circular, rectangular, oval or polygonal in shape, loosely arranged in most cases with intercellular spaces between cells. In some plants intercellular spaces are absent and the cells are compactly arranged.
- Parenchyma is composed of living cells with large internal space (lumen). Under the high power of microscope nucleus may be visible.
- Epidermis, cortex and pith are essentially composed of parenchyma tissue.

Sclerenchyma

- Sclerenchyma cells are generally found below the epidermis or just above the vascular bundles.
- The cells have very thick walls and they stain deep red when stained with safranin.
- Lumen is reduced and there is no nucleus [Fig. 25.3(b)].
- Cells are generally elongated in vertical section and polygonal in cross section; compactly arranged without any intercellular spaces.

- In the transverse section of stem which tissue occupies larger space-parenchyma or sclerenchyma?
- Draw an outline of the section of stem and indicate the regions where parenchyma and sclerenchyma are situated.
- Which tissue, when matured, has dead cells?
- Mention the main function of sclerenchyma tissue?
- You can bite fruits like guava, grapes, banana etc. but not a piece of wood. Why?





To identify and study striated muscle fibre and nerve fibre in animals.

THEORY



Animal body is made up of groups of similar cells which perform specific function. Such groups of identical cells are called tissues. There are four basic types of tissues: epithelial, connective, muscular, and neural. These tissues vary from each other not only in their structure but also in their functions.

MATERIALS REQUIRED



Permanent slides of striated muscle fibre and nerve fibre, charts of animal tissues with straited muscle fibre and nerve cell (neuron), and compound microscope.

PROCEDURE



- 1. Place a permanent slide of straited muscle fibre under a compound microscope.
- 2. Observe it first under low power and then under high power. Do you see an alternate arrangement of dark and light bands? Do you also find some nuclei along the fibre?

- 3. Identify the tissues with the help of charts. Draw diagrams of the tissues as seen under the microscope.
- 4. Replace the permanent slide of straited muscle fibre by the permanent slide of a nerve fibre. Identify different parts of a cell with the help of charts. Draw diagrams.



Striated Muscle Fibre – Under high magnification, the elongated fibre shows the presence of alternate arrangement of dark and light bands (Fig. 24.1). The dark bands represent thick filaments and the light bands represent thin filaments. Many nuclei are also observed along the fibre resulting from the fusion of many muscle cells. Such a condition is called syncytium. Cells of the tissue are long, cylindrical, nontapering and unbranched.

Nerve Fibres – Under high magnification, the nerve fibre shows nerve cells which have three parts: a cell body, dendrites, and axon, The axon may or may not be surrounded by myelin sheath (Fig. 24.2).

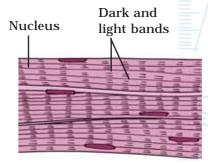


Fig 24.1 : A striated muscle fibre

RESULTS AND DISCUSSION



Tissues are organised in a specific proportion and pattern to form different organs. Muscular tissue plays an important role in all the movements of body parts and also in locomotion. It consists of different types of muscle fibres, such as (i) striated, (ii) smooth, and (iii) cardiac muscle fibres. The striated muscle fibres work according to our will (voluntary) and get tired (fatigued) when overworked. The functioning of smooth and cardiac muscle fibres are not under our control (involuntary).

Neural tissue controls the body's responsiveness to changing conditions within and outside the body. The function of neural tissue is to allow communication between different parts of the body. It is composed of neurons, which transmit impulses. The neural tissues of an organism form its nervous system. The nervous system includes the brain, spinal cord, and nerves. Neural tissue is made of nerve cells which are distinctly characterised by the axon of the cell that sends nerve impulse to the next cell.

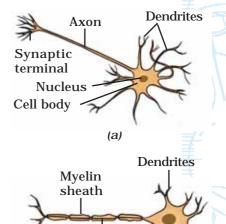


Fig. 24.2: (a) Non-myelinated nerve fibre; and (b) Myelinated nerve fibre

Axon

Cell

body

(b)

Synaptic

terminal

Nucleus

- What are the features of striated muscle fibre? Where do we find these in our body?
- Mention the function of skeletal muscles in our body.
- What are the features observed in a neuron?





To study the characteristics of Spirogyra, Agaricus, moss, fern, Pinus and an angiosperm plant.

THEORY



We know that plants of different groups exhibit different characteristics. Thallophytes, bryophytes, pteridophytes, gymnosperms, and angiosperms are the five major groups of plants. This classification is essentially based on the structure of their bodies and methods of reproduction. Thallophytes have the simplest structure. The plant body becomes more complex from bryophytes onwards, and reaches its highest complexity in angiosperms.

MATERIALS REQUIRED



Permanent slides of Spirogyra, specimen of Agaricus, moss, fern, Pinus, and an angiosperm such as Petunia, balsam, Amaranthus, Chenopodium, Tridax or other locally available plants, compound microscope.

PROCEDURE



- 1. Observe the permanent slide of Spirogyra under low power of microscope and record your observations. Draw the diagram of Spirogyra and label the parts.
- 2. Likewise, observe and record the characters of Agaricus, moss, fern, *Pinus* and an angiosperm plant. Draw their diagrams.



Observe and record the features of *Spirogyra* and *Agaricus* in Table 1. For other materials (that is Moss, fern, *Pinus*, and angiosperm) record you observations in Table 2.

Table 1: Observations of the general features of *Spirogyra* and *Agarius* (edible mushroom)

Sl.No.	Feature	Spirogyra	Agaricus
1.	Size of the plant body:		
	microscopic/macroscopic		
2.	Nature of the plant body:		
	thallus/differentiated into		
	root, stem and leaves		
3.	Thallus:		
	filamentous; branched/		
	unbranched		
4.	Stem: present/absent		
5.	Roots: present/absent		
6.	Leaf: present/absent		
7.	Rhizoids: present/absent		
8.	Fruiting body with spores:		
	present/absent		

Table 2: Observations of the general features of moss, fern, *Pinus*, and angiosperm

Sl.No.	Feature	Moss	Fern	Pinus	Angiosperm
1.	Size of the plant body:				
	microscopic/macroscopic				
2.	Nature of the plant body:				
	thallus/differentiated				
3.	Stem: (i) present/absent				
	(ii) branched/unbranched				
4.	Rhizoids/roots: present/absent				
5.	Leaf:				
	(i) simple/compound/needle-like				
	(ii) midrib: present/absent				
	(iii) Sori/Sporangia: present/absent				
6.	Cones: present/absent				
7.	Flower: present/absent				
8.	Fruits: present/absent				
9.	Seeds: present/absent				

General characteristics of all the specimens are given below for the purpose of identification.

Spirogyra (Fig. 25.1)

- The plant body is filamentous, unbranched and made up of cylindrical cells placed one above the other.
- Cells are longer with one or two spiral ribbon shaped chloroplasts.
- Each cell has a single large nucleus and a vacuole.

Agaricus (Fig. 25.2)

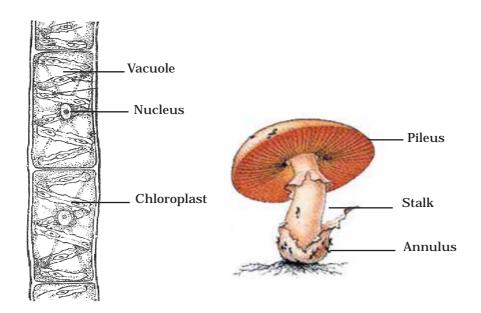


Fig. 25.1 : Spirogyra

Fig. 25.2 : Agaricus

- We generally see a fruiting body of Agaricus.
- It is macroscopic and fleshy.
- A mature fruiting body is divided into a stalk and an umbrella like cap called pileus.
- A ring like membranous structure (annulus) is attached at the base of the stalk.
- The cap on its lower side has gills which bear spores.

Moss (Fig. 25.3)

- The thallus is about three to five cm long, differentiated into central axis, leaves, and root-like structures (called rhizoids).
- The central axis is erect, branched or unbranched.
- Tiny flat green leaves are arranged spirally on the stem.
- Rhizoids are long and multiseptate and are present at the base of the central axis.

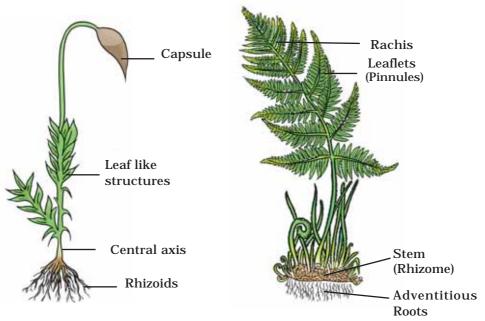


Fig. 25.3 : Moss

Fig. 25.4 : Fern

Fern (Fig. 25.4)

- The plant body is well differentiated into root, stem and leaves.
- Stem is short, stout and underground.
- From the adventitous buds on the stem arise large, compound leaves. Leaflets are small and arranged on either side of the rachis.
- Clusters of adventitous roots arise from the underside of the stem near each node.

Pinus (Fig. 25.5)

- Pinus is a tree with stem, leaves and roots.
- Stem is hard, woody and has branches bearing scaly and needle-like leaves and cones.
- Male and female cones are the reproductive organs.

• Male cones are small and tender; female cones are large and woody when mature.

Angiospermic Plant (Fig. 25.6)

- The plant body is divided into roots, stem, and leaves.
- Stem bears distinct nodes and internodes.
- · Leaves arise from nodes.
- · Plants bear flowers and fruits.
- Roots may be of fibrous (monocot plants) or tap-roots (dicot plants).

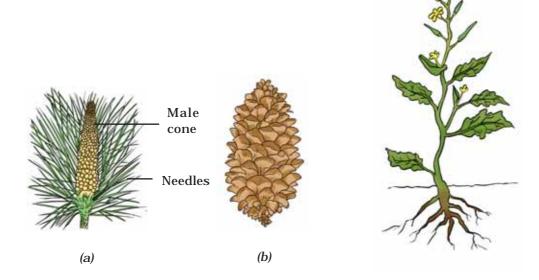


Fig. 25.5: (a) Male cone of Pinus; (b) Female cone of Pinus (not to the scale)

Fig. 25.6: An Angiosperm

- Why is a Spirogyra plant green in colour?
- Name two functions that are common to roots and rhizoids?
- What do the cones in pine represent?





To prepare herbarium sheet of a flowering plant.

THEORY



Herbarium sheets are generally prepared by botanists and stored systematically in a laboratory for an immediate reference. It consists of a thick white sheet of a specific dimension on which a dried plant specimen is mounted. The mounted specimen must have leaves, flowers and fruits (optional). Only one plant specimen is mounted on a herbarium sheet. Herbarium sheets have to be carefully preserved to prevent insect infestation. The term Herbarium refers to the place (such as a laboratory) where herbarium sheets are preserved systematically and are made available for reference.

MATERIALS REQUIRED



Plant specimen or a twig of a plant (20 - 25 cm long) with leaves and flowers, a thick white sheet (card sheet) of dimension 40×28 cm, old news papers or blotting sheets, adhesive, field press with a long rope or a heavy mass (such as a brick or a book), sewing needle, and thread.

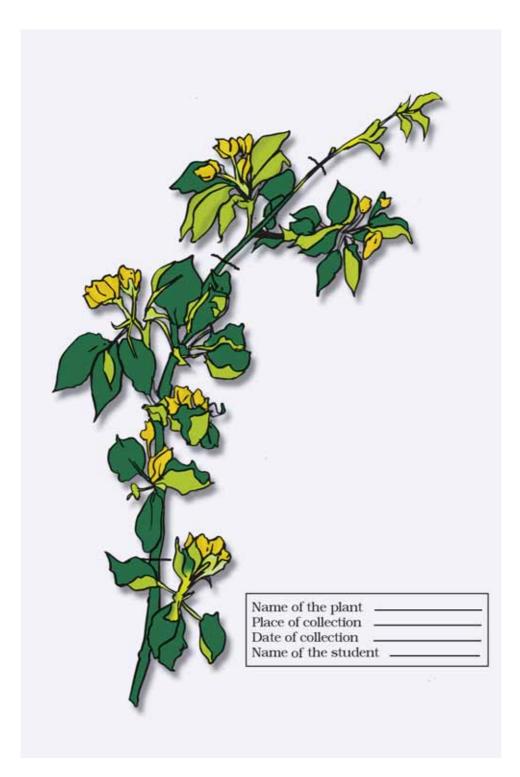


Fig. 26.1: A sample herbarium sheet

Procedure /



- 1. Collect a plant or a twig with leaves and flowers.
- 2. Place it inside the folds of a newspaper (or a blotting sheet) and spread the leaves and flowers gently without damaging them.
- 3. Turn one of the leaves so that its ventral surface faces upwards.
- 4. Cover the plant with the other half of the newspaper; place a few more sheets containing plants and a few newspaper sheets one above the other and keep a heavy mass (such as a brick or a book) on the pile. If a field press is available, the sheets of newspaper containing plant specimen may be stacked one above the other and the field press should be tied tightly using a long rope.
- 5. Next day, transfer the plant to a fresh set of dry newspapers and repeat step 4.
- 6. Repeat this process for four to five days till the plant becomes dry.
- 7. Smear a small quantity of adhesive at a few places on the stem or branches and leaves. Mount the plant on the card sheet as shown in Fig. 26.1.
- 8. Stich the twig or stem at a few places using a sewing needle and thread.
- 9. Keep this sheet in a dry newspaper (or a blotting sheet). Keep the heavy mass on the newspaper for two to three hours to allow the dried plant to stick to the card sheet.
- 10. At the bottom right corner, write your name, name of plant, place and date of collection. Now the herbarium sheet is ready (Fig. 26.1).

PRECAUTIONS



- Do not prepare herbarium sheets of aquatic plants, succulents and plants with thorns. (Why?)
- Select plants with small leaves and flowers as they are easier to handle.
- Spreading the different parts of plant on newspaper sheet has to be done very carefully before pressing them using a heavy mass.
- Mount the plant specimen after all the moisture and water has been completely removed from the plant.
- Apply a small quantity of the adhesive only at a few places on the herbarium sheet. Use of cellophane adhesive tape to stick the plant on the herbarium sheet must be avoided.

Note for the Teacher

• Professional herbarium keepers treat plants with 1 per cent mercuric chloride or 4 per cent formalin before mounting them on the

herbarium sheet. This process is called poisoning the specimen. As these chemicals are dangerous, and keeping in mind the age of students, this step has not been mentioned in the procedure here. Fumigants and naphthalene balls are placed in the cupboards where herbarium sheets are stored to prevent insect attack.

• Students may also be advised to find information about any five important international and national herbaria. They may also be encouraged to use internet or magazines or other information sources for this purpose.

- What are the advantages of a herbarium sheet?
- Why are water plants not suitable for preparing herbarium sheets?
- Why are plants treated with mercuric chloride or formalin before mounting on the herbarium sheet?
- What is the difference between a Herbarium and a herbarium sheet?





To study the features and draw diagrams of earthworm, cockroach, bony fish and bird.

THEORY



Animals are variously adapted to different kinds of habitat and environment. Adaptation is an inherent quality of living organisms which enable them to survive in specific habitats. Adaptation of organisms are due to certain modifications that are observed in the organisms at the morphological, anatomical as well as physiological levels. In this experiment, four organisms are considered for the study. For each organism, characteristics of the phylum to which it belongs to and a few adaptive features are studied and correlated with the habitat (or environment) in which they live.

MATERIALS REQUIRED



Preserved specimens of earthworm, cockroach, bony fish, a stuffed bird, charts showing detailed diagrams of animals under study, and a hand lens.

PROCEDURE



1. Observe the given specimens and for each specimen, record one specific feature of the group (phylum/class) to which it belongs.

- 2. Write down one adaptive feature of each specimen with reference to its habitat.
- 3. Draw diagrams of the specimens, using the chart(s). Identify the various parts of organisms observed.



Table 1

Sl. No.	Organism	Phylum/Class	Features of the phylum observed	Adaptive Features observed	Habitat
1.	Earthworm				
2.	Cockroach				
3.	Bony fish				
4.	Bird				

Based on your observations, record some more features of the specimens (at least five for each specimen).

Table 2

Sl.No.	Earthworm	Cockroach	Bony Fish	Bird
1.				
2.				
3.				
4.				
5.				

NOTE FOR THE TEACHER

Some characteristic features of the phylum (or class) and adaptive features of organisms are given for easy identification.

• Earthworm (Phylum: Annelida)

Specific feature of the phylum – Body surface is characterised by distinct annular segments or metameres; body is not differentiated. Adaptive features – Moist and slimy skin, presence of clitellum (merger of 14 - 17 metameric segments).

Cockroach (Phylum: Arthropoda; Class: Insecta)

Specific feature of the class – Segmented body; jointed appendages with three pairs of legs.

Adaptive feature – Nocturnal habit; body is covered by chitinous cuticle which is impervious to water; spiracles are present on the lateral sides of body for respiration.

• Bony fish (Phylum: Chordata; Class: Pisces)

Specific feature of the phylum - Presence of notochord.

Specific feature of the class – Presence of four pairs of gills covered by an operculum; and presence of fins.

Adaptive feature – They possess a streamlined body for minimum resistance to water while swimming. Presence of air bladder helps in their buoyancy.

• Bird (Phylum: Chordata; Class: Aves)

Specific feature of the phylum – Presence of notochord.

Specific feature of the class – Forelimbs are modified into wings.

Adaptive feature – Boat shaped body; presence of feathers; bones are hollow with air cavities (to reduce the mass).

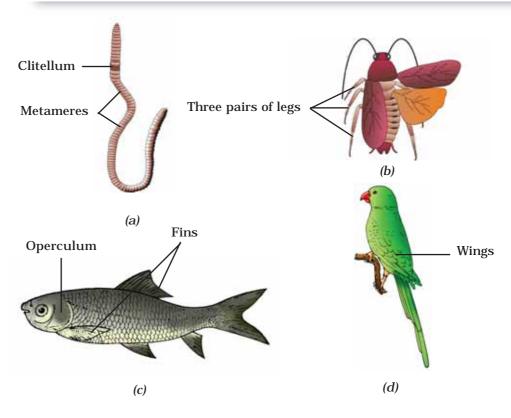


Fig. 27.1: (a) An earthworm, (b) A cockroach; (c) A bony fish; and (d) A bird

APPLICATIONS

• Earthworms are known as 'Farmer's Friend' because of their role in enhancing the fertility of soil. As they burrow into the soil, they ingest soil along with the organic matter present in it. They excrete the same soil and bring it on the top as casts. This way, it is able to loosen the soil. Earthworms are also used to prepare vermicompost that is used as manure to enhance the fertility of soil.

- Name the phyla to which earthworm, cockroach, bony fish, and bird belong.
- What is an adaptation?
- In which body segments of an earthworm is the clitellum found?
- How does a cockroach adapt itself to a wide range of habitats?
- Mention two adaptive characters of a bony fish besides the possession of a streamlined body and air bladder.
- Feathers are an adaptive feature of birds. How are they helpful to them?





To compare the external features of monocot and dicot plants.

THEORY



Angiosperms or flowering plants are the most dominant plants on the earth. They are divided into two major groups, namely monocots and dicots. Seeds of monocots, as the name suggests, have one cotyledon and those of dicots have two. Besides this major difference, there are many other distinct differences in their morphological and anatomical features. Such features enable us to differentiate between monocots and dicots even when their seeds are not available to check the number of cotyledons. In this experiment, we intend to make a comparison of external features of monocot and dicot plants.

MATERIALS REQUIRED



Plants of Hibiscus/rose/Petunia/pea and grass/maize/bamboo/lily/ Chlorophytum/any other ornamental herb with flowers and fruits, simple or dissecting microscope, a hand lens, slide, cover slip, and a razor blade.

PROCEDURE



1. From the list given above, select a dicot and a monocot plant with roots, leaves, flowers, and fruits.

- 2. Observe the differences in the external features of stem, leaf, roots, flowers, and seeds. To study the root system, wash the roots carefully and spread them on a sheet of paper and study their nature.
- 3. Study the leaves for their shape and venation.
- 4. Carefully observe the flower and identify the different floral parts. Count the number of sepals, petals and stamens in the flower. Take a transverse section of ovary and count the number of carpels.
- 5. Remove the seed coat and count the number of cotyledons.
- 6. Note down your observations; draw diagrams of all the parts you have studied.

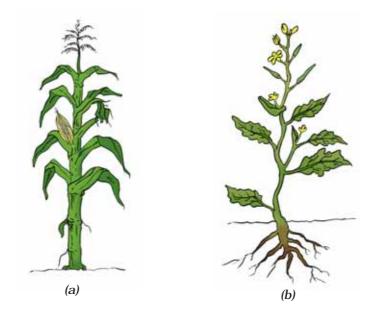


Fig. 28.1: (a) A monocot plant; and (b) a dicot plant

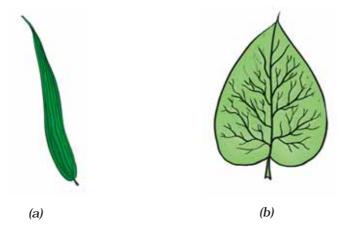


Fig. 28.2 : (a) A monocot leaf showing parallel venation; and (b) A dicot leaf showing reticulate venation

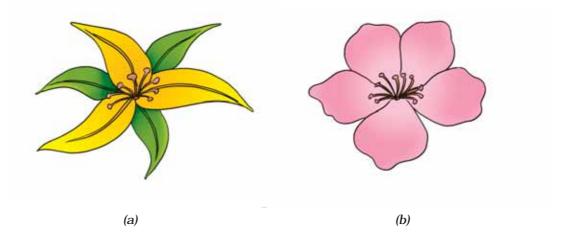


Fig. 28.3: (a) A monocot flower and (b) A dicot flower

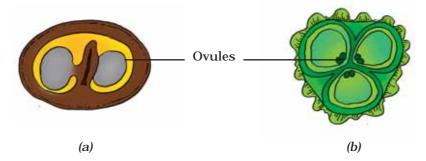


Fig. 28.4: Transverse section of ovary (a) bicarpellary and (b) tricarpellary

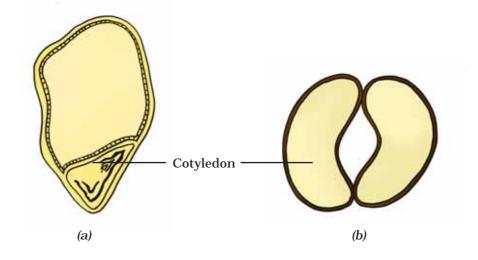


Fig. 28.5: (a) A seed with one cotyledon and (b) a seed with two cotyledons

OBSERVATIONS (A



Some important features that distinguish a monocot and a dicot plant are listed in the table given below. You may observe some more features of difference between them. Record your observations.

Sl.No.	Feature	Monocot	Dicot
1.	Roots: fibrous/tap root		
2.	Leaf shape: broad/narrow		
3.	Leaf venation: parallel/reticulate		
4.	Floral parts: multiple of 3 or 5		
5.	Sepals: number and colour		
6.	Petals: number and colour		
7.	Stamen: number		
8.	Pistil: number of carpels		
9.	Cotyledon: one or two		

RESULTS AND DISCUSSION



• The study reveals many differences between dicot and monocot plants. The distinctive features are consistently seen in most other plants belonging to these groups.

- How do we differentiate betwen fibrous root system and tap-root system?
- A plant has leaves with reticulate venation and floral parts consisting of 5 sepals, 5 petals, 5 stamens, and 5 carpels. In which group of angiosperms would you place this plant? Give
- In a plant, name two features which you would examine to categorise it into a monocot or a dicot plant.
- Do all flowers have all the floral parts? Explore.





To study the life cycle of a mosquito.

THEORY



Life cycle of a mosquito passes through several stages. Each stage is morphologically distinct. Even their habitat differs with the adult being aerial and the earlier stages being aquatic. Though there are many species of mosquitoes, their life cycles, more or less, exhibit common features.

MATERIALS REQUIRED



Chart showing the life cycle of a mosquito and/or museum specimen of stages in the life cycle, permanent slides, and compound microscope.

PROCEDURE



- 1. Observe the chart carefully and note the different stages in the life cycle.
- 2. Recall/discuss the characteristics of each stage.
- 3. Draw diagrams of all the stages.
- 4. Observe the preserved speciemen and name the stages.

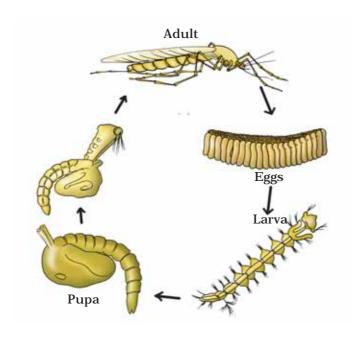


Fig. 29.1: Stages in the life cycle of a mosquito

DISCUSSION

The eggs of various species of mosquito are deposited on stagnant water bodies like ponds, ditches, cess pools, lakes etc. Any container with stagnant water is a potential breeding place for mosquitoes.

The larvae hatch out from the eggs within a few hours and begin feeding on decaying plant matter. They float on the surface of water and breath through a specialised siphon tube. The larval stage lasts for a few days during which several layers of skin are shed. This stage lasts for a few days to a few weeks. The larval stage is followed by the pupal stage.

Pupae do not feed but gradually metamorphose or change into adults. Pupal stage lasts for a few days. From the pupa an adult mosquito emerges. Before the adult starts flying it rests for a few days during which its outer cuticle hardens.

After about a week, adult female mosquito begins searching for a host. It generally feeds on blood, which is a rich source of protein that is helpful to make a fresh batch of eggs, Eggs are deposited on or near water. The male mosquito does not seek a blood meal, but prefers a sugar meal which it obtains by feeding on the nectar of flowers. The female adults also feed on nectar in between blood meals. Adult mosquitoes live for several weeks.

NOTE FOR THE TEACHER

- The mosquito goes through four distinct stages during its life cycle (Fig. 29.1)-
 - (i) egg: deposited in water; hatches in water;
 - (ii) larva (plural; larvae): lives on the surface of water; moults several times;
 - (iii) pupa (plural; pupae): A stage just prior to the adult stage; pupae do not feed; and
 - (iv) adult emerges from the pupae, body parts harden and starts flying.
- Permanent slides of different stages in the life cycle of a mosquito may be focussed under a compound microscope and shown to the students. This will enable students to have a better understanding of life cycle of a mosquito.

- Why is it important to study the life cycle of mosquito?
- At which stage in the life cycle of a mosquito, moulting takes place?
- Why does only the female mosquito require a blood meal?
- What are the conditions that are helpful for breeding of mosquitoes?
- Suggest three measures to check the breeding of mosquitoes.





To study the life cycle of malarial parasite.

THEORY



Plasmodium is commonly called the malarial parasite. The life cycle of Plasmodium is complex and involves two hosts, human being and a mosquito. Plasmodium completes its sexual cycle in mosquito and asexual cycle in human being. When female Anopheles mosquito infected with the parasite bites a healthy human, infective sporozoites are injected into the human blood stream causing the dreaded disease malaria. The mosquito which transmits the malarial parasite is called the vector.

MATERIALS REQUIRED



A chart showing the life cycle of malarial parasite, permanent slides of malarial parasite, and compound microscope.

PROCEDURE



- 1. Study the chart and carefully note down the different stages of the life cycle of *Plasmodium* beginning with the mosquito bite.
- 2. Draw a flow chart of different stages of life cycle.

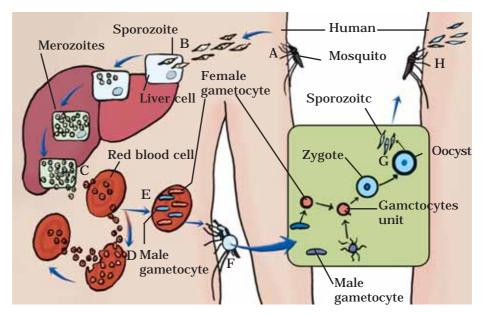


Fig. 30.1: Life cycle of malarial parasite

DISCUSSION

- There are about four hundred and thrity five known species of *Anopheles*. About thirty to forty of them are vectors of malarial parasite. The species of *Plasmodium* which are known to cause malaria are *Plasmodium vivax*, *P. falciparum*, *P. malariae* and *P. ovale*. Of these, *P. falciparum* is considered the most deadly species.
- Symptoms of malarial infection include chills, fever, sweats, headaches, nausea, vomiting, weakness and body aches. Symptoms specific to *Plasmodium falciparum* are jaundice, swollen liver and very rapid breathing. Complications that may accompany severity of disease are irregular breathing, accumulation of fluid in lungs, anaemia, behavioural abnormalities if infection reaches the brain, abnormalities in blood coagulation and cardiac problems.
- The infection can be confirmed by pathological tests that involve microscopic examination of blood smears, RDT (Rapid Dignostic Test) and other tests.
- Drugs administered to treat patients with malaria invariably contain quinine as the active ingredient.

Note for the Teacher

The life cycle of malarial parasite is completed through the following stages-

• When a mosquito infected with the malarial parasite bites a healthy human, the slender malarial parasitic cells (sporozoites) are injected into the human bloodstream (see A in Fig. 30.1).

- Within thirty minutes, the parasite invades the human liver through the blood and lymphatic system. It infects the liver cells (hepatocytes), where it multiplies producing thousands of parasitic cells within a week (See B in Fig. 30.1).
- The parasitic cells re-enter the blood stream and infect red blood cells (see C in Fig. 30.1).
- They grow in the red blood cells and undergo another phase of multiplication, eventually causing rupture of red blood cells and releasing more parasitic cells along with their toxins. This leads to manifestation of symptoms of malaria like chills and fever (see D in Fig. 30.1).
- Some parasitic cells form gametocytes (sex cells). These are of two types: (i) male gametocytes and (ii) female gametocytes (see E in Fig. 30.1).
- When another mosquito bites the infected human, it ingests the sporozoites along with blood (see F in Fig. 30.1).
- In the stomach of mosquito (midgut), the gametocytes mature and fertilization occurs resulting in the formation of zygote. Zygote develops an outer covering and becomes the oocyst. Within the oocyst thousands of sporozoites are formed. The oocysts rupture and release the sporozoites into the body cavity from where they migrate to the salivary glands of mosquito (see G in Fig. 30.1).
- When this mosquito bites another human, along with the saliva the parasites are injected and the life cycle continues.
- Permanent slide of blood smear of persons suffering from malaria can be shown to the students.

- What are the different species of malarial parasite that cause malaria?
- When do the symptoms of malaria such as fever and chills appear?
- When a mosquito bites a person infected with *Plasmodium*, which stage of the parasite will the mosquito ingest?
- How does the malarial parasite reproduce in the red blood cells?
- Why are people suffering from malaria anaemic?





To collect and study symptoms of diseases in locally available crop plants.

THEORY



Microbes like fungi, bacteria and virus are capable of causing serious diseases in plants. Such parasitic microbes affect many of our commercial crops like cereals, pulses, vegetables, fruits etc. Generally a parasitic infection is specific, that is, it infects a specific plant. Some microbes are capable of infecting plant species belonging to a particular group. The infected plant is called the host and the infecting organism is called the parasite. Parasitic microbes require a living host for completing their life cycle. They absorb nutrients from the host plants and may even kill the host. If the disease is not checked, it is capable of spreading rapidly to other plants causing severe loss. Bacterial blights, smuts, white rust, black rust, tobacco mosaic are a few common diseases of crop plants in our country.

MATERIALS REQUIRED



Two or three diseased crop plants or ornamental plants or weeds, compound microscope, permanent slides of some diseased plants, a hand lens, slides, cover slips, needle, and a brush,

PROCEDURE



- 1. Collect two to three different kinds of diseased or infected plants.
- 2. Carefully observe each plant part for visible disease symptoms such as decolouration, infection spots, coloured patches, soft and decaying parts.
- 3. Observe if the entire plant is infected or only some parts like leaves, flowers or stem are infected.
- 4. Observe the infected parts and the physical characteristics of infection and record in the observations table.
- 5. Scrape the infected spot with a needle/blade and transfer it to a drop of water on a slide. Place a cover slip and observe under the microscope.
- 6. Under the low power of microscope, observe the presence of spores/hyphae and damage caused to plant tissues (or cells).
- 7. Draw a diagram of the infected part and show the disease symptoms.

OBSERVATIONS



Sl.No.	Observation	Plant 1	Plant 2
1.	Infected part is:	(Yes/No)	(Yes/No)
	Stem		
	Root		
	Leaf		
	Flower		
	Fruit		
2.	Extent of infection:		
	Localised		
	Enitre plant		
3.	Infection spot		
	Soft patch		
	Dry patch		
4.	Are spores visible?		
5.	Are hyphae visible?		

RESULTS AND DISCUSSION



Draw the diagrams of the infected parts and label the diseased parts. Also draw diagrams of spore and hyphae.

NOTE FOR THE TEACHER

- This is a group activity. Students may be asked to work in a team.
- The task of collecting infected plants may be assigned to students in advance.
- It is advised to facilitate students in identifying diseased plants by observing the external features like stunted or abnormal growth, discolourd spots on plant parts, etc.
- All weak plants are not necessarily diseased plants. Poor growth may also be due to a deficiency of certain minerals.
- Permanent slides of diseased plant parts may be focussed under the compound microscope.
- Careful observation of a slide may reveal the presence of spores or hyphae or both. Hyphae are generally filamentous, colourless and appear as branched and delicate strands.
- Students may also be advised to find out five diseases of crop plants which lead to extensive loss of revenue in our country. It may also be suggested to use internet or magazines or other information sources for this purpose.

- What are parasites? How do they obtain food?
- How do parasitic microbes spread from plant to plant?
- How do farmers check the spread of diseases in their fields?

Moving Things, People and Ideas

32



To plot distance – time (s - t) graph for an object moving with a uniform speed from a given set of s and t data and to determine the speed of the object.

THEORY 💝

A moving object changes its position with time. If the object travels a distance s in time t then its speed is

$$\mathbf{v} = \frac{\mathbf{s}}{t} \tag{1}$$

When an object travels equal distances in equal intervals of time, it is said to have a uniform speed. But if the speed or its direction of motion changes with time then the object is said to be in non-uniform motion.

For a uniform motion the distance travelled by the object is directly proportional to time taken. Thus the graph of distance travelled against time is a straight line. This distance-time graph can be used to determine the speed of the object. Fig. 32.1 shows the distance-time (s - t)

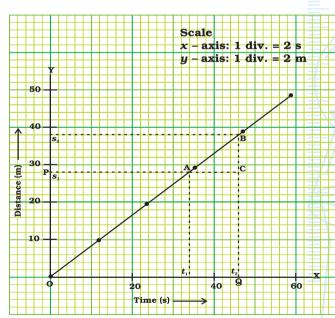


Fig. 32.1 : Distance-time graph of an object moving with uniform speed

graph of an object moving with uniform speed. To find the speed of the object consider a small part AB of the s-t graph. The two lines PAC and BCQ drawn parallel to x-axis and y-axis respectively, meet each other at point C to form a triangle ABC. The segment AC denotes the time interval $(t_2 - t_1)$ while the segment BC corresponds to the distance $(s_2 - s_1)$. From this graph it can be seen that as the object moves from the point A to point B, it covers a distance $(s_2 - s_1)$ in time $(t_2 - t_1)$. The speed, v of the object, therefore can be represented as

$$v = \frac{S_2 - S_1}{t_2 - t_1} = \frac{BC}{AC}$$
 (2)

This is also the slope of s - t graph. Larger the slope of the graph more is the speed of the object. The s-t graph can also be used to estimate the speed of the object even at the times not given in the data. One can estimate these values at a time within the range of the given time interval at which the position of the object is not given in the given data (interpolation). One can similarly use the graph to obtain the values of object position and speed at a time beyond the given range of data (extrapolation). On the other hand, Eq. (1) can only be used to determine the speed at instants for which the distance is given in the data.

MATERIALS REQUIRED



Graph paper

Procedure



1. Examine the given data of distance (s) of the object at different times (t).

Table 1: The motion of a car

Sl. No.	Time, t	Distance, s
	(s)	(m)
1.	0	0
2.	1	10
3.	2	20
4.	3	30
5.	4	40
6.	5	50
7.	6	60
8.	7	70
9.	8	80
10.	9	90
11.	10	100

- Find the difference between the highest and the lowest values of each quantity (these are the ranges of the distance and time values.) Table 1 shows the data for the distance travelled by a car (in m) and the time taken (in s) by it to cover that distance. In this table the time values range from 0 to 10 s while the distance values range between 0 and 100 m.
- 2. Take a graph paper and draw two perpendicular lines OX and OY to represent x-axis and y-axis, respectively (Fig. 32.1). Measure the lengths (or count the number of divisions available) on the graph paper along the two axes. Let, for example, the graph paper you have been provided is

- 15 cm (or 15 cm divisions) along the *x*-axis and 25 cm (or 25 cm divisions) along the *y*-axis.)
- 3. Decide the quantity to be shown along the *x*-axis and that to be shown along the *y*-axis. Conventionally, time is shown along the *x*-axis and the distance along the *y*-axis.
- 4. On the basis of available divisions on the two axes and ranges of the given distance and time data, choose a scale to represent the distance along the y-axis and another scale to represent the time along the x-axis. For example, the scales for the motion of the car as given in Table 1, could be time 1 s = 1 cm; and distance 10 m = 2 cm. (Try to utilise the maximum part of the graph paper while choosing the scales.)
- 5. Mark values for the time and the distance on the respective axes according to the scale you have chosen. For the motion of the car, mark the time 1 s, 2 s, 3 s ... on the *x*-axis at every cm from the origin O. Similarly, mark the distance 10 m, 20 m, 30 m ... on the *y*-axis at every 2 cm from the origin O.
- 6. Now mark the points on the graph paper to represent each set of values for distance and time given in the data provided.
- 7. Join all the marked points on the graph paper. This is the plotting of s-t graph of the data provided for the motion of a car. Check if this graph is a straight line. A straight line graph indicates that the car is moving with a constant speed.

OBSERVATIONS AND CALCULATIONS



To find the speed of the car, take any two points on the straight line graph and find their corresponding values of t and s (as suggested in the theory part above). For convenience it is suggested to take the points that correspond to integral values of time and distance values. Suppose the coordinates of these two points are (t_1, s_1) and (t_2, s_2) . The distance travelled by the car in time interval $(t_2 - t_1)$ is $(s_2 - s_1)$. Calculate the speed of the car during this time interval $(t_2 - t_1)$ using Eq. (2).

Sl No		Value of time for the second point chosen on on the graph, t_2	Distance at time t_1 , s_1	Distance at time t_2 , s_2	Speed of the car, using Eq. (2)
	(s)	(s)	(m)	(m)	(m s ⁻¹)
1.					
2.					
3.					
4.					

In the same way determine the speed of the car for some more time intervals by choosing different sets of points on the s – t graph. Tabulate the observations.

RESULTS AND DISCUSSION



The distance-time graph for the motion of the car is a straight line graph. This indicates that the car is moving with a uniform speed. Attach the distance-time graph in your practical record book.

The average speed of the car = $_{m} s^{-1}$.

PRECAUTIONS



- Plot graph using sharp tip pencil.
- The scales chosen for representing the distance and time quantities for the motion of the car on the two axes must be so chosen that the maximum part of the graph paper is utilised. This will help in interpreting the graph better.

NOTE FOR THE TEACHER

- In this write-up a specimen set of distance-time data for the motion of the car is presented. It is suggested that students must be provided with different sets of distance-time data for a moving object for plotting *s t* graph and to determine the speed of the uniformly moving object.
- While drawing the two axes OX and OY representing the time and distance values respectively, on the graph paper, the point O should be taken slightly away from the left bottom corner of the graph paper.
- The physical quantities and their units must be properly indicated on the axes. The scaling of the quantities may also be mentioned appropriately at the top right corner of the graph paper.

APPLICATIONS

- The slope of a s t graph is a measure of speed of the moving object.
 There may be different s t graphs for different moving objects. Their slopes can give a comparison of their speeds. Larger the slope of the graph higher is the speed of the moving object.
- The *s t* graph plotted here shows the motion of the object for a given range of time interval. One can even determine the position at a time beyond the range of time interval given in the data using this graph. For this the graph should be extrapolated.

- What is the shape of the distance-time graph for an object moving with uniform speed? Name the physical quantity represented by the slope of this graph.
- What will be the s t graph for an object at rest?
- If distance-time graph plotted for an object is parallel to the time axis, what conclusion you can draw pertaining to its motion?
- Can you imagine a motion with a distance–time graph parallel to distance axis?
- In this experiment, a suggestion is made to utilise the maximum part of the graph paper. Justify the suggestion.
- State the considerations one must adhere to while choosing the scales for plotting a graph?
- What type of speed-time graph do you expect for an object moving with varying speed?

33



To plot the velocity-time (v - t) graph for an object moving with uniform accelerations from a given set of v - t data and to determine the acceleration of the moving object and the distance moved by the object.

THEORY 📚

In a straight line motion, we know that when an object moves unequal distances in equal intervals of time then the object is said to be in non-

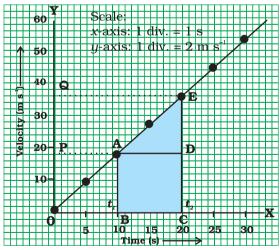


Fig. 33.1 : Velocity-time graph for a car moving with uniform acceleration

uniform motion or in accelerated motion. In such a motion the velocity of the object varies with time. It has different values at different instants and at different points of the path. The acceleration of the object is a measure of change in its velocity per unit time. If an object moving with an initial (at time 0) velocity u attains the final velocity v in time t, then the acceleration a is

$$a = \frac{v - u}{t} \tag{1}$$

If the acceleration of the object remains same at all instants of time then the object is said to be in uniformly accelerated motion. Thus the velocity-time graph of a uniformly moving object will be a straight line. Fig. 33.1 shows a velocity-time graph for a car moving with uniform acceleration. The nature of the graph shows that the velocity changes by equal amounts in equal time intervals. Thus the velocity of the car is directly proportional to the time.

In the earlier activity, we have already seen that using a distance-time graph, one can determine the velocity of a uniformly moving car at any instant. One can similarly determine the acceleration of a uniformly accelerated object by plotting its velocity-time (v - t) graph.

To find the acceleration of the moving object consider a small part AE of the v-t graph. The two lines PAD and EDC drawn parallel to x-axis and y-axis respectively, meet each other at point D to form a triangle AED. The segment AD denotes the time interval (t_2-t_1) while the segment ED corresponds to a change in the velocity of the object from v_1 to v_2 or (v_2-v_1) . The acceleration, a of the object, therefore can be represented as

$$a = \frac{v_2 - v_1}{t_2 - t_1} = \frac{ED}{DA}$$
 (2)

Thus from a given set of v – t data for an object moving under a uniformly accelerated motion, the acceleration can be computed.

One can also determine the distance moved by the moving object from its velocity-time graph. The area under the velocity-time graph gives the distance moved by the object in a given time interval. Let us look at the v-t graph for a uniformly accelerated car given in Fig. 33.1. The distance s travelled by the car in a time interval t_2 - t_1 will be given by the area ABCDE under the velocity-time graph. That is,

s = area of the rectangle ABCD + area of the triangle ADE, or

$$= AB \times BC + \frac{1}{2}(ED \times AD)$$

$$S = V_1 \cdot (t_2 - t_1) + \frac{1}{2} [(v_2 - v_1) \cdot (t_2 - t_1)]$$
 (3)

MATERIALS REQUIRED



Graph paper.

PROCEDURE



1. Examine the given data of velocity (*v*) of the object at different times (*t*). Find the difference between the highest and the lowest values of each quantity (These are the ranges of the velocity and time values.) Table 1 shows the velocity of a car (in m s⁻¹) at different instants of time. In this table the time values range from 0 to 50 s while the velocity values range between 0 and 100 m s⁻¹.

Table 1: The motion of a car

Sl. No.	Time, <i>t</i> car <i>v</i>	Velocity of the
	(s)	(m s ⁻¹)
1.	0	0
2.	5	10
3.	10	20
4.	15	30
5.	20	40
6.	25	50
7.	30	60
8.	35	70
9.	40	80
10.	45	90
11.	50	100

- 2. Take a graph paper and draw two perpendicular lines OX and OY to represent *x*-axis and *y*-axis, respectively (see Fig. 33.1). Measure the lengths (or count the number of divisions available) on the graph paper along the two axes. Let, for example, the graph paper you have been provided is 15 cm (or 15 cm divisions) along the *x*-axis and 25 cm (or 25 cm divisions) along the *y*-axis.)
- 3. Decide the quantity to be shown along the *x*-axis and that to be shown along the *y*-axis. Conventionally, time is shown along the *x*-axis and the velocity along the *y*-axis.
- 4. On the basis of available divisions on

the two axes and ranges of the given velocity and time data, choose a scale to represent the velocity along the *y*-axis and another scale to represent the time along the *x*-axis. For example, the scales for the motion of the car as given in Table 1, could be time: 5 s = 1 cm; and velocity: $10 \text{ m s}^{-1} = 2 \text{ cm}$. (Try to utilise the maximum part of the graph paper while choosing the scales.)

- 5. Mark values for the time and the velocity on the respective axes according to the scale you have chosen. For the motion of the car, mark the time 5 s, 10 s, 15 s ... on the x-axis at every cm from the origin O. Similarly, mark the velocity 10 m s^{-1} , 20 m s^{-1} , 30 m s^{-1} ... on the y-axis at every 2 cm from the origin O.
- 6. Now mark the points on the graph paper to represent each set of values for velocity and time given in the data provided.
- 7. Join all the marked points on the graph paper. This is the v t graph of the data provided for the motion of a car. Check if this graph is a straight line. A straight line graph indicates that the car is moving with a uniform acceleration.

OBSERVATIONS AND CALCULATIONS



A. Determination of Acceleration of the Object

To determine the acceleration of the car, take any two points on the straight line graph and find their corresponding values of t and v (as suggested in the theory part above). For convenience it is suggested to take the points that correspond to integral values of time and velocity. Suppose the coordinates of these two points are $(t_1, v_1, t_2, t_3, t_4, t_5)$ and $(t_2, t_2, t_3, t_4, t_5)$. Calculate the

acceleration of the car during this time interval $(t_2 - t_1)$ using Eq. (2)

$$a = \frac{v_2 - v_1}{t_2 - t_1}$$

In the same way, determine the acceleration of the car for three more time intervals by choosing different sets of points on the v – t straight line graph. Tabulate the observations.

B. Determination of Distance Moved by the Object

Using v - t graph one can determine the distance moved by the car in a

Sl. No.	Value of time for the first point chosen on the graph, t_1	Value of time for the second point chosen on on the graph, t_2	Velocity at instant t_1 , v_1	Velocity at instant t_2 , v_2	Acceleration of the car, <i>a</i> [Using Eq. (2)]
	(s)	(s)	(m s ⁻¹)	$(m \ s^{-1})$	(m s ⁻²)
1. 2. 3. 4. 5.					

given time interval. Choose a fixed time interval T, say 10 s. Using the method described in the theory part [Eq. (3)], calculate the distance travelled by the car in first 10 s. That is the distance travelled by the car between t = 0 s to 10 s. Next, calculate the distance travelled by the car in next 10 s (that is distance travelled by the car between t = 10 s to 20 s.) Calculate the distance travelled by the car in time T between different instants of time. Tabulate the calculations.

The distance travelled by the car in a given time interval can also be computed from the graph by counting squares covered under v - t graph.

Sl. No.	Initial time, $t_{_{I}}$	Final time, t_2	Velocity at time t_1 , v_1			ravelled by the interval, $(t_2 - t_1)$ By counting squares
	(s)	(s)	(m s ⁻¹)	$(m s^{-1})$	(m)	(m)
1. 2. 3. 4. 5.	0 T = 2T = 3T = 4T =	T = 2T = 3T = 4T = 5T = Time at the end of the journey			Total distance	Total distance

RESULTS AND DISCUSSION



The velocity-time graph for the motion of the car is a straight line graph sloping with the time axis. This indicates that the car is moving with a uniform acceleration. Attach the velocity-time graph in your practical record book.

The acceleration of the moving car (from the graph) = ____ m s⁻². The total distance covered by the car [from the graph, but using Eq. (3)] = ____ m; and the total distance covered by the car [by counting the squares under the v - t graph = ____ m.

It is observed that the distance travelled by the car in a given time intervals but at different instants are different. This shows that the car is in accelerated motion.

PRECAUTIONS



- Plot graphs using a sharp tip pencil.
- The scales chosen for representing the velocity and time quantities for the motion of the car on the two axes must be so chosen that the maximum part of the graph paper is utilised. This will help in interpreting the graph better.

Note for the Teacher

- It is advised that before performing this activity all students must have completed the earlier activity titled: To plot distance–time (*s t*) and graph for an object moving with a uniform velocity from a given set of *s* and *t* data and to determine the velocity of the object.
- In this write-up a specimen velocity-time data for the motion of the car is presented. It is suggested that students be provided with different sets of velocity-time data for a moving object for plotting v-t graph and to determine the acceleration of the object under uniformly accelerated motion. The distances travelled by the object between different time intervals may also be determined.
- While drawing the two axes lines OX and OY representing the time and velocity values respectively, on the graph paper, the point O should be taken slightly away from the left bottom corner of the graph paper.
- The physical quantities and their units must be properly given on the axes. The scaling of the quantities may also be mentioned appropriately at the top right corner of the graph paper.

APPLICATIONS

- The slope of a v-t graph is a measure of acceleration of the moving object. And the area under a v-t graph gives the distance travelled. One can draw several v-t graphs for different moving objects. Their slopes can give a comparison of their accelerations. Larger the slope of the graph higher is the acceleration of the moving object. Similarly larger the area under the v-t graph, more the distance travelled.
- The v-t graph plotted here shows the motion of the object for a given range of time interval. One can even determine the velocity (or acceleration) at a time beyond the range of time interval given in the data. For this, the graph should be extrapolated.

- What is the nature of the velocity-time graph for an object moving with uniform velocity? What will be the slope of this graph?
- What is the nature of the velocity-time graph for an object moving with uniform acceleration? With non-uniform acceleration?
- What will be the shape of the v t graph for an object at rest?
- What conclusion you draw if velocity-time graph plotted for an object is parallel to the time axis?
- Can you imagine a velocity-time graph parallel to velocity axis?
- Two cars run on a straight road with different uniform accelerations for 15 minutes. Thus their v-t graphs have different slopes. Which car will travel more distance?
- In this experiment it is suggested to utilise the maximum part of the graph paper. Why?
- State the considerations one must adhere to while choosing the scales for plotting a graph.

34



To study the third law of motion using two spring balances.

THEORY

The first two laws of motion tell us how an applied force changes the state of motion of an object and provide us with a method of determining the force. The third law of motion states that when one object exerts a force on another object, the second object also exerts a force back on the first. These two forces are always equal in magnitude but opposite in direction. These forces act on different objects and never on the same object. The two opposing forces are also known as action and reaction forces. Let us consider two spring balances, A and B connected together as shown in Fig. 34.1. The fixed end of balance B is attached with a rigid support, like a wall. When a force is applied through the free end of spring balance A, it is observed that both the spring balances show the same readings on their scales. It means that the force exerted by spring balance A on balance B is equal but opposite in direction to the force exerted by the balance B on



Fig. 34.1: Action and reaction forces are equal and opposite

balance A. The force which spring balance A exerts on spring balance B is called the *action* and the force of balance B on balance A is called the *reaction*. This gives us an alternative statement of the third law of motion. That is to every action there is an equal and opposite reaction. However, it must be remembered that the action and reaction always act on two different objects.

MATERIALS REQUIRED



Two identical spring balances (0 – 5 N; 0 – 500 g), weight box, inextensible thread, a frictionless pulley (which can be fixed at the edge of the table), and a pan of known mass.

PROCEDURE



- 1. Find the range and the least count of the two spring balances.
- 2. Ensure that the two spring balances are identical.
- 3. Check whether the spring balances can measure the force? If the two spring balances have the graduation markings in terms of force units well. If not, that is the spring balances have graduation markings in terms of mass only, then learn to convert it in force units as explained in the Note for the Teacher.
- 4. Hold the two spring balances vertically and ensure that their pointers are at zero mark.



Fig. 34.2: The experimental set up

- 5. Arrange two spring balances A and B, a pulley and a pan with the help of an inextensible thread, as shown in Fig. 34.2. The spring balance B must be attached to a rigid support. The spring balances may rest on the smooth table-top while the thread <u>must not</u> touch the table-top. The other end of the thread, which is attached with the pan, should also hang freely without touching the table.
- 6. What are the readings of the scales on the two spring balances? Are they equal? Is it approximately equal to the weight (w) of the pan $(m) \times$ acceleration due to gravity (g) at your place)?
- 7. Identify the action and reaction forces. The force which spring balance A exerts on B is action (reading on the scale of spring balance B). The reading on the scale of balance A shows the reaction that spring balance B exerts on A.
- 8. Put some mass M on the hanger (say 100 g). The total mass attached to the thread is now (M + m). Observe the readings of both the balances.
- 9. Repeat step 8 for at least five more masses on the pan. Tabulate your observations.

OBSERVATIONS AND CALCULATIONS



- (i) Range of the two spring balances = $_$ $_$ N or $_$ $_$ g.
- (ii) Least count of the spring balance = ___ -- __ N or ___ -- __ g.
- (iii) Acceleration due to gravity (g) at your place = = = $m s^{-2}$.
- (iv) Mass of the pan (given) $m = \underline{\hspace{1cm}} g = \underline{\hspace{1cm}} kg$.
- (v) Weight of the pan w = m (in kg) $\times g =$ ___ N.

Sl. No.	Mass on the pan, M	attac to sp	ched oring nce A	Total Weight attached to the balance A $(M + m) \times g$	S	ading spring alance A			le of t spring alanc B	3	$F_{A} \sim F_{B}$
				$F_{_{\!A}}$ $F_{_{\!B}}$			$F_{_{A}}$				
	(g)	(g)	(kg)	(N)	(g)	(kg)	(N)	(g)	(kg)	(N)	(N)
1.	0										
2.											
3.											
4.											
5.											

RESULTS AND DISCUSSION



The readings on the scales of the two spring balances are same. It means the action force; exerted by the spring balance A on B is equal to the reaction force (exerted by the spring balance B on A). Thus the action and reaction forces are equal and opposite and act on different objects. This verifies the third law of motion.

In case if the readings on the scales of the two spring balances are approximately same (that is, not exactly same), discuss the reasons.

Precautions



- Before making use of the two spring balances it should be ensured that their pointers are at zero mark.
- The readings of the two spring balances should be noted only when their pointers come to rest.
- Select spring balances having uniform and evenly spaced calibration marking.
- The thread used in experiment should be inextensible lest the stretch in the string may change the force on the spring balances.

Note for the Teacher

- In order to make use of spring balances properly, it is advised that before performing this experiment students may be given proper grooming in the use of spring balance (see Experiments 3 and 4).
- The purpose of this experiment is to elucidate the third law of motion. In order to give avoid unnecessary importance to the measuring skills, it is advised that the mass of the pan may be provided.
- A spring balance is primarily meant for measuring the weight (force) of an object. However in laboratories, a spring balance is often used to measure the mass of an object. It should be remembered that the calibration of spring balance scale is done at the place of its manufacture and depends on the value of acceleration due to gravity (*g*) at that place. Therefore, if a spring balance is used to measure mass at any other place where the value of *g* is different, an error in the measurement of mass will appear. In this experiment however, if the two spring balances are identical then this error will not matter because here we use spring balances to compare the forces due to gravity.

• In this experiment we intend to study the third law of motion, which is about the action and reaction forces. It is therefore important to measure forces rather than the masses. It is therefore suggested to use the spring balances which also measure weight (force) in N. In case such spring balances are not available and students are compelled to make use of spring balances that denotes mass readings only, then suggest them to take mass readings correctly. The mass readings then can be multiplied by the value of the acceleration due to gravity (g) at the place where the experiment is being performed.

APPLICATIONS

Look for some examples from your daily life where you can see application of third law of motion. How do we move on the road? Identify the pair of action and reaction forces. Do they produce accelerations of equal magnitudes on the two objects involved?

- Why do we find it difficult to move on sand?
- When a horse pulls a cart, according to the third law of motion, the cart also pulls the horse in opposite direction with equal force. Why does the horse-cart system move at all then?
- A spring balance is calibrated in mass. Does it measure mass or weight?
- A spring balance is calibrated in grams at Kolkata (say). The mass
 of an object measured from this balance at New Delhi is 60 g.
 What is the accurate mass of this object? What mass of the object
 will be shown by this spring balance on the surface of the moon?
- In one of the experimental observations with a good spring balance, the mass of an object was found to be 495 g. However the accurate mass of this object was 500 g. How will you explain this observation? Does it go against the third law of motion?



To study the variation in limiting friction with mass and the nature of surfaces in contact.

THEORY 👺

Whenever an object is made to slide over another surface by applying a force, the force of friction (or simply friction) opposes its motion. The force of friction acts in a direction opposite to the direction of the applied force. As the force applied on the object is increased, the force of friction also increases accordingly to balance it. The net force on the body remains zero and it doesn't move. However, the force of friction can increase only up to a certain limit. Once the applied force is increased beyond this limit, an unbalanced force acts on the object and it begins to move. The maximum value of force of friction, acting between the two solid surfaces just before the object sets into motion is called *limiting force of friction* (or simply *limiting friction*).

To study the dependence of limiting friction on the mass of an object, you will need an arrangement to measure the force applied on the object and find the force that is just sufficient to make it move on the surface. One such arrangement is shown in Fig. 35.1. In this arrangement, one end of a string is fixed to the object to be moved while its other end has a pan attached to it. The string passes over a frictionless pulley such that the pan remains suspended freely in air. When a weight is kept on the pan, a force acts on the body in the horizontal direction through the string. If the

weight of the pan is equal to the *limiting friction*, the object starts sliding. Thus,

Limiting friction = Force exerted through the string

= Mass of the pan and the mass of extra weights placed on it × acceleration due to gravity (g)

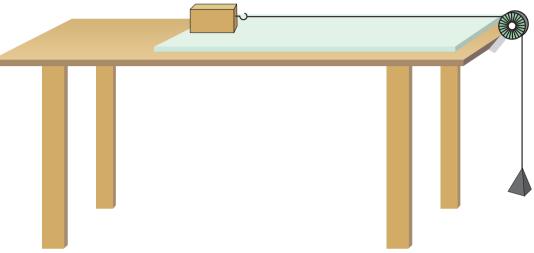


Fig. 35.1 : Experimental set up to study variation in limiting friction with the mass of the object suspended

MATERIALS REQUIRED



A wooden block with a hook, horizontal plane, two different plane top surfaces (such as glass top, a wood mica top or a hard board), a frictionless pulley (which can be fixed at the edge of the plane), a pan of known mass, a spirit level, weight box including forceps, spring balance, a string, and ten pieces of mass (say each of 100 g).

PROCEDURE



- 1. Place a clean glass sheet on the top of a table. Make the surface horizontal with the help of a spirit level. To make the glass top horizontal, pieces of paper or cardboard may be inserted below it.
- 2. Find the range and the least count of the spring balance.
- 3. Measure the mass of wooden block having hook (*M*) using a spring balance.
- 4. Fix the pulley at the edge of the table as shown in Fig. 35.1.
- 5. Tie one end of the string to the pan and other end to the hook of the block.
- 6. Place the wooden block on the horizontal glass top and pass the string

over the pulley as shown in Fig. 35.1. Make sure that the portion of string between the pulley and the wooden block is horizontal and does not touch the table-top anywhere. For this adjust the height of pulley so that its top is at the same level as the hook fixed to the wooden block.

- 7. Put a small mass (*p*), say 20 g, on the pan from the weight box. Gently tap the glass surface and observe whether it makes the block move. Increase or decrease the mass on the pan in steps till the wooden block just begins to slide on gently tapping the glass top surface. Note the mass kept on the pan.
- 8. Remove the mass from the pan and move the block to the same positon as before.
- 9. Put some mass (q), say 200 g, on the wooden block. Find out the mass required to be kept on the pan that is just sufficient to make the wooden block (together with the mass q) slide over the glass top surface. Note the mass kept on the pan.
- 10. Repeat the activity by putting different mass on the top of the wooden block and note the mass required (to be placed on the pan) to make it slide in each case.
- 11. Replace the glass top with any other surface such as wood mica, hard board and repeat the steps 6 to 10 and record your observations.

OBSERVATIONS AND CALCULATIONS



Record the observations for two different surfaces in different tables.

(i)	Range of the spring balance	=	g
(ii)	Logge count of the engine belonge		ď

- (ii) Least count of the spring balance = ____ g
- (iii) Mass of the wooden block with hook, M =______ g
- (iv) Mass of the pan, m (given) = ____ g(v) Acceleration due to gravity at your place = ____ m/s^2
 - Table 1 : Sliding of Wooden Block on Surface 1 (Glass Top)

	. Mass on the . wooden block, <i>q</i>			Mass on pan, required to make the wooden block slide on glass top, <i>p</i>	Total ma		Limiting friction = Weight of the pan = $(m + p)g$
	(g)	(g)	(kg)	(g)	(g)	(kg)	(kg m/s 2) or (N)
1. 2. 3.	-						

Table 2: Sliding of Wooden Block on Surface 2 (Wood Mica Top)

Sl. No.	Mass on the wooden block, q	Total mass of wooden block = $M + q$		Mass on pan required to make the wooden bloc slide on wood mica top, p			Limiting friction = Weight of the pan = $(m + p)g$
	(g)	(g)	(kg)	(g)	(g)	(kg)	(kg m/s 2) or (N)
1.							
2.							
3.							

RESULTS AND DISCUSSION



- The limiting friction increases with the increase in weight of the object sliding on a given surface.
- The value of limiting friction changes with the change in the nature of surfaces in contact. Friction between _____ and ____ surfaces is more than friction between _____ and ____ surfaces.

Precautions \$\square\$



- Since the friction at the pulley affects the value of limiting friction, the pulley should be as smooth as possible.
- The string should be inextensible.
- The portion of the string between the pulley and wooden block must be horizontal.
- The surface of plane (glass, wood mica, hard board etc.) and the wooden block in contact must be clean and dry.
- The pan should be attached with the string in such a manner that it remains horizontal when it is suspended freely with no mass on it.
- Whenever a mass is added to the pan, tapping on horizontal plane surface (glass, wood mica, hard board etc.) should be done very gently to check whether the block just moves or not.
- Forceps should be used while handling the weights. Ensure that mass does not slip down as the pan moves.

Note for the Teacher

- Give practice to the student for the use of spring balance (Experiments 3 and 4).
- The purpose of this experiment is to understand the phenomenon of limiting friction. It is advised that the mass of the pan (m) and that of the wooden block (M) may be provided.
- The portion of string that lies between the pulley and wooden block should remain horizontal. For this the position of pulley fixed on one end of a table may have to be adjusted (in accordance to the thickness of plane surfaces and the position of the sliding wooden block).
- It is important to make a judicious choice of the size of the block and set of mass for this experiment. If the block is too light, the force of limiting friction may be even less than the weight of the empty pan and in this situation the observations cannot be taken with the block alone. Similarly, the maximum mass of the block, which can be varied by putting a given set of mass on it, should not be so large that a large mass is required to be kept on the pan to make the wooden block slide.

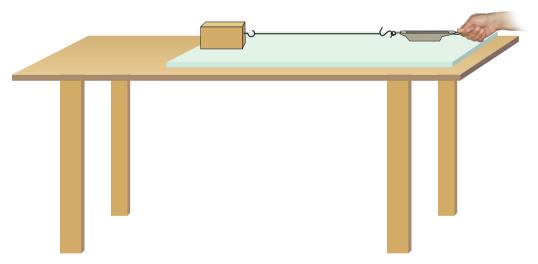


Fig. 35.2: An alternate arrangement (improvised) to study the limiting friction

• In case a pulley is not available or cannot be positioned properly, a spring balance may be used to measure the force required to make the block move. Tie one end of the string with the wooden block and its other end with the hook of the spring balance. The length of the string should be such that the spring balance could be held at one end of the table while the wooden block is kept near the other end of the horizontal plane surface (Fig. 35.2). Here too, the string should

be kept horizontal while the force is applied on the block. Now apply a small force on the wooden block by pulling the spring balance. Gradually increase the force till the block begins to slide on the horizontal surface. Note that the spring balance shows a larger value of force just before the wooden block begins to slide. This maximum reading of the spring balance gives the value of limiting friction. If the given spring balance is calibrated in newtons, the force can be measured directly. However, if it is calibrated in kilograms, then the measured value has to be multiplied with the acceleration due to the gravity.

- Why is use of a frictionless pulley advised?
- In this experiment, what will happen if the weight of the empty pan is more than the limiting friction between the surface and the wooden block you are using?
- In which direction the force of friction acts on the block?
- Why is the thread used to move the block kept horizontal to the surface and the wooden block you are using?
- How is limiting friction between two surfaces in contact affected when grease or oil is put between them?
- A 100 g block slides when tension in the string is *x* N. What will be the tension in the string when an identical block is placed at top of the first block?
- The two blocks mentioned in above question are connected and placed on the same surface. What would be the tension in the string now?
- How can you use the concept of limiting friction to measure a force?
- In the above experiment as the block slides over the surface a sound is heard. Can you explain the reason for the sound produced?

36



To verify Archimedes' principle.

THEORY 👺

Archimedes' principle, also called law of buoyancy, states that any object that is completely or partly immersed (or submerged) in a fluid at rest is acted on by an upward (or buoyant) force. The magnitude of this force is equal to the weight of the fluid displaced by the object. The volume of the fluid displaced is equal to the volume of the portion of the object submerged. Here in this experiment we shall make an attempt to verify this principle by submerging a solid object in water.

MATERIALS REQUIRED



An overflow-can, a wooden block, a measuring cylinder (100 mL and preferably with a least count of 1 mL), a spring balance, a solid object (a stone or a metallic block of size that can be easily lowered in the overflow-can), laboratory stand, and a piece of silk thread.

PROCEDURE



1. Find the range and least count of the spring balance and the measuring cylinder. In case the spring balance is calibrated in newton (N), note its range and the least count in N.

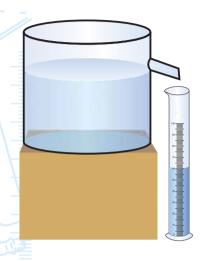


Fig. 36.1(a): The overflow-can and measuring cylinder assembly

- 2. Place an overflow-can on a wooden block and fill it with tap-water until the water begins to flow from its spout. Wait till the last drop of excess water flows out. This is to ensure that the level of water in the can is up to its brim.
- 3. Place an empty measuring cylinder under the spout of the overflow-can to collect water [Fig. 36.1(a)].
- 4. Tie the given solid with a thread and suspend it from the hook of spring balance. Clamp the spring balance with a laboratory stand such that the solid is suspended freely in air as shown in Fig. 36.1(b). Note the reading of the spring balance.
- 5. Lower the solid into the water in the overflow-can such that a part of it, say less than half of it gets immersed in water. Let the water displaced by the solid in the overflow-can flows out form its spout and gets collected in the measuring cylinder placed below (as shown

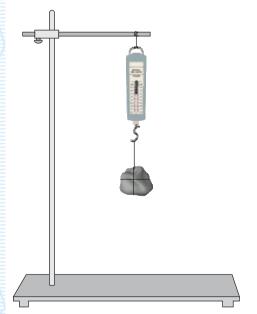


Fig. 36.1(b) : Measuring the weight of the object in the air

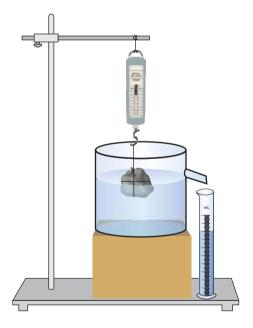


Fig. 36.1(c): Measuring the weight of the object when it is immersed in water

in Fig. 36.1(c). Wait till the water stops dripping out from the overflow-can. Note the volume of the water collected in the measuring cylinder.

- 6. Note the reading of spring balance while the solid is partly immersed in water and the dripping of water has stopped. This corresponds to the weight of the solid when it is partly immersed in water.
- 7. Lower the solid further into the water (but do not let it immerse completely) in the overflow-can. Let the displaced water be collected in the measuring cylinder as before and note the new volume of water. Note the reading of the spring balance as you did before in step 6.
- 8. Next, lower the solid further into the water till it gets completely immersed in it. Again note the volume of water collected in the measuring cylinder and the reading of the spring balance.
- 9. As a courtesy to your fellow students, clean the table as some water might have been spilled on the table while performing this experiment.

			1	
Ов	SERVATIONS AND CALCULATIONS	A		
(i)	Range of the spring balance	=	_ g =	N
(ii)	Least count of the spring balance	=	_ g =	_ N
(iii)	Range of the measuring cylinder	=	_ mL	
(iv)	Least count of the measuring cylinder	=	_ mL	
(v)	Weight of solid in air, W_0	=	_ N	
	[or W_0 = mass of solid in air, m_0 (in kg) ×			
	acceleration due to gravity g (in m/s ²)]			
(vi)	Density of water, ρ (given)	=	_ g/mL	
vii)	Acceleration due to gravity (g) at your place	=	$_{\rm m/s^2}$.	

	greater	1 0	measuring	Weight of water collected in the measuring cylinder (buoyant force), $W_w = V_{Tap} \times \rho \times g$	Difference in apparent loss in weight and the weight of displaced water $W \sim W_w$
	(N)	(N)	(mL)	(N)	(N)
1.					
2.					
3.					
4.					

RESULTS AND DISCUSSION



The difference between the apparent loss in weight of the solid when immersed in water and the weight of water displaced is negligibly small (_____ N). In each case the observed value of the apparent loss in the weight of solid immersed in water is nearly equal to the weight of displaced water. This verifies Archimedes' principle.

PRECAUTIONS AND SOURCES OF ERROR



- The graduation marks on the measuring cylinder and on spring balance should be evenly spaced.
- The impurities present in the water may alter its density.
- The solid used should be non-porous otherwise it will absorb some water. Absorption of water by the solid may affect the change in its weight and the volume of water displaced by it.
- The density of solid should be larger than that of water so that it sinks in water.
- The measuring cylinder must be kept on a horizontal surface and the line of sight should be at the same level as that of the lower meniscus of water while recording the volume of displaced water.
- Before reading the liquid meniscus in the measuring cylinder, it must be ensured that there is no air bubble inside the liquid.
- The readings of the spring balance should be taken only after its pointer comes to rest. If the spring balance has some zero error then it must be noted before taking measurements and the same should be taken into account while using the spring balance.
- The thread used in this experiment may also absorb some water.

Note for the Teacher

- Experiment 37 "To establish the relation between the loss in weight of a solid when fully immersed in (i) tap water; (ii) strongly salty water, with the weight of water displaced by it by taking at least two different solids" and this experiment have some-what similar objectives and procedure. It is therefore advised that students may be asked to perform only one of these two experiments.
- In case, an overflow-can is not available, a large size-beaker with a spout may also be used.

- Why does the pointer of a spring balance move up when the stone suspended from it is immersed in water?
- State the factors on which buoyant force acting on an object immersed in a fluid depend.
- What will be the effect on the apparent loss in weight of a stone if it is immersed in salty water instead of tap-water?
- State two precautions that should be observed while making use of an overflow-can.
- An object suspended from a spring balance is gradually lowered in an overflow-can. What will be the change in the apparent loss in the observed weight as the object is immersed in water?
- What is a fluid? Is it different from a liquid or from a gas or from a solid?

37



To establish the relation between the loss in weight of a solid when fully immersed in (i) tap water; (ii) strongly salty water, with the weight of water displaced by it by taking at least two different solids.

THEORY 📚

When a solid object is immersed in water, there is a loss in its weight. This loss is equal to the weight of the water displaced. In this experiment we shall appreciate this relationship by immersing two different solid objects in tap-water and in strongly salty water.

MATERIALS REQUIRED



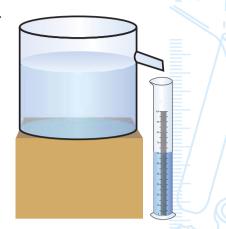
An overflow-can, a wooden block, a measuring cylinder (100 mL and preferably with a least count of 1 mL), a spring balance, two small different solid non-porous objects, laboratory stand, tap-water and strongly salted water of known densities, and a piece of silk thread.

PROCEDURE



- 1. Find the range and the least count of the spring balance and measuring cylinder.
- 2. Hold the spring balance vertically and ensure that its pointer is at zero mark.

- 3. Check whether the spring balance can measure the weight? If it has the graduation markings in terms of force units, that is N -- well. If not, that is the spring balances have graduation markings in terms of mass only, then convert it in weight by multiplying the mass with the acceleration due to gravity at your place.
- 4. Place an overflow-can on a wooden block and fill it with tap-water until the water begins to flow from its spout. Wait till the last drop of excess water flows out. This is to ensure that the level of water in the overflow-can is up to its brim.
- 5. Tie one of the two given solid objects with a thread and suspend it from the hook of spring balance. Clamp the spring balance in a laboratory stand such that the solid Fig. 37.1(a): The overflow can is suspended freely in air. Measure its mass (m_{12}) or its weight (w_{la}) in air [Fig. 37.1(b)].
- 6. Place an empty measuring cylinder under the spout of the overflow-can to collect water [Fig. 37.1(a)].



and measuring cylinder assembly

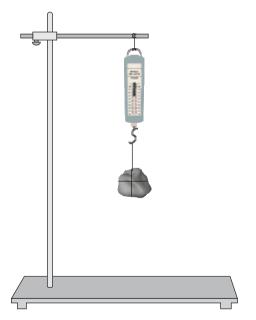


Fig. 37.1(b): Measuring the weight of the object in the air

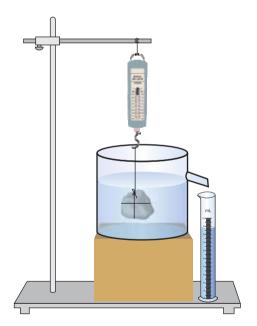


Fig. 37.1(c): Measuring the weight of the object when it is immersed in water

7. Bring the laboratory stand (clamped with the spring balance and the solid object) over the tap-water filled overflow-can. Immerse the solid fully into the tap-water in overflow-can, as shown in Fig. 37.1(c).

- 8. Collect the water displaced by the solid in the overflow-can that flows out from its spout in measuring cylinder. Wait till the water stops dripping out from the overflow-can. Note the Volume $V_{\it Tap}$ of water collected in the measuring cylinder.
- 9. Note the reading of spring balance to get the mass $(m_{_{ITap}})$ or the weight $(w_{_{ITap}})$ of the solid in tap-water. Record your observations.
- 10. Repeat step 3 onwards for second solid object.
- 11. Repeat the whole procedure for strongly salted water in place of tapwater. Do you observe difference in your readings?

OBSERVATIONS AND CALCULATIONS



-- _ N or _ --

- (i) Range of the spring balance
- (ii) Least count of the spring balance
- (iii) Acceleration due to gravity (g) at your place
- = $_{n} N \text{ or } _{n} g$ = $_{n} m s^{-2}$

(iv) Other Values:

Sl. No.	First/ Second	$\begin{array}{c} \text{Solid obje} \\ \text{Mass in air,} \\ m_{_{a}} \end{array}$		Ŭ				ensity of Strongly salty water, $\rho_{\rm SSW}$	
		(g)	(kg)	(N)	g/mL	kg/m³	g/mL	kg/m³	
1.	First								
2.	Second								

A. For tap-water

	Solid Object	spi wh obj im	ring b en th ject is	palance ne solid s fully ed in	Loss in weight of the solid when fully immersed in tap water, W_{STap}	-	ater ted in uring	Weight of tap water collected in measuring cylinder, $W_{WTap} = V_{Tap} \times \rho_{Tap} \times g$	Difference in loss inweight of solid and weight of displaced tap water $W_{STap} \sim W_{WTap}$
	First/ Second	Ma	iss	Weight W_{Tap}					
		(g)	(kg)	(N)	(N)	(mL)	(m³)	(N)	(N)
1.	First								
2.	Second								

3 7 7									
	Solid Object	spri whe obje imn	ing ben the ct is nerse ongly	alance	Loss in weight of the solid when fully immersed in strongly salty water $W_{\rm SSSW}$	stron salty collec	water cted in curing	Weight of strongly salty tap water collected in measuring cylinder, $W_{WSSW} = V_{SSW} \times \rho_{SSW} \times g$	Difference in weight of loss of solid and weight of displaced strongly salty water $W_{SSSW} \sim W_{WSSW}$
	First/ Second	Mas	SS	Weight W_{SSW}					
		(g)	(kg)	(N)	(N)	(mL)	(m ³)	(N)	(N)
1. 2.	First Second								

B. For strongly salty water

RESULTS AND DISCUSSION



The loss in weight of both the solids used in this experiment when fully immersed in tap and strongly salty water are equal (or approximately equal) to the weight of water displaced by them, respectively.

For a given solid, the weight of water displaced by it when immersed fully in strongly salty water is more than the weight of the water displaced when fully immersed in tap-water. Thus larger the density of liquid in which the solid is immersed, larger the weight of liquid displaced or larger the upward (or buoyant) force.

PRECAUTIONS AND SOURCES OF ERROR

- Before making use of the spring balance it should be ensured that its pointer is at zero mark.
- Ensure that the spring balance hangs vertically with the laboratory stand.
- The solid objects used should be non-porous otherwise they will absorb some water. This may affect the apparent change in its weight and the volume of water displaced by it.
- The density of solid should be larger than that of liquid so that it sinks in it.
- The measuring cylinder must be kept on a horizontal surface and the line-of sight should be at the same level as that of the lower meniscus of water while recording the volume of displaced water.
- Before reading the water meniscus in the measuring cylinder, it must be ensured that there is no air bubble inside the water.
- The readings of the spring balance should be taken only after its pointer comes to rest. If the spring balance has zero error then it must be noted before taking measurements and the same should be taken into account while using the spring balance.

- The graduations mark on the two spring balances may not be evenly spaced.
- The impurities present in the water may alter its density.
- The thread used in experiment may also absorb water to introduce some error.

Note for the Teacher

- The earlier experiment: "To verify Archimedes' principle" and this experiment have some-what similar objectives and procedure. It is therefore advised that students may be asked to perform only one of these two experiments.
- In case an overflow-can is not available, a large size beaker with a spout may also be used.
- Students may be provided tap water and strongly salty water separately. The density of salty water may also be provided. In case if the density of salty water is not provided then students can be asked to prepare strongly salty water by dissolving a known quantity of salt in known volume of tap water (to calculate the density of strongly salty water).
- Thread used for tying the solid objects may absorb some water to cause error. It is therefore suggested that cotton thread be not used instead a silk thread may be used.
- If the density of any solid object is less than the density of water then a sinker can be used to perform the experiment.

APPLICATIONS

This method can be used to determine the density of any liquid.

- Why is it easier to swim in sea-water rather than a swimming pool or river water?
- In which liquid—glycerin or kerosene—the loss in the weight of a solid object when fully immersed in it will be more?
- How can you perform this experiment for a solid whose density is lesser than that of the liquid used?
- What are the limitations of this experiment?
- Using this method, how would you find the density of a liquid?
- How will you select solid to perform this experiment using glycerin instead of water?



To plot temperature-time graph for a hot object as it cools.



A hot object loses heat to its surroundings in the form of heat radiation. The rate of loss of heat depends on the difference in temperature between the object and its surroundings.

MATERIALS REQUIRED



A calorimeter (500 mL) with a stirrer, a lid for the calorimeter with two holes in it, a thermometer ($-10~^{\circ}\text{C}-110~^{\circ}\text{C}$), a stop-watch or stop-clock, spirit lamp or gas burner, tripod stand with wire gauze, a laboratory stand, water and a piece of thread.

PROCEDURE



- 1. Find the range and least count of the thermometer.
- 2. Hold the thermometer vertically in air and note the room temperature.
- 3. Take about 300 mL of water in the calorimeter with a stirrer and cover it with two-holed lid. Fix a thermometer through a hole in the lid (Fig. 38.1). Make sure that the bulb of thermometer is immersed in the water.

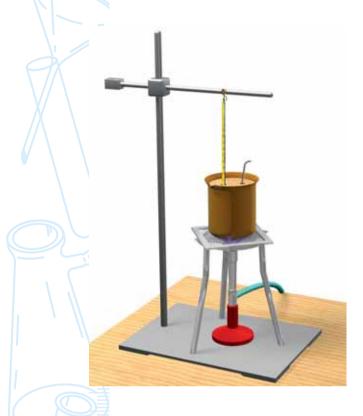


Fig. 38.1: Heating of water in a calorimeter

- 4. Place the calorimeter over the wire gauze on the tripod stand and heat it with a spirit lamp or a gas burner.
- 5. Heat the water till it attains a temperaure nearly 40 °C above the room temperature (temperature of the surroundings). Stop heating the water.
- 6. Switch on the stop-watch or stop-clock. Note the reading of the thermometer after fixed intervals of time. One can read the thermometer initially after every one minute and after every two minutes once the temperature of water falls down to nearly 10 °C above the room temperature. In order to maintain uniform temperature of the water in the calorimeter, keep it stirring gently with the stirrer.
- 7. Continue to note the temperature of water till it attains a temperature about 5 °C above that of the surroundings (room temperature).

OBSERVATIONS AND CALCULATIONS



Room temperature (temperature of surroundings), $\theta_1 =$ ___ $^{\circ}$ C = ___ K.

Sl. No.	Time, t	Temperature of water	Temperature difference, θ
	(minute)	θ ₂ (°C)	$= \theta_2 - \theta_1(^{\circ}C)$
1.			
2.			
3.			
••			
••			
9.			
10.			

GRAPH

Study the range of variation in the values of temperature difference θ and that of time t. Choose appropriate scales for the temperature and time to plot a graph between them. Draw x and y-axis on the graph paper. Take θ along the y-axis and time t along the x-axis. Plot the points on the graph for each value of temperature difference θ and the corresponding value of time t. Join all the points with as smooth (without pointed edges) a curve as possible. It is likely that a smooth curve may not be obtained by joining all points on the graph. However, a smooth curve can be drawn by joining as many points as possible. Do not bother even if some points are left out on either side of the curve drawn (Fig. 38.2).

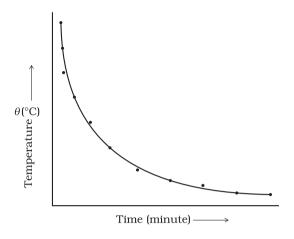


Fig. 38.2 : Curve showing cooling of hot water with time

RESULTS AND DISCUSSION



Study the curve obtained on plotting the graph. From the graph infer as to how the cooling of hot water depends on the difference of its temperature with that of the surroundings. Remember that a curve nearly parallel (or close to it) to the y-axis shows that cooling is quick (that is, rate of cooling is high). While the curve nearly parallel (or close to it) to the x-axis shows that cooling is slow (that is the rate of cooling is slow).

PRECAUTIONS



- The initial temperature of hot water in calorimeter should be about 40 °C above the temperature of surroundings (the room temperature).
- The water in the calorimeter should be gently stirred all the times during the experiment.
- The calorimeter should be covered properly to avoid (or to minimise) loss of heat by water due to convection or evaporation.
- The scale for drawing the graph should be chosen such that all the observed values could be accommodated easily. The curve drawn should not only be continuous and smooth but care should also be taken to ensure that it passes through maximum number of points in such a manner that nearly equal number of remaining points lie on either side of it. In some cases the smooth curve may be such that nearly all points lie outside it.

NOTE FOR THE TEACHER

- Blackening of calorimeter from outside will reduce the cooling of hot water by conduction. Therefore, use of blackened calorimeter should be preferred.
- In case a calorimeter is not available, then a beaker with its outer surface painted black may be used instead of a calorimeter.
- Experiments 32 and 33 provide a good practice in plotting graphs. It is therefore advised that students must first perform either of these two experiments.

- Why does the temperature fall rapidly when we start reading the temperature of given hot water in this experiment?
- Why is the calorimeter covered with a lid while performing the experiment?
- Why do we prefer to keep the calorimeter on an insulating surface while performing the experiment?
- Why does the temperature fall slowly when the temperature of hot water in the calorimeter approaches the room temperature?
- Why do we prefer to use a calorimeter whose outer surface is blackened?
- For a given hot liquid, the θ t graph is parallel to time axis. What inference do you draw from such a graph? (*Caution: This situation may not be real one.*)
- What would you infer from a temperature time graph that is parallel to temperature axis?
- In this experiment you might have observed that initially the temperature of hot water falls rapidly. But as the temperature of water comes close to the temperature of surroundings, the fall of temperature becomes rather slow. How?



To study the effect of amplitude on the time period of a simple pendulum.

THEORY 🛬



A simple pendulum consists of a small object of heavy mass, called the pendulum bob, suspended by a light inextensible thread from a fixed and rigid support [Fig. 39.1(a)]. When the bob P is released after taking its free end P slightly to one side (say to point R), it begins to oscillate about its mean position O [Fig. 39.1(b)]. The time taken by the pendulum to complete one oscillation is called its time period. The maximum departure of the pendulum from its mean position (or half the length of the swing) is called its amplitude. Does the time period of a simple pendulum depend on its amplitude? In this experiment we shall attempt to explore it.

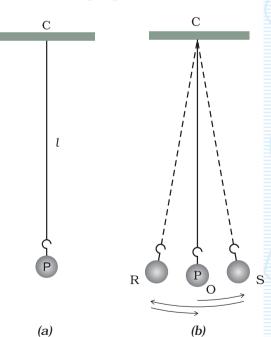


Fig. 39.1: (a) A simple pendulum; and (b) Different positions of the bob of an oscillating simple pendulum and a complete oscillation

MATERIALS REQUIRED



A heavy iron stand, a cork (split along length through middle), an inexstensible thread of about 1.5 m length, a metallic spherical bob of known radius, a stop-watch (or a stop clock), a large size protractor, and a meter scale.

Procedure 1/2



- 1. Find the least count of the given stop-watch or stop clock.
- 2. Tie one end of an inextensible thread of nearly 1.5 m length with a pendulum bob and pass the other end of thread through the split cork as shown in Fig. 39.2(a).
- 3. Clamp the cork firmly to a heavy iron stand and place it on a horizontal table. The pendulum must over-hang the table.
- 4. Fix a large size protractor just below the split cork such that its 0° -180° line is horizontal so that the pendulum, hanging vertically, coincides with the 90° line of the protractor. Also ensure that the centre of the protractor lies just below the point C of suspension of

the pendulum in its rest position

[Fig. 39.2(b)].

 A_5 A_4 A_3 A_2 A_1 M B_1 B_2 B_3 B_4 B_5 (b)

Fig. 39.2: (a) A simple pendulum fixed in a split cork; and (b) Experimental set up for studying the variation in the time period of pendulum with a change in its amplitude

- 5. Adjust the effective length of the pendulum, L, to any desired length (say 1 m). The effective length of pendulum is measured from the point of suspension (the lowest point on the split cork from which the bob suspends freely) to the centre of mass of the pendulum bob (which in the case of a spherical object is at its geometric centre), that is, length CP in Fig. 39.2(a). The length of the can be increased (or pendulum decreased) by pulling down (or up) the thread through the split cork after slightly loosening the grip of the clamp. Note the length of the simple pendulum.
- 6. Draw two lines on the surface, one parallel to the edge of table (AB) and other perpendicular to it (MN) such that the two intersect at the point O [Fig. 39.2(b)].
- 7. Adjust the position of the laboratory stand and the height of the clamp

(a)

L

- such that the point of intersection, O, of lines AB and MN lies exactly below and very close to the centre of bob in its rest position.
- 8. Divide line AB through equal divisions of 4 cm each (say) on both sides of the point O.
- 9. Gently hold the pendulum bob P just above the point O. Keeping the thread stretched, displace the bob to the first division point OA_1 (or OB_1) on line AB in either side of mean position (O). Also check the angular displacement of the bob on the protractor attached at the top of pendulum C, with the clamp. Release the bob so that it begins to oscillate about its mean position. What is the amplitude of the oscillating pendulum? It is the maximum departure (point A_1 or B_1) of the pendulum from its mean position (point P or O). Thus the amplitude of the simple pendulum is OA_1 (or OB_1). Measure the amplitude and angular displacement and record them in observation table.
- 10. Observe the time taken for appreciable number of oscillations n (say, 10 oscillations) with the help of a stop-watch or stop-clock. Record the time taken for n oscillations in the observation table.
- 11. Bring the pendulum at rest in its mean position. Displace the pendulum bob to the twice of the distance displaced earlier. Record the amplitude and angular displacement of the pendulum. Repeat step 10 for recording the time taken for *n* number of oscillations.
- 12. Repeat step 11 for more values of amplitude (and angular displacements) and record the time taken for *n* number of oscillations in each case.
- 13. Calculate the time period of the simple pendulum in each case.

OBSERVATIONS AND CALCULATIONS



(ii) Diameter of the pendulum bob, d

(iii) Radius of the pendulum bob, r = d/2

(iv) (Length of the thread + length of hook (if any), I

(v) Effective length of the simple pendulum, L = l + r

= ___ cm l = ___ cm l + r) = ___ cm

= cm

= ___ m.

Sl. No.	Amplitude of the pendulum	Angular displacement	Number of oscillations	Time taken in <i>n</i> oscillations,	Time period $T = t/n$
	a	θ	n	t	
	(cm)	(°)		(s)	(s)
1.	4				
2.	8				
3.	12				
4.	16				
5.	20				
6.	25				

GRAPH

Plot a graph between the amplitude of the pendulum, a, and time period, T for a fixed effective length of the pendulum, L. Take a along y-axis and T along x-axis. Smoothly join all the points. Attach the graph with observations.

RESULTS AND DISCUSSION



From the observation table and graph we may infer about the relation between the amplitude of simple pendulum and its time period.

You may discover that for smaller amplitudes (corresponding to angular displacements, $\theta \leq 10^{\circ}$), the time period is independent of amplitude. But for larger amplitudes (or for larger angular displacements) the time period of the pendulum changes with amplitude.

(Why is the time period independent of amplitude for smaller amplitudes and not for larger amplitudes? You will study this in higher classes.)

Precautions



- Effective length and mass of the bob of simple pendulum must be kept same for all measurements.
- Thread used must be light, strong and inextensible. An extension in the thread will increase the effective length of the pendulum. There should be no kink or twist in the thread.
- The pendulum support should be rigid. For this take a laboratory stand with heavy base.
- The split cork should be clamped keeping its lower face horizontal.
- During oscillations the pendulum should not touch the edge of the table or the surface below.
- The bob must be released from its displaced position very gently and without a push otherwise it may not move along the straight line AB. In case you notice that the oscillations are elliptical or the bob is spinning or the bob is jumping up and down, stop the pendulum and displace it again.
- At the place of experiment, no air disturbance should be present. Even all the fans must be switched off while recording the observations.
- Counting of oscillations should begin when the bob of the oscillating pendulum passes its mean position.

NOTE FOR THE TEACHER

- To simplify the experiment, the values of diameter or radius of the pendulum bob and length of hook may be provided to students.
- If it is found that the experiment is taking too much time, then the measurements of angular displacements may be skipped.
- Practically the amplitude may decrease in each swing of the pendulum with time. Thus the pendulum will not keep on oscillating for a long time. Therefore counting of the number of oscillations for measuring the time taken should be stopped before the amplitude of oscillation becomes too small. It is therefore advised that number of oscillation (n) for which time is noted should be small (say n = 10).
- A large size protractor can be improvised on a cardboard.

- Discuss how does the time period of a pendulum of fixed length vary with a change in the amplitude of oscillation?
- Observe a simple pendulum swinging with some appreciable amplitude. Does its amplitude remain constant? Discuss your findings after 10 oscillations?
- Two students perform this experiment in two different conditions, namely (i) in the school laboratory, and (ii) in vacuum, respectively. Which of the students is more likely to get better result? Discuss it
- What makes a simple pendulum oscillate when it is displaced and then released from its mean position?
- What are the factors, which are responsible for the dying out of oscillations of a simple pendulum?
- What will happen if bob of pendulum touches the edge of the table?
- While determining the time period of a pendulum why do we prefer to measure time for about ten oscillations?
- Observe Fig. 39.2(b). Locate the positions where the speed of bob is minimum and maximum. Also discuss the kinetic and potential energies of the pendulum at these points.
- Can you imagine a situation in which the time period of a simple pendulam becomes infinite?



To study the variation in time period of a simple pendulum with its length.

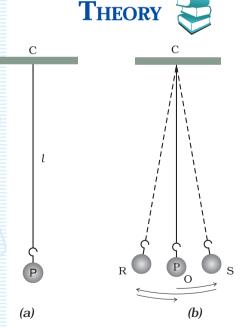


Fig. 40.1: (a) A simple pendulum; and (b) Different positions of the bob of an oscillating simple pendulum and a complete oscillation

A simple pendulum consists of a small object of heavy mass, called the pendulum bob, suspended by a light thread from a fixed and rigid support [Fig. 40.1(a)]. When the bob CP is released after taking its free end P slightly to one side (say to point R), it begins to oscillate about its mean position O [Fig. 40.1(b)]. The time taken by the pendulum to complete one oscillation is called its time period. The time period of a simple pendulum depends on the length of the simple pendulum. In this experiment we shall attempt to establish a relationship between the length of the simple pendulum and its time period.

MATERIALS REQUIRED



A heavy iron stand, a cork (split along length through middle), an inexstensible thread of about 1.5 m length, a metallic pendulum bob of known radius, a stop-watch (or a stop clock), a large size protractor, and a meter scale.

PROCEDURE



- 1. Find the least count of the given stop-watch (or stop clock).
- 2. Tie one end of an inextensible thread of nearly 1.5 m length with a pendulum bob and pass the other end of thread through the split cork as shown in Fig. 40.2(a).
- 3. Clamp the cork firmly to a heavy iron stand and place it on a horizontal table. The pendulum must over-hang the table.
- 4. Adjust the effective length of the pendulum, *L*, to any desired length (say 1 m). The effective length of pendulum is measured from the point of suspension (the lowest point on the split cork from which the bob suspends freely) to the centre of mass of the pendulum bob (which in the case of a spherical object is at its geometric centre), that is, length CP in Fig. 40.2(a). The length of the pendulum can be

increased (or decreased) by pulling down (or up) the thread through the split cork after slightly loosening the grip of the clamp. Note the length of the simple pendulum.

5. Draw two lines on the surface, one parallel to the edge of table (AB) and other perpendicular to it (MN) such that the two intersect at the point O

[Fig. 40.2(b)].

6. Adjust the position of the laboratory stand and the height of the clamp such that the point of intersection, O, of lines AB and MN lies exactly below and very close to the centre of bob in its rest or position.

7. Gently hold the pendulum bob P just above the point O. Keeping the thread stretched, displace the bob to either side, say to point X or point Y, along the line AB (the displacement of the bob should be around 10 cm from its mean position so that the angular

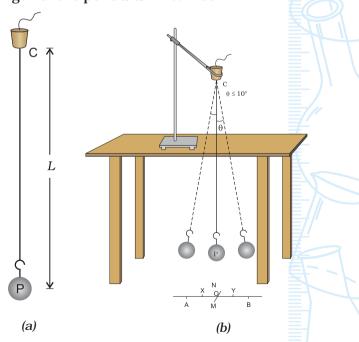


Fig. 40.2: (a) A simple pendulum fixed in a split cork; and (b) Experimental set up for studying the variation in the time period of pendulum with a change in its length

- displacement does not exceed 10°). Release the bob so that it begins to oscillate about its mean position. Also check the angular displacement of the bob on the protractor attached at the top of pendulum C, with the clamp.
- 8. Observe the time taken for appreciable number of oscillations n (say, 10 oscillations) with the help of a stop-watch or stop clock. Record the time taken for n oscillations in the observation table.
- 9. Bring the pendulum at rest in its mean position. Repeat steps 7 and 8 for the same length (L) of the pendulum and record the time taken.
- 10. Repeat the activity for different values of pendulum length in either ascending or descending order. Record the observations in observation table.

OBSERVATIONS AND CALCULATIONS (A	
(i) Least count of the stop-watch or stop clock	=	S
(ii) Diameter of the pendulum bob, d	=	cm
(iii) Radius of the pendulum bob, $r = d/2$	=	cm
(iv) Number of oscillations, n	=	
(Length of the thread $+$ length of hook, if any) I	=	cm
(v) Effective length of the simple pendulum, $L (= l + r)$	=	cm
	=	m.

	Effective length of the pendulum $L = \text{Length of thread} + \text{length of hook}$ (if any) + radius of pendulum bob, r		Time taken for <i>n</i> oscillations <i>t</i>	Time period $T = t/n$	Mean time period, T	T^2
	(cm)	(m)	(s)	(s)	(s)	(\mathbf{S}^2)
1.						
2.						
3.						
4.						
5.						
6.						

GRAPH

Plot a graph between the effective length of pendulum, L, and square of mean time period, T^2 , taking L along x-axis and T^2 along y-axis. Draw a line to join all the points marked by you with a straight line such that maximum number of points lies on it (Fig. 40.3). Some points may not lie on the straight line graph and may be on either side of it. Extend the straight line backwards to check whether the observed graph passes through the origin.

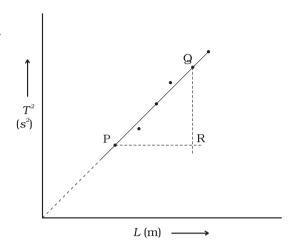


Fig. 40.3: Graph between L and T2

RESULTS AND DISCUSSION



The graph between the length of pendulum and square of its time period is a straight line. This means that the time period of a simple pendulum is proportional to the square root of the length of the pendulum.

PRECAUTIONS



- Thread used must be thin, light, strong and inextensible. An extension in the thread will increase the effective length of the pendulum. There should be no kink or twist in the thread.
- The pendulum support (laboratory stand) should be rigid.
- The split cork should be clamped keeping its lower face horizontal.
- During oscillations the pendulum should not touch the edge of the table or the surface.
- The displacement of pendulum bob from its mean position must be small.
- The bob must be released from its displaced position very gently and without a push otherwise it may not move along the straight line AB.
 In case you notice that the oscillations are elliptical or the bob is spinning or jumping up and down, stop the pendulum and displace it again.
- At the place of experiment, no air disturbance should present. Even all the fans must be switched off while recording the observations.
- Counting of oscillations should begin when the bob of the oscillating pendulum passes its mean position.

NOTE FOR THE TEACHER

- To simplify the experiment, values of diameter or radius of the pendulum bob and length of hook may be provided to students.
- Practically the amplitude may decrease in each swing of the pendulum with time. Thus the pendulum will not keep on oscillating for a long time. Therefore counting of the number of oscillations for measuring the time taken should be stopped before the amplitude of oscillation becomes too small. It is therefore advised that number of oscillation (n) for which time is noted should be small (say n = 10).

- Define mean position of a simple pendulum.
- The amplitude of an oscillating pendulum keeps on decreasing with time. Suggest the factors responsible for it.
- When you displace a pendulum form its mean position and then release, it executes to-and-fro motion. Why does it happen? Discuss it with your friends and teacher.
- Which pendulum will oscillate for a longer period of time the one which is oscillating in air or the one which is oscillating in vacuum?
- What will happen if bob of pendulum touches the edge of the table?
- Why should the amplitude be small for simple pendulum experiment?
- While determining the time period of a pendulum, why do we prefer to measure time for about ten oscillations?
- Observe Fig. 40.2(b). Decide the positions where the speed of bob is minimum and maximum. Also discuss the kinetic and potential energies of the pendulum at these points?
- Would the measurements of time period of pendulum be most accurate with a long or short thread?
- What will be the shape of the graph plotted between the total length, (L) and time period (T) of a pendulum?
- Can you imagine a situation in which the time period of a simple pendulum becomes infinite?



To study the effect of mass on the time period of a simple pendulum.

THEORY 📚

A simple pendulum consists of a small object of heavy mass, called the pendulum bob, suspended by a light thread from a fixed and rigid support

[Fig. 41.1(a)]. When the bob CP is released after taking its free end P slightly to one side (say to point R), it begins to oscillate about its mean position O [Fig. 41.1(b)]. The time taken by the pendulum to complete one oscillation is called its time period. The force responsible for maintaining the oscillations in the simple pendulum is the restoring force which involve mass of the bob. In this experiment we shall study the effect of mass of the pendulum bob on its time period.

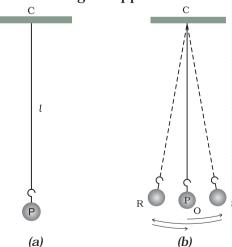


Fig. 41.1: (a) A simple pendulum; and (b) Different positions of the bob of an oscillating simple pendulum and a complete oscillation

L

(a)

MATERIALS REQUIRED

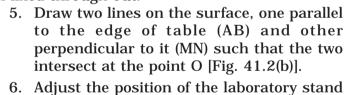


A heavy iron stand, a cork (split along length through middle), an inextensible thread of about 1.5 m length, three different metallic spherical bobs of known masses and diameters. a stop-watch or a stop clock, a large size protractor, and a meter scale.

PROCEDURE



- 1. Find the least count of the given stop-watch or stop-clock.
- 2. Tie one end of an inextensible thread of nearly 1.5 m with the metallic bob of first pendulum having mass m_i and diameter d_i and pass the other end of thread through the split cork as shown in Fig. 41.2(a).
- 3. Clamp the cork firmly to a heavy iron stand and place it on a horizontal table. The pendulum must be over-hanging.
- 4. Adjust the effective length of the pendulum, *L*, to any desired length (say 1 m). The effective length of pendulum is measured from the point of suspension (the lowest point on the split cork from which the bob suspends freely) to the centre of mass of the pendulum bob (which in the case of a spherical object is at its geometric centre), that is, length CP in Fig. 41.2(a). The length of the pendulum can be increased (or decreased) by pulling down (or up) the thread through the split cork after slightly loosening the grip of the clamp. Keep the length of the simple pendulum fixed through out.



- 6. Adjust the position of the laboratory stand and the height of the clamp such that the point of intersection, O, of lines AB and MN lies exactly below and very close to the centre of bob in its rest or mean position.
- 7. Gently hold the pendulum bob P just above the point O. Keeping the thread stretched, displace the bob to either side, say to point X or point Y, along the line AB (the displacement of the bob should be around 10 cm from its mean position so that the angular displacement does not exceed 10°). Release the bob so that begins to oscillate about its mean position. Also check the angular displacement of the bob on the protector attached at the top of pendulum C, with the clamp.

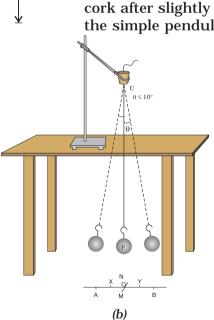


Fig. 41.2: (a) A simple pendulum fixed in a split cork; and (b) Experimental set-up for studying the variation in the time period of pendulum with a change in its mass

- 8. Observe the time taken for appreciable number of oscillations n (say, 10 oscillations) with the help of a stop-watch (or stop-clock). Record the time taken for n oscillations in the observation table.
- 9. Bring the pendulum at rest in its mean position. Repeat step 8 again for the same metallic pendulum bob. Record the total time taken in *n* oscillations.
- 10. Replace the metallic pendulum bob of the pendulum with the second bob of known mass (m_2) and diameter (d_2) . Using the method given in step 4, adjust the total length of the simple pendulum same, that is L. Repeat steps 8 and 9 to again record the total time taken in completeing n oscillations.
- 11. Repeat step 10 for the third given metallic bob.

OBSERVATIONS AND CALCULATIONS



- (i) Least count of the stop-watch or stop-clock
- (ii) Specifications of the three given metallic bobs.

Bob	Mass m (g)	Diameter d (cm)	Radius r (cm)	length of the hook attached, h (cm)
First Second Third	$m_1 = m_2 = m_3 = m_3 = m_3$	$d_1 = d_2 = d_3 = d_3 = d_3$	$egin{aligned} r_1 &= \\ r_2 &= \\ r_3 &= \end{aligned}$	$h_1 = h_2 = h_3 =$

- (iii) Total length of the simple pendulum, L = length of thread + r + h =___ cm = ___ m
- (iv) Number of oscillations, $n = _{--}$.

	Mass of the bob, m	Length of the thread, <i>I</i>	0	Time taken n oscillations, t	Time period $T = t/n$	Mean time period
	(g)	(cm)	(cm)	(s)	(s)	(s)
1. 2.	$m_{_1}$		L L			
3. 4.	$m_2^{}$		L L			
5.	m_3		L			
6.			L			

RESULTS AND DISCUSSION



From the observations, infer the effect of the mass of the simple pendulum on its time period. You are likely to see that the time period of a simple pendulum does not depend on its mass. (You will be studying about this independence in detail in higher classes.)

PRECAUTIONS



- Total length of the simple pendulum must be kept same throughout the experiment.
- Thread used must be strong and inextensible. An extension (which may
 depend on the mass of the bob) in the thread will increase the effective
 length of the pendulum. There should be no kink or twist in the thread.
- The pendulum support (laboratory stand) should be rigid.
- The split cork should be clamped keeping its lower face horizontal.
- During oscillations the pendulum should not touch the edge of the table or the surface below.
- The displacement of pendulum bob from its mean position must be small.
- The bob must be released from its displaced position very gently and without a push otherwise it may not move along the straight line AB. In case you notice that the oscillations are elliptical or the bob is spinning, stop the pendulum and displace it again.
- At the place of experiment, no air disturbance should be there. So switch off all fans while taking the observations.
- Counting of oscillations should begin when the bob of the pendulum passes its mean position while it is oscillating.

Note for the Teacher

- In order to avoid unnecessary emphasis on measuring skills, the value of diameters or radii of the pendulum bobs, their masses, and their lengths of hooks may be provided to students. It is not necessary that the metallic bobs are made up same material. These can be different.
- Practically the amplitude may decrease in each swing of the pendulum with time. Thus the pendulum will not keep on oscillating for a long time. Therefore counting of the number of oscillations for measuring the time taken should be stopped before the amplitude of oscillation becomes too small. It is therefore advised that number of oscillation (n) for which time is noted should be small (say n = 10).

- The masses of the metallic bobs must not be very large. Otherwise the thread may break. Moreover, the amplitude of the swinging pendulum may die out quickly (friction at the point of suspension of the pendulum!).
- To ensure a constant length is pretty difficult. A small bowl may be used as pendulum bob whose mass may be altered by filling it with different materials.

- Does the time period of a simple pendulum depend on the mass of the pendulum bob?
- Does the time period of a simple pendulum depend on the size of the bob? Does it depend on the shape of the bob?
- You are provided with two simple pendulums of same length but of different masses. The two pendulums are displaced by the same amount and then released to oscillate freely about their mean positions. If the air resistance is same for both the simple pendulums, compare their time periods of oscillation?



To determine the speed of a transverse pulse propagated through a stretched string.

THEORY 💝

A pulse is a small disturbance in a medium that usually lasts for a short time. The motion of a pulse can be observed on a long stretched string or in a stretched slinky. A pulse can be classified by the direction in which it disturbs the medium. A transverse pulse is a disturbance that moves the medium at the right angles to the direction in which the pulse travels. If the disturbance is in the direction of motion of the pulse then the pulse is longitudinal.

The motion of a transverse pulse can be observed on a long stretched string that is fixed at one end. A hump created at one end of the string by giving it a jerk, is an example of a transverse pulse. A sudden pulse created at the end, held in hand moves, to the other end along the string where it dies out. However, if the string is fixed at both the ends the pulse may reflect back and forth a few times before it dies out [Fig. 42.1(a-g)]. The speed of a pulse along the string can be determined by measuring the time taken T by it to travel through a known length of the string I. The length of the string divided by the time gives the speed of the pulse in the string. That is,

$$\mathbf{v} = \frac{1}{T}$$
.

MATERIALS REQUIRED



A 10 m long tightly knitted cotton string or rope of about 0.5 cm diameter, a stop-watch or a stop clock, and a meter scale.

PROCEDURE



- 1. Find the least count of the stop-watch or the stop-clock.
- 2. Fix one end of the tightly knit cotton string (the type of the one used in skipping) or rope by tying its one end to a door handle or to a window grill or to a hook on a wall. Stretch a known length of the string (say l_1) while holding the other end firmly with your hands. The other end of the string can also be tied to another door handle, or a hook. The string might sag in the middle due to its weight. However, a little sagging do not affect your observations.
- 3. Give a small transverse horizontal jerk to the string at one end to create a pulse. Let the pulse travel along the string. It may require some practice to create a single pulse that moves smoothly along the string.

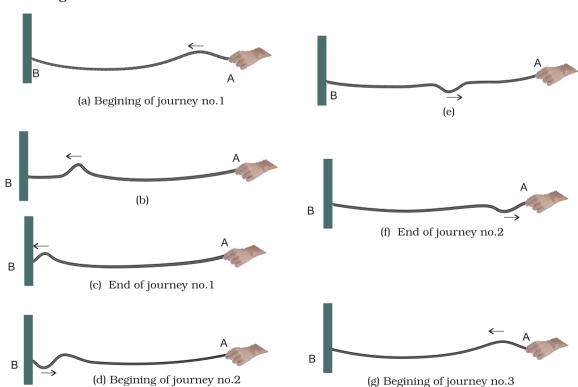


Fig. 42.1(a-g): A pulse moves back and forth along a string fixed at both ends before it dies out

- 4. Observe the pulse as it moves along the string and note what happens when the pulse reaches at the other end of the string. Does it get reflected back? Does the same phenomena occur when it reaches the end where the pulse originated?
- 5. Holding one end of the stretched string give it a jerk to create a pulse. Ask one of your friends to switch on the stop-watch or clock as soon as you give a jerk to the stretched string. Measure the time taken by the pulse to make *n* number of journeys along the entire length of the string between its two ends [Figs. 42.1(a-g)]. This could be possible if the pulse moves back and forth along the string a few times before it dies out. The starting and closing of the stop-watch or stop-clock must be simultaneous with the creation of the pulse and its arrival at the end up to which the measurement are to be taken. Care should also be taken in counting the number of times the pulse travels through the entire length of the string.
- 6. Repeat the experiment with different lengths of the same string (say l_2 and l_3) by changing the distance between the two ends to which it is tied. Note the time taken by a pulse for making n journeys through different lengths of the string.

OBSERVATIONS AND CALCULATIONS



(i) Least count of the stop-watch or stop-clock = $___$ s

	Length of the string between two ends		Time taken by the pulse in making one	Speed of the pulse in string
	1	journeys, t	journey, $T = t/n$	v = l/T
	(m)	(s)	(s)	(m/s)
1.	l ₁ =			$\mathbf{v}_{_{1}} =$
2.	$I_2 =$			\mathbf{v}_{2} =
3.	$I_3 =$			$V_3 =$

RESULTS AND DISCUSSION



The speed of pulse in the string at different lengths are given in table above. In this experiment you probably find different values of speeds of the transverse pulse for different values of lengths of the string. Discuss and state the factors which affect the speed of the pulse with your friends and teacher.



- The string should not be too tight (large tension) when it is tied at the two ends otherwise the velocity of pulse may be high to observe and to measure time of its travel. Some sagging due to the weight of the string is helpful in creating the pulse and observing its motion.
- The string should not be placed on a rigid surface (in contact with) as in such a situation the pulse would die out quickly making observations difficult.
- It must be ensured that no part of the stretched string, except the two ends, touches any surface. Why?
- The string should not have any knots or kinks at any point along its length.
- The counting of pulse journeys must start from zero (and not from one). That is, the creation of pulse and pressing of the knob of stopwatch must be simultaneous.
- The efforts should be made to keep the amplitude of pulse appreciably high so that it can get reflected sufficient number of times from the fixed ends of the string.

NOTE FOR THE TEACHER

- This experiment requires a good amount of practice and therefore should be performed in a group of two or three students.
- Strings or ropes made of jute or plastic or some other material may also be tried instead of cotton.
- This experiment should preferably be performed in a hall or in a gallery.
- In this experiment, the speed of pulse changes for different string lengths. It is suggested that students may try to repeat the observations for the same length of string say $l_{\rm I}$. They will probably find different values of speed the pulse. Encourage the students to find the reasoning.
- It is advised that this experiment be performed at a place where external effects such as air are minimal. Switch off the fan while performing this experiment.
- The speed of a pulse (or a wave) in a string is found to be proportional to the square root of tension in the string and inversely proportional to the square root of mass per unit length of the string. In order to keep the time measurements recordable, it is suggested to make a judicious choice of the string and of stretching it.

- What is the difference between a pulse and a wave?
- State the nature of pulse generated in a stretched string. Is it transverse or longitudinal? Can a longitudinal pulse be generated in a string or a thread (an amateur's telephone!)?
- Why we prefer a longer string to perform the obove experiment?
- In this experiment, you must have noticed that while expressing the result for the speed of a pulse in a string, it is not suggested to take the average value of speeds determined with different lengths of the string. Why?

43



To determine the speed of a longitudinal pulse propagated through a stretched slinky.

THEORY 📚

A pulse is a small disturbance in a medium that usually lasts for a short time. The motion of a pulse can be observed on a long stretched string or in a stretched slinky. A pulse can be classified by the direction in which it disturbs the medium. A longitudinal pulse is a disturbance that causes the particles of the medium oscillate parallel to the direction of motion of the pulse. If the disturbance moves the particles of the medium at the right angles to the direction of motion of the pulse then the pulse is transverse.

A longitudinal pulse can be created in a metallic slinky if the slinky is stretched out in a horizontal direction and the first few coils of the slinky are compressed and then released horizontally. In such a case, each individual coil of the medium (slinky) is set into vibrational motion in directions parallel to the direction of motion of the pulse. A traveling longitudinal pulse in a slinky is composed of *compression*, where the parts of the medium (coils of the Slinky) are closer together

Fig. 43.1: A longitudinal pulse in a metallic slinky

than normal, or *rarefaction*, where the parts of the medium are farther apart than normal. The compression or rarefaction (pulse) travel along the length of the slinky. If the two ends of the stretched slinky are rigidly fixed, the pulse may reflect back and forth a few times before it dies out. The speed of the pulse in the metallic slinky can be determined by measuring the time taken (*T*) by the pulse to travel through a 'known length' (*I*) of the stretched slinky. The speed of the pulse *v* is

$$\mathbf{v} = \frac{1}{T}$$

MATERIALS REQUIRED



A long metal slinky, an inextensible thread, a meter scale (or a measuring tape), and a stop-watch or a stop-clock.

PROCEDURE



- 1. Find the least count of the given stop-watch (or the slop clock).
- 2. Fix one end of the metal slinky to a rigid support such as a door handle, or a window grill or a hook on a wall.
- 3. Firmly hold the other end of the slinky and stretch it to a known length l_1 (Fig. 43.2). Stretch the slinky until its coils are nearly 1 cm apart. The slinky might sag in the middle due to its weight. However, a little sagging may not effect the observations. Here the known length of the slinky means the length of the stretched-sagged slinky

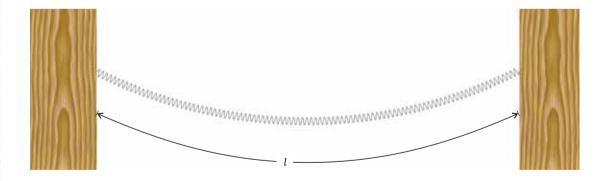


Fig. 43.2: A stretched slinky of known length l

as shown in Fig. 43.2. For measuring this length use a measuring tape along the sagged path of the stretched spring. You can alternatively use a thread and meter scale to measure the length l of the stretched slinky.

- 4. What do you observe? The slinky is vibrating! Allow the slinky to come to rest and stable position. For this the purpose ask your friend to gently hold the stretched slinky somewhere in between for some time. This will help the slinky to come to rest quickly.
- 5. At the end where you are holding the slinky, gather a few slinky coils towards you. Quickly release them. Observe the direction in which the pulse move and the direction in which the coils of the stretched



Fig. 43.3: Formation of a longitudinal pulse in a slinky

slinky (the medium) move. Are the two motions in the same direction? Is the pulse a transverse or longitudinal?

6. In this case the slinky coils do not move at right angles to the direction of the disturbance. The coils rather bunch up in an area and the bunch appears to move forward in the slinky. The slinky coils move back and forth. Thus the pulse created is longitudinal (Fig. 43.3).

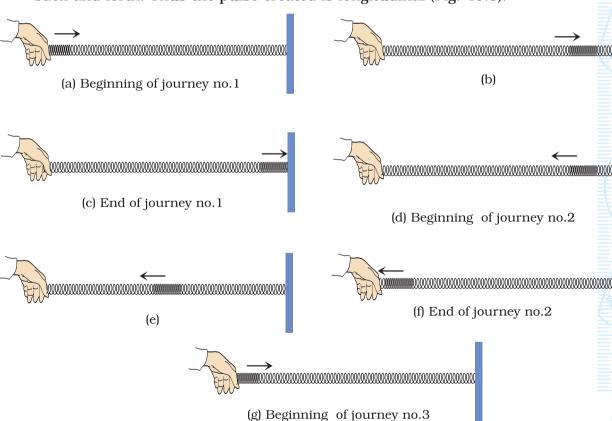


Fig. 43.4 (a-g) : A longitudinal pulse moves back and forth along a slinky fixed at both ends before it dies out

- 7. Again bring the slinky to rest as done in step 4.
- 8. Holding one end of the stretched slinky gather a few slinky coils towards you and quickly release them. Ask one of your friends to be ready to switch on the stop watch simultaneously as you release the coils. Measure the time taken by the pulse to make n number of journeys along the entire slinky between its two ends as shown in Fig. 43.4(a-g). This could be possible if the created pulse moves back and forth in the slinky a few times before it dies out. The starting and closing of the stop watch or clock must be simultaneous with the creation and its arrival at the end up to which the measurements are to be taken (after *n* number of journeys). Care should also be taken in counting the number of times the pulse travels through the entire length *l*₁ of the stretched slinky.

In fact your fingers holding one end of the stretched slinky can also very well feel the pulse reflections reaching after completing two, four, six, eight, ... journeys in the slinky. Every time the pulse reaches your fingers exerts a pressure on your fingers.

9. Repeat the experiment with different lengths of the same slinky, say l_2 and l_3 . For this you may change the position of your hand holding one end of the slinky (or changing your position) while keeping the other end fixed at the same place. Record your observations in the table.

OBSERVATIONS AND CALCULATIONS



Least count of the stop watch or clock = _____ s.

Sl. No.	O	Time taken by the pulse making n journeys, t	Time taken by the puse in making 1 journey, $T = t/n$	Speed of the pulse in the slinky, v $v = l/T$
	(m)	(s)	(s)	(m s ⁻¹)
1.	$I_1 =$			$\mathbf{v}_{_{1}} =$
2.	$I_2 =$			\mathbf{v}_2 =
3.	$I_3 =$			v ₃ =

RESULTS AND DISCUSSION



The speed of the longitudinal pulse in the stretched slinky at different lengths are given in the table above.

In this experiment you probably find different values of speed of a

longitudinal pulse for different values of known lengths of the stretched slinky. Discuss and state the factors which affect the speed of the pulse with your friends and teacher.

PRECAUTIONS



- Do not over-stretch the slinky while performing this experiment. Overstretching of the slinky will destroy its spring nature.
- It must be ensured that no part of the stretched slinky touches surface. Why? Any contact of coils of the stretched slinky with any surface leads to the absorption of pulse energy in the medium in contact and you may not be able to observe appreciable number of pulse journeys in the slinky.
- While creating the longitudinal pulse in the slinky, the release of compressed slinky coils must be gentle and quick. No force must be applied on the slinky while releasing the gathered coils.
- The slinky should not have any knot or any kink at any point along its length. The slinky coils must also not be entangled.
- At the time of creation of the pulse the counting must start from zero and the stop watch should be started at the same time.
- The efforts should be made to keep the amplitude of the pulse appreciably large so that it can get reflected sufficient number of time at the fixed ends of the slinky. By trial one can find the amplitude that produces best result.

Note for the Teacher

- This experiment requires a good amount of practice and therefore should be performed in a group of two or three students.
- In this experiment, a metallic slinky is suggested to use. However this experiment may also be performed with a plastic slinky. But you may not be able to observe (or feel) the persistence of the pulse in the slinky for appreciable time.
- It is advised that this experiment be performed at a place where external effects such as air, are minimal. (Switch off the fan while performing the experiment.)
- The speed of a longitudinal pulse in the stretched slinky is sufficiently high to measure the time taken by the pulse in a single journey. It is therefore advised to take the number of journeys for the measurement of time as large as possible.

• If the set-up of this experiment has a larger amount of sagging in the slinky, the slinky may be provided a few supports with the help of light threads as shown in Fig. 43.5.

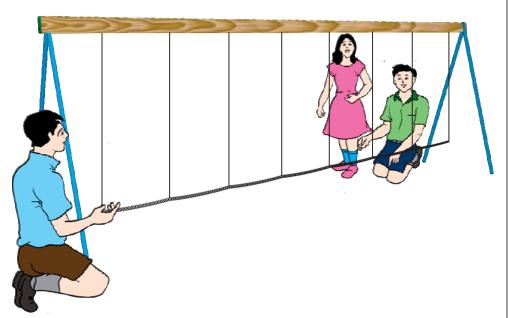


Fig. 43.5: A large slinky is supported with several elastic threads

QUESTIONS

- In this experiment you are suggested to find the least count of the stop-watch or the stop-clock. At the same time you are also using a meter scale or a measuring tape. But you are not suggested to find the least count of this length measuring equipment. Why?
- Why the release of gathered slinky coils be quick at the time of creation of a longitudinal pulse in the slinky?
- How a longitudinal pulse travels in a slinky?
- Why should you take a long slinky in this experiment?
- What will happen if the middle portion of the stretched slinky touches a surface while a longitudinal pulse is traveling through it?
- While creating a longitudinal pulse in the slinky instead of quickly and gently releasing the gathered coils, a student happens to move his hand, holding one end of the slinky, sideways. What kind of pulse will be created in the slinky? Explain your answer.

- In this experiment you probably find different values of speed of a longitudinal pulse for different values of lengths of the stretched slinky. Why?
- Why do we measure time for larger number of pulse journeys in the stretched slinky in this experiment?

44



To study the reflection of sound.



Sound is reflected following the same laws as followed by light rays. That is, the reflected ray lies in the same plane of incidence (in which the incident ray and normal to the reflecting surface at the point of incidence lies), and the angle of reflection $(\angle r)$ is equal to the angle of incidence $(\angle i)$.

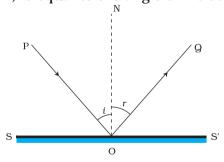


Fig. 44.1: Reflection of sound

MATERIALS REQUIRED



Two identical plastic pipes of length approximately 1 m and of diameter approximately 10 cm or less, a protractor (preferably of big size), a meter scale, and a source of low-amplitude sound such as a table-clock.

PROCEDURE



- 1. In this experiment, you are required to hear very low-amplitude sound waves, it is therefore important to have a peaceful atmosphere. To hear such sounds clearly, it is further advised to put the fan off.
- 2. Using a chalk piece or a pencil, draw a line ON on the table (as shown in Fig. 44.2) normal to the wall surface.
- 3. Now draw a line OC making an $\angle i_i$ (say 30°) with the line ON.
- 4. Put one of the two plastic pipes (say PQ) along this line OC such that the end P of the plastic pipe is very close to point O on the wall. Now the axis of pipe PQ lies over the line OC (Fig. 44.2).
- 5. Now put the second plastic pipe RS on the table, keeping its end R towards the wall on the other side of the normal ON. Mark the position of end R on the table.
- 6. Keep the table-clock close to the open end Q of pipe PQ.
- 7. Bring your ear close to the end S of pipe RS. Try to hear the sound of the table-clock through this pipe. Do you hear any sound? Keeping the position of the end R, adjust the position of pipe RS

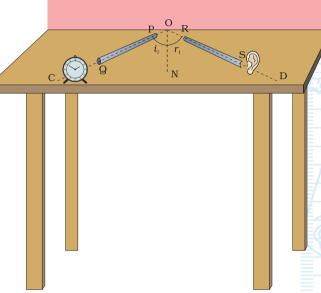


Fig. 44.2: The experimental set-up

- on the table to hear the sound of the table-clock. Mark the position of end S of the pipe RS where you hear the maximum sound.
- 8. Draw a line OD joining the point O on the wall, the point representing the position of end R, and the point representing the position of end S.
- 9. Measure \angle NOD. This is the angle of reflection (say $\angle r_{i}$) for angle of incidence $\angle i_{i}$. Record observations.
- 10. Keeping the position of the end R fixed, lift the end S of pipe RS vertically to a small height. Are you able to hear the sound of the table-clock through the pipe RS? If yes, lift end S pipe vertically to some more height. Do you still hear any sound? You will observe that on raising the height of end S, the sound of the table-clock either weakens or completely diminishes.
- 11. Repeat step 2 onwards for three different values of angle of incidence $\angle i$ and find the corresponding values of angle of reflection $\angle r$.

12. You might have drawn several lines on the table. As courtesy to the students coming to perform this experiment next, it is advised to remove all the lines drawn on the table.

OBSERVATIONS AND CALCULATIONS



Sl. No.	Angle of incidence, ∠i	Angle of reflection, $\angle r$	∠i ~ ∠r
	(°)	(°)	(°)
1.			
2.			
3.			
4.			

RESULTS AND DISCUSSION



- 1. The angle of reflection is equal to angle of incidence in all cases.
- 2. When the pipe through which the sound is heard, is lifted vertically the sound of the table-clock is either weakened or diminishes completely. It shows that the reflected ray lies in the same plane of incidence.

These observations verify that the sound reflects at the surface of a solid and follows the same laws of reflection as in case of light. In case if your observations are different from what are expected, discuss the reasons.

PRECAUTIONS



- It is obvious that to hear a clear reflected sound, the incident sound must be clear and smooth.
- When sound falls on any surface, it is not only reflected but a part of it is also absorbed by the surface of the wall. Hence the sound that you hear through the pipe depends on the nature of the wall. For a smooth reflecting wall, the reflection will be more. It is thus important to have a smooth reflecting surface.
- If we take a larger-amplitude sound source, then you may hear the sound of the source directly (that is the waves coming reaching directly to your ear and not after traveling through pipe QP, reflection from the wall, and through the pipe RS). It is therefore important to have low-amplitude sound source. And for the reasons mentioned here, it is advised to close your other ear while taking observations.
- In this experiment it is assumed that the table-clock produces a ray
 of sound that is incident on the wall along the path QPO and reflected

- along the path ORSD (Fig. P44.2). That is, the sound source is directional. In reality it is not so. Because of unwanted sound, it is advised to take the pipes of larger length and smaller diameter.
- Measurements of angles should be done taking the axis of the pipes as incident and reflected rays. Take utmost care and precaution in placing the two pipes and in drawing the lines OC and OD.
- Since you are dealing with relatively larger dimensions, it is suggested to use a bigger protractor to measure angles

NOTE FOR THE TEACHER

- In this experiment, two identical plastic pipes are recommended to use. In case plastic pipes are not available, pipes can be prepared using chart papers or news papers.
- In order to absorb all unwanted sound rays (as explained in point 4 in the Precautions and Sources of Errors), the inner surfaces of the two pipes may be painted black and kept rough. In case of plastic pipes, a layer of news papers may be inserted into these pipes. A rough paper is a good absorber of sound. This way the sound reaching to the ear of an observer will become clear and distinct.
- In place of a table-clock, a mobile phone may also be used in its vibratory mode. Some other sources of low-amplitude sound may also be explored and used.
- A cardboard (or a wooden partition) along the normal ON may help to avoid direct sound from the source.

QUESTIONS

- While performing this experiment why do we prefer to use pipes of larger length but of smaller diameter?
- How the experiment of reflection of sound is different from the experiment on laws of reflection of light?
- Which sheet will you choose as sound reflecting surface for this experiment: (a) a smooth wooden board, or (b) a thermo-cole sheet. Why?
- Suppose the whole experimental set up of this experiment is submerged in water. What changes do you expect in observations?
- Why do we require a low-amplitude sound source in this experiment?
- What alterations can be made in the pipes to make the reflected sound more distinct and clear?



Appendix

Appendix A

DENSITY OF WATER AT DIFFERENT TEMPERATURES

Temperature in °C	Density in kg/m³	Temperature in °C	Density in kg/m³
-30	983.854	-25	989.585
-20	993.457	-15	996.283
-10	998.117	-8	998.647
-4	999.414	-2	999.762
0	999.840	2	999.940
4	999.972	6	999.940
8	999.848	10	999.700
12	999.497	14	999.244
16	998.943	20	998.204
24	997.297	28	996.234
32	995.026	36	993.684
40	992.216	44	990.628
48	988.927	50	988.036
55	985.695	60	983.199
65	980.555	70	977.770
75	974.899	80	971.798
85	968.620	90	965.320
95	961.900	100	958.364

Note: $1 \text{ kg/m}^3 = 0.001 \text{ g/mL}$

Appendix **B**

DENSITY OF VARIOUS SOLIDS AT ORDINARY ATMOSPHERIC TEMPERATURE

Substance	Density (kg/m³)	Substance	Density (kg/m³)
Aluminium Bone Brass (60/40) Camphor Cast iron Celluloid Clay Coke Copper Dimond Gold (pure)	(kg/m³) 2700 1700 - 2000 8600 990 7000 1400 1800 - 2600 1000 - 1700 2160 3010 - 3520 19300	Asbestos Brick Butter Cardboard Cement Chalk Coal Common salt Constantan Glass (common) Granite	(kg/m³) 2400 1400 - 2200 865 690 2700 - 3000 1900 - 2800 1400 - 1800 2160 8900 2400 - 2800 2640 - 2760
Gold (pure) Graphite Ivory Lime (slaked) Magnetite Mica Platinum Quartz Rock salt Rubber (soft) Silica (fused)	19300 2300 - 2720 1830 - 1920 1300 - 1400 4900 - 5200 2600 - 3200 21400 2650 2180 1100 2210 7800	Granite Ice Lead Limestone Manganin Paper Porcelain Resin Rubber (hard) Sand Silver	2640 - 2760 917 11378 2680 - 2760 8500 700 - 1500 2300 - 2500 1070 1190 2340 1005 1530
Staffless Steel Sugar Topaz Wax (sealing) Wood (teak) Wood (willow)	1590 3500 - 3600 1800 6600 - 8800 4000 - 6000	Talc Tour maline Wood (bamboo) Wood (walnut) Zinc	2700 - 2800 3000 - 3200 3100 - 4000 6400 - 7000 7100

Appendix **C**

DENSITY OF VARIOUS LIQUIDS AT ORDINARY ATMOSPHERIC PRESSURE

Substance	Temperature (°C)	Density (kg/m³)
Acetone	20	792
Alcohol (ethyl)	20	792
Benzene	0	900
Chloroform	20	1489
Caster Oil	15	970
Coconut Oil	15	925
Ether	0	736
Gasoline	660 - 690	
Glycerin	0	1260
Heavy Water	5	1106
Kerosene		820
Mercury		13600
Milk		1028 - 1035
Methylated spirit	0	810
Olive Oil	15	918
Paraffin Oil	0	810
Turpentine	4	870
Sea Water		1025
Water	4	999.972

Appendix D

DENSITY OF VARIOUS GASES AT STANDARD TEMPERATURE AND PRESSURE (S T P)

Substance	Density (kg/m³)
Air Ammonia Carbon dioxide Carbon monoxide Chlorine Hydrogen Hydrogen sulphide Methane Nitrogen Sulphur dioxide Water vapour (273 K)	1.293 0.771 1.977 1.250 3.214 0.090 1.640 0.717 1.250 2.927 0.800

Appendix **E**

THE GREEK ALPHABET

Alpha	A	α	Iota	I	ι	Rho	P	ρ
Beta	В	β	Kappa	K	κ	Sigma	Σ	σ
Gamma	Γ	γ	Lambda	Λ	λ	Tau	T	τ
Delta	Δ	δ	Mu	M	μ	Upsilon	Y	υ
Epsilon	E	ε	Nu	N	ν	Phi	Φ	ф
Zeta	Z	ζ	Xi	Ξ	ξ	Chi	X	χ
Eta	Н	η	Omicron	O	O	Psi	Ψ	Ψ
Theta	Θ	θ	Pi	П	π	Omega	Ω	ω

Appendix **F**

ACCELERATION DUE TO GRAVITY

Place	Acceleration due to	Place	Acceleration due to	
	gravity, g		gravity, g	
	(m/s^2)		(m/s^2)	
Agra	9.791	Ajmer	9.789	
Aligarh	9.781	Allahabad	9.789	
Amritsar	9.792	Bangalore	9.780	
Bhubaneswar	9.787	Chennai	9.783	
Delhi	9.792	Dehradun	9.791	
Equator	9.781	Gorakhpur	9.789	
Guwahati	9.790	Hyderabad	9.789	
Indore	7.790	Jaipur	9.785	
Kanpur	9.790	Kolkata	9.788	
Ludhiana	9.792	Madurai	9.781	
Meerut	9.792	Mumbai	9.786	
Nagpur	9.785	Patna	9.784	
Pole	9.832	Srinagar	9.790	
Tirupati	9.782	Thiruvananthapuram	9.781	
Udaipur	9.788	Varanasi	9.789	

Appendix **G**

REFRACTIVE INDEX OF SUBSTANCES

(for Sodium light, $\lambda = 589.3$ nm)

Solid	Refractive index	Liquid	Refractive index
Diamond Glass (crown) Glass (flint) Glass (soda) Ice Mica Rocksalt Quartz (fused)	2.417 1.48 - 1.61 1.53 - 1.96 1.50 1.31 1.56 - 1.60 1.54 1.458	Water Alcohol (ethyl) Alcohol (methyl) Benzene Canada balsam Carbon disulphide Glycerin Kerosene oil Olive oil Paraffin oil Turpentine	1.333 1.362 1.329 1.501 1.53 1.628 1.475 1.390 1.460 1.440

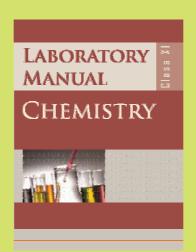
Appendix **H**

SPEED OF SOUND IN DIFFERENT SUBSTANCES

Solids	Speed	Liquids	Speed	Gases	Speed
	at 25 °C		at 25 °C		at 0 °C
	(m/s)		(m/s)		(m/s)
Aluminium	5000	Alcohol	1210	Air	331
Brass	3480	Caster oil	1477	Ammonia	415
Brick	3650		1324	Carbon dioxide	275
		Glycerol			
Copper	3750	Mercury	1450	Hydrogen	1284
Cork	500	Sea-water	1531	Coal gas	453
Fused Silica	5760	Turpentine	1255	Nitrogen	334
Glass (crown)	4540	Water	1756	Oxygen	316
Glass (flint)	3720	Water (dist.)	1497	Sulphur dioxide	213
Iron	5200			Ethanol vapour	269
Lead	1200			Methanol vapour	335
Nickel	4900			Water vapour	494
Paraffin	1300			(134 °C)	
Platinum	2800				
Silver	2680				
Steel	5000				
Tin	2730				
Wood (Oak)	3800				
Zinc	3850				



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