PHYSICS EXPERIMENTS USER GUIDE

FOR

LOWER SECONDARY SCHOOLS
(S1-S3)

FOREWORD

Dear Teacher,

Rwanda Basic Education Board is honored to present to you this Physics experiment user guide which serves as a guide to competence-based teaching and learning to ensure consistency and coherence in the learning of physics subject. The Rwandan educational philosophy is to ensure that you achieve full potential at every level of education which will prepare you to be well integrated in society and exploit employment opportunities.

The government of Rwanda emphasizes the importance of aligning teaching and learning materials with the syllabus to facilitate your learning process. Many factors influence what you learn, how well you learn and the competences you acquire. Those factors include the instructional materials available among others. Special attention was paid to the activities that facilitate the learning process in which you can develop your ideas and make new discoveries during concrete activities carried out individually or with peers.

In competence-based curriculum, learning is considered as a process of active building and developing knowledge and meanings by the learner where concepts are mainly introduced by an activity, a situation or a scenario that helps the learner to construct knowledge, develop skills and acquire positive attitudes and values.

For efficiency use of this guide, your role as teacher is to:

- Ensure that laboratory working conditions are safe, with proper equipment on hand to deal with any potential extreme hazard or mishap.
- Plan your experiment and prepare appropriate equipment.
- Provide instructions in laboratory technique and in handling materials before students conduct experiments
- Provide supervised opportunities for students to develop different competences by giving tasks which enhance critical thinking, problem solving, research, creativity and innovation, communication, and cooperation.
- Facilitate students while they conduct experiments.

I wish to sincerely extend my appreciation to REB staff who organized the development process of this book. Special gratitude goes to the university Lecturers, IEE, AIMS, teachers, independent people, illustrators, and designers who diligently worked to successful completion of this book. Any comment or contribution would be welcome for the improvement of this book.

Dr. MBARUSHIMANA Nelson

Director General, REB

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I wish to express my appreciation to all the people who played a major role in the development of Physics experiments user guide for lower secondary. It would not have been successful without their active participation.

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I owe gratitude to the Rwanda Basic Education Board staff particularly those from Curriculum, Teaching and Learning Resources Department who were involved in the whole process of the development work.

Finally, my word of gratitude goes to RQBE Project for its financial support towards improving the quality of education.

Joan MURUNGI,

Head of Department of Curriculum, Teaching and Learning Resources

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GENERAL INTRODUCTION

1. Laboratory experiments in the Competence Based Curriculum

Physics, and natural science in general, is a reasonable enterprise based on valid experimental evidence, criticism, and rational discussion. It provides us with knowledge of the physical world, and it is experiment that provides the evidence that grounds this knowledge. Experiment plays many roles in science. One of its important roles is to test theories and to provide the basis for scientific knowledge. It can also call for a new theory, either by showing that an accepted theory is incorrect, or by exhibiting a new phenomenon that is in need of explanation. Experiment can provide hints toward the structure or mathematical form of a theory, and it can provide evidence for the existence of the entities involved in our theories. Finally, it may also have a life of its own, independent of theory. Scientists may investigate a phenomenon just because it looks interesting. Such experiments may provide evidence for a future theory to explain. A single experiment may play several of these roles at once.

Physics experiments are largely concerned with the verification of physics laws and determination of constants, e.g refractive index, acceleration due to gravity, spring constant, etc. Some of the experiments are however designed to investigate the relationship between physical quantities. In every case there is need for an accurate use of the apparatus involved in order to realise the purpose of the experiment. Physics as a subject of study consists of two parts.i.e the theory part and the practical part.

The theory involves the study of physics laws and principles. The practical part on the other hand involves the application of the theory knowledge to practical situations, assessment of experimental procedures and observations made. A course in practical physics is therefore designed to give the students an opportunity of acquiring the skills and techniques in the manipulation of apparatus, the use and understanding of the instruments involved. These skills and techniques can easily be acquired by students through regular practice.

Common mistakes made in physics practicals

- Wrong recording of units and symbols.
- Wrong use of instruments
- Wrong recording of experimental values

- Wrong manipulation of data in the main table of results.
- Use of scales which are not suitable and convenient
- Wrong substitution of values into the given expression
- Drawing tables which are not detailed, thus leaving out some of the data.
- Misinterpretation of the given expressions
- Failure to hand in tracing papers for questions involving tracing the outline of glass block or prism
- Labelling columns of the table of results and axes of the graph wrongly.

A competence-based curriculum (CBC) focuses on what learners can do and apply in different situations by developing skills, attitudes, and values in addition to knowledge and understanding. This learning process is learner-focused, where a learner is engaged in active and participatory learning activities, and learners finally build new knowledge from prior knowledge. Since 2015, the Rwanda Education system has changed from Knowledge Based Curriculum to Competence Based Curriculum for preparing students that meet the national and international job market requirements and job creation. Therefore, implementing the CBC education system necessitates qualitative laboratory experiments.

2. Type of lab experiments

The goal of the practical work defines the type of practical work and how it is organized. Therefore, before doing practical work, it is important to have a clear idea of the objective.

- **Equipment-based practical work:** the goal is for students to learn to handle scientific equipment like using a microscope, doing titrations, making an electric circuit, etc.
- **Concept-based practical work:** learning new concepts.
- **Inquiry-based practical work:** learning process skills. Examples of process skills are defining the problem and good research question(s), installing an experimental setup, observing, measuring, processing data in tables and graphs, identifying conclusions, defining limitations of the experiment etc.

Note:

- To learn the new concept by practical work, the lesson should start with the practical work, and the theory can be explained afterward (explore – explain). Starting by teaching the theory and then doing the practical work to prove what they have learnt is demotivating and offers little added value for student learning.
- The experiments should be useful for all learners and not only for aspiring scientists. Try to link the practical work as much as possible with their daily life and preconceptions.

3. Safety rules and precautions during lab experiments

Regardless of the type of lab you are in, there are general rules enforced as safety precautions. Each lab member must learn and adhere to the rules and guidelines set, to minimize the risks of harm that may happen to them within the working environment. It is important to know that some laboratories contain certain inherent dangers and hazards. Therefore, when working in a laboratory, you must learn how to work safely with these hazards to prevent injury to yourself and other lab mates around you. You must make a constant effort to think about the potential hazards associated with what you are doing and think about how to work safely to prevent or minimize these hazards as much as possible. Before doing any scientific experiment, you should make sure that you know where the fire extinguishers are in your laboratory, and there should also be a bucket of sand to extinguish fires. You must ensure that you are appropriately dressed whenever you are near chemicals or performing experiments. Please make sure you are familiar with the safety precautions, hazard warnings, and procedures of the experiment you perform on a given day before you start any work. Experiments should not be performed without an instructor in attendance and must not be left unattended while in progress.

A. Hygiene plan

A laboratory is a shared workspace, and everyone has the responsibility to ensure that it is organized, clean, well-maintained, and free of contamination that might interfere with the lab members' work or safety.

For waste disposal, all chemicals and used materials must be discarded in designated containers. Keep the container closed when not in use.

When in doubt, check with your instructor.

B. Hazard warning symbols

To maintain a safe workplace and avoid accidents, lab safety symbols and signs need to be posted throughout the workplace. Chemicals pose health and safety hazards to personnel due to innate chemical, physical, and toxicological properties. Chemicals can be grouped into several different hazard classes. The hazard class will determine how similar materials should be stored and handled and what special equipment and procedures are needed to use them safely.

Each of these hazards has a different set of safety precautions associated with them.

C. Safety rules

Safety is the number one priority in any laboratory. All students are required to know and comply with good laboratory practices and safety norms; otherwise, they will be asked to leave the laboratory. Make sure you understand all the safety precautions before starting your experiments, and you are requested to help your learners to understand too.

The following are some general guidelines that should always be followed:

Lab coat

While working in the lab, everyone must always wear a lab coat to prevent incidental and unexpected exposures to the skin and clothing. The primary purpose of a lab coat is to protect against splashes and spills. The lab coat must be wrist-fitted and must always keep buttoned. A lab coat should be non-flammable and should be easily removed.

Safety glasses

For eyes protection, goggles must always be worn over by all persons in the laboratory while students are working with chemicals. Safety glasses, with or without side-shields, are not acceptable. The eyes protection safety indicates the possibility of chemical, environmental, radiological, or mechanical irritants and hazards in the laboratory.

Breathing Masks

Respirators are designed to prevent contamination from volatile compounds that may enter in your body through the respiratory system. "Half mask" respirators cover just the nose and mouth; "full face" respirators cover the entire face, and "hood" or "helmet" style respirators cover the entire head. The breathing mask safety sign lets you know that you are working in an area with potentially contaminated air.

Eye Wash Station

Eyes wash stations consist of a mirror and a set of bottles containing saline solution that can be used to wash the injured eye with water. The eye wash station is intended to flood the eye with a continuous stream of water.

Eyes wash stations provide a continuous, low-pressure stream of aerated water in laboratories where chemical or biological agents are used or stored and in facilities where non-human primates are handled. The eyewash stations should easily be accessed from any part of the laboratory, and if possible, located near the safety shower so that if necessary, the eyes can be washed while the body is showered.

Footwear

Shoes that cover entirely the toes, heel, and top of the foot provide the best general protection. Closed shoes must always be worn while in the laboratory, regardless of the experiment or curricular activity. Shoes must fully cover your feet up to the ankles, and no skin should be shown. Socks do not constitute a cover replacement for shoes. Sandals, backless and open shoes are unacceptable.

Gloves

When handling chemical, physical, or biological hazards that can enter the body through the skin, it is important to wear the proper protective gloves. Butyl, neoprene and nitrile gloves are resistant to most chemicals, e.g., alcohols, aldehydes, ketones, most inorganic acids, and caustics.

Hair dressing

If hair is long, it must be tied back. It is good to report all accidents including minor incidents to your instructor immediately.

Eat and drink

Never drink, eat, taste, or smell anything in the laboratory unless you are allowed by the lab instructor.

Hot objects

Never hold very hot objects with your bare hands. Always hold them with a test tube holder, tongs, or a piece of cloth or paper.

4. Guidance on the Management of laboratory materials

A good management of science laboratory is characterized by:

- Clean laboratory room or shelves, without dust and any other undesirable materials. All materials should also be cleaned.
- Well stored and arranged materials with labels in the shelves or boxes.
- Timetable showing when classes occupy the laboratory room.
- Updated Soft or hard copies showing physical state and all quantities found in laboratory rooms held by persons in charge of the school laboratory. This copy may show also all quantities received during the delivery process.
- Inventory of laboratory or science kit items including received, damaged, stolen, expired and used up chemicals, and remaining items carried out every term. This should be printed and signed by the school representative.
- All waste materials should be stored in properly labeled closed containers in a secure waste storage area waiting for their disposal. The disposal may not take a long time.

5. Storage of laboratory materials and science kits

a) Storage of science kits

Science kits are supplied to schools without laboratory rooms. They are then stored in metal boxes designed to store the kits safely, but they can also be stored in shelves where they are available and accessible. It is recommended to store the box with the contents to a safe place where kit's items are not lost, stolen or intentionally damaged. It is preferred to keep them in the safe room equipped with shelves or cupboard to store items and tables. When the kits materials are stored in the cupboard, their items are grouped according to their types and purpose and labelling to facilitate the localization of items.

N.B: Only one teacher of science and/or mathematics chosen from his colleagues should manage the store of the kit materials.

b) Storage of laboratory materials (apparatuses and chemicals)

Normally, a laboratory is composed of two parts: A preparation room and learning and teaching room.

A preparation room is a room where science materials are stored, and a science teacher or laboratory technician prepare solutions prior to teaching. The Learning and teaching room is a room where science practical lessons are conducted. In the laboratory we find apparatuses and chemicals. Apparatuses are sometimes stored depending on the materials they are made of. In the laboratory, chemicals are whether solids or liquids. Science laboratory materials are supplied to schools with laboratory rooms. They are stored in shelves in the preparation room.

i) Storage of laboratory glassware

Laboratory glassware requires serious attention or mindful care. Once it's been cleaned and inspected, it should be stored to prevent it from becoming dirty, getting broken, or getting lost. Glassware is stored inside shelves in the preparation room out of the way of regular daily activities. Glass items are consistently in use in laboratories; when you need them, it's important to be able to find them without wasting time walking and searching. Glassware can be grouped with others of its type, size, or according to the purpose. For example, test tubes, bakers, conical flasks, measuring cylinders, distillation set of apparatus, …; all these placed in shelves with clear labels. This will ensure that they are easily found when needed. Before storing them, the glassware equipment should have been cleaned.

Specific glassware may require certain guidelines to ensure their safety in storage. These are volumetric flasks, Burettes, Pipettes and Round-Bottom Flasks.

ii) Storage of other materials

Science laboratories are not equipped only by Glassware but also by other materials made of wood, plastic, rubber and metals. These laboratory materials are also stored in the preparation room arranged following their types or their usage. To facilitate their localization, labeling is needed.

6. Maintenance of laboratory materials and science kits

The care and maintenance of laboratory equipment is an important part of quality assurance in the lab. Keeping your lab equipment clean means that it will always be ready for use when you need it, and ensures that no impurities contaminate samples and skew data. Lab equipment or science kits should be cleaned after every use.

Making sure that devices are properly stored, cleaned, and well maintained will save you time and money, as well as making your projects and jobs much more comfortable.Inadequate maintenance can lead to dangerous situations, accidents and health problems.

a) How to clean laboratory equipment in general?

- Carry out a daily wipe down of all equipment exteriors.
- Carry out a weekly deep clean of all equipment.
- Carry out a regular deep clean of microscopes using a 70:30 mixtures of ether and alcohol – this ensures that they are sufficiently clean to yield most accurate results.

b) How to clean laboratory glassware?

- To remove organic residues, rinse glassware briefly with an organic solvent (acetone or ethanol, hexane). ...
- Use warm tap water and a brush with soapy water to scrub the inside of curved glassware. ...
- Remove soapsuds with deionized water to avoid harsh water stains.

c) Rinse All Glassware

- First, rinse glassware very thoroughly with running tap water, filling, shaking and emptying it at least six times. ...
- Then, rinse all glassware in a large bath of distilled or high purity water.
- Finally, rinse each piece individually in high purity water.

7. Role and responsibilities of teacher and learners in lab experiment

a) The roles and responsibilities of teacher during a lab experiment

Before conducting an experiment, the teacher will do the following:

- Decide how to incorporate experiments into class content best,
- Prepare in advance materials needed in the experiment,
- Prepare protocol for the experiment,
- Perform in advance the experiment to ensure that everything works as expected,
- Designate an appropriate amount of time for the experiment. Some experiments might be adapted to take more than one class period, while others may be adapted to take only a few minutes.
- Match the experiment to the class level, course atmosphere, and your students' personalities and learning styles.
- Verify lab equipment before lab practices.
- Provide the experiment protocol and give instructions to learners during lab session.

During practical work, the teacher's role is to coach instead of helping with advice or questions. It is better to answer a learner's question with another question than to immediately give the answer or advice. The additional question should help learners to find the answer themselves.

b) The Role of a lab technician during a laboratory-based lesson

In schools having laboratory technicians, they assist the science teachers in the following tasks:

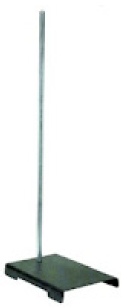
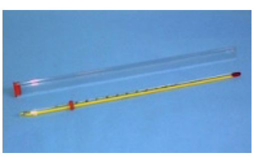
- Maintaining, calibrating, cleaning, and testing the sterility of the equipment,
- Collecting, preparing and/or testing samples,
- Demonstrating procedures.

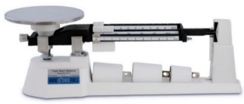
c) The learners' responsibilities in the lab work

During the lab experiment, both learners have different activities to do. General learner's activities are:

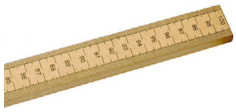
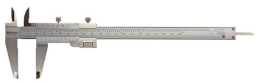
- Experiment and obtain data themselves,
- Record data using the equipment provided by the teacher,
- Analyze the data often this involves graphing it to produce the related graph,
- Interpret the obtained results and deduct the theory behind the concept under the experimentation,
- Discuss the error in the experiment and suggest improvements and make a conclusion of the experiment,
- Cleaning and arranging material after a lab experiment.

8. Usage of the main laboratory equipment.

NAME	PICTURE	USE
Electronic balance		Used for weighing substances or objects, usually in grams.
Retort stand		Used to hold items being heated. Clamps or rings can be used so that items may be placed above the lab table for heating by Bunsen burners or other items. Used also to hold burette
Thermometer		Used to take temperature of solids, liquids, and gases.

Microscope		A microscope is an instrument that can be used to observe small objects, even cells.
Triple beam balance		The triple beam balance is measuring instrument that measures mass very precisely. It has a reading error of +/- 0.05 gram..
Resistor		A resistor is an electrical component that provides electrical resistance in a circuit. It is used to reduce current flow, adjust signal levels, to divide voltages, bias active elements etc.
Multimeter		A multimeter is an electronic measuring instrument that combines several measurement functions in one unit. It can measure voltage, current, and resistance
Voltmeter		A voltmeter is an instrument used for measuring electrical potential difference between two points in an electric circuit.
Ammeter		An ammeter is an instrument used to measure the current, either direct or alternating electric current, in a circuit.

Galvanometer		The galvanometer is the device used for detecting the presence of small current and voltage or for measuring their magnitude. The galvanometer is mainly used in the bridges and potentiometer where they indicate the null deflection or zero current. It works as an actuator, by producing a rotary deflection (of a "pointer"), in response to electric current flowing through a coil in a constant magnetic field.
Compass		A compass is an instrument that shows directions. It has a needle, called a compass rose, which points in North-South direction. The "N" mark on the rose points northward.
Prism		A prism is a transparent optical element with flat, polished surfaces that refract light. It can be used to split light into its constituent spectral colours (the colours of the rainbow) where each colour has different wavelengths
Optical bench		The optical bench is a long steel pipe with a linear scale applied to it. It is used in optics experiments.
Pendulum bob		A pendulum is a weight suspended from a pivot so that it can swing freely. It is used in many experiments. Eg. Determination of acceleration due to gravity, etc

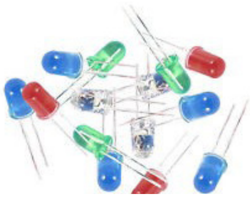
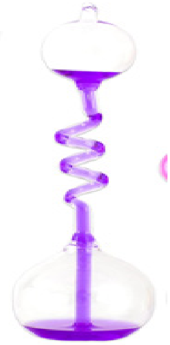
Spring balance		Spring Balance is used to measure force using Hooke's law. It is also used to measure the mass of an object.
Meter scale		Meter Scale is the most common measuring tool that we use in day-to-day activity. Often know as ruler, it as equally spaced markings along its length used to measure distances long the straight lines.
Vernier calliper		Vernier Calliper is a measuring apparatus that can measure objects up to 15 cm in length. It is made up of a main scale and a vernier scale. It can measure in the increments of 0.1 cm on the main scale. It has a pair of external jaws to measure external diameter, pair of internal jaws to measure internal diameter and a long rod to measure depth
Screw gauge		Screw Gauge is a measuring apparatus that can measure dimensions in the range of millimetres up to 5 cm. With a least count of 0.01mm, it can measure the dimension in increments of 0.01mm. Screw Gauges are widely used to measure diameter of wires, screws and bolts

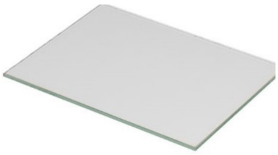
Handheld Centrifuge		**A centrifuge** is a device that uses centrifugal force to separate various components of a fluid. This is achieved by spinning the fluid at high speed within a container, thereby separating fluids of different densities (e.g. cream from milk) or liquids from solids.
Ball and ring apparatus		A useful apparatus for **demonstrating thermal expansion.** The ball fits easily through the ring at room temperature. When the ball is heated over a flame, it expands and no longer fits in the ring.
Bar magnet		Bar magnets are **used as stirrers in laboratory for magnetic experiments.** They also find applications in medical procedures. Electronic devices such as telephones, radios, and television sets use magnets.
Bimetallic Strip		A bimetallic strip is used **to convert a temperature change into mechanical displacement.** The strip consists of two strips of different metals which expand at different rates as they are heated.

Calorimeter set joule		Calorimeter is a device for measuring the heat developed during a mechanical, electrical, or chemical reaction, and for calculating the heat capacity of materials
Capacitor		Capacitors are used for **storing energy,** which can be used by the device for temporary power outages whenever they need additional power. Capacitors are used for blocking DC current after getting fully charged and yet allow the AC current to pass through the circuit of a circuit.
Cell holder		A cell holder is a simple device for holding 1.5V cells {batteries} for use in school laboratories.
Copper wire		A copper wire allows the flow of electricity through them easily and to protect this copper wire from surrounding environment, generally copper wires are coated with insulator materials such as plastic or enamel which prevents the charging of wire and it helps in managing any other environmental effects.

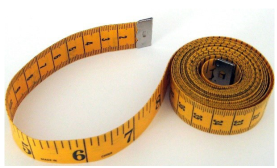
Crocodile clips		They are typically used to connect two wires or to connect one wire to the anode or cathode of a device.
Drawing pins		They are used to fasten papers to a soft board during optics experiments.
Electromagnet		An electromagnet is a temporary magnet which behaves like a magnet when an electric current is passed through the insulated copper wire and loses its magnetism when current is stopped
Electrostatic kit		The Electrostatics Kit is a collection of materials designed for students to investigate the creation of charges through friction between various rods and fabrics.
Fuses		The fuse breaks the circuit if a fault in an appliance causes too much current to flow. This protects the wiring and the appliance if something goes wrong.

Glass block		Rectangular Glass Block is used to **verify the laws of refraction** in your physics class. Determine the refractive index of this glass block by determining the angle of incidence and the angle of emergence of the ray. Determine the lateral displacement of the emergent ray from the initial incident ray.
Gold leaf electroscope		A gold-leaf electroscope is an instrument used (mainly historically) for the measurement of electric charge or potential, based on one or two fine gold foils suspended vertically and free to deflect under electrostatic repulsion when an electric charge was applied.
Iron fillings		They are very often used in science demonstrations to show the direction of a magnetic field.
Lamp/bulb holder		A lamp holder is the device for holding a light bulb or lamp.

Lens		It is used to form an image of an object by focusing rays of light from the object.
Light bulb		A bulb gives out (emits) light.
Light Emitting Diode		Light-emitting diodes (LEDs) and produce light when a current flows through them in the forward direction.
Lovemeter		It is used in the expansion of liquid . When the gas in the bottom bulb is heated with your hand, the increase in temperature creates an increase in air pressure. This increased pressure pushes the liquid up the tube to the top bulb
Magnifier		A simple magnifier is a converging lens and produces a magnified virtual image of an object located within the focal length of the lens.

Manometer		A manometer is a scientific instrument used **to measure gas pressures.** Open manometers measure gas pressure relative to atmospheric pressure
Curved mirrors		They are used to focus light.
Plane mirror		A plane mirror **makes an image of objects in front of the mirror;** these images appear to be behind the plane in which than mirror lies.
Nichrome wire		Nichrome is used for making heating element of electrical appliances. **Because nichrome does not oxidize and burn easily at high temperature.**
Optical pins		They are used to map light patterns in optical experiments

Diode		A diode is a device that allows current to flow in one direction but not the other.
Switch		A switch is an electrical component that is used **to turn on and turn off any equipment like television, washing machine, lights, fans, etc.** When the switch is off, the circuit is open and there is no flow of current.
Aneroid barometer		An aneroid barometer is an instrument used for **measuring air pressure as a method that does not involve liquid.**
Pulley		It is used as a simple machine to lift objects.
Electric cable/ wire		It is used to connect electric circuit and used for transmission of electricity or electrical signals.

Resistance coil		It is a coil of wire introduced into an electrical circuit to provide resistance.
Spring		A spring can be seen as a device that stores potential energy, specifically elastic potential energy, by straining the bonds between the atoms of an elastic material.
Slotted masses		The slotted masses and weight hanger combination allows a student or researcher to quickly create any desired amount of mass, to use in experiments involving force, acceleration, and mass.
stopwatch		It is used to measure time in physics experiments.
Tape measure		A tape measure is a portable measurement device used to quantify the size of an object or the distance between objects.

DATA MANAGEMENT OF EXPERIMENTAL RESULTS

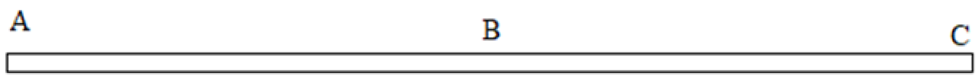
1. RECORDING MEASUREMENTS IN AN EXPERIMENT

In physics practicals, there are two types of measurements or readings i.e. single and repeated measurements.

1.1 RECORDING SINGLE MEASUREMENTS

Single measurements are measurements whose procedure is not repeated e.g measurement of diameter of the wire, thickness of wood or glass block, breadth (width) of wood or glass block, length of thread or wire etc. the common instruments for taking single measurements are:

micrometer screw gauge, vernier callipers and meter rule, other instruments can also be used. Single measurements should be carried out three times, at different points of the objects under test. The measurements should be recorded according to the unit and the precision of the instrument being used. As an example, consider the measurement of the diameter d of a wire using a micrometer screw gauge.



Measure the diameter of the wire at A, B and C. suppose the measurements obtained are 0.34 mm, 0.34 mm, 0.35 mm, respectively. The measurements should be recorded as follows:

d_1 /mm	d_2/mm	d_3 /mm
0.34	0.34	0.35

$$Average\, d : \frac{d_1 + d_2 + d_3}{3}$$

$$= \frac{0.34 + 0.34 + 0.35}{3}$$

$$= 0.34\, mm$$

Note:

1. The average should be recorded according to the precision of the instrument being used; in the above example a micrometer screw gauge precision is to 2 dp. In the case the value of the diameter is to be recorded in meters, the units in the table and average should be meters and the values converted from mm to m.
2. For measurement of the mass of an object, the measurement is carried out once thus there is no need to measure three times. This also applies to measurement of room temperature and focal length of converging lens or concave mirror.

1.2 RECORDING REPEATED READINGS

Repeated readings are noted twice in the procedure. They are reading taken on variable quantities like current, voltage, extension, angle of refraction, balance length for experiments involving potentiometer or meter bridges, etc. such readings must be recorded in the main table of results.

2. DESIGN OF THE TABLE OF RESULTS

The table of results should be in columns and not in rows. This is by the agreed convention. The table should be closed at the top and bottom. The table of results can be drawn and written in pencil or pen (blue or black).

Each column should have a heading which includes: the physical quantity and its appropriate unit where applicable. The physical quantities should be separated from its unit by use of forward slash /, e.g. L/m, t/s, m/kg etc. The physical quantities should be on the same level with the unit except for the degree symbol, which should be written slightly the level of the quantity. The case (capital or small letter) of the symbol of the physical quantity given in the procedure must not be altered e.g. L should not be written as l, y should not be written as Y, $\frac{1}{x}$ should not be written as x^{-1} *or* $1/x$, t etc. this also applies when writing the title of the graph and labeling axes . units of the derived quantities should be written in a recommended way e.g. kgm^{-3} *not* kg/m^3, Nm^{-2} *not* N/m^2 etc. in case a power of ten is used in the heading of a particular column, it should be written inside the brackets e.g. L (10^2m), $\sin\theta\left(10^{-1}\right)$

The examples below show typical tables of results:

1.

L/m	$\frac{1}{L}$ /m^{-1}	t/s	T/s	T^2/s^2

2.

x/cm	X^2/cm^2	I/ ^{0}	Sin i	Sin^2 i	$\frac{1}{\sin^2 i}$

Note:

Once the units are written in the heading of a column, there is no need of repeating them within the column. The table of results should be systematic, neat and well organized as shown in the two examples above. The table of results must be as detailed as possible. As an example, consider an experiment to determine the width of a glass block. Suppose the student is given values of angle i and is required to obtain values of angle r, length x and to tabulate the results including values of sin r, $1/x^2$ and sin^2 i the table of results should be drawn as:

i/^{o}	Sin i	Sin^2 i	r /^{o}	Sin r	x/cm	x^2 /cm	$1/x^2$ /cm^2

The table of results must be self-explanatory.

In a given experiment the student is required to measure time for 20 oscillations. In case the symbol for time for 20 oscillations has not been given, the student can use any symbol say t, but must define it e.g. let t = time for 20 oscillations.

In a particular column in a table of results, values must be recorded to the same number of decimal places although the number of decimal places may differ from one column to another.

The method of calculation should not be shown in the table of results instead the final values should be recorded. Values recorded in the table of results from instruments must be according to the precision (decimal places) of the instruments. The trend of the values recorded from instruments varies; they can increase or decrease or both.

Note: The table of results should be drawn well in advance before the experiment is done, and there is no need to have a rough table.

3. MANIPULATION OF DATA

There are two categories of operations used in manipulation of data from the table of results:

i) Addition and subtraction

ii) Multiplication and division

3.1. Rule for adding and subtraction numbers

When adding and subtraction numbers, the answer should be expressed using the same number of decimal places as the quantity with the least number of decimal places.

Examples:

1. $2347.56(2dp) + 53.9521(4dp) = 2401.51(2dp)$
2. $3.2576(4dp) - 1.1(1dp) = 2.2(1dp)$
3. $43(float) + 0.62(2dp) = 43.62(2dp)$

Note:

i. When adding two whole numbers, the total should be a whole number.

ii. The difference between two whole numbers should be a whole number.

3.2 Significant figures

Non-zero digits 1, 2, 3, 4, 5, 6, 7, 8, 9 are counted as significant figures whether they're in the left hand side or right hand side of the decimal point. Zero (s) in the middle of a number is/are just as important as any digit and should therefore be counted as significant figures. Zero at the end of a number may be significant or not. If the zeros at the end of the numbers are as a result of rounding off, then they are not counted as significant. For example, if some distance is measure as 211 km, it can be written to one significant figure as 200 km, the zeros at the end are not significant but they keep/show place values and hence are called place values zeros. Without them the meaning of the number would change. To two significant figures 211 km would be written as 210 km. As a further example, consider a value 3623.67. This can be expressed to different number of significant figures as follows:

4 significant figures the values is 3624

3 significant figures the values is 3620

2 significant figures the values is 3600

1 significant figures the values is 4000

If a distance is measured as 30.0cm, the zeros at the end are not as a result of rounding-off and thus they are counted as significant, in this case there are three significant figures. Zeros at the beginning of the number are present only to locate the decimal point and are not significant figures. Therefore, the number 0.0003405 has four significant figures. Significant figures are used to show the sensitivity or least count of the instrument from which the measurements were derived.

3.3 Rule for multiplying and dividing numbers.

When multiplying and diving numbers, the answer should be expressed to the same number of significant figures as that quantity with the least number of significant figures (sf).

Example:

1. $2.5765(5sf)\times1.27(3sf)=3.27(3sf)$
2. $0.265(3sf)\times0.265(3sf)=0.0702(3sf)$

3. $0.782(3sf) \div 0.218(3sf) = 3.59(3sf)$

4. $30.78(4sf) \div 1.9(2sf) = 16(2sf)$

When multiplying/dividing a whole number or recurring decimal with another number, the numbers of significant figures of the number are used. When adding/ subtracting a whole number or recurring decimal to/from another number, the numbers of decimal places of the number are used. For example $\frac{1}{0.356}$, the numbers of significant figures to be used are those of 0.356 not of 1. This is because 1 is called a float value which has infinite number of significant figures. In this case the answer should be expressed to three significant figures of 0.356, thus

$\frac{1}{0.356} = 2.81(sf)$

Example:

a) Evaluate 4π (2.71)2.

(2.71)2=$7.34(3sf \times 3sf = 3sf)$ 4 and π are float values. Therefore, the final answer should be expressed to three significant figures of 2.71. Thus 4π (2.71)2 = $4\pi \times 7.34 = 92.2(3sf)$

b) $0.678(sf) \times 3(float) = 2.03(3sf)$

4. APPROXIMATIONS

In every calculation, the answer obtained either terminates or recurs. It may be necessary to approximate the answer obtained to a whole number, to one or more number of decimal places.

When approximating to a required number of decimal places, check the digit in the next (right hand side) number of decimal places. If the next digit is greater than five (5), then one is added to the digit in the number of decimal places required.

Example:

Express 2.786 to two decimal places. $2.786 \approx 2.79(2dp)$

If the next digit is less than five (5), then one is not added to the digit in the number of decimal places required.

Express 13.726 to one decimal place $13.726 \approx 13.7(1dp)$

If the next digit is exactly five (5) and there is no digit on the right hand side of side (5), then the number is just half way and one is not added to the digit to the number of decimal places required.

Example:

Express 0.625 to two decimal places $0.625 \approx 0.62(2dp)$

If the next digit is exactly five (5) and there are digits on the right hand side of five (5), then the number is beyond half way and 1 is added to the digit in the number of decimal places required.

Example:

Express 1.72501 to two decimal places. $1.72501 \approx 1.73(2dp)$

5. MANIPULATION OF DATA IN THE TABLE OF RESULTS

When manipulating data in the table of results, there is need to recall the rules for adding and subtracting numbers, multiplying and dividing numbers and approximations. When multiplying/dividing numbers, significant figures are used to determine the number of decimal places in a column.The following examples have been carefully selected to guide the students on how to manipulate data.

Table 1: y = 0.950m

x/m	d/m	$\frac{x}{y}$
0.100	0.002	0.105
0.200	0.004	0.211
0.300	0.006	0.316
0.400	0.008	0.421
0.500	0.011	0.526
0.600	0.014	0.632

In the column of x, the first value 0.100 has 3sf and the value of y has 3sf. The column of involves division, so significant figures are used when manipulating data in this column.

Thus, 3sf divided by 3sf give 3sf.

$0.100(3sf) \div 0.950(3sf) = 0.105(3sf)$ The value 0.105 has 3sf but 3dp. Therefore, values in the column of $\frac{x}{y}$ should be recorded to 3dp.

Table 2:

x/m	t/s	T/s	$\frac{1}{x}$ /m^{-1}
0.90	19.0	0.950	1.1
0.80	21.0	1.050	1.2
0.70	23.0	1.150	1.4
0.60	27.0	1.350	1.7
0.50	32.5	1.625	2.0
0.40	39.5	1.975	2.5

Where: t = time for 20 oscillations

T = period

Column of T:

The values in the column of t are used to calculate the values of T. The first value 19.0, in the column of t has 3sf. To obtain the value of T, the value of t is divided by 20, which is a float.

Therefore the values in the column of T will depend on only the number of significant figures to the first value in the column of t. The value of T should be recorded to 3sf.

$19.0(3sf) \div 20(float) = 0.950(3sf)$

The value 0.950 has 3sf but 3dp therefore; the values in the column of T should be recorded to 3dp.

Note: The number of sf and therefore number of dp of T will depend on the number of sf of the first value in the column of t but not on the number of sf of the values in the entire column.

Column of $\frac{1}{x}$:

The number of significant figures in the column of $\frac{1}{x}$ depends on only the number of significant figures in the first value of x since 1 is a float.

The first value 0.90, in the column of x has 2 significant figures, thus $1(float) \div 0.90(2sf) = 1.1(2sf)$

The values in the column of $^1/_x$ should be recorded to 1 dp.

Table 3:

x/m	x^2/m^2	t/s	T/s	T^2/s^2
0.10	0.010	14.5	0.725	0.526
0.15	0.022	15.0	0.750	0.562
0.20	0.040	16.0	0.800	0.640
0.25	0.062	17.0	0.850	0.722
0.30	0.090	18.0	0.925	0.856
0.35	0.122	20.0	1.000	1.000

T = time for 20 oscillations

Column of x^2:

The first value 0.10, in the column of x has 2 sf therefore the first value in the column of x^2 should have 2sf, $0.10(2sf) \times 0.10(2sf) = 0.010(2sf)$
The value 0.010 has 2sf but 3dp, therefore the values in the column of x^2 should be recorded to 3dp.

Column of T:

The first value 14.5 in the column of t has 3sf. The first value in the column of T should be recorded to 3sf. Thus $14.5(3sf) \div 20(float) = 0.725(3sf)$
The value 0725 has 3sf but 3dp therefore the values in the column of T should be recorded to 3dp.

Column of T^2:

The first value 0.725 in the column of T has 3sf. The first value of T^2 should be recorded to 3sf. $0.725(3sf) \div 0.725(3sf) = 0.526(3sf)$. The value 0.526 has 3sf but 3dp, therefore the values in column of T2 should be recorded to 3dp.

6. GRAPH WORK

Graph work is yet another method of analyzing data obtained from experiments. The main components of a good graph are:

6.1. TITLE OF THE GRAPH

The graph must have a title clearly written at the top of the graph paper. A title of graph should show what is being plotted on the graph e.g. A graph of T^2 against l. This means the values of T^2 are plotted along the vertical axis and the values of l along the horizontal axis. The title of a graph must not have units on the physical quantities being plotted. The case (capital or small letters) of the physical quantity must be maintained on the graph, as in the procedure. The word versus can be used in place of against, in the title but not vs. The title of a graph must not be written as: A plot of T^2 against l or A graph showing T^2 against l or Graph of T^2 against l. The title of a graph should be written on only one line.

6.2 AXES

The axes should be drawn perpendicular to each other with an arrow on each axis, showing increasing values. Axes should be drawn without broken lines. Each axis must be clearly and correctly marked after every 10 small squares (2 cm) starting from the origin. It's important to note that the graph may not necessarily start from the origin (0,0). Axes should be labeled correctly with their appropriate units where applicable. When labeling the axis if a unit exists, it must be written on the same level with the physical quantity except for the unit degrees, which should be written slightly above the level of the physical quantity. The physical quantity should be separated from its unit by use of a forward slash /.

When drawing the axes, select a suitable position on the graph paper and draw the axes so as to cover all the values (positive and negative if any) in your table.

6.3 SCALE

Each axis must have a single scale, which should be uniform. The plotted points should cover at least half of the graph page except for intercept where the pints may or may not cover at least half the graph page. The origins of each axis must be indicated i.e where exactly the axis starts. The origins of the axes may or may not be the same. When the intercept on the vertical axis is required, the origin of the horizontal axis must be zero; the origin of the vertical axis may be zero. When the intercept on the horizontal axis is required, the origin of the vertical axis must be zero; the origin of the horizontal axis may be zero. It is advisable that the values of the scale must not be recurring. It is also advisable that the multiples and sub-multiples of 1, 2, 5, be used as values are easy to use when plotting.

How to obtain convenient scale:

a) Obtain the range on both the vertical and horizontal axes.

b) Divide the vertical range by 110 or 100 small squares and the horizontal range by 90 or 80 small squares.

c) The figure values obtained in (b) is what one small square represents on the vertical and horizontal axes respectively.

For convenience we use scales involving digits 1,2,4,5,8 and 10, their multiples or their submultiples such as 0.1,0.2,0.4,0.5,0.8,1.0 or 0.01,0.02,0.04,0.05,0.08,0.1 or 10,20,40,50,80,100 etc. if the figure value obtained in (c) falls exactly on one of the convenient scale like the ones above, then use it as it is.

d) If the value obtained in (b) does not fall exactly on one of the convenient scales, take the nearest upper value from the set of convenient scales e.g. if the figure value in (b) is 0.043, take 0.05, if the value obtained is 3.3, take 4, if the value in 0.008356, take 0.01 etc. the value chosen is what 1 small square will represent on the particular axis.

e) Multiply the figure value obtained in (d) by 10 to obtain what 2 cm (10 small squares) will represent.

If the scale used leaves out some values, then use a greater value from the set of convenient scales in (c) above e.g. if 0.01 fails try 0.02, if 0.02 fails try 0.04 or 0.05 etc.

6.4. PLOTTING POINTS ON THE GRAPH PAPER

How to use the scales to plot points on the graph paper.

To plot a given point on the graph paper, divide the values for the quantities to be plotted by their respective scales to obtain the number of small squares to be counted on each axis. Then locate the position of the point by counting the small squares obtained on each axis.

Example

Suppose you want to plot the value 0.174 on the vertical axis and 0.139 on the horizontal axis using the scales HA 1:0.005 and VA 1:0.01 then,

Horizontal axis

$$Number\ of\ small\ squares = \frac{0.139}{0.005} = 27.8$$

Vertical axis

$$Number\ of\ small\ squares = \frac{0.174}{0.01} = 17.4$$

Thus, to plot the point (0.139,0.174), we count 27.8 (and not 27 or 28) small squares on the horizontal axis and 17.4 (not 17 or 18) small squares on the vertical axis. This will give the exact position where the point lies.

This is only true if the axes begin from zero. If a given axis does not begin from zero, subtract the starting value (on that particular axis) from the value to be plotted and divide the figure value obtained by what 1 small square represents to get the number of small squares to be counted along that axis.

Symbols or signs used when plotting points

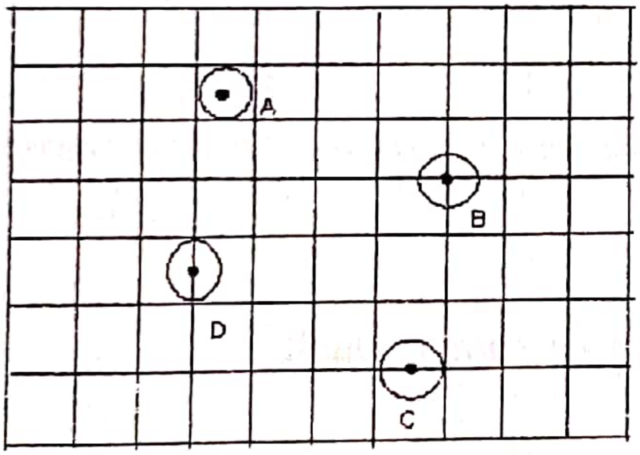
The experimental points should be plotted on the graph paper using a hard sharp pointed pencil marking them with a dot, . or a cross, or a dot encircled ⊙ or across encircled ⊗ but not *

The cross and the circle should cover less than four small squares of your graph paper. When plotting, be consistent in the marking of points i.e points must be marked with the same sign. Do not use ⊗ for some points and X or ⊙ for others.

Note:

- The intersection of the cross is the correct point plotted and the circling is to enable the visibility of your plotted points.
- If the points are marked with a dot and a circle, the circle must be of half small square radius

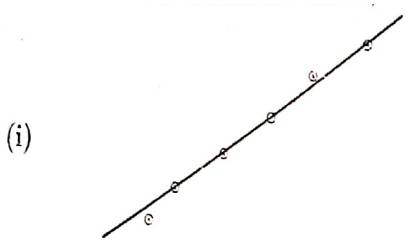
The diagram below shows how this should be done for points lying at different positions on the graph paper.

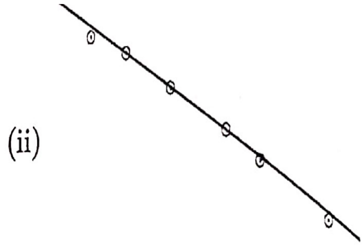


- If the point is in the middle of the square (A), the inclosing circle should not go beyond the boundaries of the square.
- If the point is at the intersection of lines (B), then the circle must cut the midpoints of the perpendiculars from it.
- If the point is on the horizontal (C), the enclosing circle must be between the boundaries of vertical lines before and after the point and should not touch the upper and lower lines.
- If a point is on the vertical (D), the enclosing circle must be between the boundaries of the upper and the lower lines and should not touch the lines before and after the point.

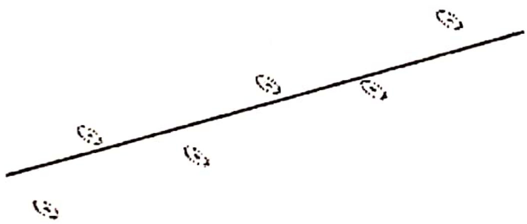
6.5. BEST STRAIGHT LINE OR BEST CURVE

For the best straight line use a 30cm transparent ruler and a sharp pencil. The best straight line is the line which passes through most or all the points plotted, leaving equal number of points below as above the line. Points which are below and above the line should approximately be the same distance from the line. Use a sharp pencil for drawing the best curve. The curve must be a smooth one.





If a line that satisfies the above condition cannot be obtained, draw a line that averages the plotted points. That is illustrated in the diagram below



If the graph is a curve, the best curve must be smooth and needs not to pass through all the plotted points.

6.6 SLOPE OR GRADIENT

In order to obtain a slope, a right-angled triangle is drawn touching the best straight line and enclosing all plotted points. The triangle should not touch any plotted points. The triangle should be drawn such that it touches the best straight line at the points of intersection of the squares. The coordinates of the slope must be accurately read from the triangle of the slope.

The slope should be calculated from the coordinates read. A slope may or may not have units depending on physical quantities that have been plotted. To obtain number of decimal places of the slope, the number of significant figures of the first values in the columns in the table of results a being plotted are used. The rule for multiplying and dividing numbers is then applied.

The unit of the slope must be derived from the labels on the axes of the graph. If the value of the slope is not in SI units, convert to SI units before using it in the next stage except for light experiments.

7. ERROR PROPAGATION

This is aimed at helping students know the possible sources of errors and how they can be minimized for better accuracy. It's not necessary for the students to include the error bounds and the possible sources of error in their practical answers.

There are three main types of errors that are actually incurred during experimental investigations. Learners are advised to take the necessary precautions to minimize these errors.

7.1 INSTRUMENTAL ERRORS

These are errors inherent in the apparatus itself and in the instruments used for measuring a physical quantity. It should be realized that, in a teaching laboratory, no apparatus can give high degree of accuracy. The results of any measurement should be considered with the degree of accuracy of the instrument in mind. However, measuring instruments used must be reliable enough.

Note: Instrumental errors cannot be eliminated by repeated measurements using the same apparatus. Generally, measuring instruments are accurate to about the smallest division.

7.2 SETTING OR ADJUSTMENT ERRORS

These are personal errors that arise from a faulty alignment of apparatus or wrong adjustment of apparatus.

Setting errors are perhaps the most common in teaching laboratory and may give rise to unnecessarily large errors in the final results. This calls for care and precision in setting up the apparatus for a given experiment.

Before arranging the apparatus, students are advised to ask for a clear set up of the experiment to avoid making a wrong alignment of the apparatus.

7.3 RANDOM ERRORS

These arise due to numerous fluctuating disturbances and uncertainties during an experimental investigation.

Sources of random errors include;

i) Observational errors, which may arise due to parallax and scale interpolation estimates.

ii) Pressure variation, where pressure is supposed to be constant.

iii) Temperature fluctuations, where temperature is supposed to be constant.

iv) Voltage or current fluctuations, where voltage or current is supposed to be constant.

The following example is used to guide on graph work.

Example 1: Determination of acceleration due to gravity by using Simple Pendulum

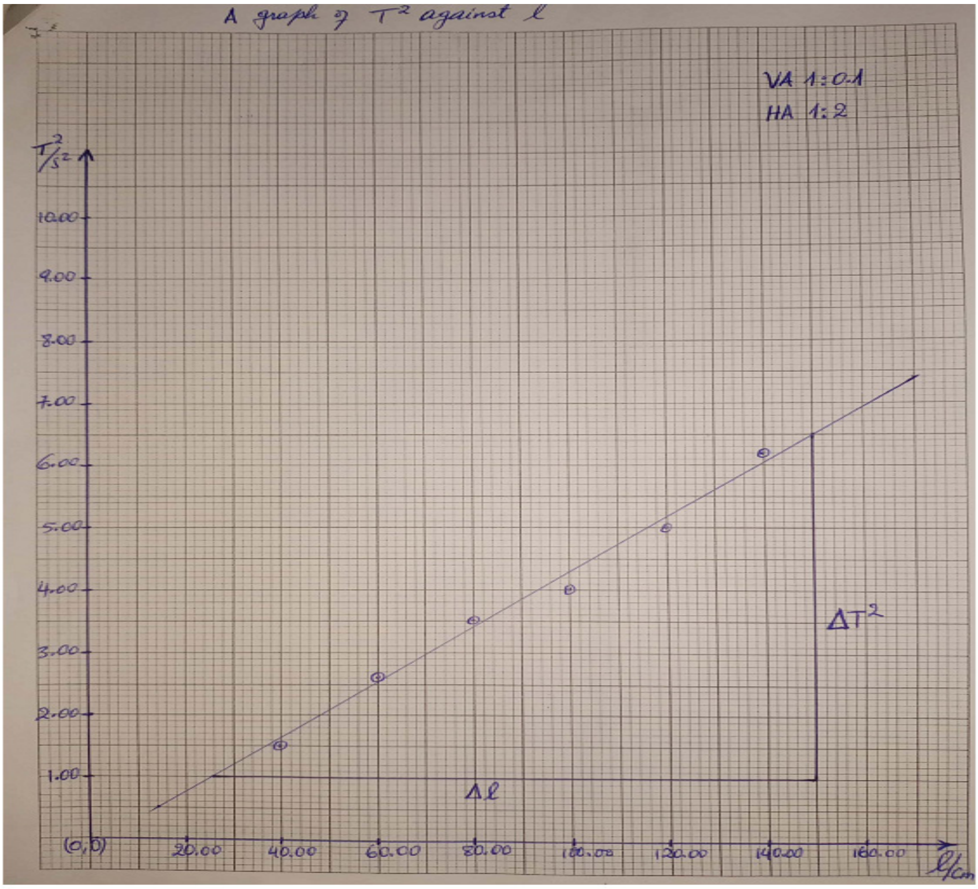
Table of results

L/cm	t/s	T/s	T^2/s^2
40.00	25.00	1.25	1.56
60.00	30.00	1.50	2.25
80.00	35.00	1.75	3.06
100.00	40.00	2.00	4.00
120.00	45.00	2.25	5.05
140.00	50.00	2.50	6.25

Where t is time for 20 oscillations

Interpretation of results

1.



2. Slope, $m = \frac{T_B^{\,2} - T_A^{\,2}}{l_B - l_A} = \frac{(6.50 - 1.00)s^2}{(150.00 - 26.00)cm} = \frac{5.50s^2}{124cm} = 0.04\, {s^2}/{cm}$

3. SI Unit of slope, $m =, s^2 \, ? \, cm$

$$m = \frac{4\pi^2}{g}$$

$$g = \frac{4\pi^2}{m} = \frac{(3.14)^2 \times 4}{0.04\, {s^2}/{cm}} = 985.96 cm/s^2$$

$$Thus,\ g = 985.96\, {cm}/{s^2} = 9.86\, {m}/{s^2}$$

4. Yes, he was correct, since $T = 2\pi\sqrt{\frac{l}{g}}$, then T& $\sqrt{l}$. (i.e. as l increases, period T increases)
5. Air resistance affects the period T of the pendulum, by increasing.

Conclusion

As conclusion, the value of gravitational acceleration obtained in our experiment is 9.86 m/s^2, the actual value of g is 9.81 m/s^2. However due to errors which may be made in the experiment the value of g should vary in the range of 9.71 and 9.91.

UNIT 1 LABORATORY SAFETY RULES AND MEASUREMENTS OF PHYSICAL QUANTITIES.

Experiment 1.1: Measurement of length, width, and height of a glass block (You might use any kind of block such as wooden block, a brick or even improvise your own block to use.)

Rationale

By using meter rule or meter stick, you can be able to measure the length and the height of bodies or objects mostly in carpentry, construction and in manufacturing industries, health care and other fields.

Objective

In this experiment, you will measure the length, width and the height of a glass block/wooden block or a brick.

Materials:

- Transparent meter rule
- Glass block or wooden block or a brick.
- A pencil and rubber
- Paper sheet

Set up

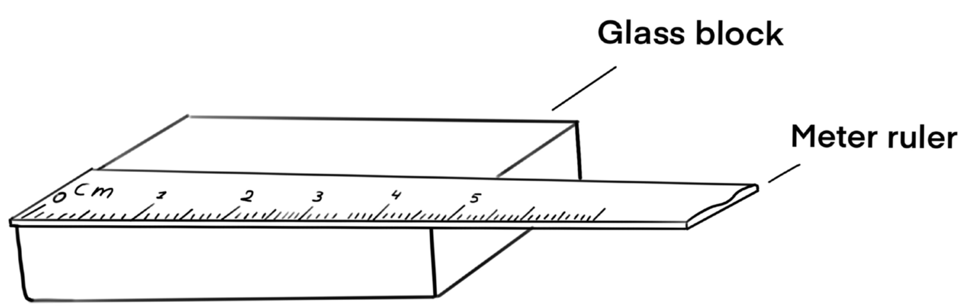


Fig. 1.1Measurement of length.

Procedures

1. Place the meter rule in contact with the block as shown in Fig. 1.1. The zero mark on the scale is placed at the edge of the block.
2. Position your eyes vertically above at the other end of the block as shown in Fig. 1.1 position. Suggest the reason for this position of the eyes. Read the measurement L1 and record it down on a piece of paper.
3. Remove the ruler and replace it again and measure length L_2
4. Repeat procedure 3 to obtain length L_3
5. Calculate the average of L_1, L_2 and L_3.
6. Re-read the measurement of the length (L_2) and length (L_3) and calculate the average of L_1, L_2 and L_3.
7. Repeat the steps 1 to 5, this time measuring the width (w) and thickness (t) of the block.
8. Record your reading in tabular form as shown in table below.

No.	Length	Width	Thickness
Reading 1			
Reading 2			
Reading 3			
Average reading			

Questions to guide interpretation of results

1) What is the length, width and thickness of used glass block?
2) What was the smallest division or the least count of used meter rule?
3) What is the importance of reading the measurements three times?
4) Why did the groups get different results?

Experiment 1.2: Measurement of diameter of optical pin by using Micrometer screw gauge

Rationale

By using micrometer screw gauge, you can be able to measure the thickness of your notebook paper sheet, your pencil, your pen or even your brother's toothbrush diameter at home.

Objective

In this experiment, you will measure the diameter of the optical pin provided by using Micrometer screw gauge.

Materials:

- Micrometer screw gauge
- Optical pin

Set up:

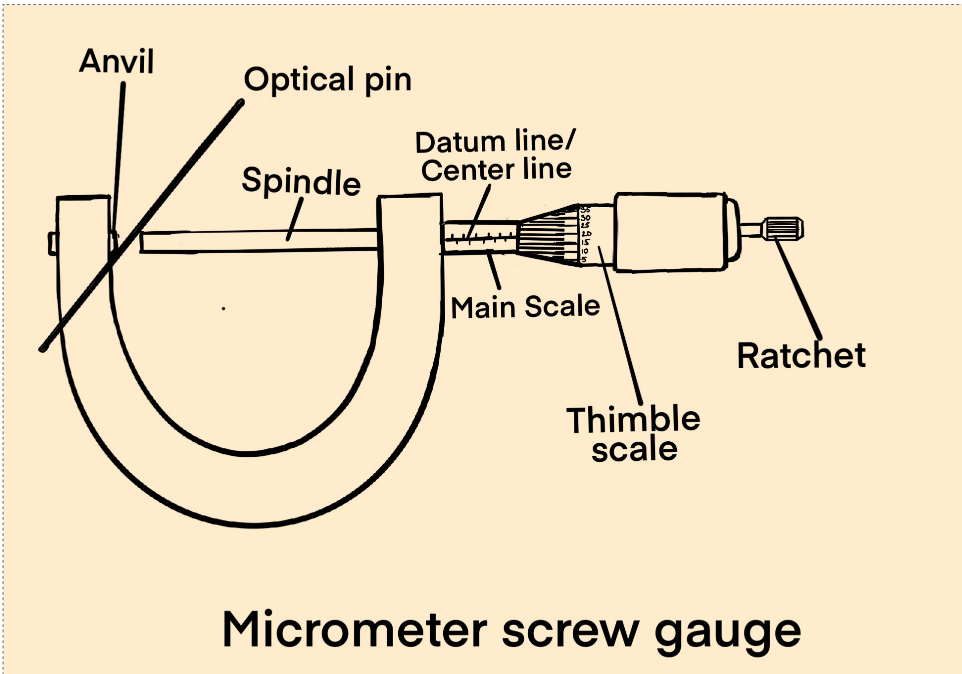


Fig. 1.2. *Measuring using micrometer screw gauge.*

Procedures

1. Clean the faces of the spindle and the anvil to remove any dirt.
2. Close the gap between the anvil and the spindle to check for zero error. In case of any error, remove it by rotating the zero-adjustment screw clockwise or anticlockwise as the case may demand. Alternatively, you may note the error as a negative or a positive value and add it to or subtract it from the final reading accordingly.
3. Turn the spindle to open a suitable gap for holding the optical pin between the anvil and the spindle.
4. Turn the ratchet until it makes first click (first sound) as in Fig. 1.2.
5. Take the readings on the main scale and the thimble scale and record them down in your exercise book.
6. Repeat procedure 3 to 5 by taking two more measurements. Deduce the average value.
7. Multiply the thimble scale reading by 0.01 mm.
8. Add the main scale reading (in mm) and the thimble scale reading (in mm) to get the diameter of the optical pin.
9. Record your readings in tabular form as shown in table below.

Diameter	Measured value
D1	
D2	
D3	
Average diameter, D	

Questions to guide interpretation of results

1) Specify the measured diameter of the optical pin.
2) What was the smallest division or the least count of used of micrometer screw gauge?
3) What is the importance of reading the measurements three times and why do we calculate the average?

Experiment 1.3: Measurement of internal diameter of the test tube by using a vernier caliper.

Rationale

By using vernier caliper, you can measure the diameter, depth as well as the thickness of the small objects mostly in carpentry, construction companies and in manufacturing industries.

Objective

In this experiment, you will determine the internal diameter of the test tube using vernier caliper.

Materials

- Test tube
- Vernier caliper

Set up

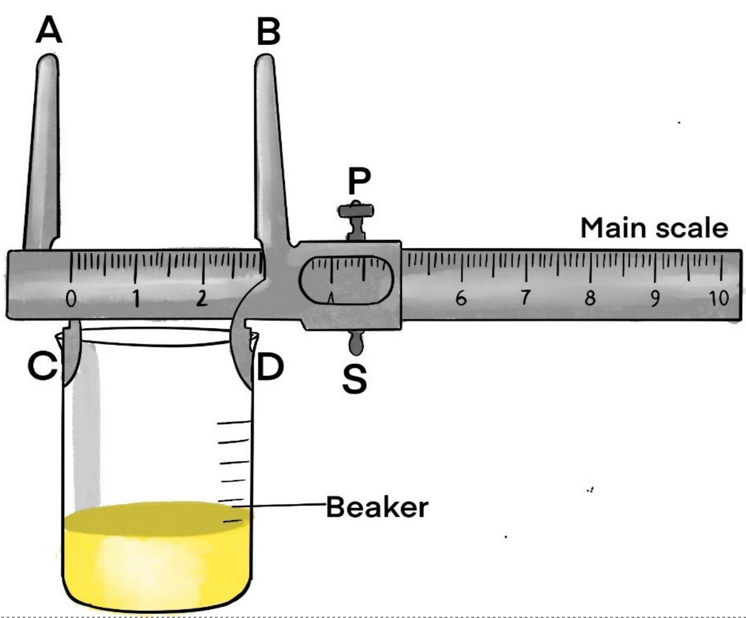


Fig. 1.3. *Measurement of inner diameter of the test tube.*

Procedures

1. Insert the inside jaws of a vernier calipers into the test tube.
2. Move the sliding jaws until the jaws just touch the inside walls of the test tube as shown in Fig. 1.3.
3. Read and record the readings on the main scale and of the vernier scale.
4. Use these readings to determine the internal diameter of the test tube.
5. Read and record the results in the table below

Measurements of the internal diameter of test tube.	Main scale readings/ cm	Vernier scale readings/ cm	Diameter/cm
Reading 1			
Reading 2			
Reading 3			
Average diameter D			

Questions to guide interpretation of results

1) According to the results you have got, what is the internal diameter of the test tube?
2) Explain the advantages of using a vernier caliper over a meter rule in measuring the diameter of a test tube?

Experiment 1.4: Measurement of the external diameter of the test

Rationale

By using vernier caliper, you can measure the diameter, depth as well as the thickness of the small objects mostly in carpentry, construction companies and in manufacturing industries.

Objective

In this experiment, you will determine the external diameter of test tube using a vernier caliper.

Materials:

- Test tube
- Vernier caliper

Set up

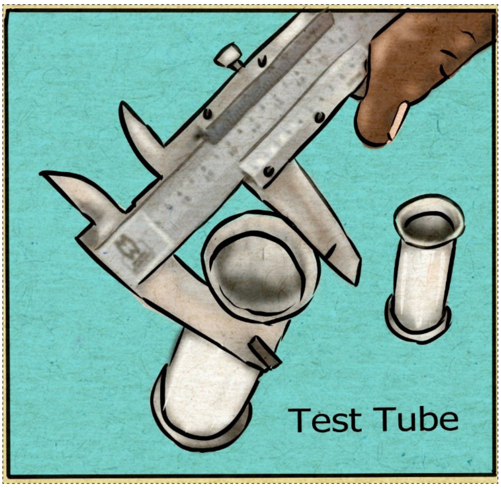


Fig.1.4. *Using Vernier Caliper to measure external diameter*

Procedures

1. Place the test tube to be measured between the outside jaws as shown in Fig. 1.4.
2. Record the readings on the main scale and the vernier scale. The main scale reading is the mark on the main scale that is immediately before the zero mark of the vernier scale.
3. Multiply the vernier scale reading by 0.01 cm
4. Add the main scale reading (in cm) and the vernier scale reading (cm) to get the diameter of the test tube and record your reading in table below.

Measurements of the external test tube.	Main scale readings/cm	Vernier scale readings /cm	Diameter/cm
Reading 1			
Reading 2			
Reading 3			
Average diameter D			

Questions to guide interpretation of results

1) What is the value of external diameter of measured test tube?
2) What are the causes of deviation resulting in this experiment?

Experiment 1.5: Measurement of the depth of the beaker using a vernier caliper.

Rationale

By using vernier caliper, you can measure the diameter, depth as well as the thickness of the small objects mostly in carpentry, construction companies, manufacturing industries and other fields.

Objective

In this experiment, you will determine the depth of beaker using a vernier caliper.

Materials:

- Beaker
- vernier caliper

Set up

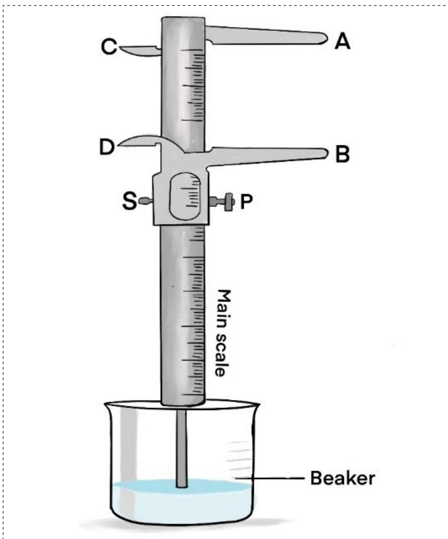


Fig. 1.5. *Measuring the depth of the beaker.*

Procedures

1. Turn thumb screw to extend depth rod.
2. Move the thumb screw gradually until the end of the beam scale makes contact with the top of the hole.
3. Position rod in hole and turn lock screw
4. Read measured values and record your readings in table below.

Measurements of depth of the beaker	Main scale readings/ cm	Vernier scale readings/cm	Depth/cm
Reading 1			
Reading 2			
Reading 3			
Average readings			

Questions to guide interpretation of results

1) What the depth of used beaker?
2) Explain the advantages of using a vernier caliper over a meter rule in measuring the depth of a beaker?
3) Compare your results to the rest of the class members.
4) Why do you think some of your classmates got different results?

Experiment 1.6: Measurement of the thickness of the test tube

Rationale

By using vernier caliper, you can measure the thickness of the test tube mostly in carpentry, construction companies and in manufacturing industries.

Objective

In this experiment, you will determine the thickness of test tube using a vernier caliper.

Materials:

- Test tube or Beaker,
- Vernier caliper

Set up

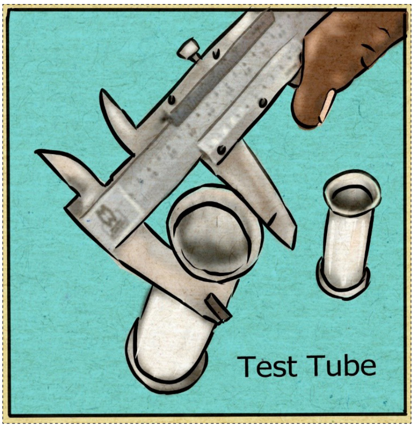


Fig 1.6. *Thickness of test tube*

Procedures

1. Measure and record the external diameter of test tube
2. Multiply the vernier scale reading by 0.01 cm.
3. Add the main scale reading (in cm) and the vernier scale reading (in cm) to get the diameter internal and external of the test tube.
4. Repeat the procedures (1) to (3) for inner diameter of test tube.
5. Subtract internal from external diameter of the test tube in order to get thickness of the test tube and record your reading in table below:

Internal diameter of test tube.	External diameter of test tube.	thickness of the wall of test tube.

Questions to guide interpretation of results

1) What is the thickness of the wall of the test tube?
2) Explain the advantages of using a vernier calipers in determination of thickness wall of the test tube?
3) What do you expect to be the sources of deviation from the correct measurement?

Experiment 1.7. Measurement of the mass of an object by using a spring balance

Rationale

By using Spring Balance, you can measure the mass of an object mostly in shops, markets, industries, etc.

Objective

In this experiment, you will measure the mass of an object by using a spring balance.

Materials:

- 1 Spring balance (or 1 Newton meter)
- Any mass you want to measure (you can use a small Stone, dry cell, wooden block etc)
- Retort stand, clamp and bosses.
- Piece of thread 50 cm long.

Set up

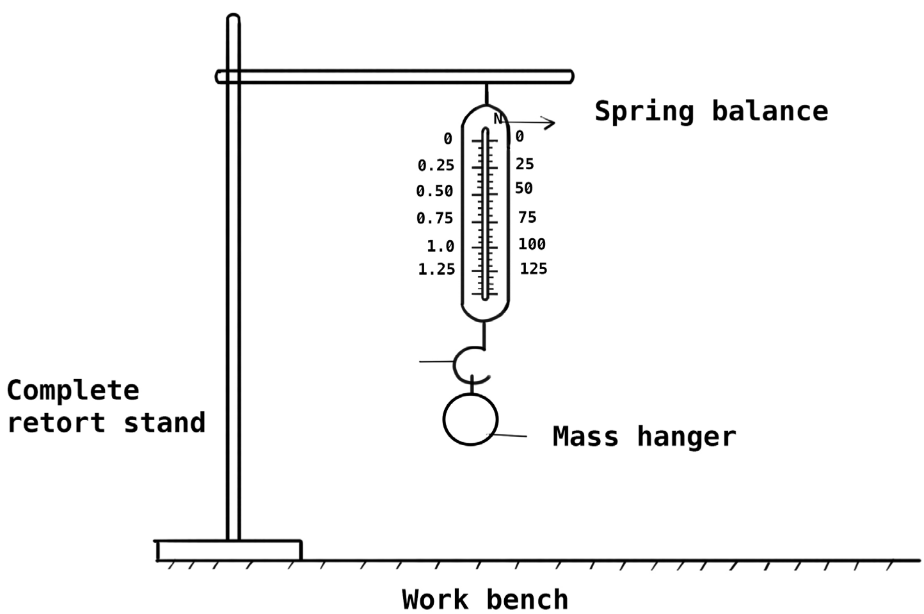


Fig. 1.7 *The use of Spring balance for mass measurements.*

Procedures:

1. Clamp vertically the spring balance as shown in the fig.1.7
2. Be sure that the spring balance is at rest and the is at zero mark.
3. Hang the hanger on the spring balance
4. Read and record the mass of hunger and call m1
5. Repeat procedures (3) and (4) for a small stone and dry cell.
6. Repeat procedures (2) to (4) using triple beam balance for mass hunger, a small stone and dry cell.
7. Repeat procedures (2) to (4) using electronic balance for mass hunger, a small stone and dry cell.
8. Record your data in tabular form as in table

Object	Mass		
	Spring balance	**Triple beam balance**	**Electronic balance**
Mass hanger			
Small stone			
Dry cell			

Questions to guide interpretation of results

1) What is the unit of measured mass?
2) Do the measured objects have the same mass using the same type of balance?

Experiment 1.8. Measurement of the time by using stopwatch

Rationale

By using stopwatch, you can measure the time of the activities you would like to perform.

Objective

In this experiment, you will measure time using stopwatch.

Materials:

- Stopwatch
- Pencil and rubber
- Sheet of paper or a notebook

Set up:

Fig.1.8. *Stopwatch*

Procedures

1. Verify the caliber of the stopwatch
2. Reset the stopwatch
3. Practice starting, stopping and resetting the stopwatch
4. Put hand on your chest
5. Be ready to start the stopwatch as you start counting heart beats.
6. Star stopwatch and counting the heart beeps
7. Stop timing immediately as soon as you count for 72 beats
8. Read and record the time taken for 72 beats
9. Record your data in tabular form as in table below.

Number of heart beats	Time taken

Questions to guide interpretation of results

1) Find the duration between two heart beats?
2) Find the average of time interval between two heart beats among your group members.

3) The normal range of the time interval between two heart beats for age group of 6-16 years is 0.60 to 0.75. did your calculated average range match with the normal range?

Experiment 1.9: Determination the volume of an irregular shaped solid (stone) using Eureka can

Rationale

By using Eureka can and cylinder, you can measure the volume of the irregular objects mostly in manufacturing industries.

Objective

In this experiment you will measure the volume of the irregular object provided.

Materials:

- Eureka can
- Irregular stone
- Water
- Measuring cylinder
- Thread

Set up:

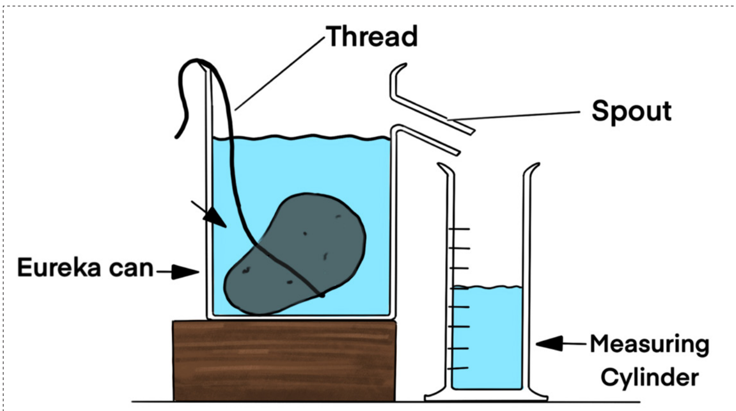


Fig. 1.9. *Measuring the volume of an irregular solid using Eureka can.*

Procedures

1. Fill a Eureka can with water until some of it overflows through the spout.
2. Once the overflow stops, put the measuring cylinder at the mouth of the spout.
3. Tie the irregular solid with a string and lower the solid carefully into the can. Make sure the solid is completely immersed.
4. Collect and measure the volume V_1 of the water displaced (Fig. 1.9).
5. Repeat the procedures 1, 2,3 and 4 for the second and the third time to find V_2 and V_3.
6. Record your reading in tabular form as shown in table below.

Number of Readings	Volume/ml
V_1	
V_2	
V_3	
Average volume	

Questions to guide interpretation of results

1) By reading on the measuring cylinder, what was the position of the eyes?
2) Calculate the average volume to get the exact volume of water displaced.
3) If you found the volume of water displaced, then what could be the volume of the irregular solid?

Experiment 1.10: Determination of the volume of a regular shaped solid using a measuring cylinder.

Rationale

By using Cylinder, you can measure the volume of the regular objects mostly in beverages companies and industries.

Objective

In this experiment you will measure the volume of a regular shaped solid using a measuring cylinder.

Materials

- Meter rule
- Pendulum bob
- Measuring cylinderWater
- thread

Set up

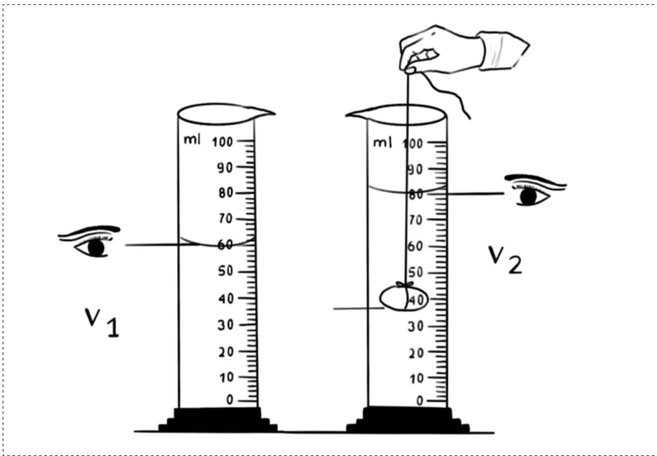


Fig. 1.10. *Measuring volume by displacement.*

Procedures

1. Using vernier calipers, measure and record the diameter D1 of the pendulum bob.
2. Carefully, repeat procedure (1) for other two more times.
3. Calculate its volume using the formula $V_0 = \frac{4}{3}\pi r^3$,where r is radius of the bob.
4. Partly fill a measuring cylinder with water and record the initial volume of the water V_1. Carefully lower the bob into the water in the measuring cylinder (see Fig. 1.10). Record the new volume of the water V_2.
5. Find the volume of the water displaced, $V = V_2 - V_1$

Questions to guide interpretation of results

1) Compare the volume V with the volume, V_o, of the bob calculated using the formula
2) Did you get the difference between the two, and why do you think they might be equal or different?

Experiment 1.11. Measurement of density by using spring balance and a measuring cylinder

Rationale

Measuring the density of an object helps to determine whether or not an object will float on water. If the object's density is less than the density of water, it will float; if its density is less than that of water, it will sink. you can determine the density of the objects mostly in beverages companies and industries.

Objective

In this experiment you will measure the density of the regular objects using spring balance and a measuring cylinder.

Materials

- Spring balance
- Measuring cylinder,
- Water,
- Solid body (denser than water)
- 20cm long thread
- Pencil and rubber
- Sheet of paper

Set up

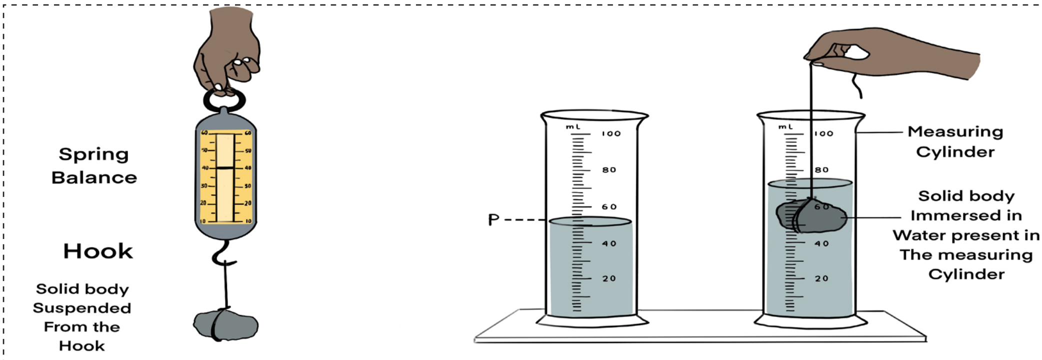


Fig 1.11 *Measuring the density of object*

Procedures

1. Tie the solid with a thread and suspend the given solid body from the hook of the spring balance as in the figure 1.11.
2. Read and record the true mass of the solid in grams
3. Take the measuring cylinder and half fill it with water.
4. Read and record the initial reading of the cylinder, V_1 in cm^3
5. Gently immerse the given solid body completely in water and note the final reading of cylinder, V_2 in cm^3.
6. Estimate the volume of solid $V = V_2 - V_1$

Questions to guide interpretation of results

1) Calculate the density ρ_s of a solid from the formula $\rho_s = m/V$
2) Estimate the density ρ_s of the solid in kilogram per cubic meter, kg/m^3.

Experiment 1.12: Measurement of relative density of a solid

Rationale

Relative density can help to quantify the buoyancy of a substance in a fluid or gas or determine the density of an unknown substance from the known density of another. Relative density is often used by geologists and mineralogists to help determine the mineral content of a rock or other sample.

Objective

In this experiment, you will measure the relative density of a solid.

Materials:

- Spring balance
- Measuring cylinder,
- Water,
- Solid body (denser than water)
- 20cm long thread
- Pencil and rubber
- Sheet of paper of notebook

Set up

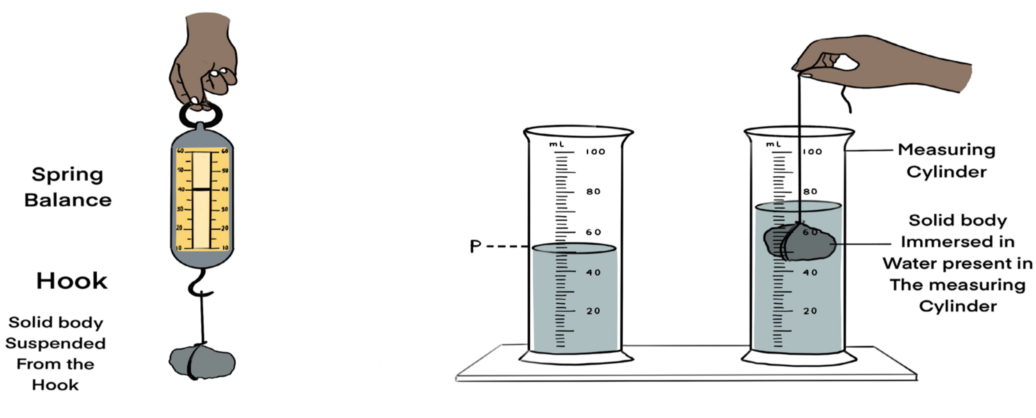


Fig 1.12 Measurement of relative density of a solid

Procedures

1. Tie the solid with a thread and suspend the given solid body from the hook of the spring balance as in the figure 1.12.
2. Read and record the true mass of the solid in grams
3. Take the measuring cylinder and half fill it with water.
4. Read and record the initial reading of the cylinder, V_1 in cm^3
5. Gently immerse the given solid body completely in water and note the final reading of cylinder, V_2 in cm^3.
6. Estimate the volume of solid $V = V_2 - V_1$

Questions to guide interpretation of results

1) Calculate the density ρ_s of a solid from the formula $\rho_s = m/V$.

2) Estimate the density ρ_s of the solid in kilogram per cubic meter, kg/m^3.

3) Calculate the relative density of solid from ρ_s/ρ_w where ρ_s is density of a solid and $\rho_w = 1000\, kg/m^3$ is density of water.

4) What is the SI unit of relative density?

Experiment 1.13: Measurement of the density of liquid (water or any other)

Rationale

The density of liquids is an important physical parameter that plays an essential role not only in consumer protection, trade, safety and healthcare, taxation, and environmental protection but also in research and development. It is needed, for example, for the characterization of oils and fuels as well as for determination of alcohol concentration in alcoholic beverages for fiscal purposes or the determination of sugar content in non-alcoholic beverages. Knowledge of the density is also needed to quantify large amounts of liquid goods when converting a mass flow into a volume flow or vice versa

Objective

In this experiment you will measure the density of water.

Materials:

- Electronic balance
- Graduated cylinder
- Water
- Pencil and rubber
- Paper sheet or notebook

Set up

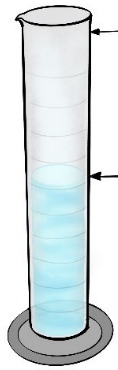


Fig.1.13. *Measurement of density of the liquid*

Procedures:

1. Using the electronic balance, measure and record the mass mc of your graduated cylinder.
2. Add 20 mL of water to the graduated cylinder. Precisely measure this volume V of water.
3. Measure and record the new mass m, (cylinder plus water), in grams.
4. Find the mass of water by subtracting the mass of the empty cylinder from combined mass, $m_o = m - m_c$
5. Find the ratio $\rho = m_0 / V$
6. Repeat procedures (2) to (5) for other 3 readings of volume by increasing the volume with about 20mL each time.
7. Record the results in a tabular form as shown in table here below.

V /cm³	m_o / g	$\frac{m_o}{V} / gcm^{-3}$
20		
30		
40		
50		

Questions to guide interpretation of results

1) What is the observation in the ratio $\rho = m_0/V$

2) From this experiment, estimate the density of water.

Experiment 2.1: Measurement of acceleration due to gravity by using spring balance

Rationale

By performing this experiment, you can measure the acceleration due to the gravity of falling objects to the ground at any location.

Objective

In this experiment you will use the spring balance to estimate the acceleration due to gravity.

Materials:

- 1 Spring balance (or 1 Newton meter)
- 1 mass of 50g slotted on a hanger of 50 g (or either 100g Stone, box of chalks, wooden block etc)
- Retort stand, clamp and bosses

Set up

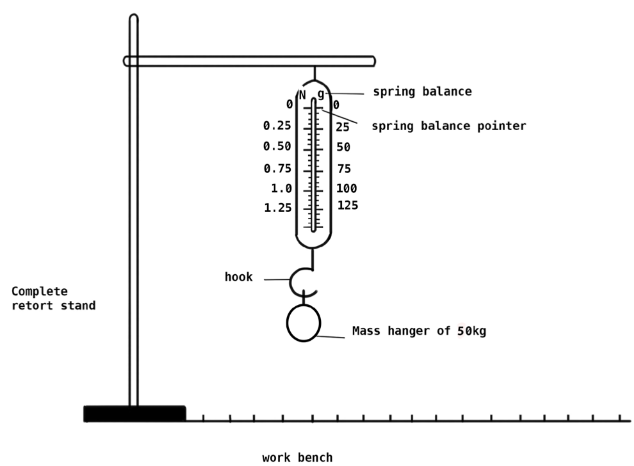


Fig 2.1 *Measurement of the acceleration due to the gravity*

Procedures

1. Clamp vertically the spring balance as shown in the fig.2.1.
2. Hang mass m=100g (the hanger with mass) on the spring balance
3. Read and record the weight and call W_1
4. Re-read the measurement of the weight W_2 and W_3
5. Calculate the average of W_1, W_2 and W_3 and call it W.
6. Record your data in tabular form as in table below.

Reading	Weight
W_1	
W_2	
W_3	
Average weight, W	

Questions to guide interpretation of results

1) Express the mass m =100g in kilogram, (kg).
2) Calculate the constant g from the formula $g = W/m$
3) What is the unit of g calculated in part (2) above?
4) What is the meaning of constant g?

Experiment 2.2: Measurement of velocity of a moving body

Rationale

The velocity of a moving body can be defined as the rate of change of the body's position with respect to a frame of reference and time. Velocity determine how fast is a moving body and in which specific direction.

Objective

In this experiment, you will determine the velocity of moving body correctly using displacement sensors and stopwatch.

Materials:

- A ruler
- Stopwatch
- Tennis ball or marble
- Table

Set up

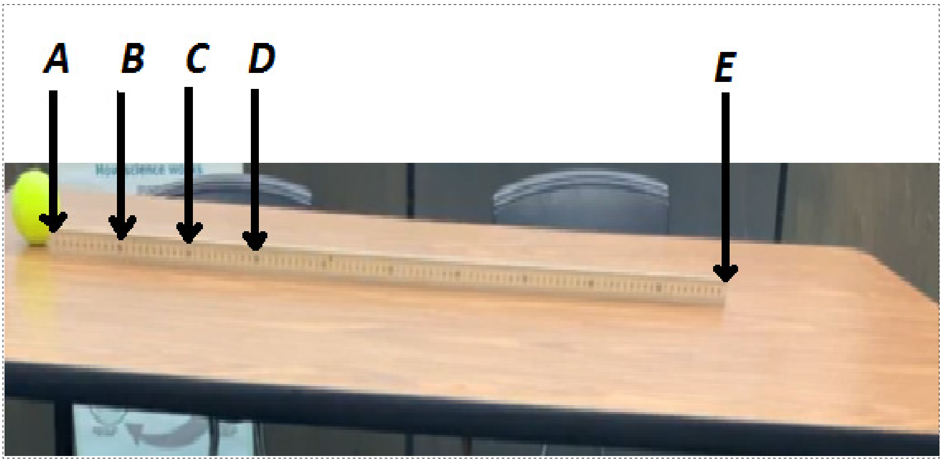


Fig.2.2 Inclined table

Procedures

1. Arrange the table inclined so that the ball will move freely.
2. Mark different starting positions of the ball using a meter rule and marker pen.
3. Mark the starting point by A at 0*cm*, B at 10cm mark from A, C at 20*cm* mark from point A, D at 30*cm* mark from point A and E at 100*cm* mark from A.
4. Place the marble at the point A mark, and let it move (roll) down to point E.
5. Use the stopwatch to measure the time used by the body to move from the point mark A to the point mark E.
6. Repeat the step (2) and step (3) with the body starting its motion from B, C and D
7. Record your data in tabular form as in table below:

Stages	Displacement(d)/m	Time(t)/s	Displacement over time $\left(\frac{d}{t}\right)$/ $m.s^{-1}$
From A to E			
From B to E			
From C to E			
From D to E			

Questions to guide interpretation of results

1) Plot the graph of displacement against time.
2) Find the slope
3) How do you compare different values obtained for $\frac{d}{t}$ at A, B, C and D?
4) How does the value of d/t at point A, B, C and D compare with the slope calculated from the graph?
5) What does the slope of the graph represent?

Experiment 2.3: Determination of the linear acceleration of a moving object

Rationale

Acceleration of a moving body is a vector quantity defined as the rate of changes of its velocity. A moving body is accelerating if it is changing its velocity (in magnitude or direction) throughout time.

Objective

In this experiment you will determine the acceleration of moving object.

Materials:

- Marble or tennis ball
- ruler,
- ramp,
- Stopwatch
- wooden block.

Set up

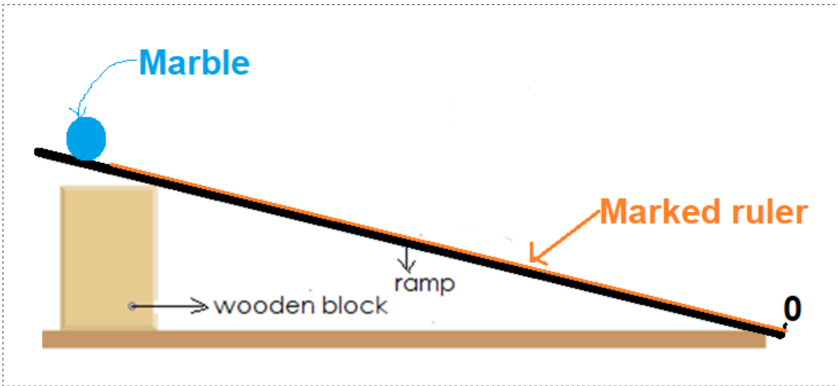


Fig.2.3: *A ramp*

Procedures

1. Set up a ramp balanced on a wooden block at one end.
2. Attach the meter rule on the ramp.
3. Mark out X_1 = 30 cm from mark 0cm at bottom. Avoid making the ramp too steep, as this will cause the trolley to roll too quickly, which could make measuring difficult.
4. Place the marble or ball at 30cm mark on the runway and hold it in place gently with the finger
5. By simultaneously releasing the marble or ball to descend and starting the stopwatch.
6. Measure and record the time t_1, taken by the marble or ball to reach the lower end of the runway (It is advisable to measure the time twice and record the average time)
7. Repeat procedures (3), (4) and (5) for X_2 = 50cm, X_3 = 70cm and X_4 = 90cm mark
8. Record your data in tabular form as in table below:

X/cm	t/s	t^2/s^2	$\frac{2x}{t^2}$ / ms^{-2}
30			
50			
70			
90			

Questions to guide interpretation of results

1) What does $\frac{2x}{t^2}$ stand for?
2) Find the average value of all values of $\frac{2x}{t^2}$
3) What is the unit of result in (2)?

Experiment 3.1: Demonstration of effect of friction force on the motion

Rationale

Friction force is very important in life, it can slow things down and stop stationary things from moving.

Objective

In this experiment you will use the light spring to demonstrate the effects of friction force on the motion of a brick.

Materials

- A wooden block
- Pencil
- A spring balance.
- A bench or a fixed table

Setup

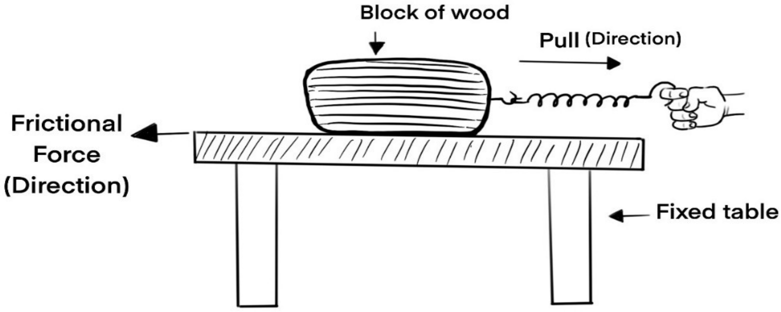


Fig. 3.1. *Direction of friction force.*

Procedures

1. Attach the wooden block to the spring balance placed on the bench.
2. Read and record the measurement of spring balance.
3. Pull the block a brick using a spring balance slowly until it starts moving slightly.
4. Read and record the maximum force Fo at which the brick starts moving.
5. Repeat procedures (2) and (3) for two times and find the average of the maximum force.
6. Then pull the block and let it move.
7. Then for the second time, pull it a bit faster across the bench. (Fig. 3.1). Observe what happens comparing to (2).
8. Discuss the observations made in (2).
9. Place a pencil on the horizontal bench and give it a slight push. Observe and explain what happens.

Questions to guide interpretation of results

1) What did you observe before the block started moving?
2) Discuss what happened after the block started moving?
3) What are types of force does table acting on the block?
4) From this experiment explain the effects of friction on the motion of the body.

Experiment 3.2: Demonstration of upthrust force

Rationale

When the ship or the boat is sailing in the sea or ocean it is by the help of the upthrust force which makes it to float on the water. And when a person is swimming, the upthrust force helps him stay at the top of the pool or lake.

Objective

In this experiment you will use the spring balance to determine the upthrust force.

Materials:

- Retort stand
- A spring balance (0 – 1N)
- Beaker with water
- A solid mass of 50g.

Set up

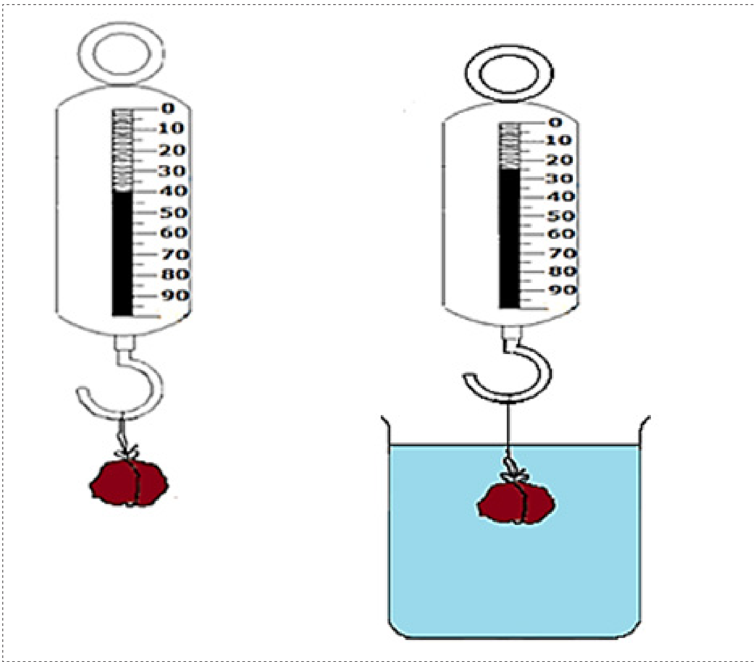


Fig. 3.2. *Demonstration of upthrust force*

Procedures

1. Suspend a solid in air on a retort stand, using a spring balance. Note down its weight (Wo).
2. Place the beaker with water in it, under the suspended solid.
3. Lower the clamp of the retort stand slowly until it reaches in the beaker and let it submerge in the water fully. What is the weight (W) of the solid? Note it down.

Questions to guide interpretation of results

1) Compare the weight of the solid in the air and in the water.
2) What type of the force did the water apply on the solid?
3) Estimate the upthrust force applied by water on the mass.
4) How do you think of the influence of the water on the solid's weight?

Experiment 3.3: Determination of spring constant and the verification of Hook's law

Rationale

The spring-constant is important as it shows the basic material property. This gives exactly how much force is required to deform any spring of any material. The higher spring's constant shows the material is stiffer and the lower spring's constant shows the material is less stiff.

Objective

In this experiment you will determine the spring constant of a spring provided and verify Hook's law.

Materials:

- Retort stand
- Meter ruler
- Helical spring
- Slotted masses

Setup

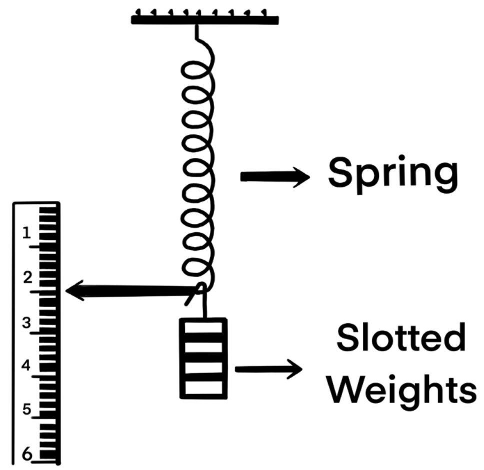


Fig. 3.3. *Demonstration of added masses to the spring to measure the extension*

Procedures

1. Suspend the spring balance from rigid support as shown in the Fig.3.3.
2. Read and record the initial position of the pointer of the spring X_o when it does not have any mass on it.
3. Add a weight of 50g to the spring and, by the use of meter rule, read and record the new position of the pointer of the spring X_1.
4. Repeat procedure 3, for other three times adding a mass of 50g each time. Note: hold together strongly adequate to grasp it in position.
5. Record your reading in tabular form as shown in table below

Mass/g	New position (X_1/ cm)	Extension $X = (X_1 - X_o)$ /cm	$F = m \times g$	Constant, k/Nm^{-1}
50				
100				
150				
200				

Questions to guide interpretation of results

1) Calculate the force $F = m \times g$, take g = 10N/kg and do this for every mass added.
2) Find constant k, using $F = -kx$ for every extension x in cm.
3) Compare the values of constant, k for all masses and deduce the constant, k of the spring balance used by calculating the mean.

Experiment 3.4: Demonstration of the existence of an electrostatic force

Rationale

Many practical applications of electrostatics exist, including photocopiers, laser printers, ink jet printers, and electrostatic air filters. Rubbing the plastic ruler on dry piece of cloth, you will be able to prove the existence of electric charges.

Objective

In this experiment you will prove the existence of an electrostatic force with the use of silk piece of cloth.

Materials:

- Plastic ruler/pen
- Dry piece of cloth
- Pieces of paper

Setup

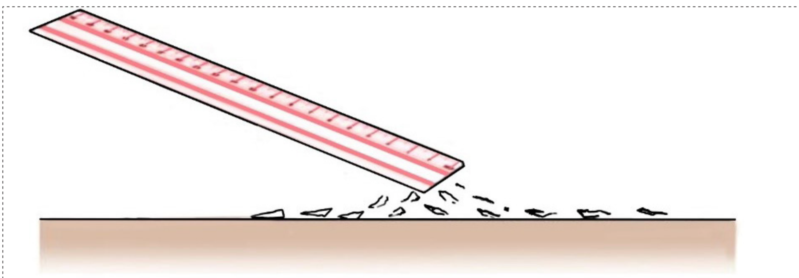


Fig. 3.4. *Ruler pulling up papers*

Procedures

1. Rub a plastic ruler against a dry piece of cloth. Suggest a reason why we do so.
2. Just immediately after rubbing the plastic ruler, bring the plastic ruler close to small pieces of paper (Fig 3.4).
3. Repeat procedure 1 and 2, but this time on, use a pen. Did you obtain the same result?

Questions to guide interpretation of results

1) What was the behavior observed between the ruler and the pieces of paper? What is the cause of that behavior?
2) What do you conclude from your own observation?

Experiment 3.5: Demonstration of the existence of a magnetic force

Rationale

Every young kid wishes to become an engineer or even to own an industry which makes car and maybe electrical equipment like television, fridge, microphones, etc. So in order to achieve this, you have to know some working principles of those items, and among those principles includes application of "Magnetic force".

Objective

In this experiment you will demonstrate how magnet force exists between metal rod and magnet as well as between two magnets.

Materials:

- 2 bar magnets
- A thread
- Iron rod

Set up

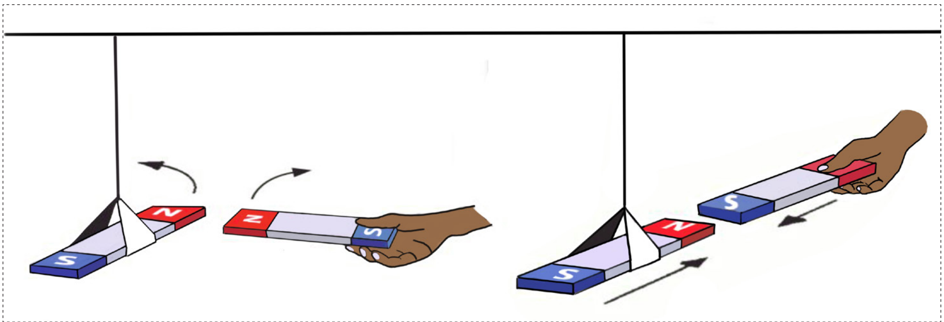


Fig. 3.5. *Two poles of bar magnets brought near one another*

Procedures

1. Suspend a bar magnet from a support using a light thread. Allow the bar magnet to swing freely until it comes to rest.
2. Bring the north pole of the second bar magnet near the north pole of the first one (Fig 3.5). What do you observe?
3. Now bring the south pole of the second bar magnet near the north pole of the first one (Fig 3.5). What do you observe?
4. Repeat step 1 and 2 using a bar magnet and iron rod. What do you observe?

Questions to guide interpretation of results

1) Explain your observations in procedure 2.
2) Explain your observations in procedure 3.
3) Give a comment on procedure (4).

Experiment 4.1: Demonstration of inertia using a coin

Rationale

If you throw a rock straight up, it will not vary from its direction. Inertia enables ice skaters to glide on the ice in a straight line. If the wind is blowing, a tree's branches are moving. A piece of ripe fruit that falls from the tree will fall in the direction the wind is moving because of inertia.

Objective

In this experiment you will demonstrate inertia using a coin.

Materials:

- A coin
- A beaker
- A smooth cardboard or a sheet of paper

Set up

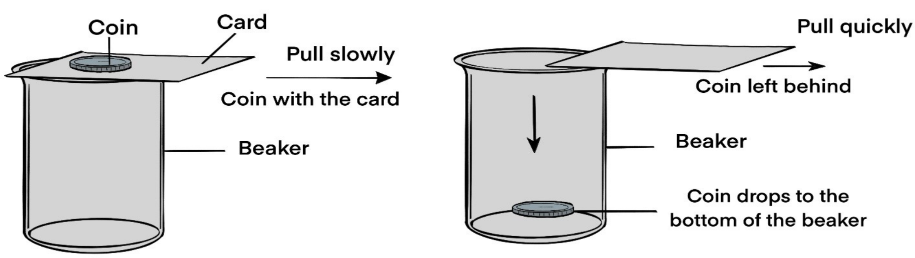


Fig 4.1 Existence of inertia

Procedures

1. Place a coin on a smooth cardboard and place it over a beaker. Pull the card away slowly.
2. Repeat the activity but this time pull the card away suddenly.

Questions to guide interpretation of results

1) Observe what happens to the coin in procedure 1.
2) Observe what happens to the coin in procedure 2.
3) Suggest a reason why the coin behave differently in these procedures.

Experiment 5.1: Location of the position of centre of gravity of a regular object.

Rationale

The location of the centre of gravity is sometimes useful in designing static structures (e.g., buildings and bridges) or in predicting the behaviour of a moving body when it is acted on by gravity.

Objective

In this experiment you will locate the position of centre of gravity of a rectangular card using a table.

Materials

- A table,
- Thin rectangular card

Setup

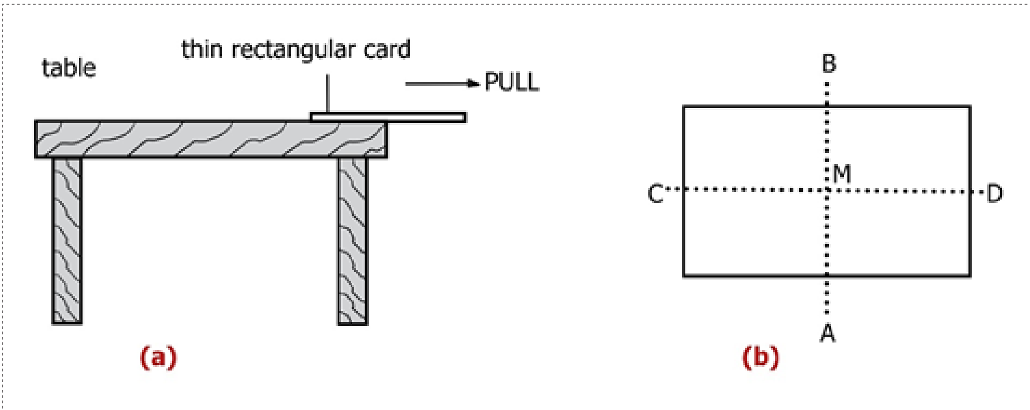


Fig 5.1 Determination of centre of gravity

Procedures

1. Place a thin rectangular cardboard near the edge of the bench top.
2. Pull the card slowly away from the bench until it is just about to topple over then released as shown in Fig.5.1. (a).
3. Using a ruler, mark and draw the line AB along which the card balances.
4. Repeat the activity with the other side of the card, mark and draw the line CD along which the card balances. The lines AB and CD intersect at a point M in Fig 5.1. (b)
5. Now, try to balance the card with the point M placed at the tip of your fore finger.

Questions to guide interpretation of results

1) What do you notice in procedure 5?
2) Suggest reason for this observation.

Experiment 5.2: To locate the centre of gravity of a regular lamina

Rationale

The location of the centre of gravity is sometimes useful in designing static structures (e.g., buildings and bridges) or in predicting the behaviour of a moving body when it is acted on by gravity.

Objective

In this experiment, you will locate the centre of gravity of a regular lamina using drawing pin.

Materials

- A regular lamina.
- Plumb line.
- A drawing pin.

Setup

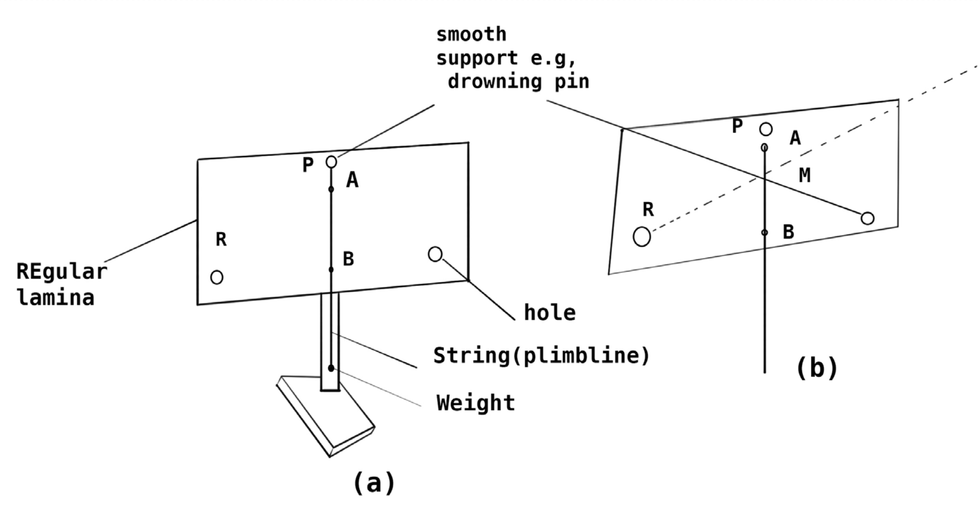


Fig 5.2. *Determination of center of gravity*

Procedures

1. Make three holes P, Q and R on a regularly shaped lamina as close as possible to the edges and far away from each other. The holes should be large enough to allow the lamina turn freely when supported through a drawing pin.
2. Suspend the lamina on the clamp using the drawing pin through each hole at a time.
3. Suspend a plumb line (a thin thread with a small weight at one end) from the point of support, P as shown in Fig. (a), and draw the line of the plumb line on the lamina by marking two points A and B far apart and joining them.
4. Repeat the procedures (3) with the support Q and mark the point M where the two lines intersect.
5. Check the accuracy of your method by suspending the lamina at R. What do you observe?

Questions to guide interpretation of results

1) From procedure (5), does the plumb line pass through M?
2) Explain the meaning of point M.

Experiment 5.3: Determination of centre of gravity (c.o.g) of irregular lamina.

Rationale

It is important to know the centre of gravity because it predicts the behaviour of a moving body when acted on by gravity. It is also useful in designing static structures such as buildings and bridges

Objective

In this experiment, you will determine the Centre of mass of an irregular lamina using a plumb line.

Materials

- An irregular lamina,
- Plumb line,
- A drawing pin

Set up

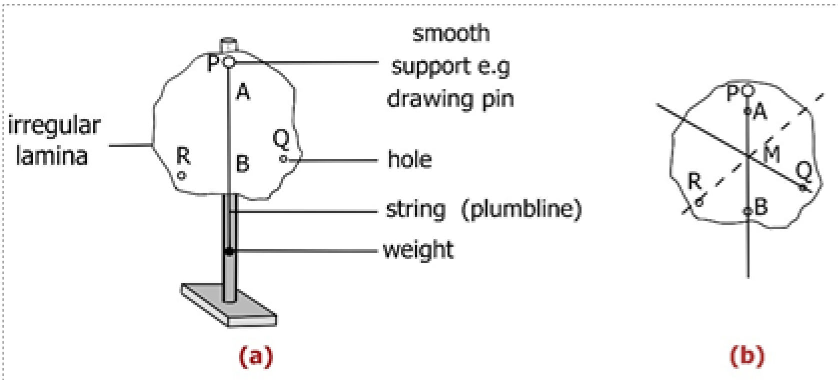


Fig 5.3. *Determination of center of gravity.*

Procedures.

1. Make three holes P, Q and R on an irregularly shaped lamina as close as possible to the edges and far away from each other. The holes should be large enough to allow the lamina turn freely when supported through a drawing pin.
2. Suspend the lamina on the clamp using the drawing pin through each hole at a time.

3. Suspend a plumb line (a thin thread with a small weight at one end) from the point of support, P as shown in Fig. 5.3.(a) and draw the line of the plumb line on the lamina by marking two points A and B far apart and joining them.
4. Repeat the steps with the support Q and mark the point M where the two lines intersect.
5. Check the accuracy of your method by suspending the lamina at R. What do you observe?

Questions to guide interpretation of results

1) From procedure (5), does the plumb line pass through M?
2) Check the results again by balancing the lamina on the top of your finger about point M. What do you observe?

UNIT 6 WORK, POWER, AND ENERGY (1)

Experiment 6.1: Determination of work done in pulling an object along a horizontal surface.

Rationale

Work is done whenever a force moves something. Everyday examples of work include walking upstairs, lifting heavy objects, pulling a sledge and pushing a shopping trolley, etc. Whenever work is done, energy is transferred from one place to another.

Objective

In this experiment you will determine the work done in pulling an object along a horizontal surface

Materials:

- a block of wood,
- a spring balance
- a tape measure/metre ruler.

Set up

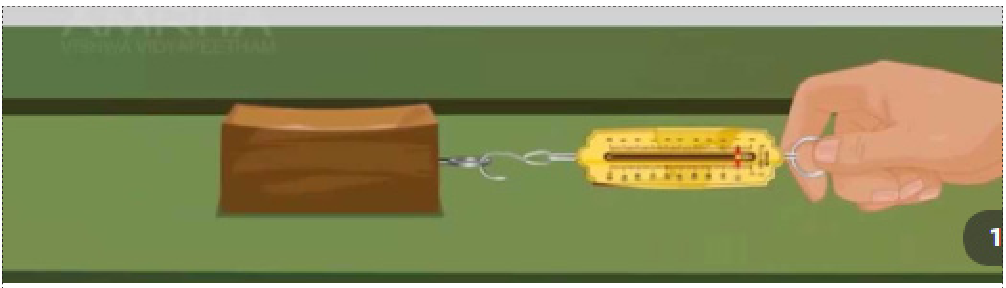


Fig 6.1 *Demonstration of work done in pulling an object*

Procedures:

1. Place the block of wood on a smooth horizontal surface.
2. Attach the spring balance on the block and pull it slowly.
3. Record the force needed to pull the block of wood.

4. Measure the distance d through which the block of wood has moved from the beginning to the end sin meters using a tape measure/metre ruler,
5. Read and record the force

Force F/N	Distance d/m	Work done W/J

Questions to guide interpretation of results

1) What do you observe when you attached a spring balance on the block and pull it slowly?
2) Calculate the work done in pulling the block.

Experiment 6.2: Demonstration of the law of conservation of Mechanical Energy using a swinging pendulum

Rationale

The law of conservation of energy definition emphasizes that energy is not something that can be destroyed or created. It's important to understand what that really means. Energy is constantly being transformed so that it can be used. For example, solar panels don't create solar energy. They harness energy from the sun and transform it into another type of energy (electricity).

Objective

In this experiment you will demonstrate the law of conservation of Mechanical Energy using a swinging pendulum.

Materials:

- A retort stand
- A clamp
- A boss
- a bob
- string
- spring balance

Set up

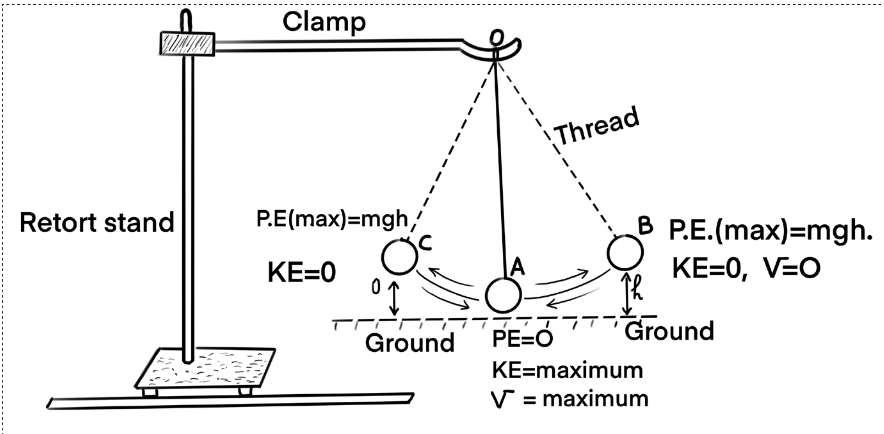


Fig 6.2. *Conservation of mechanical energy by using simple pendulum*

Procedures:

1. Using the balance measure and record the mass m of a pendulum bob in kilogram.
2. Tie a string to the bob and fix it to a retort stand and adjust the length of pendulum to be 70 cm.
3. Measure and record the position ho (in meter) of the bob from the bench.
4. Displace the bob from A to B through an angle of 45°.
5. Read and record the new position h_1 (in meter) of the bob above the bench.
6. Find the height h from the formula $h = h_1 - h_o$

Questions to guide interpretation of results

1) Estimate the potential energy when bob is at B
2) From your observation, discuss the change in speed of the bob at positions A, and B
3) Compare the Kinetic energy KE_A at position A and KE_B at position B.
4) Estimate mechanical energy (ME) and maximum speed of the bob while it is passing through A.
5) Does the ME change during the experiment? Explain.

Experiment 7.1: Determination of the mass of the meter rule by using principle of levers

Rationale

Every day we need to measure the mass of different substances, this experiment helps to measure the mass of an object by using principle of levers.

Objective

In this experiment you will determine the mass of the meter rule using principle of levers.

Materials

- 1meter ruler,
- 1wooden block,
- 1 knife edge
- 2 masses of 10g each
- 1 Pencil and rubber
- 1 Paper sheet or notebook

Set up

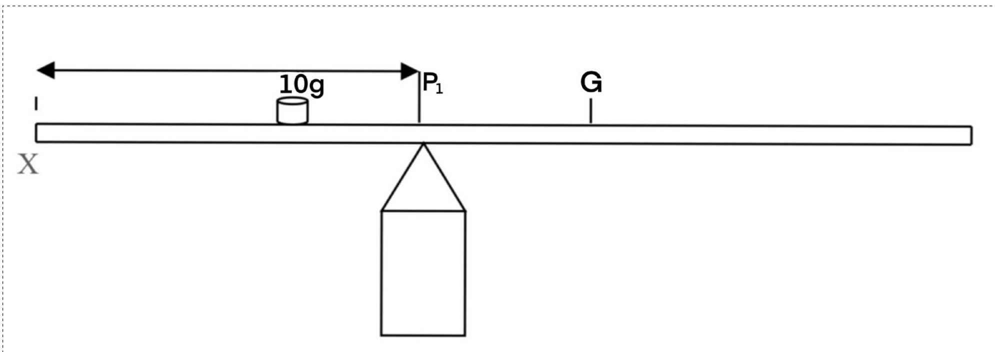


Fig 7.1: *Determination of mass of the solid*

Procedures:

1. Balance the beam on the knife edge provided. Mark the balance point G
2. Measure and record the distance X_G from the end of the beam marked X.
3. Place a 10 g mass at the end X of the wooden beam.
4. Adjust the position of the knife-edge until the beam balances horizontally.
5. Denote this position of the knife edge by P_1
6. Measure and record the distance GP_1 and P_1X
7. Calculate the ratio $U_1 = \frac{GP_1}{P_1X}$
8. Repeat the procedures (3) and (4) above for a mass of 40g and denote the position of the knife edge by P_2
9. Calculate the ratio $U_2 = \frac{GP_2}{P_2X}$

Questions to guide interpretation of results

1) Calculate the mass m, of provided meter ruler, in g from
$$m = \frac{30}{(U_2 - U_1)}$$
2) Express the mass m in kilogram.

Experiment 7.2: Determination of velocity ratio of a system of pulleys

Rationale

Pulleys are used in window blinds, on ships to raise and lower sails, elevators, exercise equipment, theater curtains, extension ladders, garage doors and more. Rock climbers also use pulleys to help them climb. As with all simple machines like the pulley, they are designed to help make work easier to do.

Objective

In this experiment you will determine the velocity ratio of a system of pulleys.

Materials:

- A tackle pulley system,
- Mass (load)
- 120 cm piece of thread,
- 1 metre rule
- Retort stand set.
- Paper sheet or notebook

Set up

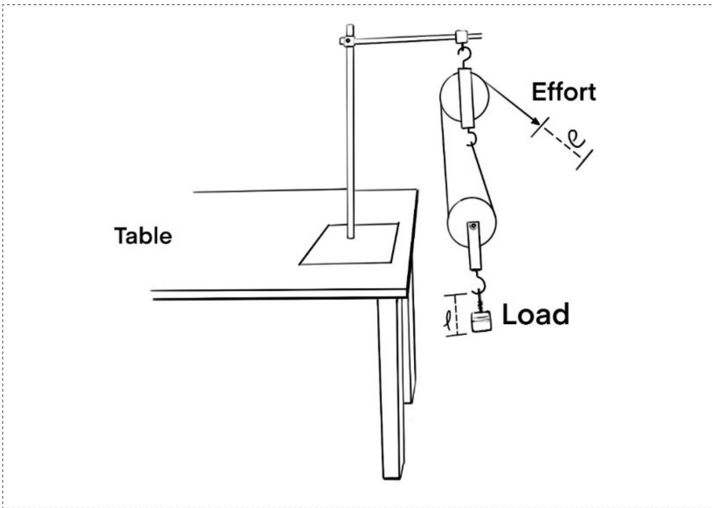


Fig 7.2 *Determination of mass*

Procedures.

1. Set up the experiment as shown in the above figure.
2. Pull the effort downwards through a distance $e = 10cm$
3. Read and record distance l moved by the load.
4. Repeat procedures (2) and (3) for e = 20 cm,30cm, and 40cm
5. Record the result in a suitable table and find the average value of the effort.

Distance moved by effort e / cm	Measured value of l_1 / cm	$l = (l_1 - l_0) / cm$	Velocity ratio e / l
10			
20			
30			
40			

Questions to guide interpretation of results

1) What is your observation in the ratio of e and l for each distance moved by the effort?

2) What is the unit of ratio e / l?

3) From this experiment deduce approximate value of velocity ratio of the pulley system given in this experiment.

Experiment 7.3: Determination of the mechanical advantage of a system of pulleys

Rationale

The mechanical advantage of a machine is important because it tells people how much force a machine exerts when a certain amount of force is applied to it.

Objective

In this experiment, you will determine the mechanical advantage of a system of pulleys

Materials:

- 1 Newton meter (0 to 10N)
- A tackle pulley system,
- Mass (load)
- 120 cm piece of thread,
- 1 metre rule
- Retort stand set.
- Paper sheet or notebook

Set up

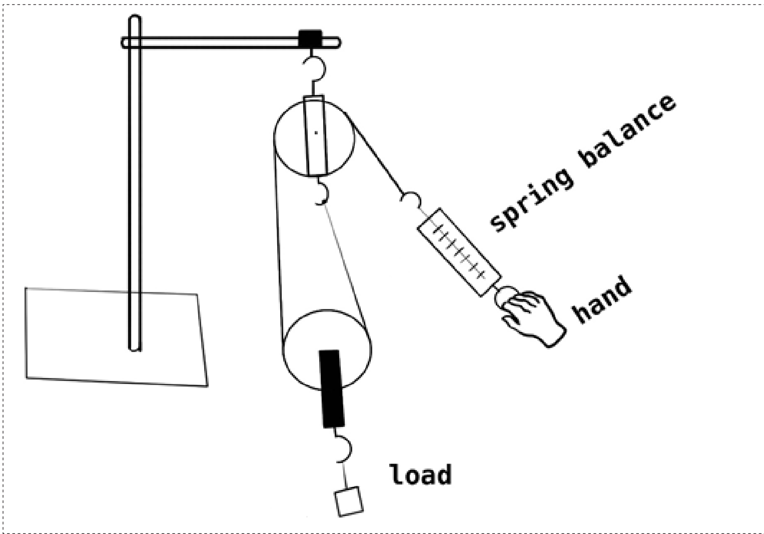


Fig 7.3 *Determination of mechanical advantage of the system of pulleys*

Procedures

1. Set up the experiment as shown in the above figure.
2. Connect a spring balance on the effort string.
3. Hang the mass m=0.100kg on the load string, and calculate load $L = m \times g$
4. Where g =10N/kg
5. Pull the string balance on the effort until the load just begins to rise steadily.
6. Read and record the reading of the spring balance, which is the effort E.

Questions to guide interpretation of results

1) Calculate mechanical advantage $M.A = L/E$.
2) Give the unit of mechanical advantage

Experiment 7.4: Determination of the efficiency of a system of pulleys using spring balance

Rationale

By using pulley and spring balance, you will be able to determine the efficiency of system

Objective

In this experiment, a learner will determine the efficiency of a system of pulleys.

Materials:

- 1 Newton meter (0 to 10N)
- A tackle pulley system,
- Mass (load)
- 120 cm piece of thread,
- 1 metre rule
- Retort stand set.
- Paper sheet or notebook

Set up

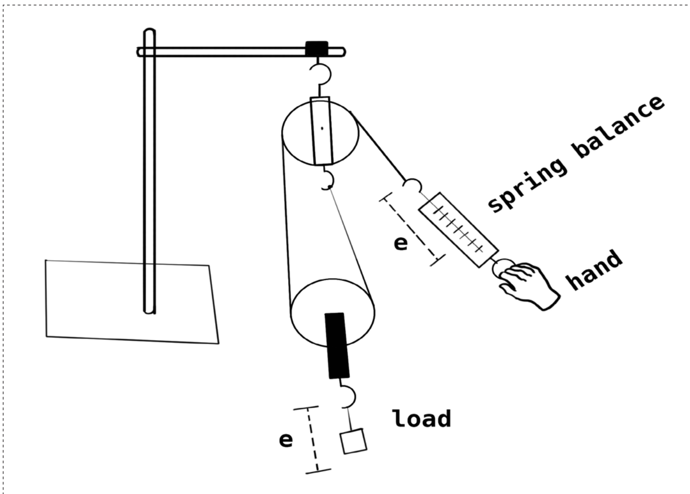


Fig 7.4 *Determination of the efficiency by using pulleys and spring balance*

Procedures

1. Set up the experiment as shown in the above figure.
2. Connect a spring balance on the effort string.
3. Hang the mass m=0.100kg on the load string, and calculate load $L = m \times g$ where g = 10N/kg
4. Pull the effort downwards through distance e to raise load through length, $l = 20cm$ from its initial position.
5. Read and record the reading of the spring balance, which is the effort E.
6. Measure and record the distance, e , moved by the effort.

Questions to guide interpretation of results

1) Calculate mechanical advantage $M.A = L/E$
2) Find the velocity ratio $V.R = e/l$
3) Find the efficiency $\eta = M.A/V.R$
4) Express the efficiency in percentage
5) What is the SI unit of efficiency?

Experiment 8.1: Comparison of viscosity of two liquids (Water and cooking Oil)

Rationale

The oil used as a lubricant for heavy machinery parts should have a high viscous coefficient. The highly viscous liquid is used to damp the motion of some instruments and is used as brake oil in hydraulic brakes. Blood circulation through arteries and veins depends upon the viscosity of fluids.

Objective

In this experiment, you will compare the viscosity of water and cooking oil.

Materials:

- 2 measuring cylinders,
- 2 marbles or ball bearings,
- stopwatch,
- water and cooking oil.

Set up

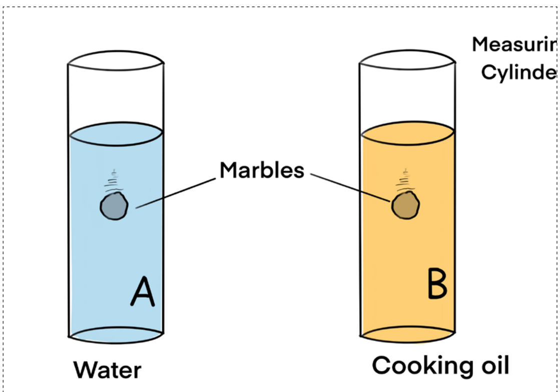


Fig 8.1 *Comparison method of viscosity of liquids*

Procedures:

1. Label one measuring cylinder as A and another as B.
2. Poor water in the cylinder A, and cooking oil in the cylinder B, and make sure they are of equal amount.
3. Drop marble gently into the measuring cylinder A.
4. Use a stopwatch to read and record the time for the marble to reach the bottom of the measuring cylinder A
5. Repeated procedures (3) and (4) for the measuring cylinder B.

Questions to guide interpretation of results

1) In which cylinder, the marble took shorter time to reach the bottom?
2) Explain why the marble did not use the same time to reach the bottom of cylinder A and B?

Experiment 8.2: Determination of melting point of water

Rationale

The melting point is an important physical property of a compound. The melting point can be used to identify a substance and as an indication of its purity.

Objective

In this this experiment you will determine the melting point of water (Ice)

Materials

- Laboratory thermometer
- Beaker
- Small ice cubes or crushed ice
- Stopwatch
- Pencil and rubber
- Paper sheet or notebook

Set up:

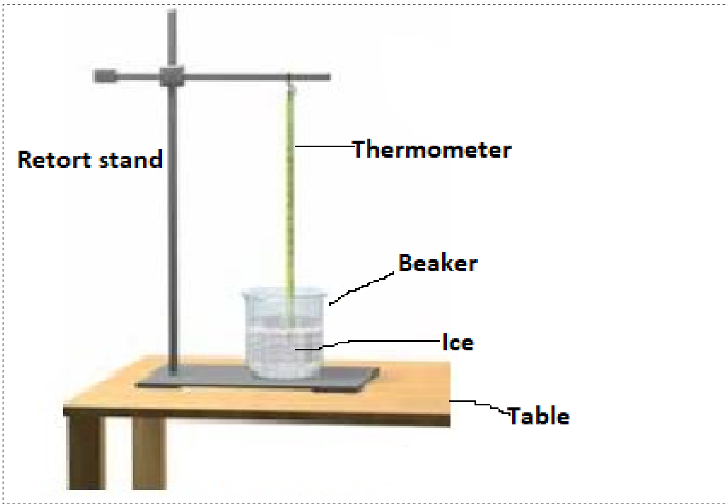


Fig 8.2 *Determination of melting point of water*

Procedures:

1. A beaker is taken and filled up to half with crushed ice
2. Bulb of the thermometer is inserted into the ice and let it stand in a vertical position
3. Stopwatch is switched on and the reading of thermometer is noted and the state of ice in the beaker is observed after every one minute till the whole of ice melts.
4. Recording of temperature is continued till the temperature of the water so formed rises up to 2-3°C
5. Record your data in a suitable table as here below.

Time, t/s	Temperature, T/°C

Questions to guide interpretation of results

1) What value of temperature that last a long time period without changing?
2) From this experiment, what is the melting point of the Ice?

Experiment 8.3: Determination of boiling point of water

Rationale

Boiling point elevation depends on the identity of the solvent and the concentration of solute particles, but not the identity of the solute. Consequently, just like freezing point depression, boiling point elevation can be used to determine the molar mass of a solute.

Objective

In this experiment, you will determine the boiling point of water.

Materials

- Laboratory thermometer
- Beaker
- Bunsen burner
- 200 ml of water
- Glass stirrer
- Stopwatch
- Iron stand
- Paper sheet or notebook
- Pencil and rubber

Set up

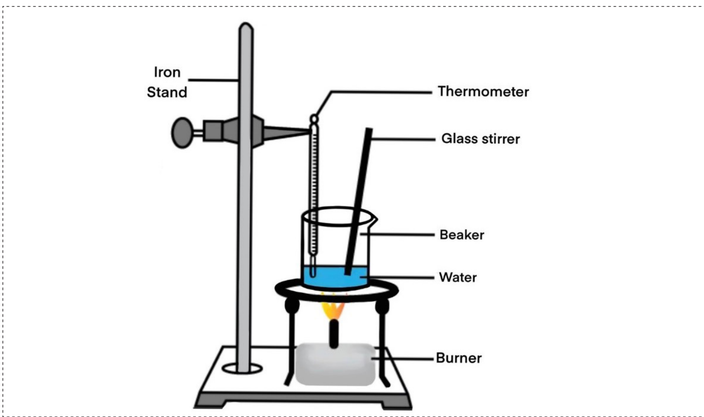


Fig 8.2 *Determination of boiling point of water*

Procedures:

1. Take around 100 ml of water in a glass beaker and arrange bit on a tripod stand with the burner below it as shown in the above diagram.
2. Clamp the thermometer in such a way that the bulb is in contact with the water as shown in the diagram.
3. Switch on the flame of the burner and keep checking the readings on the thermometer.
4. Read and record the initial temperature T_1 when the water is just beginning to heat up.
5. Keep monitoring the temperature change in the thermometer while the water is heating up further.
6. After a while, notice the vapors coming out of the boiling water.
7. Read and record the temperature T_2 when half of the water has evaporated.

Questions to guide interpretation of results

1) What is the value of temperature T_1?
2) What is the value of temperature T_2?
3) From this experiment, what is the boiling point of the water?
4) What happened on the reading of thermometer when temperature $T=100^0C$?

Experiment 9.1: Investigation of the difference between heat and temperature

Rationale

Heat is used to make things warm, to boil water and fry eggs and to melt metal to build cars. Heat is used to generate electricity at a thermal power plant for our daily lives. Temperature is the measure of how hot or cold matter is.

Objective

In this experiment, you will investigate the difference between heat and temperature

Materials:

- 1 measuring cylinder
- 1 cooking oil,
- 2 identical test tubes,
- 2 identical thermometers,
- 1 beaker
- 400cm3 of water
- 1 stirrer
- Stopwatch
- 2 sets of retort stand
- Pencil and rubber
- Paper sheet or notebook

Set up:

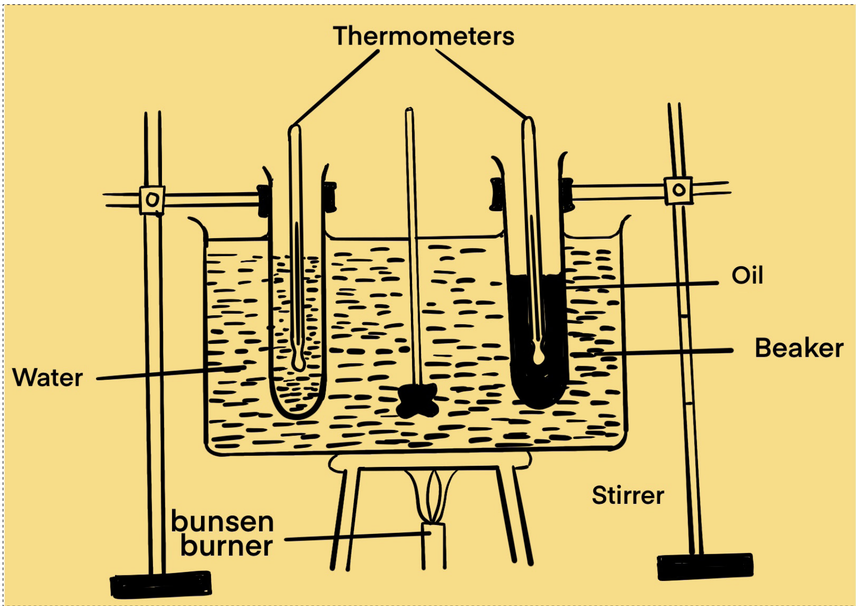


Fig 9.1. *Difference between heat and temperature*

Procedures:

1. Set up the experiment by arranging the materials as in the above set up.
2. Take equivalent volume V= 15cm^3 of water and cooking oil in two identical test tubes fitted with two identical thermometers.
3. Place these test tubes in a large beaker containing 200cm^3 water.
4. Note the initial temperature of both water ($T_{1\ w}$) and oil ($T_{1\ oil}$) in the tubes.
5. Heat the water in the beaker and make sure that the heat is distributed uniformly by stirring the water.
6. After 6 minutes, read and record the temperature water ($T_{2\ w}$) and oil ($T_{2\ oil}$) in the tubes.

Questions to guide interpretation of results

1) What is the value of temperature T_{2w}?
2) What is the value of temperature T_{2oil}?
3) Are the two temperatures, ($T_{2\ w}$) and oil ($T_{2\ oil}$), the same? Explain.

UNIT 10 MAGNETISM (I)

Experiment 10.1: Determination of the poles of bar magnet using the earth's magnetic field.

Rationale

A needle in the compass is a magnet itself that is why, when we are using a compass to know the right direction, we are applying the knowledge of knowing different poles of a magnet.

Objective

In this experiment, you will determine the poles of a bar magnet using the earth's magnetic field.

Materials:

- A bar magnet
- 1-meter-long thread
- Retort stand to hang the thread

Set up

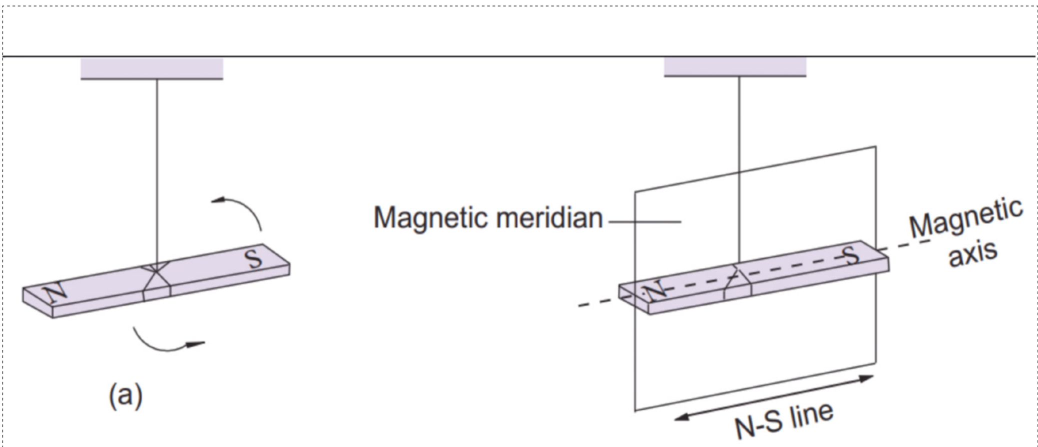


Fig. 10.1. *A freely suspended magnet on diagram a and b.*

Procedures

1. Suspend a bar magnet freely at its center by a length of a cotton thread from a retort stand (Fig. 10.1 (a)). Make sure there are no steel or iron objects near the magnet.
2. Displace the magnet slightly so that it swings in a horizontal plane.
3. Note the direction in which the magnet finally comes to rest. Suggest a reason why it rests in that direction.
4. Repeat the activity at different places and note the resting direction of the magnet. What do you observe? Explain

Questions to guide interpretation of results

1) What was the direction of the bar magnet when it comes at rest?
2) What do you say of the magnet's axis when it was at rest?
3) Relate this to earth's magnetic field.

Experiment 10.2: Demonstration of difference in magnetic, ferromagnetic and non-magnetic materials.

Rationale

Magnetic metals & non-magnetic metals both play an important role in engineering. Magnetism is the basis for many applications. At the same time, this property may also be unwanted in certain circumstances.

Objective

In this experiment you will demonstrate differences in magnetic, ferromagnetic and non-magnetic materials.

Materials:

- Iron and steel nails
- bar magnet
- copper metal
- cobalt
- wood
- zinc

- glass rods

Set up

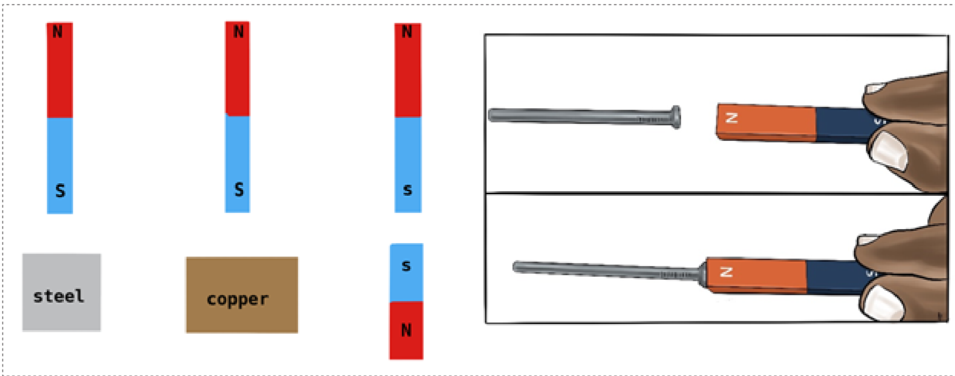


Fig. 10.2. *Action of magnets on different materials*

Procedures

1. Place some iron nails on the table. Bring a bar magnet close to the iron nails and observe what happens. Explain your observations.
2. Repeat the activity with other material such as copper, cobalt, steel, Sulphur, brass, wood, cork, nickel, plastic, pens, wax, zinc, glass rods, carbon, aluminum, paper, chalk etc.
3. Record your observations in tabular form.
4. Discuss your observations in step 3 and suggest the name given to substances that are attracted by a magnet and those that are not.

Substances attracted by a bar magnet	Substances not attracted by a bar magnet
1.	1.
2.	2.
3.	3.
4.	4.

Questions to guide interpretation of results

1) Why did some materials behave in a way they behaved?
2) How do you classify those materials? Why did you classify them that way?
3) Now, say the behaviors of the materials on the magnet?

Experiment 10.3: Demonstration of poles of a bar magnet.

Rationale

Like radios or, refrigerators and other appliances that use magnets to operate, the industry operators have to identify the poles of a bar magnet.

Objective

In this experiment you will demonstrate the poles of a bar magnet.

Materials:

- A bar magnet,
- 1 meter long thread
- Compass

Set up

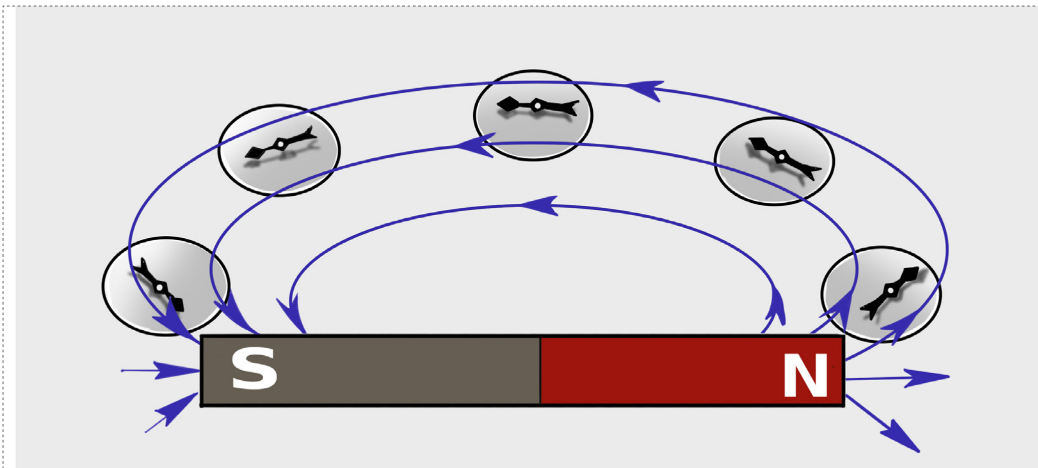


Fig. 10.3. *Poles of bar magnet*

Procedures

1. Suspend a bar magnet freely at its center by a length of a cotton thread from a support as shown in Fig. 10.3. Make sure there are no steel or iron objects near the magnet.
2. Displace the magnet slightly so that it swings in a horizontal plane.
3. Note the direction in which the magnet finally comes to rest.
4. Place a compass at a place far away from the suspended bar magnet.
5. Note the pole of the suspended bar magnet that is pointing in the same direction as North Pole or South Pole of the magnetic compass.

Questions to guide interpretation of results

1) Compare the direction of the compass needle to the poles of the magnet.
2) Deduce the poles of the magnet.

Experiment 10.4: Demonstration of magnetic field by using a compass needle.

Rationale

Compasses are mainly used in navigation to find direction on the earth. This works because the Earth itself has a magnetic field which is similar to that of a bar magnet. Some animals can detect magnetic fields, which helps them orientate themselves and navigate. Animals which can do this include pigeons, bees, Monarch butterflies, sea turtles and certain fish.

Objective

In this experiment you will demonstrate the magnetic field with the use of a compass needle.

Materials:

- Bar magnet
- Magnetic compass

Set up

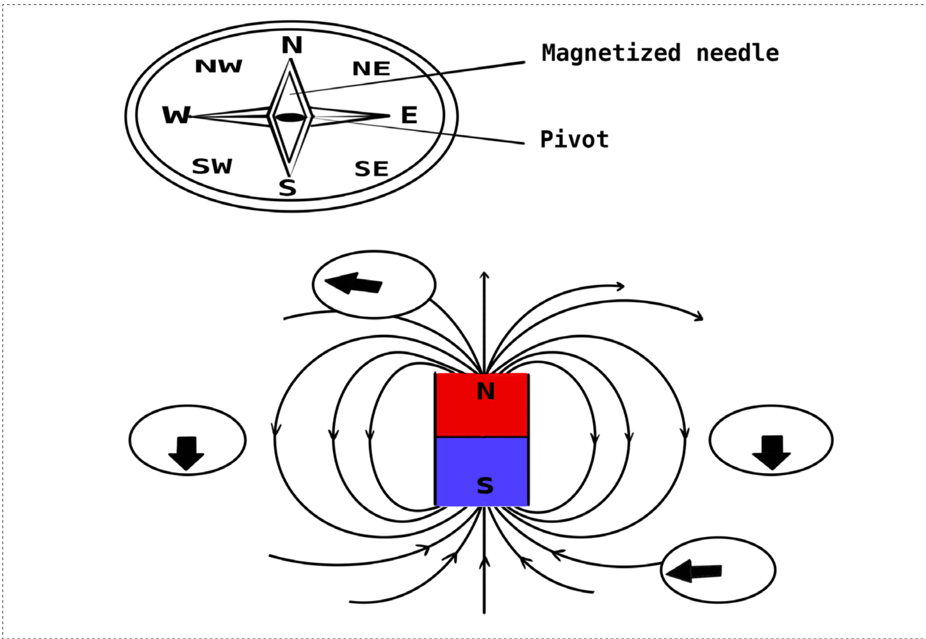


Fig. 10.4. *Magnetic field relative to compass needle.*

Procedures

1. Place a bar magnet on a table.
2. Pass the magnetic compass over the bar magnet and observe what happens.
3. Now, move the magnetic compass along the sides of the bar magnet.

Questions to guide interpretation of results

1) Explain your observation in procedure 2.
2) What did you observe? In procedure 3.
3) State two behaviors of the magnetic force.
4) What does this tell you about the users of the compass when they are on their journey, for instance, soldiers and ship sailors?

Experiment 10.5: Demonstration of the action of one pole of a magnet to another.

Rationale

Magnet's power has application in speakers in stereos, earphones, and televisions. Also, Magnets are used to store data in computers, and are important in scanning machines called MRIs (magnetic resonance imagers), which doctors use to look inside people's bodies. So, knowing the basic law of magnetism is essential.

Objective

In this experiment you will investigate the action of one pole of a magnet to another.

Materials:

- Two bar magnets
- cotton thread.
- Retort stand to hang the thread.

Set up

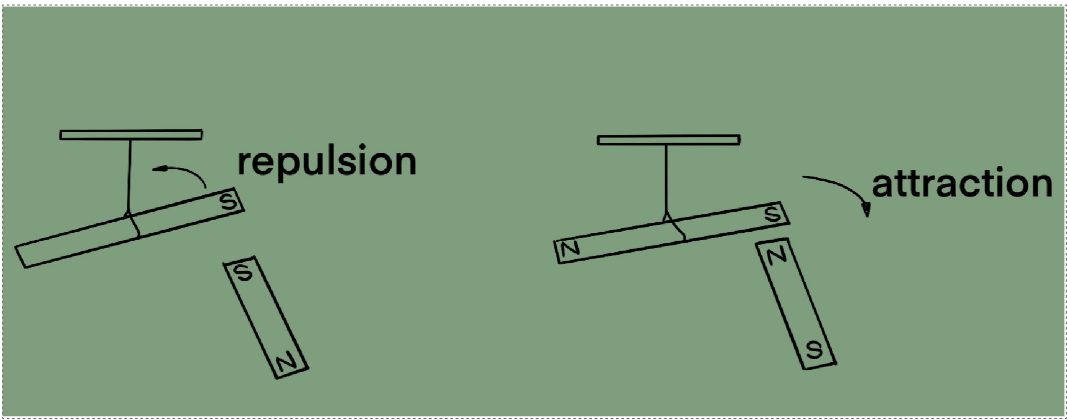


Fig. 10.5. Action of magnets on each other.

Procedures

1. Suspend a bar magnet using a light cotton thread with its north and South Pole clearly marked.
2. Bring a S-pole of a second bar magnet slowly towards the S-pole of the suspended magnet. Observe what happens (Fig. 10.5.(a)).
3. Repeat the activity using the S-pole of the suspended magnet and the N-pole of the second magnet (Fig. 10.5.(b)).
4. Repeat using the other poles and record your observation in a tabular form as shown in table 10.1.

Poles of suspended magnet	Pole of second magnet	Observation
South	South	
South	North	
North	South	
North	North	

Questions to guide interpretation of results

1) How did the North Pole behave to the South?
2) How did the South pole behave to the South?
3) What do we call those behaviors in Question 1 and 2 in physics?

Experiment 11.1: Find out materials that produce static electric charges when they are rubbed together.

Rationale

Static electricity has several uses, also called applications, in the real world. One main use is in printers and photocopiers where static electric charges attract the ink, or toner, to the paper. Other uses include paint sprayers, air filters, and dust removal. Static electricity can also cause damage.

Objective

In this you will find out materials that produce static electric charges when they are rubbed together.

Materials:

- glass rod
- silk cloth
- metal rod
- electroscope

Set up

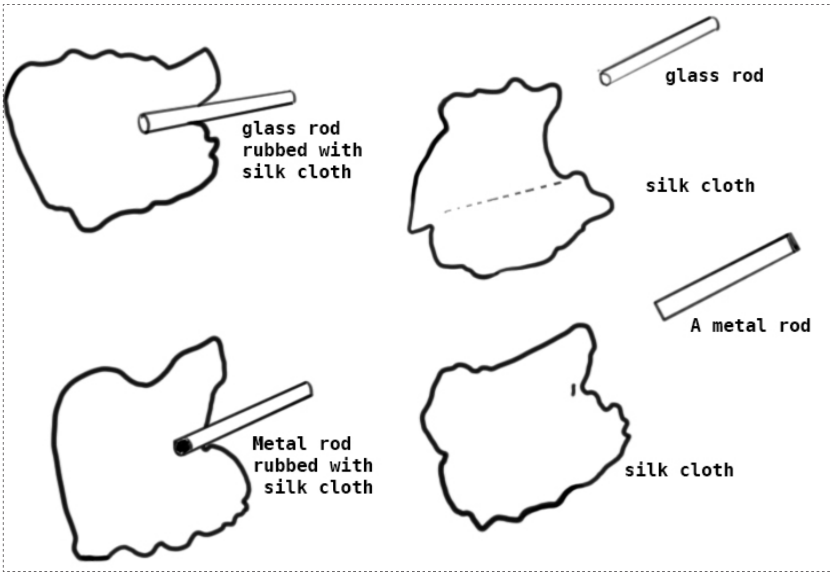


Fig 11.1 *Rubbing Methods*

Procedures

1. Take a glass rod rubbed with silk cloth and bring it near (not touch) the electroscope cap. What happens on the leaf of the electroscope?
2. Also bring the used silk cloth near (not touch) the electroscope cap. What happens on the leaf of the electroscope?
3. ake a metal rod rubbed it with silk cloth and bring it near (not touch) the electroscope cap. What happens on the leaf of the electroscope?
4. Now bring the silk cloth used to rub near (not touch) the electroscope cap. What happens on the leaf of the electroscope?
5. So, if you have two different rods a glass and a metal rod rubbed them with silk cloth see and note the difference or changes between two rods on static electric charges.

Questions to guide interpretation of results

1) What did you observe when you rubbed silk cloth and a glass rod? Do they have the same charge?
2) What did you observe when you rubbed silk cloth and a metal rod?

3) Explain your observations according to those two rods (glass and metal).

Experiment 11.2: Demonstration of charging a body by rubbing.

Rationale

In different experiments, you may need some bodies to be charged. There are many ways of making surfaces to be charged. One of the methods is charging a body by rubbing.

Objective

In this experiment you will demonstrate how to charge a body by rubbing.

Materials:

- Glass rod
- Silk cloth
- Pieces of paper
- Pen
- Retort stand
- Thread

Set up

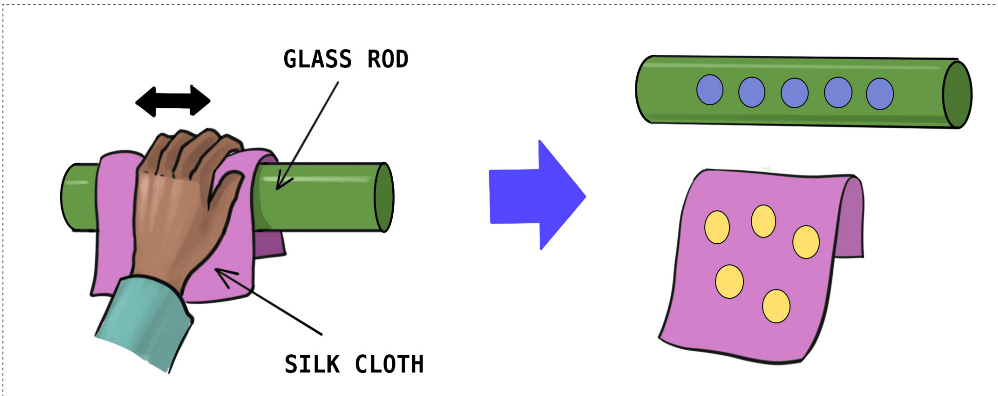


Fig. 11.2. *A neutral glass rod being charged by rubbing.*

Procedures

1. Take a glass rod and rub it with a silk cloth.
2. Then after rubbing bring that glass rod close to the pieces of paper. Observe what happens.
3. Repeat procedure 1 and 2 but this time use a pen instead of a glass rod and in the place of a silk cloth, use your dry hair. Observe what happens.
4. Take a pen and rub it again in your dry hair, then hang that pen on the retort (This should be done in a short period of time) stand using a thread.
5. Let the charged pen come at rest, then bring the charge glass rod closer to it. Observe what happens.

Questions to guide interpretation of results

1) What happened to the pieces of papers in procedure 1 and 3?
2) What happened to the pen in procedure 5?
3) Explain the reason of what you answered in Q1 and 2 above.

Experiment 11.3: Demonstration of charging a body by conduction.

Rationale

In different experiments, you may need some bodies to be charged. There are many ways of making surfaces to be charged. One of the methods is charging a body by conduction.

Objective

In this experiment you will demonstrate a body being charged by conduction.

Materials:

- A balloon
- Gold leaf electroscope
- A woolen cloth

Set up

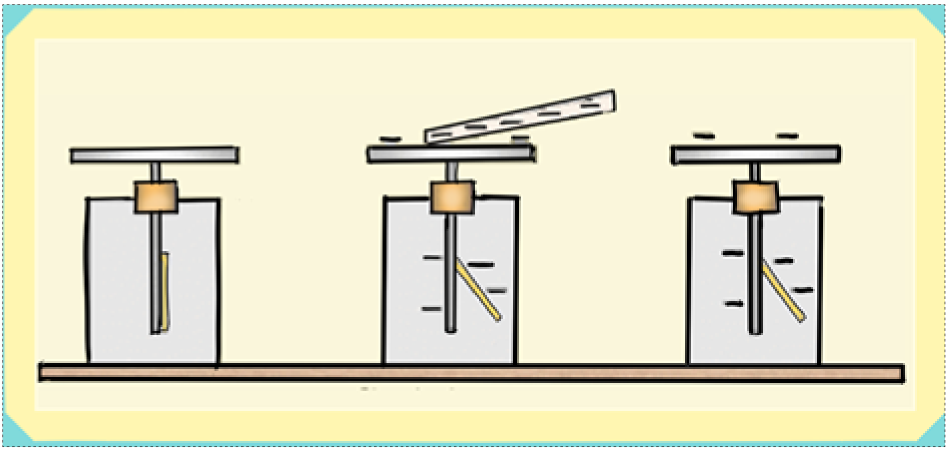


Fig. 11. 3. *Charging an electroscope by conduction*

Procedures

1. Touch the plate of the gold leaf electroscope with your hand.
2. Bring a negatively charged rod near the electroscope. Note the changes.
3. Rub a balloon with a woolen cloth and bring it near the plate of an electroscope without touching in to check the charge of the electroscope.
4. To charge the electroscope again, bring a positively charged balloon and attach it to the electroscope.
5. Repeat procedure 3, deduce the charge of the electroscope on this stage.

Questions to guide interpretation of results

1) What was the initial charge of the electroscope before and after touching it with your hand?
2) What was the charge of the electroscope when attached it with the balloon?
3) What is the name of the method used to charge the electroscope?

Experiment 11.4: Charging a body by induction.

Rationale

In different experiments, you may need some bodies to be charged. There are many ways of making surfaces to be charged. One of the methods is charging a body by induction.

Objective

In this experiment you will charge an electroscope by induction.

Materials:

- Gold leaf electroscope
- Glass rod
- A silk cloth
- Balloon
- Woolen cloth (Sweater)

Set up

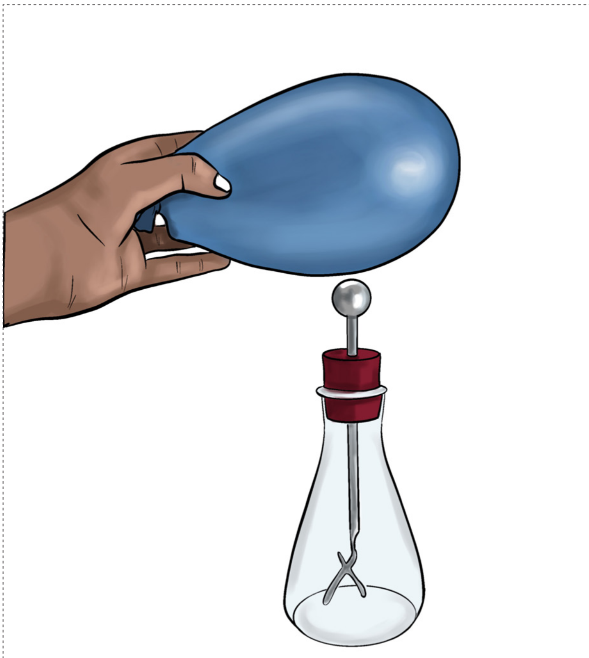


Fig. 11.4. *Charging an electroscope using induction method.*

Procedures

1. Rub a glass rod with a piece of cloth.
2. Bring a positively glass rod near but not touching- the plate of the gold leaf electroscope. Observe the changes of the leaves of the electroscope.
3. Repeat procedure 1 and 2 to see what happens on the leaves of the electroscope. Did you get any change? Deduce the type of charge of your electroscope on this stage.
4. Take a balloon and rub it with a woolen cloth (your sweater). Bring a balloon close to the electroscope. Observe the changes.

Questions to guide interpretation of results

1) What was the initial charge of an electroscope before bringing the glass rod near it?
2) What type of charge did it acquire after induction?
3) What will happen to the electroscope after some 5min of it being charged?

Experiment 11.5: Determination of type of charge of charged body using electroscope.

Rationale

Knowing whether a body is charged or not is very important. Scientists are always interested to know this. One can therefore determine whether a body is charged or not by using gold leaf electroscope.

Objective

In this experiment you will determine the type of a charge on body using electroscope.

Materials:

- Electroscope
- A silk cloth
- Any metal
- Glass rod
- Pen

Set up:

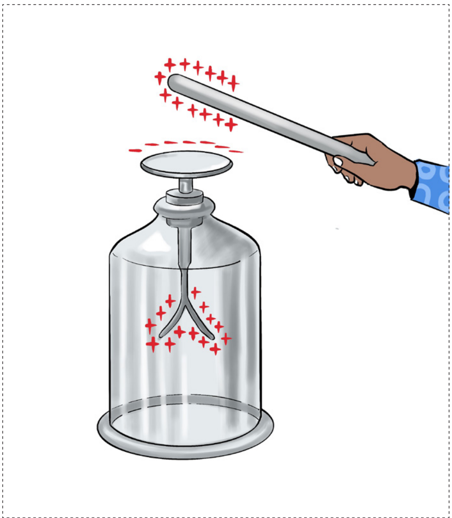


Fig. 11.5. *Testing the charge of the glass rod.*

Procedures:

1. Touch the electroscope to make it negatively charged.
2. Rub the glass rod with a silk piece of cloth.
3. Bring the glass rod close to the electroscope and check what happens to the leaves of the electroscope.
4. Repeat procedure 1 and 2 and attach the silk cloth to the electroscope. Observe what happens.
5. Rub a metal using a silk cloth.
6. Bring the charged metal close to the electroscope. Note the changes in the electroscope.
7. Charge different material you might find around by rubbing. Observe the changes and note them down.

Questions to guide interpretation of results

1. What was the charges of the glass rod in 3, charge of silk in 4 and the charge of the metal 6?
2. Mention any two materials you used in procedure 7, and state their charges.

Experiment: 12.1: Measurement of electric current, potential difference, and resistance in simple circuit.

Rationale

Knowing the amount of electric current, potential difference and resistance in a circuit is very important. For example, when you get to know the amount of current generated or flowing in each circuit, it helps you to know which appliance can be used.

Objective

In this experiment you will measure electric current, potential difference, and resistance in a simple circuit.

Materials:

- 2 Dry cells
- 1 Ammeter
- 1 Voltmeter
- 1 Switch
- 6 piece connecting wires
- 1 Cell holder
- 1 Bulb

Set up:

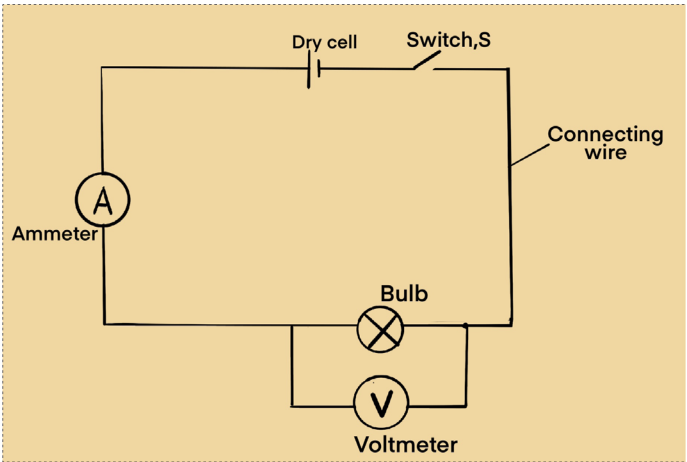


Fig.12.1. *Simple circuit*

Procedures:

1. Connect in series a dry cell, an ammeter A, a rheostat R and a switch S.
2. Connect a voltmeter V across the bulb.
3. Close the switch of the circuit.
4. Read and record the current I from ammeter, and voltage V from voltmeter.

Questions to guide interpretation of results

1) What happened after closing the switch S of the circuit?
2) What is the value of the voltage (or potential difference) across the bulb?
3) What it is the average current of the circuit?
4) Find electric resistance of the bulb from R=V/I.

Experiment 12.2: Verification of Ohm's law.

Rationale

Ohm's law is useful in carrying out calculations such as in determining the value of resistors or the current in a circuit or in measuring the voltage. Additionally, Ohm's law helps us describe how current flows through materials such as electrical wires, etc.

Objective

In this experiment you will verify Ohm's law

Materials:

- 2 Dry cells
- Ammeter
- Voltmeter
- Rheostat
- Switch
- Connecting wires
- Crocodile clips

Set up

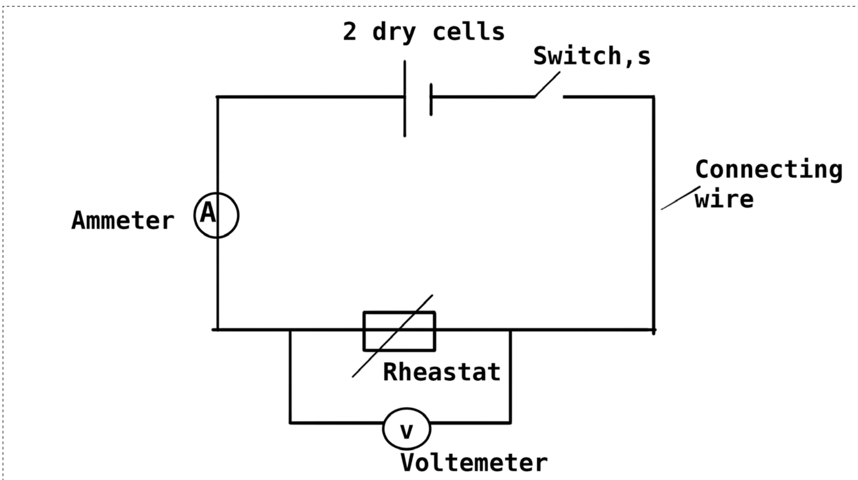


Fig.12. 2. *Circuit to verify Ohm's law*

Procedures

1. Connect the circuit as shown above
2. Close the switch, S and adjust the rheostat so that the reading I on the ammeter is $0.20A$
3. Read and record the voltmeter reading, U.
4. Open the switch, S.
5. Repeat procedures (3) to (4) with $I = 0.4, 0.6, 0.8, 1.0$ and $1.2A$.
6. Tabulate your measurements in the form shown in the table below.

Current, I/A	Voltage, U/v
0.2	
0.4	
0.6	
0.8	
1.0	
1.2	

Questions to guide interpretation of results

1) Plot a graph of U (on vertical axis) against I (on horizontal axis)
2) Find the slope of the graph
3) What is the unit of the slope?
4) From the slope, deduce the Ohm's law?

Experiment 12.3: Investigation of the chemical effect of electric current.

Rationale

Electric current has a lot of effects. Some of them are negative and others are positive. Therefore, it is always important to know the effect of current before using it.

Objective

In this experiment you will investigate the chemical effect of electric current

Materials:

- 3 dry cells
- 1 bulb
- 1 switch
- 1 beaker
- 2 nails
- 6 pieces of copper wire
- 30 g of table salt

Set up

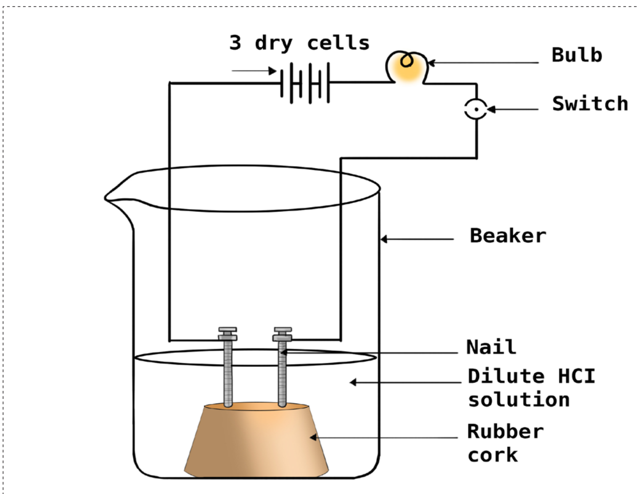


Fig.12.3. *Chemical effect of the current*

Procedures:

1. Take two iron nails and clean them with sandpaper.
2. Wrap copper wire around both the nails and connect the other ends to the battery.
3. Take 350 ml of water in a beaker and add a little amount of salt or acid to it.
4. Immerse the nails in the solution.
5. Close the switch S.

Questions to guide interpretation of results

1) After closing the switch, does the bulb light up?
2) Observe the nails carefully. What do you see? Explain your answers.

Experiment 12.4: Investigation of the heating effect of electric current

Rationale

The heating effect of current is used in various electrical heating appliances such as electric bulb, electric iron, room heaters, geysers, electric fuse, etc.

Objective

In this experiment you will investigate the heating effect of electric current

Materials:

- 1 bulb
- 1 Stopwatch
- 2 dry cells
- Dry cell holder
- 1 Bulb holder
- 1 switch
- 5 pieces of connecting wire

Set up

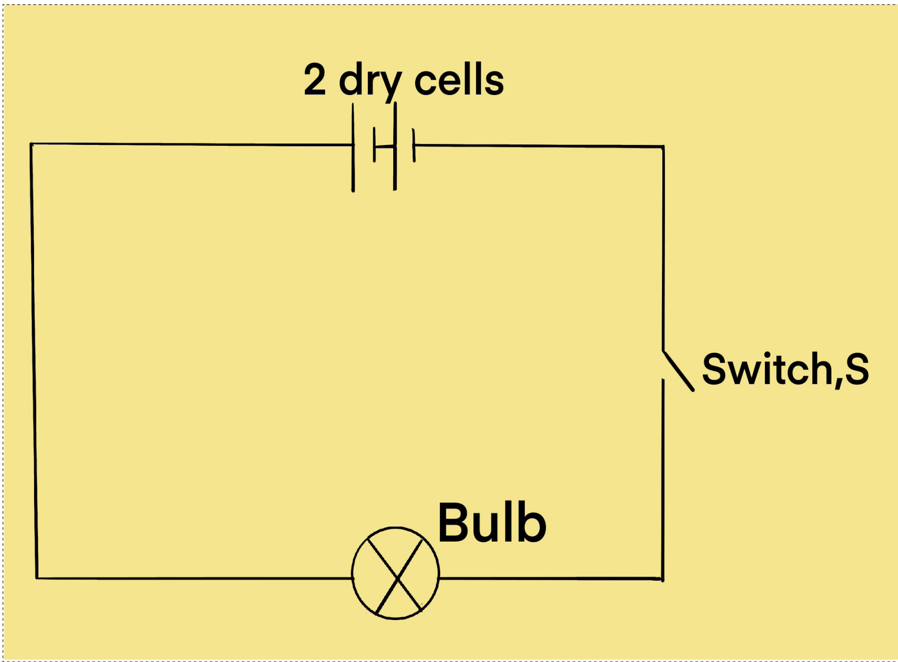


Fig. 12.4. *Electric circuit.*

Procedures:

1. Connect the circuit as in the above diagram
2. Close the switch of the circuit
3. Touch on the bulb and note if the bulb is hot or cold.
4. Now waiting for 4 minutes, and retouch the bulb.

Questions to guide interpretation of results

1) Did the bulb get hot or cold after 4 minutes?
2) What do you think caused the bulb to be cold or hot?

Experiment 12.5: Investigation of the magnetic effect of electric current

Rationale

An electric current-carrying wire behaves like a magnet. Magnetic effect of electric current has been used in making powerful electromagnets is used in loudspeakers, radio receivers, transformers and other electronic devices that we use in our daily life.

Objective

In this experiment you will investigate the magnetic effect of electric current

Materials:

- 1 needle compass
- 1 bulb of resistance R
- 1 switch
- 2 dry cells
- Cell holder
- 5 pieces of wire
- Pencil and rubber
- Paper sheet or notebook.

Set up

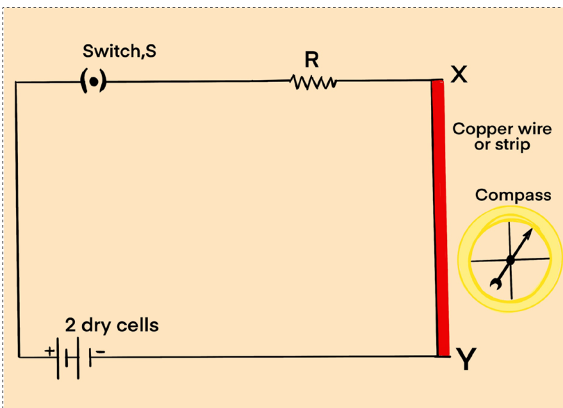


Fig.12.5 *Magnetic effect of electric current*

Procedures:

1. First take a straight thick copper wire or strip and place it between the points X and Y in an electric circuit, as shown in above diagram.
2. Now we place a small needle compass near to this copper wire.
3. After placing the needle compass note the position of its needle.
4. Now close the circuit and pass the current through the circuit.
5. Observe and note the change in the position of the compass needle.

Questions to guide interpretation of results

1) What happened on the needle compass placed near the copper wire when the circuit was open?
2) Comment what happened on the needle compass after closing the circuit.

RECTILINEAR PROPAGATION OF LIGHT

Experiment 13.1: Image formed by pin hole camera

Rationale

Pin hole cameras put in application of cameras. They form images on the translucent screen. Pin hole cameras can be used to analyse the characteristics of the images that are formed.

Objective

In this experiment you will characterize the image formed by pin hole camera.

Materials:

- 1 Optical pin
- 1 scissors
- 1 meter rule
- 1 candle (Source of light)
- Paper sheet or notebook
- Pencil and rubber

Set up:

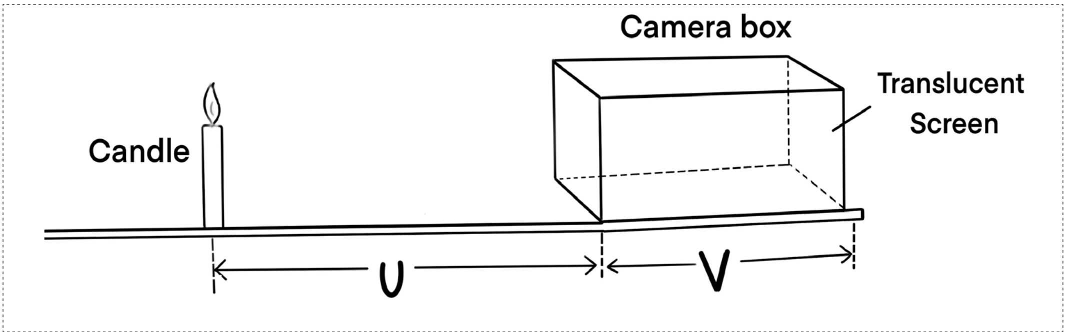


Fig 13.1. *Pin hole camera*

Procedures:

1. If black paint is available, paint the inside of the box black or stick black paper inside. You can also use a dark box.
2. Pierce a small hole with the tip pin on one side.
3. Cut a small opening on the opposite side and paste a grease proof paper or a tracing paper (any translucent material will be sufficient).
4. Read and record the distance v between pin hole and translucent material
5. Place the box so that the pin hole faces a bright candle in a semi dark room and read and record distance u.
6. View the translucent screen.
7. Measure and record the size I of the image formed.

Questions to guide interpretation of results

1) What are the values of distance u and v?
2) What is the size of image I?
3) Find the linear magnification from m = v/u
4) Find the size of the flame of the candle from O = I /m
5) Characterize the image formed by a pin hole camera.

Experiment 13.2: Verification of the laws of reflection using optical pins.

Rationale

It is very important to know laws of reflection. For example, using a plane mirror one can see that when a ray falls on it, it is then reflected. Different surfaces can demonstrate reflection of light like silvered surfaces and others.

Objective

In this experiment, you will be able to verify laws of reflection.

Materials:

- A soft board
- White sheet of paper
- A plane mirrors
- 4 Drawing pin
- Plasticine
- 4 optical pins
- Protractor
- 1 soft board

Set up

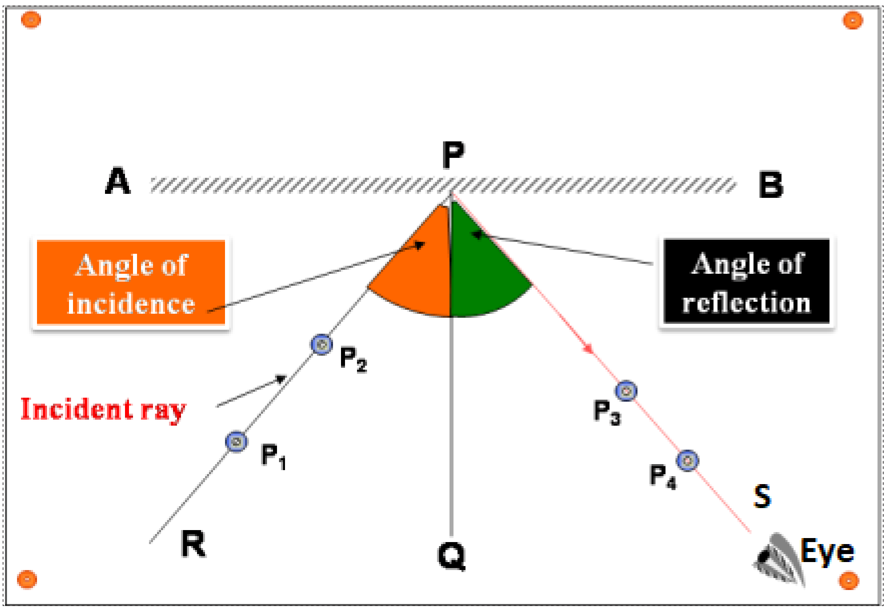


Fig.13.2 *Laws of reflection*

Procedures:

1. First of all fix the white drawing paper on the soft board using drawing pins.
2. Place the plane mirror along with its stand and fix its position AB.
3. Draw a line AB respect the edge of the mirror.

4. Now draw a line PQ which passes through the mid-point 'P' of AB and perpendicular to AB.
5. Draw a ray RP which makes an angle i= 10^0 with the normal (PQ).
6. On the ray RP fix two pins P_1 and P_2 vertically with 2-3 cm separation between them.
7. Now from the other side of PQ, see the images of pins P1 and P_2 fix other two pins P_3 and P_4 vertically so that pins P_3, P_4 and images P_1 and P_2 appears collinear at their lower ends.
8. Now remove the pins and the mirror.
9. Join the marks of P_3 and P_4 and obtain the reflected ray PS.
10. Measure and record the angle between r.
11. Repeat procedures (5) to (10) for different angles of i=20^0, 30^0, 40^0, 50^0, 60^0, and 70^0.
12. Tabulate the results in a suitable table as shown here below

$i/^0$	$r/^0$
10	
20	
30	
40	
50	
60	
70	

Questions to guide interpretation of results

1) Rename the angles i and r
2) What is the relationship between angle i and r?
3) From this experiment, state the laws of reflection.

Experiment 13.3: Location of image on plane mirror

Rationale

A plane mirror has several different uses and applications, including periscopes and kaleidoscopes, automobiles, shaving mirrors, dentists' mirror, torch lights, solar cookers, and security-related purposes.

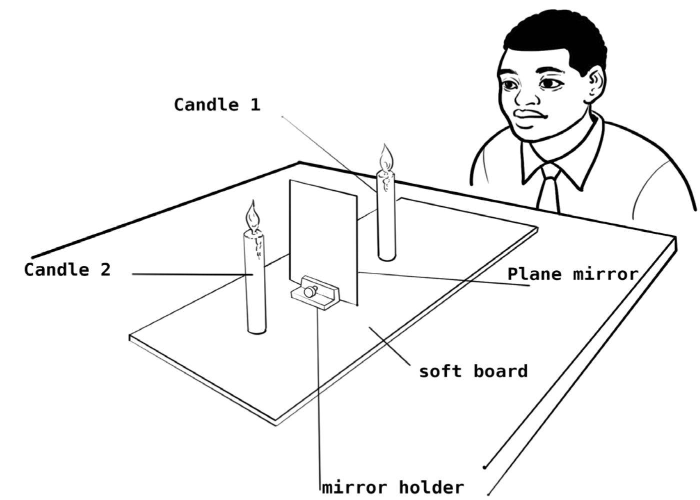
Objective

In this experiment, you will locate the image of an object by using plane mirror

Materials:

- 1 Soft board
- 1 Holder for mirror
- 1 Plane mirror
- 1 meter ruler
- 2 Candles
- White sheet of paper
- 4 drawing pins

Set up



Procedures

1. First, fix the white drawing paper on the soft board using drawing pins.
2. Use candle 1 as the object, and candle 2 as a decoy to catch the image.
3. Stand one candle in front of the mirror as the object, and measure and record distance x between candle 1 and mirror.
4. Place the candle 2 behind the mirror as the image catcher.
5. Move the candle 2 about until it exactly replaces the virtual image as the eye is moved upwards.
6. View the arrangement from other directions to check the position of the image.
7. Measure and record distance y between mirror and candle 2.

Questions to guide interpretation of results

1) What is the value of distance x?
2) What is the value of distance y?
3) Compare the distances x and y. Provide the comment.
4) Characterize the image formed by the plane mirror

Experiment 13.4: Verification of rectilinear propagation of light

Rationale

The concept of rectilinear propagation of light is applied in a pin hole camera, formation of shadows and eclipses, etc.

Objective

In this experiment you will verify rectilinear propagation of light using three cardboards.

Materials:

- 3 cardboards
- 3 holders of cardboard
- 1m of piece of thread
- Source of light such as candle

Set up

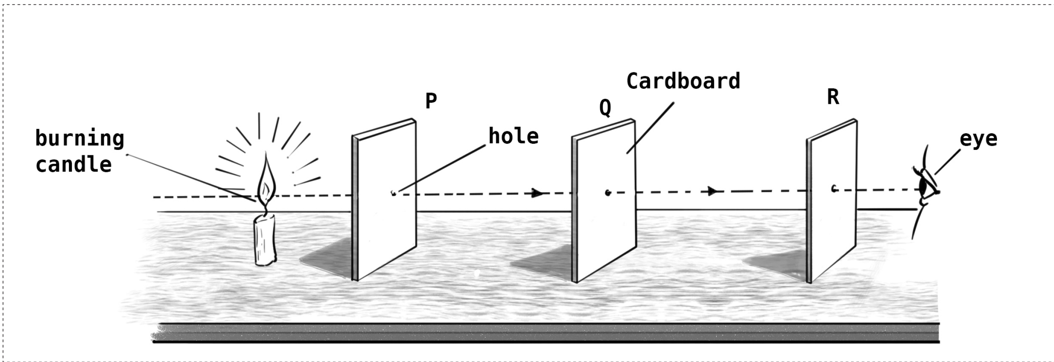


Fig.13. *Rectilinear propagation of light*

Procedures:

1. Take three cardboards P, Q and R of equal sizes mounted on wooden stands.
2. Make small holes on the cardboards at the same height and also at equal distances from the edges on each cardboard.
3. Place the cardboards on a flat surface (bench) and pass a thread through the holes to ensure they lie on a straight line.
4. Remove the string without disturbing the setup of the three cardboards.
5. Place a lit candle in front of the hole in cardboard P and view from the hole in R as shown in above diagram. Record your observation.
6. Disorganize the arrangement by moving cardboard Q slightly to one side. Try viewing the candle from the hole in cardboard R. Record your observation.

Questions to guide interpretation of results

1) What did you observe when three cardboards are all on straight line?
2) What did you observe when you disorganized the arrangement by moving cardboard Q slightly to one side?

Experiment 13.5: Construction of a simple periscope

Rationale

A periscope is an optical tool used in land and sea combat, submarine navigation, and other applications to allow an observer to see his surroundings while remaining concealed, behind armor, or underwater.

Objective

In this experiment you will construct a simple periscope

Materials

- Cardboard
- Paper tape
- 2 mirrors (6x6)
- Superglue or scotch tape
- Pencil, plastic ruler, and protector
- Scissor

Set up

Figure.1.11. *A simple periscope*

Procedures

1. Cut a box into 4 pieces of rectangular cardboards of 120cm length and 13cm width each.
2. Attach each rectangular cardboard to one another to make a long cuboid box as illustrated in the setup above.
3. Close both outlets of the cuboid with another piece of cardboard.
4. Trace a diagonal line of 45° from about 15cm to the outlet of one of the 4 sides of a cuboid. But do not let that line reach to the end of cuboid outlet.
5. Repeat procedure 3 on the opposite side of the cuboid of the same outlet of the cuboid
6. Link those two lines you traced on the opposite sides with a horizontal line and draw a small rectangle with that horizontal line as the width.
7. Cut the cuboid along those marks you made in procedure 3 to 5 using a razor blade.
8. Repeat procedure 3 to 7 at the other outlet of the cuboid.
9. Take the mirror and insert it within the two diagonal lines you have drawn, and do this to both outlets of the cuboid.
10. Now the periscope is ready, use the periscope to try to see the objects behind the walls of laboratory through the window.

Questions to guide interpretation of results

1) Where you able to see anything?
2) What are the characteristics of the images you observed?
3) What is the principle used by periscope you have made to observer the image?

Experiment.13.6: Determination of the number of the images formed by two plane mirrors inclined at an angle of θ

Rationale

A plane mirror has several different uses and applications, including periscopes and kaleidoscopes, automobiles, shaving mirrors, dentists' mirror, torch lights, solar cookers, and security-related purposes.

Objective

In this experiment you will determine the number of images formed by two inclined plane mirrors

Materials

- 2 plane mirrors
- Protractor
- An object (e.g candle)

Set up

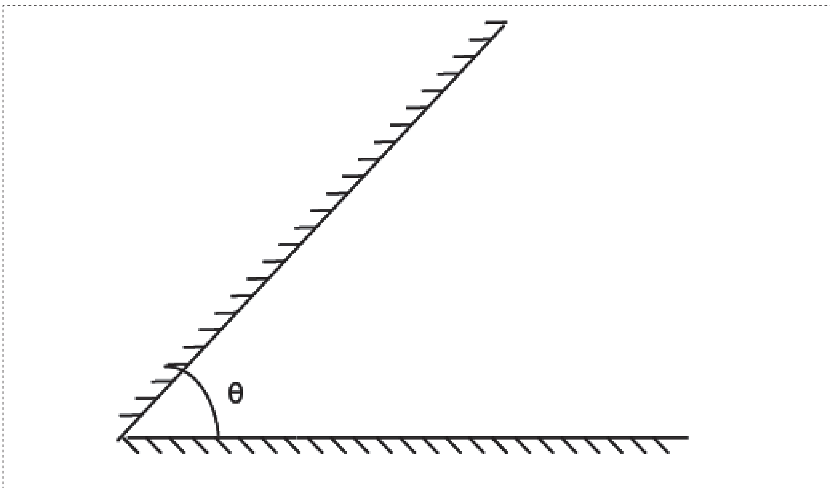


Fig.13.5. *Diagram for image formation*

Procedures

1. Draw two lines which are at angle of $\theta = 180^o$ to each other i.e simply a straight line.
2. Place two mirrors along the two lines to touch one another at point of intersection of the line
3. Place an object between the two mirrors and count the numbers of images formed. Note the number do you can see.
4. Repeat procedures 1 to 3 for $\theta = 90^o, 60^o, 40^o, 30^o$

Questions to guide interpretation of results

1) For each value of angle used, provide the number of images you have observed.
2) The empirical formula used to find the number of images formed is $n = \frac{360^o}{\theta} - 1$,use this formula to estimate the number of images for each angle $\theta = 180^o, 90^o, 60^o, 40^o, 30^o$
3) Compare, the answers of 1 and 2 above. What can be your conclusion?

SENIOR TWO EXPERIMENTS

Experiment 1.1: Determination of absolute error in single measured physical quantities

Rationale

Measurement of uncertainty is critical to risk assessment and decision making based on reports containing quantitative measurement of data.

Objective

In this experiment you will determine the absolute error in measured length.

Materials

- Ruler,
- 2 pieces of paper,
- Pencil,
- Calculator.

Set up

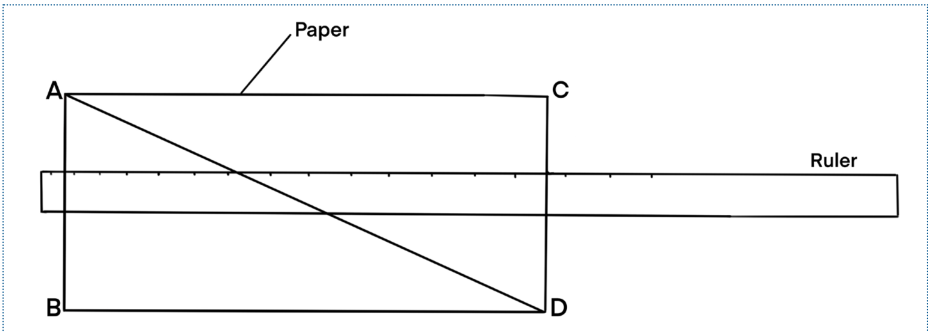


Fig. 1.2: *Measuring the width and the length of a piece of paper.*

Procedures:

1. Measure and record the length, l_1 of the piece of paper (two decimal places)
2. Measure and record the width, W_1 of the piece of paper (two decimal places)
3. Record your results in a suitable table below

	Length /cm	Width/cm
Reading 1		
Reading 2		
Reading 3		

Questions to guide interpretation of results

1) Suggest some factors that cause those differences?
2) What can you do to minimize the differences resulted in readings/measurements taken by a ruler?

Experiment 1.2: Investigation of compound errors in measurements of length

Rationale

Measurement of uncertainty is critical to risk assessment and decision making based on reports containing quantitative measurement of data.

Objective

In this experiment, you will investigate propagation of errors by sum.

Materials:

- Ruler,
- 2 pieces of paper,
- Pencil
- Calculator
- Optical pin.

Set up

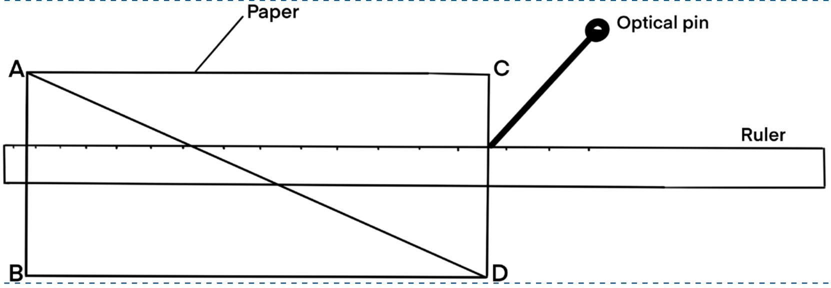


Fig. 1.2: *Measuring the width and the length of a piece of paper.*

Procedures

1. Measure and record the length, L_1 with two decimal places of the piece of paper
2. Measure and record the width, W_1 with two decimal places of the piece of paper
3. Calculate the absolute error ΔL_r where ΔL_r is the half of the smallest division of the meter rule used
4. Record your results in a suitable table below

	Length /Cm $L = L \pm \Delta L$	Width /Cm $W = W \pm \Delta W$
Reading 1		
Reading 2		
Reading 3		

Questions to guide interpretation of results

1) Calculate the circumference of the paper (ABCD) as illustrated in the figure (Please consider the error propagation/ propagation of uncertainty)
2) Calculate the surface of the paper (ABCD) as illustrated in the figure (Please consider the error propagation/ propagation of uncertainty)
3) Why uncertainty in the final result is larger than the uncertainty in the individual measurements?

Experiment 1.3: Investigating of propagation of errors in measurement of volume.

Rationale

Measurement of uncertainty is critical to risk assessment and decision making based on reports containing quantitative measurement of data.

Objective

In this experiment you will investigate sources and types of errors.

Materials:

- Beaker
- Ruler
- Mass bob (stone)
- Water
- Pencil
- Calculator

Set up

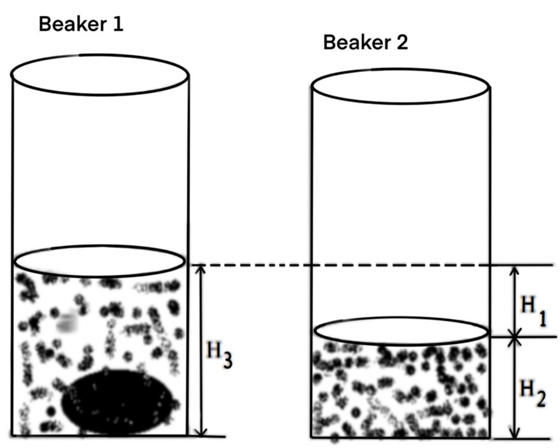


Fig 1.3: *Investigating the errors of smallest division.*

Procedures

1. Calculate the absolute error ΔL_r where ΔL_r is the half of the smallest division of the meter rule used

2. Measure and record the diameter of the beaker $D_1 = D \pm \Delta L_r$ (two decimal place)

3. Tie a small solid object with a thread and put it into beaker.

4. Poor water into the beaker; then measure and record the height H_3 of the water in beaker, $H_3 = H \pm \Delta L_r$ (two decimal places)

5. Remove the solid object from beaker. Measure and record the height H_2 of the water in beaker two, $H_2 = H \pm \Delta L_r$ (two decimal place).

Questions to guide interpretation of results

1) Calculate the volume corresponding to H_3, H_2 and H_1 (Please consider the error propagation/ propagation of uncertainty).
2) What is the relationship between volume of water corresponding to H_1 and that of solid object?
3) Estimate the relative (or percentage) error in the volume corresponding to H_1.

Experiment 1.4: Rounding of numbers

Rationale

Measurement of uncertainty is critical to risk assessment and decision making based on reports containing quantitative measurement of data

Objective

In this experiment, you will round numbers

Materials:

- Ruler
- Books
- Notebook
- Desk
- Tables
- Chairs

Set up

Learners will use any technics and position to measure the length and width of the provided piece of paper

Procedures

1. Measure and record the length, L_1, in meters, of the object (s) at two decimal places. Measure it three times
2. Measure and record the width, $W_{1,}$ in meters, of the object (s) at two decimal places. Measure it three times
3. Calculate the average of your measurement
4. Round your results to 2 decimal places

Questions to guide interpretation of results

1) What are the advantages of using rounding of numbers?
2) How can you relate the gained knowledge with the other subjects?

Experiment 1.4: Investigation of the good position on an eye to give a correct reading

Rationale

This experiment gives student an opportunity to identify and minimize some sources of errors while taking measurement and how they can minimize those errors.

Specific Objective

In this experiment you will identify and minimize human errors.

Materials

- Ruler/meter ruler
- Glass block/book/table.

Set up

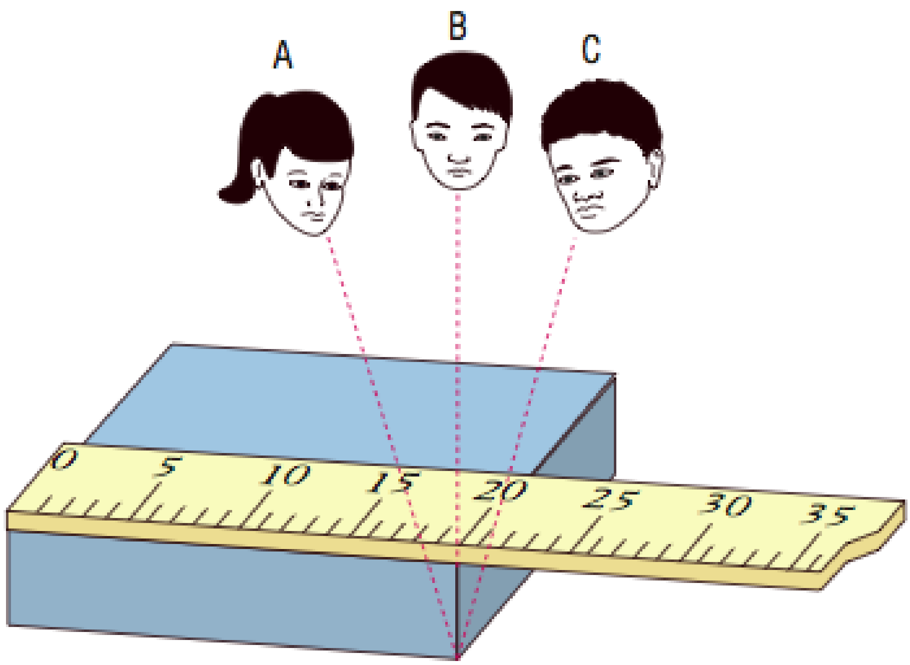


Fig.1.5 *Position of the eye while reading*

Procedures

1. Place the glass block/book on the desk.
2. Position the ruler to try to measure the length of the glass block/book and hold it in position.
3. Call upon a group of three students to read and record the length of the glass block/book.

4. Position the students as shown in the figure 1.5 (first student at **a**, second student at **b** and third student at **c**).
5. Repeat the step (3) and (4) for 5 more groups of students.
6. Record the reading of the three students in the table below.

Position of observer	Reading of the student at (a)	Reading of the Student at (b)	Reading of the Student at (c)
Group 1			
Group 2			
Group 3			
Group 4			
Group 5			

Questions to guide interpretation of results

1) Compare the reading of the three students in the three different positions around the point to be read.
2) What is the good position of eye to give correct reading?

Experiment 2.1: Determination of acceleration due to gravity.

Rationale

Satellites orbiting around the planets and other celestial bodies like the moon and earth are subjected to the gravitational force and the fruit falling from the tree after it's ripped. Since the mass of the object increases, it falls down.

Objective

In this experiment, you will determine the acceleration due to gravity.

Materials:

- 1 Spring Balance
- 1 Complete retort stand set
- 1 mass hanger of 20g and 9 masses of 20g each.
- A pencil and rubber
- A sheet of paper

Set up:

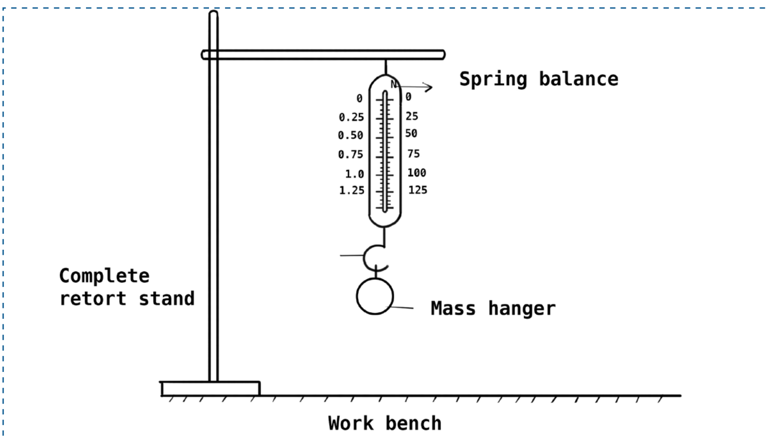


Fig 2.1: *Measurement of acceleration due to gravity*

Procedures

1. Clamp the spring balance as shown in the fig.2.1 above.
2. Read and record the initial position of the pointer on left side, the initial weight (W_o).
3. Place the mass hanger of 20 g on the spring balance, read and record the weight (W_1)
4. Without removing the mass hanger, add the other mass of 20 g on the spring balance; read and record the new weight (W_2).
5. Repeat step 3 and step 4 for values m = 60g, 80g, 100g, 120g, 140g, 160g, 180g, 200g; read and record the weights W_3, W_4, W_5, W_6, W_7, W_8, W_9, W_{10} respectively.
6. Record your results in a suitable table including mass and corresponding weights.

Mass/g	Weight/N
20	
40	
60	
80	
100	
120	
140	
160	
180	
200	

Questions to guide interpretation of results

1) Plot a graph of weight on Y-axis and mass on X-axis.
2) Find the slope, S, of the graph.
3) What is the SI Unit of the slope?
4) Compare the expressions of slope in this experiment and the known average value of g = 9.81m/s^2, how are they related?
5) Why the spring balance is being stretched as long as the mass is hanged from it?

Experiment 2.2: Determination of acceleration due to gravity by using simple pendulum

Rationale

Pendulums are used in many engineered objects, such as clocks, metronomes, amusement park rides and earthquake seismometers. In addition, engineers know that understanding the physics of how pendulums behave is an important step towards understanding motion, gravity, inertia and centripetal force.

Objective

In this experiment, you will determine the acceleration due to gravity by using simple pendulum.

Materials:

- Long Thread
- Stopwatch
- Retort stand with clamp and boss
- A pencil and rubber
- A sheet of paper
- A pendulum bob

Set up:

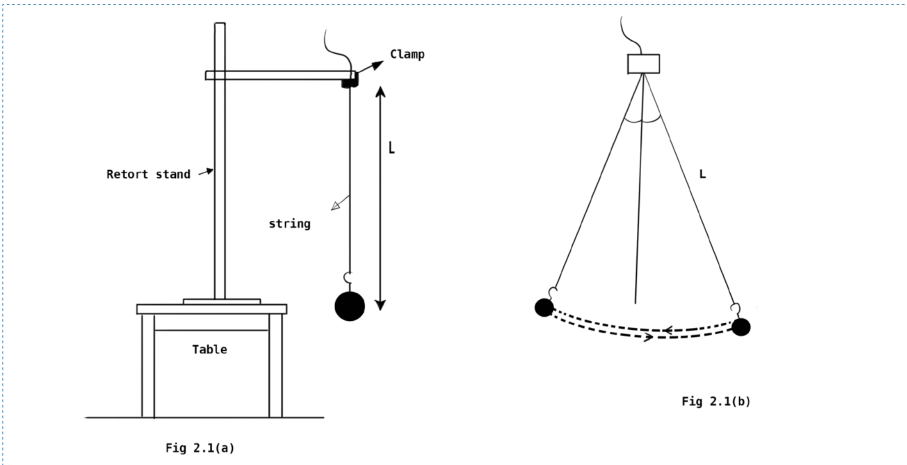


Fig 2.2: *Using simple pendulum to determine the acceleration due to gravity*

Procedures

1. Assemble the apparatus as shown in fig 2.2 (a)
2. Displace the pendulum bob attached on a thread of length l = 40 cm through a small angle and release it. Fig. 2.2 (b).
3. Use a stopwatch to record time **t** for 20 oscillations.
4. Repeat the activity three times and calculate the average time for 20 oscillations.
5. Repeat procedures (2), (3), and (4) by using l = 60 cm, 80 cm, 100 cm, 120 cm, 140 cm.
6. Record your results in a suitable table (Table 2.2).

$l\,/\,cm$	$t\,/\,s$	$T(\frac{t}{20})\,/\,s$	$T^2\,/\,s^2$
40			
60			
80			
100			
120			
140			

Questions to guide interpretation of results

1) Draw a graph of T^2 against l.
2) Draw the line of the best fit through the points. Determine the gradient, m, of the line.
3) What is the SI Unit of the slope found in this experiment?
4) Calculate the acceleration due to the gravity by using this expression, $m = 4\pi^2/g$
5) Would you conclude that Galileo was correct in his observation that the period of a simple pendulum depends only on the length of the pendulum?
6) What effect, if any, does air resistance have on your results?

Experiment 2.3: Determination of acceleration of a body using inclined plane and marble

Rationale

Acceleration information was subsequently used to determine information about the velocity or displacement of an object after a given period of time. In this manner, Newton's laws serve as a useful model for analyzing motion and making predictions about the final state of an object's motion

Objective

In this experiment, you will determine the acceleration of a body using inclined plane and marble

Materials:

- A marble or a small ball
- Stopwatch
- Inclined rail of wooden planch with marked strips 1m each.
- A pencil and rubber
- A sheet of paper

Set up:

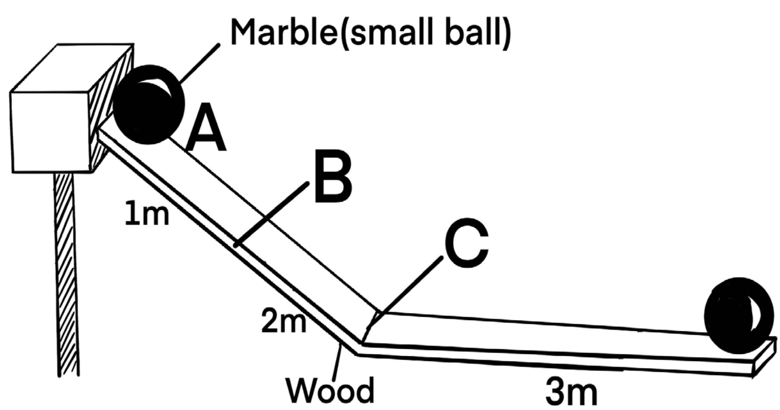


Fig 2.3: *Acceleration of a moving marble or a ball.*

Procedures

1. Arrange the inclined plane as shown in Figure 2.3.
2. Allow a marble to roll from rest at point A to point B, to point C down the rail to point D.
3. Time the marble as it moves the first 1 m.
4. Time the marble as it moves through the first 2 m.
5. Time the marble as it moves the 3 m.
6. Record your reading in the table below.

Distance, d /m	Time, t/s	Initial velocity, V_i/m.s^{-1}	Final velocity, V_f/m.s^{-1}
1			
2			
3			

Questions to guide interpretation of results

1) What is the average velocity as the marble moves the first 1m (from A to B)?
2) What is the average velocity of the marble as it moves the second 1 m (from B to C)?
3) What is the average velocity of the marble as it moves the third 1 m (from C to D)?
4) Where is the marble moving fastest?
5) Calculate the acceleration of the marble as it is rolling from A to C

Experiment 3.1: Determination of the coefficient of friction

Rationale

This experiment shows clearly that the coefficient of friction determines the "stickiness" between two objects and many areas of everyday life are affected by friction issues. Eg: If the friction is zero, the vehicle would fail to move forward.

Objective

In this experiment, you will determine the coefficient of friction between two surfaces by using an inclined plane.

Materials:

- Beam balance
- different masses
- inclined plane
- thread
- scale pan
- block of wood with a hook
- pulley and protractor

Set up

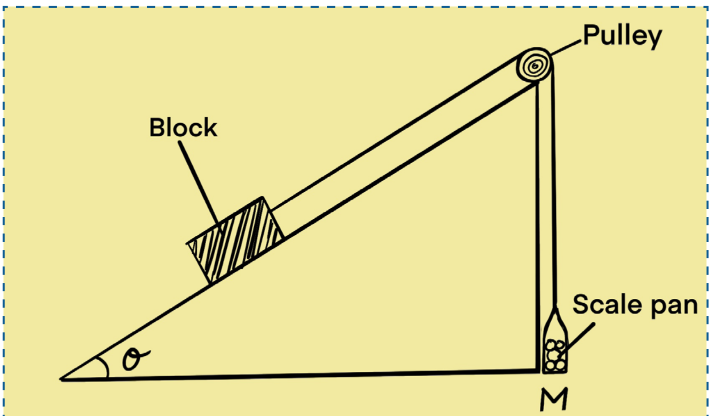


Fig 3.1: *Friction between two surfaces by using an inclined plane*

Procedures

1. Measure the mass (m) of the wooden block by using a beam balance and record it.
2. Set the inclined plane angle, θ, at 20° to the horizontal.
3. Place the block of wood on the inclined plane and connect it with a thread (see figure 3.1).
4. Pass the thread over the fixed pulley and attach the scale pan to the loose end.
5. Place masses one after the other onto the pan until the block of wood barely starts to move up the plane. Record the total mass collected on the scale pan as M.

Questions to guide interpretation of results

1) Calculate the coefficient of friction of the wooden block using the $\mu = \frac{Mg - mg\sin\theta}{mg\cos\theta}$ where, μ is a coefficient of friction
2) If the inclined plane were rougher, would you obtain the same value of μ?
3) If the angle of inclination remains constant, but the weight of the block on the inclined plane increases, what would have to happen to the weight on the scale pan to obtain a proper value for the coefficient of friction?
4) What is the purpose of increasing the angle of inclination in this experiment?

Experiment 3.2: Investigation of tension force

Rationale

Tension force has many applications. For example: Pulling on a rope in a tug of war game or a car towing another car with the help of a chain. Pulling a rope on a well which is connected to a pulley.

Objective

In this experiment you will investigate the effects of tension force.

Materials:

- Rope
- Stones of different masses
- Spring balance (Newton meter).

Set up

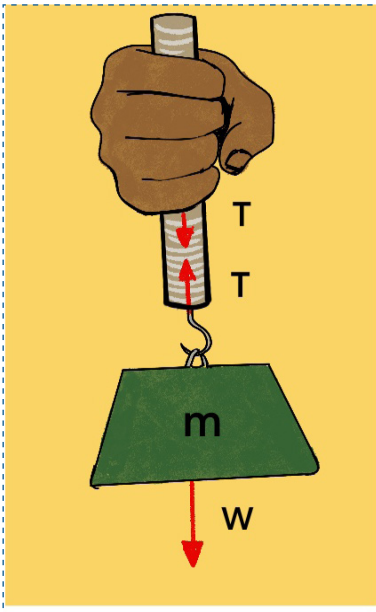


Fig 3.2: *Measurement of Tension force*

Procedures

1. Tie the rope on the stone and hang it on the spring balance fixed on a retort stand
2. Read and record the mass and the weight of the stone.
3. Change the stone and repeat the first two steps and note the observation.

Questions to guide interpretation of results

1) What is the type of force applied to the stone?
2) Suggest the effect of this force on the stone.

UNIT 4 DENSITY AND PRESSURE IN SOLIDS AND FLUID

Experiment 4.1: Investigation of pressure of a solid

Rationale

When vegetables are cut with a knife, pressure is applied by the knife on the vegetables. A porter feels pressure of load carried on his head. Pressure applied on a wooden planck when we push a nail into it.

Objective

In this experiment, you will investigate the pressure of solid.

Materials:

- A concrete brick
- Balance
- Calculator
- Sand
- Beam of wood
- Ruler
- Pencil

Set up

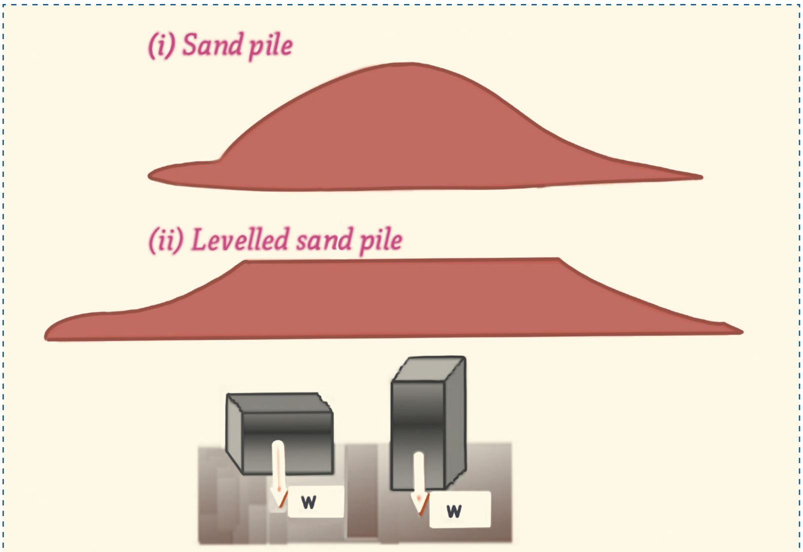


Fig 4.1. *Investigating pressure of solid.*

Procedures

1. Measure the mass m of the brick and calculate its weight W, (g =10m/s²)
2. Pour two bucketsful of sand outside your laboratory such that it forms a Pire as shown in figure 4.1.i.
3. Use the long wooden beam to spread the sand such that you have a fairly large plain surface on top of the sand pile as shown in 4.1. ii.
4. Take measurement of dimensions of one of the large surface side of brick and calculate its area A_1
5. Take measurement of the dimensions of the small side of the brick and calculate its area A_2
6. Gently place the brick in the sand on its big side(A_1) and let it rest on the sand for 15 seconds.
7. Careful remove the brick from the sand. Carefully measure and record the depth of depression formed on the sand.
8. Repeat the procedure (6) and (7) for small side (A_2) of the brick.
9. Gently place the brick on the sand on its smaller side but at a point away from the first experiment.

Questions to guide interpretation of results

1) Calculate pressure exerted by large side of the brick using

$$P_1 = \frac{W}{A_1}$$

2) Calculate the pressure exerted by the brick $P_2 = \frac{W}{A_2}$
3) Compare P_1 and P_2 and explain the reason behind the difference in pressures
4) Explain the reason behind the difference in depth

Experiment 4.2: Investigation of pressure in liquids

Rationale

When we spray de-odorants or paint through a bottle, we use in syringes, when we open a bottle of coke, when we open the tap we find the water gushing out through great pressure, this is the real application of pressure in liquid.

Objective

In this experiment, you will investigate the pressure in liquids.

Materials:

- Manometer
- Water
- Beaker
- Ruler

Set up

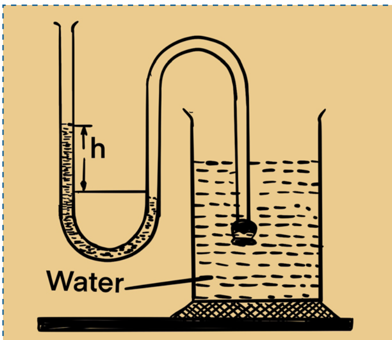


Fig 4.2: *Changes the levels of water in a manometer.*

Procedures

1. Pour water into the beaker
2. Note the level of the manometer liquid
3. Lower the manometer nozzle in water
4. Note the change in the level of the manometer liquid
5. Lower it deeper than before and note the new change

Questions to guide interpretation of results

1) What change did you observe in procedure 2 and 4.
2) Discuss the meaning and the cause of that change

Experiment 4.3: Determination of the densities of two liquids by means of Hare's apparatus

Rationale

An example of real life application of density is «ice floating on water", you know that ice is water in solid state, but its density when it is floating on water is different to that of water.

Objective

In this experiment you will determine the densities of two liquids by means of Hare's apparatus

Materials:

- Hare' apparatus
- Water
- Table
- Beakers (2)
- Copper (II) sulphite solution
- Rule

Set up

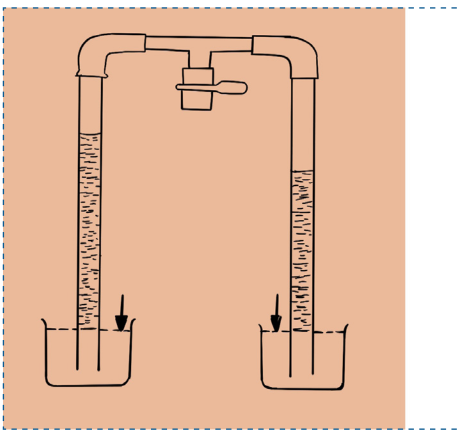


Fig 4.3: *Hare's apparatus measuring the densities.*

Procedures

1. Set the Hare' apparatus as shown in figure 4.3.
2. Attach the rule on the Hare's apparatus
3. Pour water in beaker A and copper (II) sulphite solution in beaker B. Make sure that water and copper (II) sulphite solution are at the same level.
4. Open the clip on Hare' apparatus. Measure and record h_1 and h_2

Questions to guide interpretation of results

1) What did you notice in procedure 4?
2) Which cause the difference in h_1 and h_2?
3) Using the information in (4), calculate the relative density of copper (II) sulphite solution. (Note that the relative density of water is equal to 1000Kg/m^3)

Experiment 4.4: Measurement of atmospheric pressure using barometer

Rationale

Atmospheric pressure is an indicator of weather. Meteorologists use barometers to predict short-term changes in the weather. Low-pressure systems are associated with cloudy, rainy, or windy weather. A rapid increase in atmospheric pressure pushes that cloudy and rainy weather out, clearing the skies and bringing in cool, dry air.

Objective

In this experiment, you will measure the atmospheric pressure using an-eroid barometer

Materials:

- Plastic bag
- An aneroid barometer
- Table
- Thread

Set up

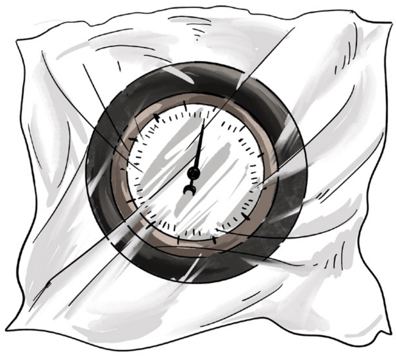


Fig 4.4: *An aneroid barometer changing with pressure.*

Procedures

1. Insert the barometer in the plastic bag
2. Add air in the plastic bag
3. Close the plastic bag using the thread and place it on the table
4. Squeeze the plastic bag and look on the barometer inside the plastic bag

Questions to guide interpretation of results

1) What change are you observing from procedures 1 to 4.
2) Discuss the meaning and the cause of that change

Experiment 4.5: Demonstration of the use of a Siphon

Rationale

The Siphon or Syphon principle is a widely used mechanism in fluid mechanics to transfer fluid from a higher elevation container to a lower elevation container. Therefore, Flush toilets often have some siphon effect as the bowl empties. Some toilets also use the siphon principle to obtain the actual flush from the cistern.

Objective

In this experiment, you will demonstrate the use of the siphon principles in fluid.

Materials:

- A jerry can
- Water
- Bucket
- A long flexible plastic pipe
- table

Set up

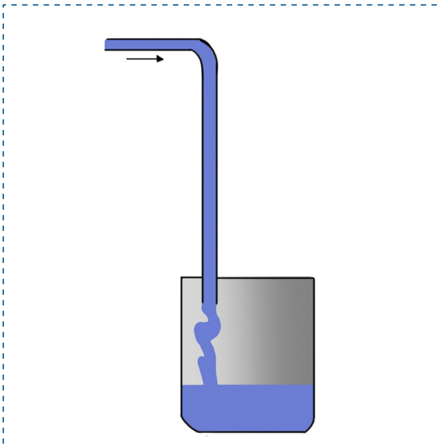


Fig 4.5. *Water flowing in a container using a Siphon.*

Procedures

1. Fill a jerry can of water on the table
2. Place the bucket down on the lower level of the table
3. Lower one end of the plastic pipe in the jerry can
4. Let the other end of the plastic pipe be at a lower level than of the water in the jerry can
5. Suck water from the jerry can, and release after the water has come to your mouth (Please consider measures related to hygiene)
6. Let the water flow from the jerry can to the bucket freely.

Questions to guide interpretation of results

1) What causes the water to flow from the jerry can to the bucket?
2) Why does the water continue to flow without sucking again?

Experiment 4.6: Making a simple air pressure drinks dispenser.

Rationale

The atmospheric pressure involves in different daily activities:

- The movement of air occurs due to change in atmospheric pressure.
- we can fill ink inside pen, medicine inside syringe, etc with the help of atmospheric pressure.
- Air pump water pump work on the presence of atmospheric pressure.

Objective

In this experiment you will make an air drinks dispenser

Materials

- Balloon
- Peg – optional, but helpful
- Plastic Straw
- Beaker or any Small container.
- Plastic bottle (500ml bottle of drinking)
- Plasticine or putty
- Water

Set up

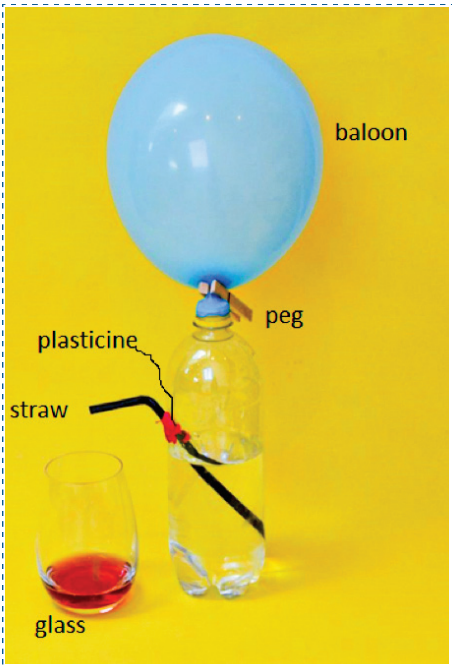


Fig.4.6: *Simple air drinks dispenser.*

Procedures

1. Carefully make a small hole about halfway up the bottle
2. Push the straw through the bottle leaving its significant part on the outside.
3. Fill the bottle about three quarters full of water.
4. Blow up the balloon, twist and seal the neck with a peg.
5. Carefully place the end of the balloon on the bottle neck and place a glass under the straw.
6. When you're ready remove the peg and note your observation.

Questions to guide interpretation of results

1) What do you observe when the balloon is pegged?
2) What happens when the peg is removed?Explain

Experiment 4.7: A can/ plastic bottle crushing (deformation) experiment

Rationale

Even though most of the time you can't see or feel it, the air around us is pushing against every surface and by making a change in air pressure.

Objective

In this experiment, you will learn how you can crush a plastic bottle without ever touching it.

Materials:

- Empty plastic bottle with lid
- Ice
- Half little hot water
- Pan (10cmx12cm)
- Pitchmen of ice water

Set up

Fig 4.7: *A bottle being crushed by ice.*

Procedures

1. Filling the pan with ice
2. Pour hot water into the plastic bottle, wait for two minutes
3. After two minutes have passed, screw the lid back on the bottle. Make sure that it is on tight
4. Lay the bottle on its side in the pan full of ice (you may need to hold it in place)

5. Slowly pour the pitcher of ice water onto the bottle. Take a moment to make more observation
6. Stand the bottle up to get a closer look

Questions to guide interpretation of results

1) What happens to the bottle?
2) Why do you think the plastic bottle crushed in?

Experiment 4.8: Investigation of atmospheric pressure by using candle

Rationale

When air is sucked out of a drinking straw, the air pressure inside it decreases, and the atmospheric pressure outside forces the liquid to go inside the straw.

Objective

In this experiment, you will Investigate atmospheric pressure using candle.

Materials:

- Water
- Matches box
- Glass or canonical flask
- Dish or plate
- Candle
- Colored solution

Set up

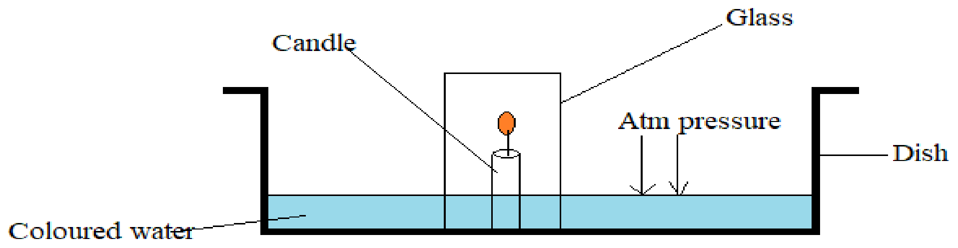


Fig 4.8: *Demonstration of atmospheric pressure using a candle.*

Procedures

1. Put a little water on the plate and mixt it with colored solution
2. Place a candle in the middle of the plate and light it
3. Slowly bring the glass until it stands on the water and plate

Questions to guide interpretation of results

1) From your observations, what happened to the candle and water section in the glass?
2) What might be the cause of the effect observed?

MEASURING LIQUID PRESSURE WITH MANOMETER

Experiment 5.1: Investigating pressure in liquids using communicating vessel

Rationale

In cities, water towers are frequently used so that city plumbing will function as communicating vessels, distributing water to higher floors of buildings with sufficient pressure. Hydraulic presses, using systems of communicating vessels, are widely used in various applications of industrial processes.

Objective

In this experiment, you will investigate pressure in liquids using communicating vessel.

Materials:

- Communicating vessel
- Colored water (colored liquid)

Set up

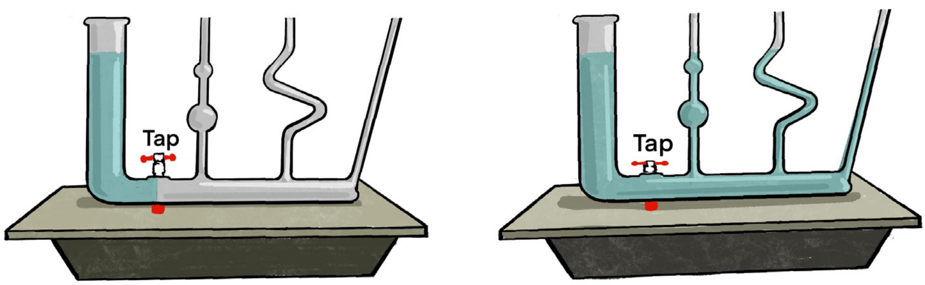


Fig 5.1: *Pressure in liquid by a communicating vessel.*

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Procedures

1. Pour coloured water (coloured liquid) of the communicating vessel as shown in figure (a)
2. Open the tap and observe what happens
3. Is it the same as shown in figure (b)

Questions to guide interpretation of results

1) What do you think of the water distributed and the shape of the container as well as the volume of the container?
2) Why are the levels of water in all branches like that (see figure b) after opening the tap?

Experiment 5.2. Investigation of the pressure in liquids

Rationale

The use of Hydraulic force, used in lifting the vehicles in the repairing shops and the force which pushes the lid of the coke when applied some force on it. Even from the water tank at your home you will observe the difference in the force of water when it is full and when the water is at the bottom.

Objective

In this experiment you will investigate the pressure using liquids

Materials:

- Plastic bottle
- Water
- Hammer
- Nail
- Ruler

Set up

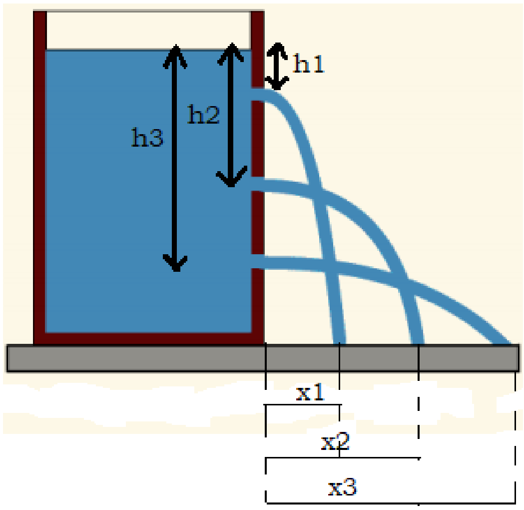

Fig 5.2 *Distribution of water by pressure.*

Procedures

1. Make 3 holes in the sides of the container, one below the other at 2cm intervals and name them by h_1, h_2 and h_3 from the top of the water level (depth)
2. Close the three holes with the sellotape.
3. Fill the container with water.
4. Remove the sellotape on the holes.
5. Measure the distance x_1, x_2 and x_3 from the bottom of the container to the point that the water squirts on the ground from each hole.
6. Plot a graph of depth (distance of the hole from the top of the water level) versus the distance water squirts on the ground from each hole.

Questions to guide interpretation of results

1) What is pushing water to squirt out from the containers?
2) Why is water falling at different distances?
3) Discuss and explain the situation

Experiment 5.3. Determination of relative density using a manometer

Rationale

Relative density is often used by geologists and mineralogists to help determine the mineral content of a rock or other sample. Gemologists use it as an aid in the identification of gemstones. Water is preferred as the reference because measurements are then easy to carry out in the field.

Objective

In this experiment, you will investigate the relative density using liquids.

Materials:

- U- tube manometer
- Water
- Cooking oil
- Retort stand
- Meter rule

Set up

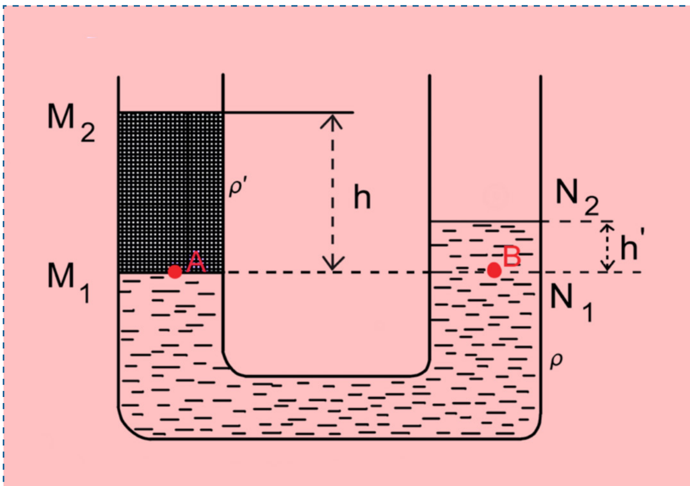

Fig 5.3. *U-tube Manometer having water and cooking oil.*

Procedures

1. Hang the U-tube manometer on the retort stand in equilibrium position.
2. Pour the water into the U-tube manometer and wait until the water in U-tube manometer comes at rest, measure and record the position M_1, and N_1
3. Pour the oil on one end of U-tube manometer and wait until the system comes at rest as shown in figure above, measure and record the position N_2, and M_2
4. Measure and record the distance h and h' as shown in figure

Questions to guide interpretation of results

1) What causes the difference in h and h'?
2) Discuss and explain these observations
3) Using the information in the above procedures, calculate the relative density of cooking oil. (Note that the relative density of water is equal to 1000 kg/m^3)

UNIT 6 APPLICATION OF PASCAL'S PRINCIPLE

Experiment 6.1. Investigation of the variation of Pressure with Depth

Rationale

The braking systems of cars, buses, work on Pascal's principle. The hydraulic brakes allow equal pressure to be transmitted throughout the liquid. When the brake pedal is pushed, it exerts a force on the master cylinder, which increases the liquid pressure in it.

Objective

In this experiment, you will investigate the variation of Pressure with Depth.

Materials:

- Clean water bottle
- Water
- 1 Pin
- Syringe
- Syringe needle

Set up:

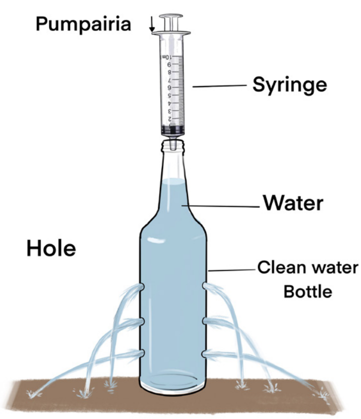

Fig. 6.1: *Transmission of pressure inside a bottle containing water.*

Procedures:

1. Pour water in a bottle fully.
2. Connect a needle to the syringe.
3. Through the closed mouth of bottle, pierce a bottle with a syringe.
4. By using a pin, pierce the sides of bottle at different heights from bottom to the top of bottle.
5. Apply a force on the piston of the syringe to pump air into a bottle.
6. Observe each hole, how far the water travels before hitting the ground.

Questions to guide interpretation of results

1) Is there a relationship between the depth (distance from the surface of the water to the tube) of the tube and the distance traveled by the water from the bottle?
2) How is the distance the liquid travels related to the speed the water leaves the bottle?
3) How might the speed which the water shoots out of the holes be related to the pressure in the liquid at that point?
4) How is the pressure related to the depth in the liquid?

Experiment.6.2: Verification of Pascal's principle

Rationale

Pascal's principle states that pressure exerted on an enclosed fluid is equally transmitted in all directions. This principle is important in real life, such as hydraulic lift pump.

Objective

In this experiment you will verify Pascal's principle.

Materials

- 2 Syringes of different sizes (5mL and 20mL)
- Water
- Delivery tube

Set up

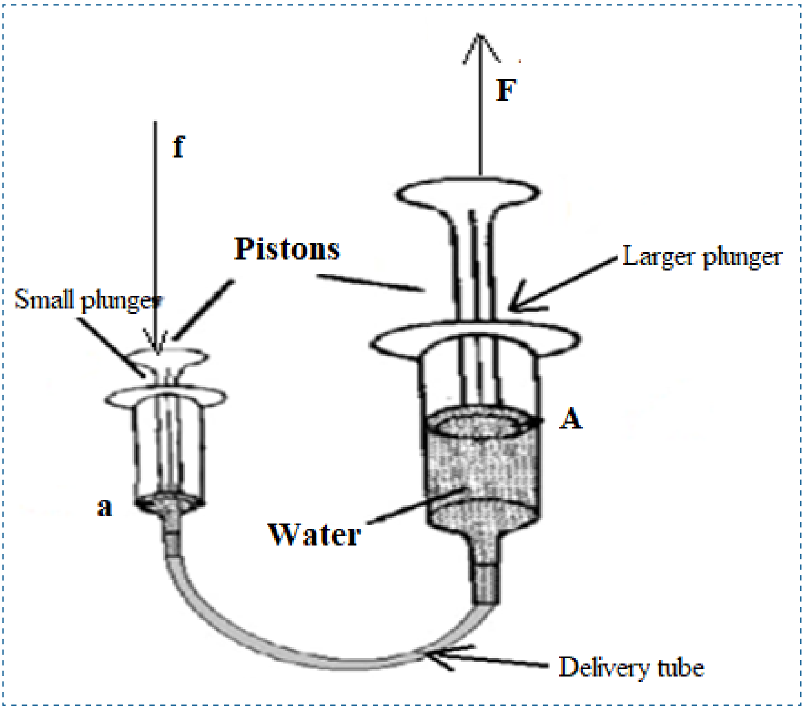

Fig. 6.2. *Pascal principle*

Procedures

1. Fill water in the large syringe and attach one end of the rubber tube to its end.
2. Attach the other tube to the small syringe.
3. Push the plunger of the larger syringe.
4. Observe what happens to the small syringe.
5. Push the plunger of a small syringe.
6. Observe what happens.

Questions to guide interpretation of results

1) What do you observe when you push a larger plunger or small plunger?
2) Compare your observations.
3) Which principle does this represent?

UNIT 7 ARCHIMEDES PRINCIPLE AND ATMOSPHERIC PRESSURE

Experiment 7.1. Demonstration of the existence of atmospheric pressure

Rationale

Atmospheric pressure helps in transferring liquids solution from one container to another using dropper. This experiment proves that there is a huge atmospheric pressure exerted on everything on the earth. This pressure pushes down on anything below it.

Objective

In this experiment, you will demonstrate the existence of atmospheric pressure

Materials:

- Drinking Glass
- Water
- Thick Sheet of Paper that is long and wide enough to cover the entire mouth of the glass. (We used a piece of poster board)
- Large Container or Sink

Set up

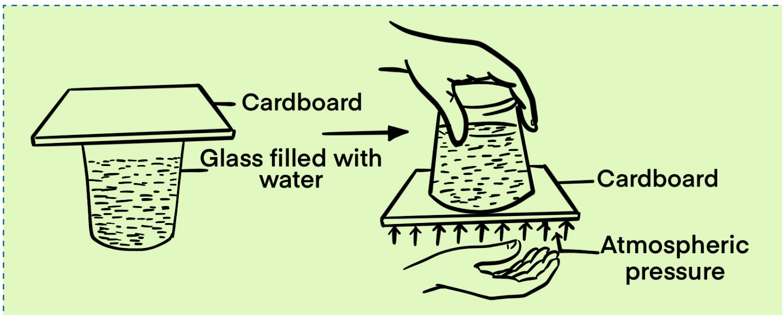

Fig 7.1: *Demonstration of Atmospheric pressure acting on a paper.*

Procedures

1. Begin by filling the empty glass with water. Helpful Tip: Ensure that the water is completely to the top of the glass. If there is any space between the water and the paper, the experiment won't work.
2. Gently place the paper on the top of the glass.
3. Move the glass over the container or sink.
4. Gently place your hand on the paper, and then flip the glass over.
5. Remove your hand from the bottom and watch in amazement as the paper stays covering the glass and the water doesn't spill out.

Questions to guide interpretation of results

1) What do you think make the cardboard not fall?
2) Why did water stay in inverted glass?

Experiment 7.2. Investigation of atmospheric pressure using capillary tube.

Rationale

Weather forecasts around the world are affected by atmospheric pressure, but many don't actually know what actually it is. Meteorologists use barometers to predict short-term changes in the weather. Again Scientists suggest that a fall in air pressure allows the tissues (including muscles and tendons) to swell or expand.

Objective

In this experiment, you will investigate the presence of atmospheric pressure using a capillary tube.

Materials:

- Potassium permanganate
- Beaker
- Capillary tube
- Water
- Ruler

Set up

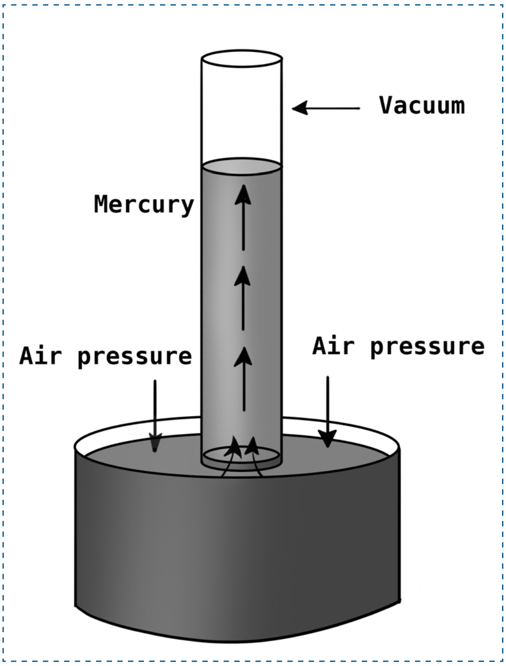

Fig 7.2. *Effect of air pressure*

Procedures

1. Pour water into a beaker and put $KMnO_4$ to color it.
2. Stir the mixture of water and potassium permanganate until it colored
3. Check whether there are no liquid bubbles in the capillary tube.
4. Place the capillary tube vertically in the container. Wait for 1 minute until stops raising in the capillary tube. (Make sure that the capillary tube does not touch the bottom surface of the container).
5. Put your finger on the top of capillary tube and remove it from the container.
6. Using a ruler measure the extent to which water rose.

Questions to guide interpretation of results

1) What happened after inserting the capillary tube in water?
2) What do you think is the cause for your observation in 1 above?

Experiment 7.3. Investigation of the upthrust (buoyancy) of water

Rationale

Ships or boats float on water as they transport goods and passengers. That means that the boat resists from sinking into water.

Objective

In this experiment you will investigate the upthrust or buoyant force of water.

Materials

- A solid of less than 100 g.
- Water
- Eureka can
- Sewing thread
- Dynamometer (0 to 1.0N)
- Measuring cylinder

Set up

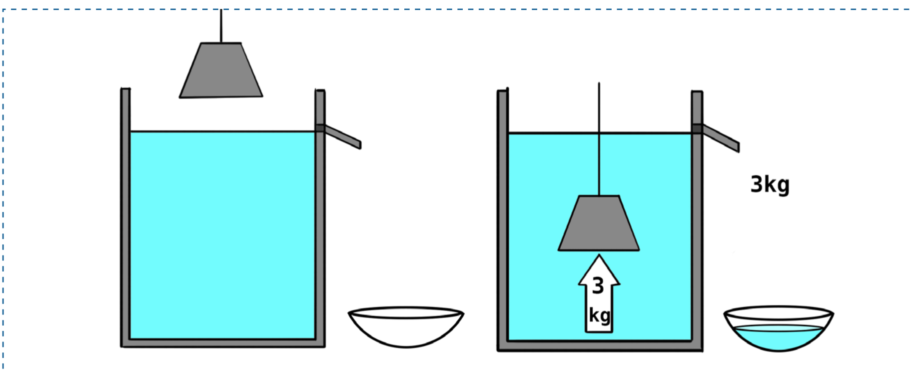

Fig 7.3: *The upthrust (buoyancy) of water*

Procedures

1. Pour water in the Eureka can and make it full.
2. Tie the thread on the mass and to the dynamometer.
3. Measure its weight in air using the dynamometer and record it to be w_1.
4. Submerge the stone in mass in water while it is still tied on the dynamometer and record the new weight $w_{2.}$
5. Measure the weight of water overflown in the measuring cylinder and record it as w_3.

Questions to guide interpretation of results

1) Find the difference $w' = w_1 - w_2$
2) Why some objects float or sink when immersed in a liquid?
3) What is the volume of the solid?
4) Discuss and explain your findings in question 1.

Experiment 7.4. Verification of Archimedes' principle

Rationale

Ships or boats float on water as they transport goods and passengers. That means that the boat resists from sinking into water.

Objective

In this experiment, you will verify Archimedes principle.

Materials:

- Solid mass
- Spring balance.
- Water
- Thread
- Measuring cylinder

Set Up

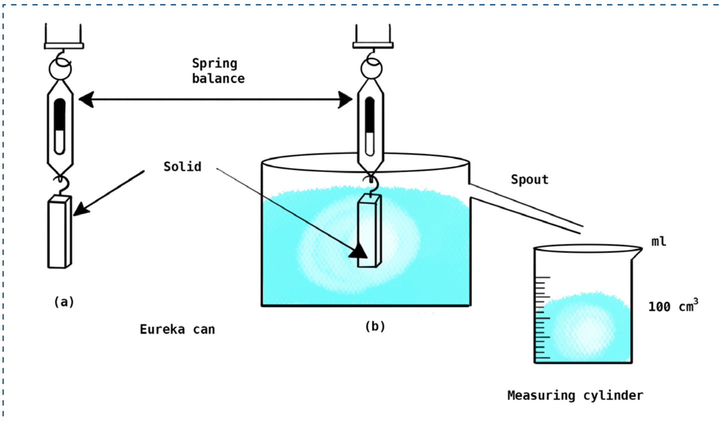

Fig. 7.4. *Verification of Archimedes principles*

Procedures

1. Take a solid (eg: stone) of known volume with density greater than water
2. Tie a solid at the end of a spring balance.
3. Hang the solid with a spring weighing balance and observe the reading of the spring balance due to the weight of the solid;
4. Record the mass m_1 (=W_1) and volume V.
5. Now, immerse the solid mass gently in water in a container and weighing balance into water slowly such that the mass is completely immersed in water (weighing machine is not immersed).
6. Note the new reading of the weighing machine m_2 (=W_2) and volume of water collected in the measuring cylinder.

Questions to guide interpretation of results

1) What makes the changes on the reading of spring balance?
2) What do you think is the reason for the decrease in the reading of the spring balance?
3) Make the comparison between the upward forces exerted by the water and the weight of water displaced.
4) Calculate Upthrust = Difference in weights, $\Delta W = (m_1 - m_2)\, g$
5) Calculate weight of water displaced, $W_w = \rho_w V g$

Experiment 7.6. Determination of the density and relative density of a solid using Archimedes principle.

Rationale

Density can be used to identify and determine how pure a substance is. Another way density is useful to man is that it helps to know whether a substance will float or sink when immersed in a liquid. That is why a boat or ship will float on water because it is less dense than water.

Objective

In this experiment, you will determine the relative density of a substance using Archimedes principle.

Materials

- Small beaker
- A solid object
- Overflow vessel
- Spring balance

Set up

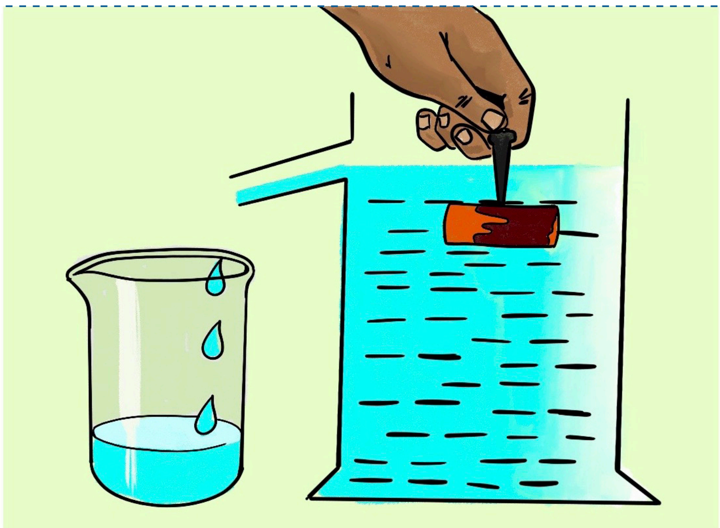

Figure 7.6. *Water dripping from beaker*

Procedures

1. Measure and record the weight of the solid object.
2. Place a beaker under overflow vessel.
3. Put the object into the vessel filled of water with the help of string until it is totally submerged.
4. Read and record the volume V of collected water into the beaker.

Questions to guide interpretation of results

1. What is the volume of the solid object?
2. Find the density of the solid object according to the following formula: Density of substance = **Mass / Volume**
3. Deduce the unit of density

Experiment 8.1. Determination of the personal power

Rationale

Owning your power leads to increased confidence and an understanding of how you can help others make decisions and achieve their objectives. Owning your power allows you to create and maintain strong relationships both in and out of the workplace.

Objective

In this experiment, you will determine the personal power.

Materials

- 1 flight of stairs,
- 50 cm rule,
- Stopwatch,
- Bathroom scales marked in kg.

Set Up

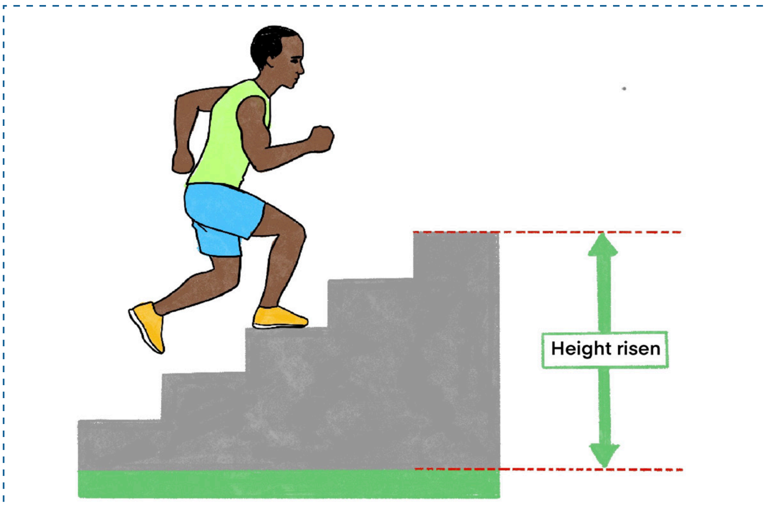

Fig 8.1. *Moving up the stairs*

Procedures:

1. Measure the persons mass in kg using bathroom scales.
2. Convert it to weight using W = mg. This equals the upward force that will move up the stairs.
3. Use a stopwatch to measure the time you take to run up a flight of stairs.
4. Count the number of steps, measure the height of each, and calculate the total height climbed in meter.
5. Repeat for two more steps and calculate the average height in meter and time taken.

Questions to guide interpretation of results

1) Calculate the vertical height = number of steps x average height of 1 step.
2) Calculate the work done in climbing the stairs (work = force x vertical height).
3) Calculate the persons average power using: *Power = Work done / Time taken*

UNIT 9 CONSERVATION OF MECHANICAL ENERGY IN ISOLATED SYSTEM

Experiment 9.1. Demonstration of energy conversion

Rationale

The rapid development of civilization on earth has been made possible by the development of different kinds of device to carry out mechanical work through the energy conversion processes. Mechanical energy can either be stored as potential or Kinetic energy.

Objective

In this experiment, you will demonstrate energy conversion.

Materials

- Complete retort stands with Clamp
- Long thread
- Small metal ball or pendulum bob

Set up

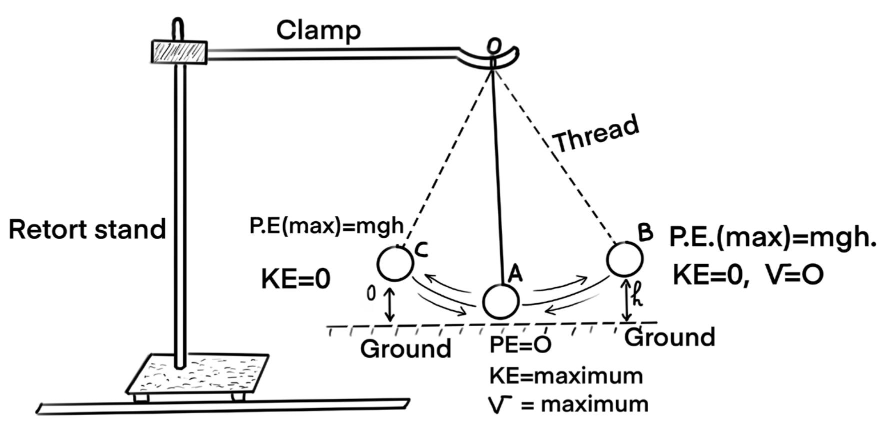

Fig. 9.1. *Energy exchange in Simple pendulum.*

Procedures

1. Take a retort stand and place it on the table.
2. Take a long thread say 40 cm long.
3. Tie a small heavy object like a metal ball or Bob to the side.
4. Suspend it freely from the retort stand and wait the bob comes to rest (at the mean position).
5. Displace the metal ball or bob to the side of extreme position left through a small angle and release it.
6. Observe the motion of the bob.

Questions to guide interpretation of results

1) What is the cause of the fourth and backward movement of the bob?
2) What do you understand from mean position?
3) At mean position, what do you think of kinetic energy and potential energy?

Experiment.9.2: Investigating elastic potential energy

Rationale

It provides the skills of weighting the body and how the energy is restored. The catapult uses elastic potential energy for its actions.

Objective

In this experiment you will investigate elastic potential energy

Materials

- Springs
- dynamometer
- Retort stand set
- Slotted mass (50g or 100g)

Set up

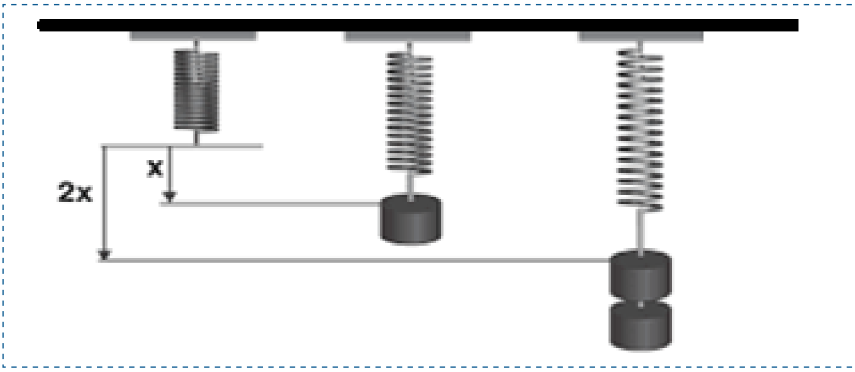

Fig. 9.2 *Elastic energy*

Procedure/steps

1. Fix the retort stand
2. Hang the spring or dynamometer on the retort stand
3. Hang the mass M_1 on the spring and measure X_1
4. Tie different slotted masses of 100g, 150g or 200g and note the corresponding extension x for each mass
5. Record the results in the table below

Mass/ kg	Extension(x)/m	Force/N	k = F/x	Elastic potential energy $E = \frac{1}{2}kx^2$
0.100				
0.150				
0.200				

Questions to guide interpretation of results

1) Which energy is involved in that system?
2) What is the physical meaning of the constant k?
3) Discuss what happened to the elastic potential energy as the extension increases?

Experiment 9.3. Investigation of the open and closed system

Rationale

In real life, there are open and closed system. After this experiment you should identify open and closed systems.

Objective

In this experiment, you will investigate the open and closed system.

Materials:

- retort stand with clamp
- calorimeter
- Beaker of 250 ml
- 150 ml of water
- Gauze
- Tripod stand
- Bunsen Burner or any source of heat
- 2 Thermometers
- Stopwatch
- Wooden handle

Set up

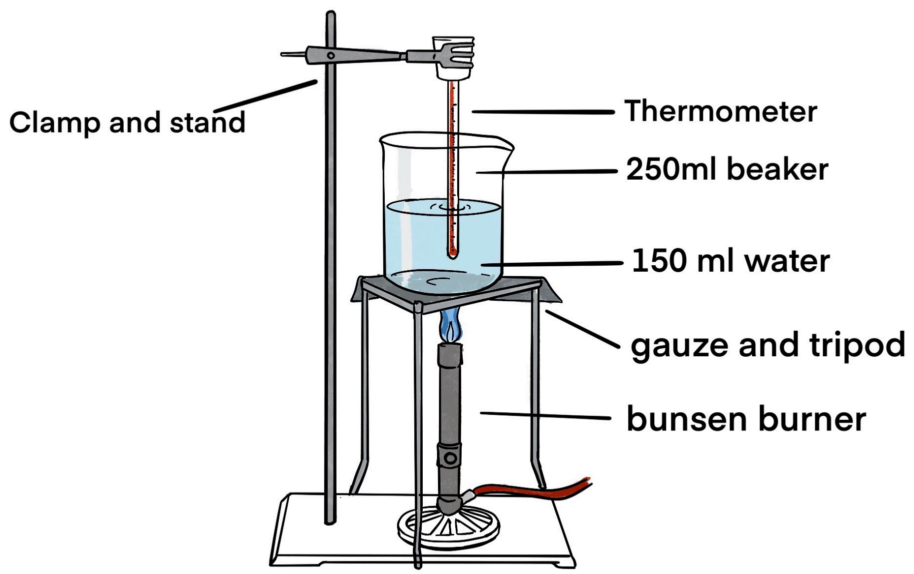

Fig. 9.3. *Closed and Open systems.*

Procedures

1. Fill an empty beaker with exactly 150ml of water (check side-scale of the beaker)
2. Set up apparatus as shown in fig 9.3 above.
3. Put thermometer into the beaker and ensure that it is about 2cm above the bottom of the beaker.
4. Place the beaker on gauze and tripod stand.
5. Light the bunsen burner and put on a blue flame. Heat up the water until thermometer reads 90 °C. As you light up the burner, immediately start the stopwatch
6. Record the time taken to achieve the temperature of 90°C
7. After the water has boiled, pour part of it into the calorimeter and close it, then leave another part in the cooking vessel.
8. Remove the cooking vessel and the boiling water from the Bunsen burner.
9. Leave the water in the calorimeter and that in the cooking vessel for a period of 5 min.
10. Measure the temperature of the water in the vacuum flask T_1 after those 5 min
11. Measure the temperature of water in the cooking vessel T_2 after those 5 min.

Questions to guide interpretation of results

1) Compare the two temperatures T_1 and T_2
2) Discuss the results obtained.
3) What is the difference between the calorimeter system and the cooking vessel system?

Experiment 10.1. Verification of Boyle's law

Rationale

Boyle's law has many applications in real life such as breathing, inflating tyres, soda bottle, working of a syringe, spray paint, etc.

Objective

In this experiment, you will verify Boyle's law

Materials

- At least two small balloons such as water balloons
- Large plastic syringe (approximately 60 milliliters works well), ensure that it is airtight and does not have a needle.

Set up

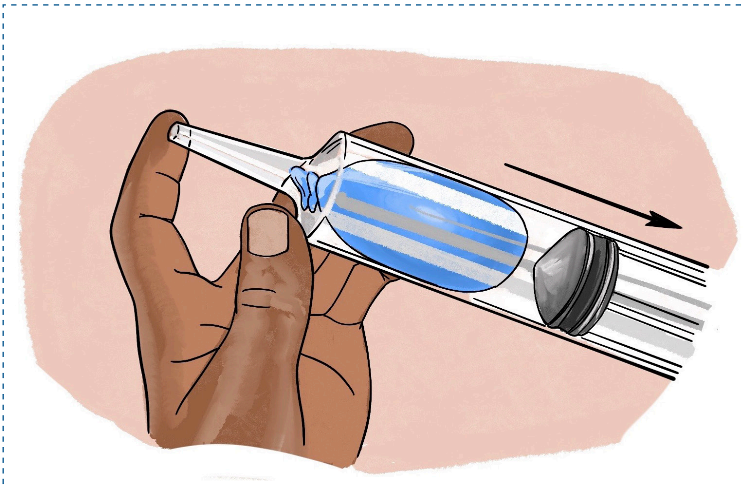

Fig. 10.1. *Demonstration of Boyle's law.*

Procedures

1. Place the air-filled balloon and close it tightly
2. Place the balloon inside the large opening at the back of the syringe.
3. Insert the plunger into the syringe,
4. By using your finger close the small opening of syringe
5. Try to push the plunger in the syringe.
6. While the small opening of the syringe is closed, pull the plunger back again and note down your observation.

Questions to guide interpretation of results

1) What happened when you push the plunger?
2) What was your observation when you pull back the plunger?
3) What was held constant in this experiment?

Experiment 10.2. Verification of Charles's law

Rationale

Charles Law application in real life can be seen in our kitchen too. In order to make bread and cakes soft and spongy, yeast is used for fermentation. Yeast produces carbon dioxide gas. When bread and cakes are baked at high temperatures; with an increase in temperature, carbon dioxide gas expands

Objective

In this experiment, you will verify Charles' law.

Materials

- Two balloons
- Water
- Conical flask
- Laboratory Bunsen Burner
- Tripod stand with gauze

Set up

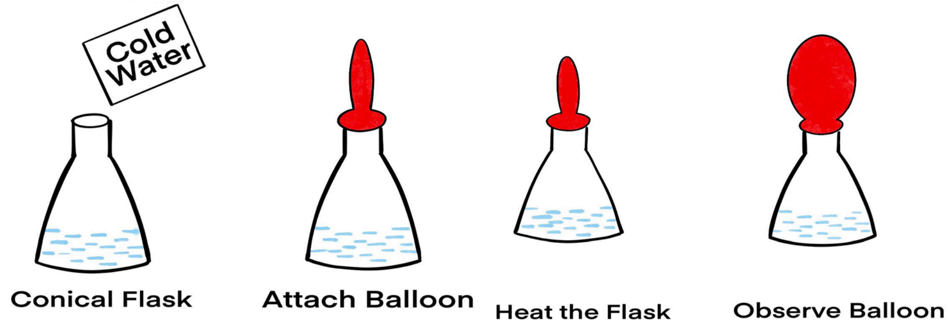

Fig. 10.2. *Demonstration of Charles's law.*

Procedures

1. Add a half cup of cold water in the conical flask
2. Attach balloon over the mouth of the conical flask
3. Place the conical flask on the bunsen burner and start heating it
4. Now observe the balloon. You will notice that the balloon will inflate in some time.
5. Remove the flask from the heat and allow it to cool down.

Questions to guide interpretation of results

1) What is the reason behind the inflation of the balloon?
2) Why does gas expand on heating?

Experiment 10.3. Verification of Pressure law

Rationale

Some real-life examples of pressure law are the rupture of a pressure cooker, an aerosol can, firing a bullet, and a tyre. All these substances explode when expose to higher temperatures. The scientific reason behind the explosion is explained by Gay-Lussac's Law.

Objective

In this experiment, you will verify Pressure laws.

Materials

- Round bottomed flask
- Water
- Ice
- Tripod Stand with gauze
- Laboratory bunsen burner
- Stirrer
- Beaker
- Thermometer
- Pressure gauge (Bourdon gauge)

Set up

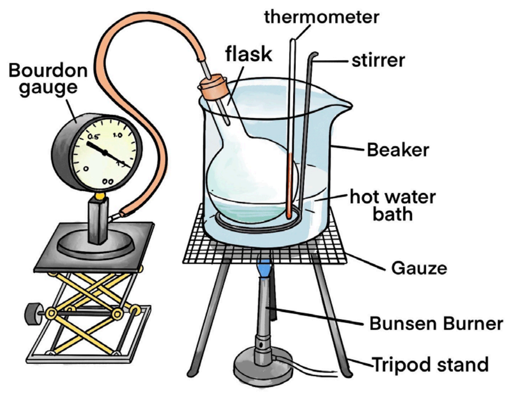

Fig. 10.3. *Demonstration of Pressure law.*

Procedures

1. Make a set up as shown in fig.10.3
2. Pour water in a beaker with some ice to cool water near 0 ^{0}C.
3. Use thermometer to record temperature of the water mixed with ice and use bourdon or pressure gauge to record pressure in the flask.
4. Light the Bunsen burner and heat the water slowly.
5. Stir continuously so that the temperature is uniform in the flask.
6. At 30 ^{0}C, record the pressure of the air in the flask from the pressure gauge.
7. Record the results in table 10.3 below

Temperature/ ^0C	30	40	50	60	70	80	90
Pressure/ kPa							

Questions to guide interpretation of results

1) Write down the temperature of the water and the pressure of the air at 40 ^0C, 50 ^0C, 60 ^0C, 70 ^0C, 80 ^0C, 90 ^0C.
2) Plot the graph of pressure (P) on Y-axis and temperature (T) on X-axis.

Experiment 10.4. Verification of Dalton's law of Partial Pressures

Rationale

People who ascend to high altitudes experience Dalton's law when they try to breathe. As they climb higher, oxygen's partial pressure decreases as total atmospheric pressure decreases in accordance with Dalton's law. Oxygen has a difficult time making it into the bloodstream when the gas's partial pressure decreases.

Objective

In this experiment you will verify Dalton's law of Partial Pressures.

Materials

- 3 Bourdon gauges,
- 3 graduated containers of the same volume
- 2 different gases (Oxygen and Nitrogen)

Set up:

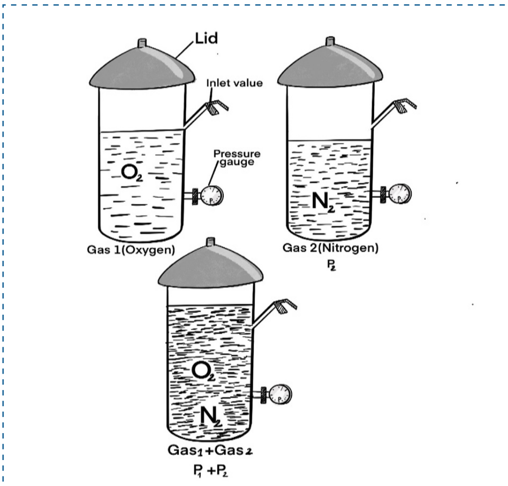

Fig. 10.4. *Demonstration of Dalton's law of partial pressure.*

Procedures

1. Put the three containers in the same room at the same temperature.
2. Fill first container with Oxygen gas and second container with Nitrogen gas through their respective inlet valves.
3. Note that other types of gases should be used.
4. Record pressure P_1 inside the first container of Oxygen gas from its pressure gauge.
5. Record pressure P_2 inside the second container of Nitrogen gas from its pressure gauge.
6. Fill the third container with the oxygen gas and Nitrogen gas from 2 containers.
7. Record pressure P of the mixture of oxygen and nitrogen.

Questions to guide interpretation of results

1) From your records of step 3 and step 4, calculate the sum of P_1 and P_2.
2) Compare the value found in step 6 and the value of the sum calculated.
3) Discuss your findings

UNIT 11 MAGNETIZATION AND DEMAGNETIZATION

Experiment 11.1. Magnetization by electric current

Rationale

Electromagnetism is the interaction of two important forces. Electricity and magnetism are integral to the workings of nearly every gadget, appliance, vehicle, and machine we use.

Objective

In this experiment, you will explain the magnetization process by electric current

Materials

- Copper wire
- Any ferromagnetic rod like steel rod.
- Nail
- 9.0 V Battery
- Switch

Set up

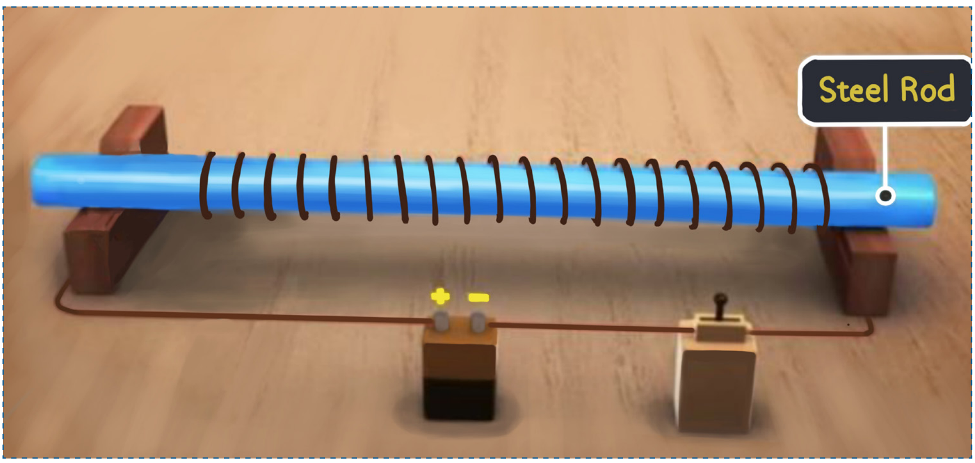

Fig.11.1. *Magnetization by electric current*

Procedures

1. Take the steel bar and place it closer the iron nails. Note down your observation.
2. Wound an insulated copper wire on a steel rod
3. Connect the free ends of the copper wire on the battery. Care must be taken that ends of the copper wire must be not insulated.
4. Close the switch (arrow the current to follow) for 10 minutes.
5. Bring the nail closer to the ferromagnetic rod and remove it slowly.

Questions to guide interpretation of results

1) What was the effect of the steel rod on the nail before winding copper wire on it?
2) On bring the iron nail towards the steel rod after 10 minutes, explain what happened to the nail as you tried to take it away from the steel?
3) Discuss and explain the cause of your observation.

Experiment 11.2. Magnetization a steel bar by single-touch method

Rationale

Bar magnets are used as stirrers in laboratory for magnetic experiments. They also find applications in medical procedures. Electronic devices such as telephones, radios, and television sets use magnets.

Objective

In this experiment, you will explain the magnetization process by single touch method

Materials:

- Table
- Magnet bar
- Steel rod
- Iron Nails

Set up

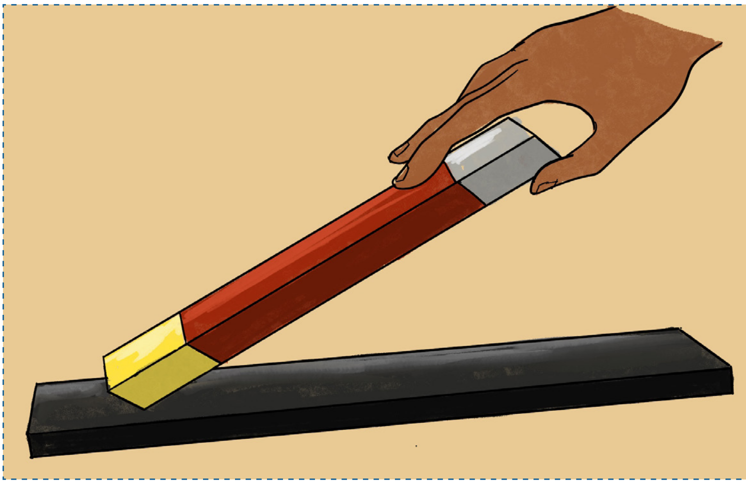

Fig.11.2. *Magnetization process by single touch method*

Procedures

1. Take the steel bar and place it closer the iron nails
2. What happens to the steel rod?
3. Place the steel bar on the table
4. Take a bar magnet and place one of its poles to one of end of steel rod
5. Stroke the steel bar with bar magnet from end(A) to (B). Stroke should be done for 30 times while keeping the magnet bar inclined.
6. When the magnet bar reaches at the position B, lift it and place it again on position A
7. Turn the steel rod upside down and stroke again for 30 times.
8. Take the steel rod and place it closer the iron nails.

Questions to guide interpretation of results

1) What was the effect of the steel rod on the nails before stroking?
2) What was the effect of the steel rod on the nails after stroking?
3) Discuss and explain the cause of your observation in (1) and (2) above.

Experiment 11.3. Magnetization by induction

Rationale

When a permanent magnet is moved relative to a conductor, or vice versa, an electromotive force is created. If the wire is connected through an electrical load, current will flow, and thus electrical energy is generated, converting the mechanical energy of motion to electrical energy.

Objective

In this experiment, you will magnetize a steel bar by induction.

Materials:

- Steel bar
- Strong magnetic bar
- Iron nails

Set up

Fig 11.3. *Magnetization process by induction*

Procedures

1. Take the steel bar and place it closer the iron nails
2. What happens to the steel rod?
3. Place the steel bar on the table
4. Take a strong magnet bar and place one of its poles on one of end of steel bar but not touching and wait for a time
5. Take the steel bar and place it closer the iron nails
6. What happens to the steel rod?

Questions to guide interpretation of results

1) What did you notice when you brought the steel rod towards the iron nail before putting steel rod near a strong magnet?
2) Explain what happened to the nail as you move it towards the steel rod after it had spent like 10 minutes near a strong magnet?
3) Discuss and explain the cause of your observation in (2) and (3)

Experiment 11.5. Demagnetization by electric heating

Rationale

Since the magnetization of a sample at a given location depends on the total magnetic field at that point, the demagnetization factor must be used in order to accurately determine how a magnetic material responds to a magnetic field.

Objective

In this experiment, you will demagnetize a magnet by heating

Materials:

- Bunsen burner
- Tripod stand
- Wire gauge
- Match box
- Magnet bar
- Iron nails
- Wooden handle

Set up

Fig 11.5. *Demagnetization by heating*

Procedures

1. Check the strength of magnet you have by using an iron nail. See how the magnet attracts the iron nail.
2. Set the system as illustrated in the figure above
3. Put the magnet bar on the wire gauge
4. Light the Bunsen burner (Note: Do not play with fire, fire hurts)
5. Heat the magnet bar until it changes the color.
6. Switch off the Bunsen burner.
7. Slowly withdraw the magnet using a wooden handle and let it cool down
8. Place the magnet bar near the iron nails

Questions to guide interpretation of results

1) Was the heated magnet able to attract the nail?
2) Explain your observations in (1) above.

Experiment 11.6. Demagnetization by Hammering

Rationale

Since the magnetization of a sample at a given location depends on the total magnetic field at that point, the demagnetization factor must be used in order to accurately determine how a magnetic material responds to a magnetic field.

Objective

In this experiment, you will demagnetize a magnet by hammering.

Materials:

- Hammer
- Magnet bar
- Iron nails

Set up

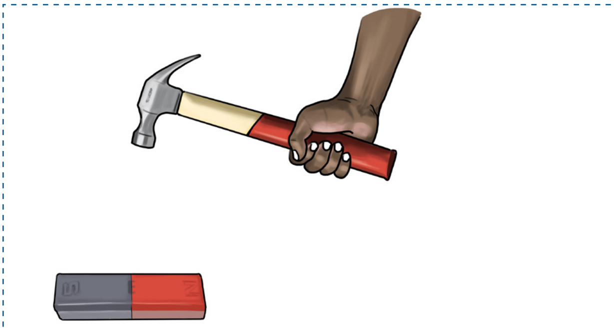

Fig 11.6. *Demagnetization process by hammering*

Procedures

1. Place the magnet bar on a plane surface
2. Hammer the magnet bar in East-West direction several times. Make sure it does not break
3. Place the magnet bar near the iron nails

Questions to guide interpretation of results

1) What did you observe as you brought the hammered magnet towards the nail?
2) Discuss your observations in (1) above.

UNIT 12 APPLICATIONS OF ELECTROSTATICS

Experiment 12.1 Investigation of the electric charges on a rubbed balloon

Rationale

Static electricity has several uses, also called applications, in the real world. One main use is in **printers and photocopiers** where static electric charges attract the ink, or toner, to the paper. Other uses include paint sprayers, air filters, and dust removal.

Objective

In this experiment you will investigate the electric charges on a rubbed balloon.

Materials:

- 2 inflated balloons with string attached
- Your hair
- Aluminum can
- Woolen fabric

Set up

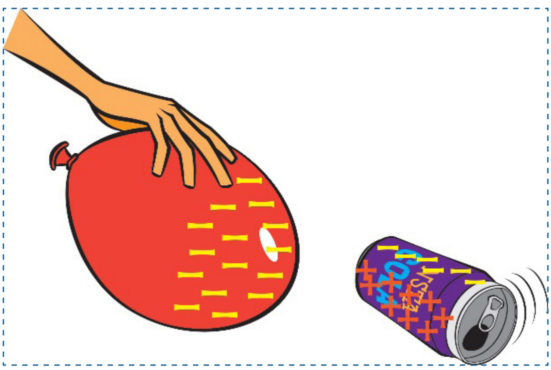

Fig.12.1 *Electric charges on a balloon and aluminum can*

Procedure:

1. Rub the 2 balloons one by one against the woolen fabric, and then try moving the balloons together. Do the balloons want to or are they unattracted to each other?
2. Rub 1 of the balloons back and forth on your hair then slowly pull it away. Ask someone nearby what they can see or if there's nobody else around try looking in a mirror and discuss your observations.
3. Put the aluminum can on its side on a table, after rubbing the balloon on your hair again hold the balloon close to the can and watch as it rolls towards it, slowly move the balloon away from the can and it will follow.

Questions to guide interpretation of results

1) Discuss and explain the observations made in all cases.
2) What causes the balloons to behave as in (1)?
3) What causes the aluminum can to behave as in (3)?

Experiment 12.2: Investigation of electric field

Rationale

Electric fields (e-fields) are an important tool in understanding how electricity begins and continues to flow. Electric fields describe the pulling or pushing force in a space between charges.

Objective

In this experiment you will investigate the electric field.

Materials:

- One battery cell (1.5V)
- A conducting wire
- 5 magnetic needles
- A slotted cardboard

Set up

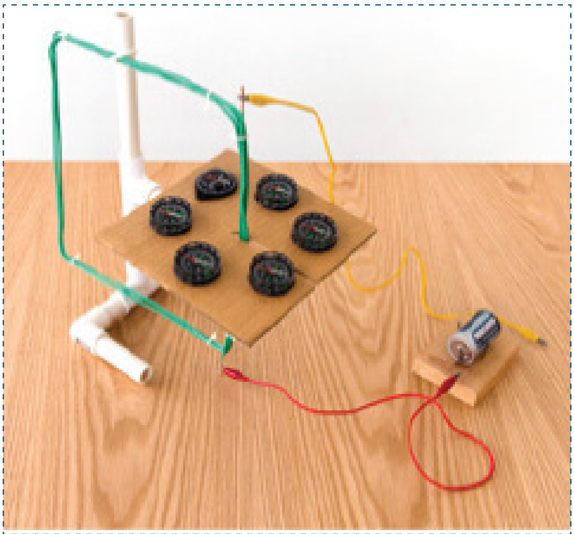

Fig.12.2 Demonstration of electric field

Procedure

1. Arrange the materials as shown in Fig. 12.2.
2. Remove the battery and note the changes on needles.
3. Reconnect the battery and note the changes on needles.

Questions to guide interpretation of results

1) What is the main cause of the directions change when the battery is connected?

UNIT 13 ARRANGEMENT OF RESISTORS IN AN ELECTRIC CIRCUIT

Experiment 13.1. Investigation of the magnetic effect of the electric current

Rationale

Appliances like the electric bulb, fan, television, refrigerator, washing machine, motor, radio, everything works due to electricity. When electric current passes through current carrying conductor or coil then a magnetic field is produced around it.

Objective

In this experiment you will investigate the magnetic effect of the electric current.

Materials

- Thick Copper wire (**Metallic conductor**)
- Connecting wires
- Needle Compass
- Switch
- 2 Batteries of 1.5 V each

Set up

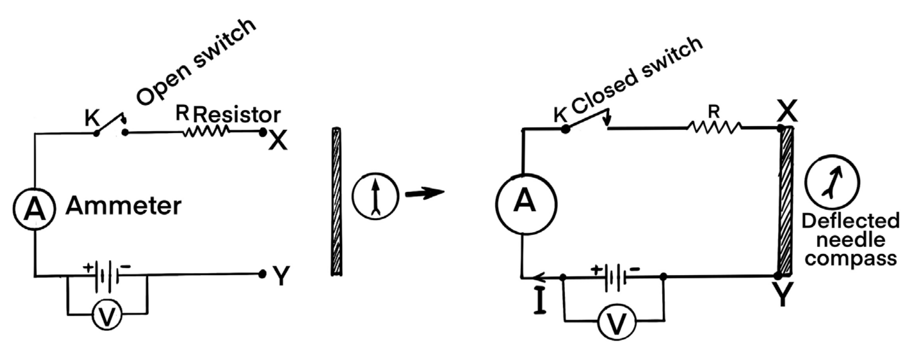

Fig. 13.1. *(a) and (b). Magnetic effect.*

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Procedures:

1. Connect electric wires across the terminals of batteries, switch, resistor, and ammeter to read the current flowing through the circuit all connected in series.
2. Connect voltmeter in parallel across the batteries to read the voltage.
3. Take a straight thick copper wire and place it between the points X and Y in an electric circuit as shown in fig 13. 1 (b).
4. Place a small compass near to this copper wire and see the position of its needle as the switch remains open.
5. Pass the current through the circuit by closing the switch.

Questions to guide interpretation of results

1) What happens to the compass needle when the switch is open?
2) What happens to the compass needle when the switch is closed?
3) Discuss the cause of the position of the compass needle in the procedure 4

Experiment 13.2. Investigation of the heat effect of the electric current

Rationale

The heating effect of current is utilized in the working of electrical heating appliances such as electric iron, electric kettle, electric toaster, electric oven, room heaters, water heaters (geysers), etc.

Objective

In this experiment you will investigate the heat effect of the electric current

Materials

- Bulb
- 2 batteries of 1.5 V
- Switch
- Electrical wires

Set up

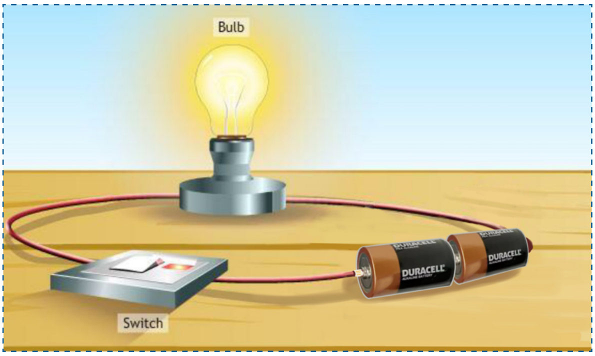


Fig.13.2. *Heat Effect of the current.*

Procedures:

1. Connect the 2 batteries in series
2. Also connect bulb and switch by using electrical wires
3. Put your hand near the bulb before the circuit is closed and note your observation.
4. Note: for your safety, do not touch the bulb but put your hand near the bulb.
5. Close the circuit and wait for about 1 minute, put again your hand near the bulb. Note your observation.

Interpretation of results:

1) Before closing the circuit, what did you feel? Is the bulb hot or cold?
2) What was your observation after 1 minute of closing the circuit?

Experiment 13.3. Investigation the chemical effect of the electric current.

Rationale

Electrolysis of water is used to produce hydrogen which is used as a fuel for powering internal combustion engines or electrical motors and electrolysis is used for extraction and purification of metals like aluminum and copper from their ores.

Objective

In this experiment you will Investigate the chemical effect of the electric current

Materials:

- water
- conducting wires
- bulb
- switch
- 3 batteries (dry cells) of 1.5v each
- beaker
- salt
- 2 metal electrodes

Set up:

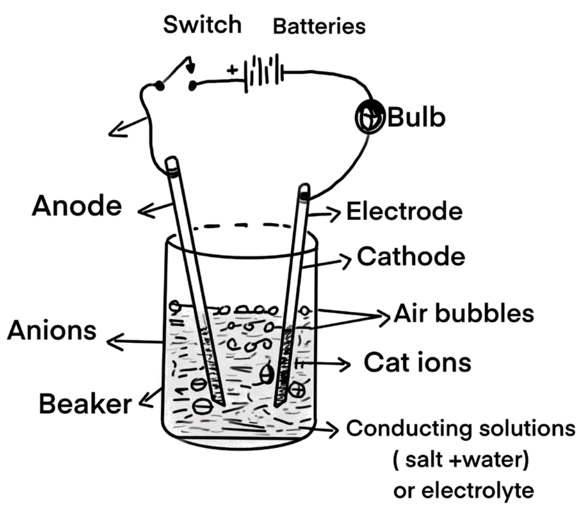


Fig. 13.3. *Electrolysis.*

Procedures:

1. Pour water in a beaker,
2. Mix water with table salt,
3. Arrange the circuit as shown in fig. 13.3
4. Close the circuit and make sure that the bulb is lighting (to prove that the current is passing through the solution)
5. Wait for 1 minute and observe the change on the liquid.
6. Observe carefully, the lighting bulb for 3 minutes, and note down what is happening on the bulb.

Questions to guide interpretation of results

1) What happened on one of the electrode?
2) Explain the observed changes on the lighting bulb for 3 minutes.

Experiment .13.4: Designing a simple electric circuit

Rationale

An electric circuit includes a device that gives energy to the charged particles constituting the current, such as a battery or a generator; devices that use current, such as lamps, electric motors, or computers; and the connecting wires or transmission lines.

Objective

In this experiment you will make a simple electric circuit.

Materials

- Battery
- Incandescent lamp
- Conducting wires
- Switch.

Set up:

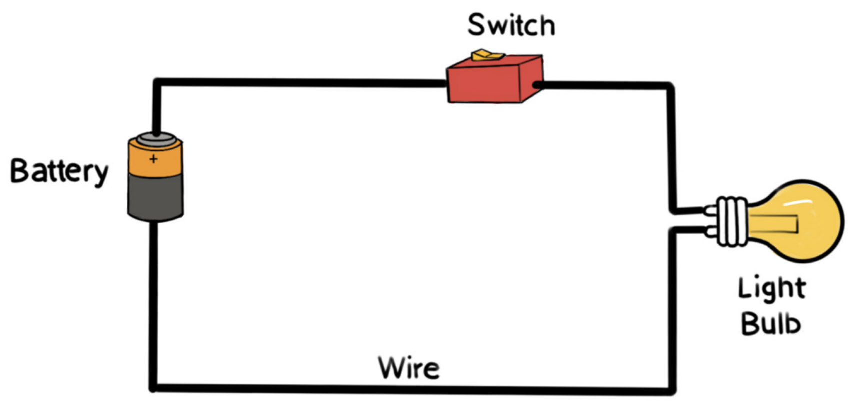


Fig. 13.4. *Simple Electric Circuit*

Procedures:

1. Connect the wires across the terminals of the battery
2. Connect the switch in series with battery
3. Connect the lamp to the battery as shown in the Set up above fig.13.4.
4. Switch on the circuit.
5. Observe what happens on the bulb.

Questions to guide interpretation of results

1) What happens on the bulb when you switching on the circuit in the procedure 4?
2) What causes the bulb to behave like the observation made in 1 above?

Experiment. 13.5: Measurement of electric current using Ammeter

Rationale

The ammeter can be used to measure both the DC and AC current. This comes in all sizes and can be used anywhere to measure the current like in electric heaters, cars, heavy and sensitive machinery, fridges etc.

Objective

In this experiment you will measure electric current using Ammeter

Materials:

- 3.0V Battery (2dry cells)
- 2 Ammeters
- 2 Incandescent lamps
- Conducting wires
- Switch.

Set up:

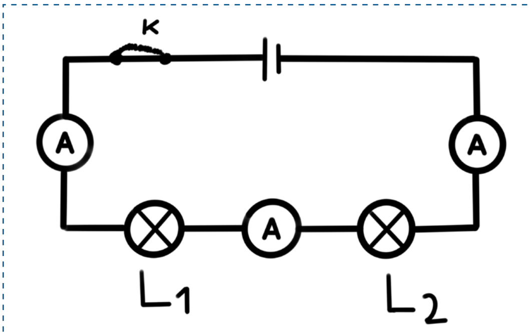


Fig. 13.5. *Ammeters connected in series.*

Procedures:

1. Set up the circuits with 2 bulbs in series with a 3.0V supply.
2. Connect 3 ammeters in series with the components as shown in Fig 13.5
3. Close the circuit
4. Read and record the readings on the ammeters.

Questions to guide interpretation of results

1) What conclusions can you draw from your measurements of current?
2) What is the link between the brightness of the bulb and the current in it?
3) What is the unit of the measured current?

Experiment 13.6: Measure potential difference using voltmeter

Rationale

A voltmeter could be used to measure the voltage at the outlet, and if it is not around 120 volts, then the wall outlet could be broken.

Objective

In this experiment you will measure potential difference using voltmeter.

Materials:

- 3.0V Battery (2 dry cells)
- 3 Voltmeters
- 2 Incandescent lamps
- Conducting wires
- Switch.

Set Up:

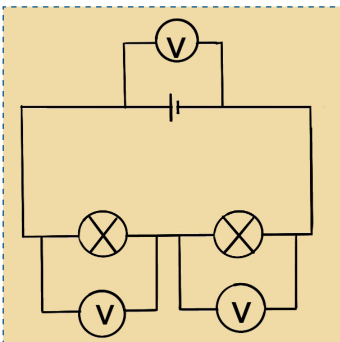


Fig. 13.6. *Voltmeters connected in parallel.*

Procedures:

1. Set up the circuit with 2 bulbs in series with a 3.0 V battery.
2. Connect 3 voltmeters in parallel with the components as shown in fig 13.6
3. Switch on the circuits
4. Read and record the potential difference on the voltmeters.

Questions to guide interpretation of results

1) What conclusions can you draw from your measurements of voltage?
2) What is the link between the brightness of the bulb and the voltage in it?
3) What is the unit of the p.d recorded?
4) Deduce the value of the smallest division of your voltmeter.

Experiment 13.7. Investigation of series and parallel connections

Rationale

Series circuit connection gives us the opportunity to connect more than two loads to a common switch. Streetlights are a very good example of this. Parallel circuit connection makes it possible for us to connect loads to their individual switch.

Objective

In this experiment, you will be investigating series and parallel connections.

Materials

- Battery
- 3 torch light bulbs
- Conducting wires
- Switch.

Set up:

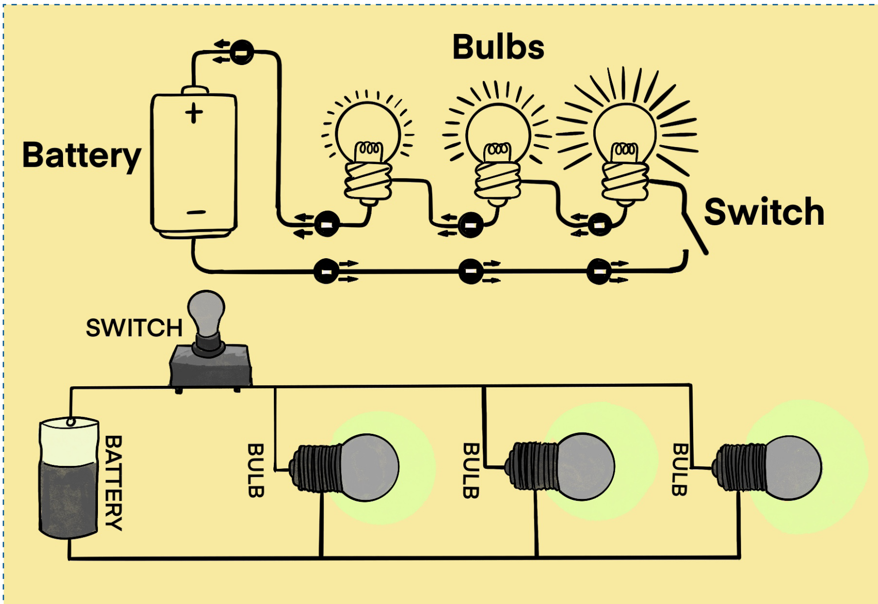


Fig. 13.7 *Series and Parallel Circuit*

Procedures:

(a) A series Circuit

1. Arrange the circuit correctly as in fig.13.7 (a)
2. Connect an ammeter in series and voltmeters in parallel on the terminals each bulb.
3. Now close the circuit.
4. Observe what happens on the bulb.
5. Read and record the readings of the ammeter and voltmeters.
6. Remove one bulb and note your observation.

(b) A parallel Circuit

1. Arrange the circuit as in **fig. 13.7 (b)**.
2. Connect an ammeter in series and voltmeters in parallel on the terminals each bulb.
3. Close the circuit

4. Observe what happens on the bulb.
5. Read and record the readings of the ammeter and voltmeters.
6. Remove one bulb and note your observation.
7. Remove the second bulb, again note your observation.

Questions to guide interpretation of results

(a) A Series circuit.

1) What happened to the bulbs in the circuit of fig.13.7. (a) when you close the switch? one bulb is removed?
2) What is the potential difference across each bulb?
3) Estimate the maximum current of the circuit.

(b) A parallel circuit

1) What happened to the bulbs in the circuit of fig.13.7. (a) when you close the switch? one bulb is removed?
2) What happened in the circuit 13.7.(b) when the second bulb is removed?
3) What is the current through each bulb?
4) Estimate the potential difference across each bulb.

Experiment 13.8: Investigation of Ohm's law.

Rationale

By shifting the regulator to and from, we can regulate the speed of the fans in our houses. By controlling the resistance via the regulator, the current flowing through the fan is managed here.

Objective

In this experiment, you will investigate the Ohm's law.

Materials:

- 5 Batteries (Dry cells)
- Voltmeter
- Ammeter
- Conducting wires
- Resistor (Bulb)
- Switch.

Set up:

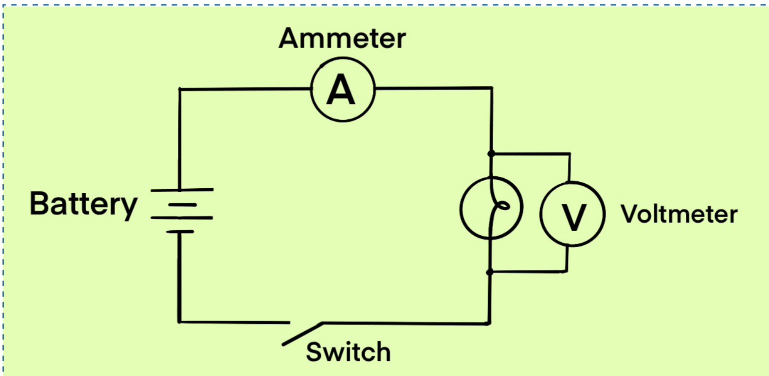


Fig. 13.8 *Circuit to verify Ohm's law*

Procedures:

1. Arrange the simple electric circuit, comprising the above materials as shown in fig.13.8
2. The Voltmeter should be parallel to the resistor or bulb.
3. The Ammeter should be in series with resistor.
4. Use one cell, note and read the value given by the ammeter and voltmeter.
5. Use two cells in series, note and read the value given by the voltmeter and the ammeter.
6. Then three cells in series then four and then five but each time read and record the different values of current and voltage.
7. Record your readings in a table below:

Number of Batteries	Voltage / V	Current (I)/A	Resistance (V/I)/ Ω
1			
2			
3			
4			
5			

Questions to guide interpretation of results

1) Plot a graph of V against I
2) Carefully determine the gradient of the slope of your graph.
3) Compare the value of the gradient of your graph with the values of *V/I* in your table.
4) What do you notice?

UNIT 14 REFLECTION OF LIGHT IN CURVED MIRRORS

Experiment 14.1: Verification of laws of reflection for plane mirror

Rationale

Reflection is said to occur when light rays bounce off the surface of an object. Eg: Drivers use side mirrors to observe cars behind them, in saloons there are shaving mirrors, and mirrors have many other applications in industry and science.

Objective

In this experiment you will verify the law of reflection through a plane mirror

Materials:

- a plane mirror
- a white sheet of paper
- a pencil
- a protractor.
- 4 optical pins
- 4 drawing pins
- soft board

Set up

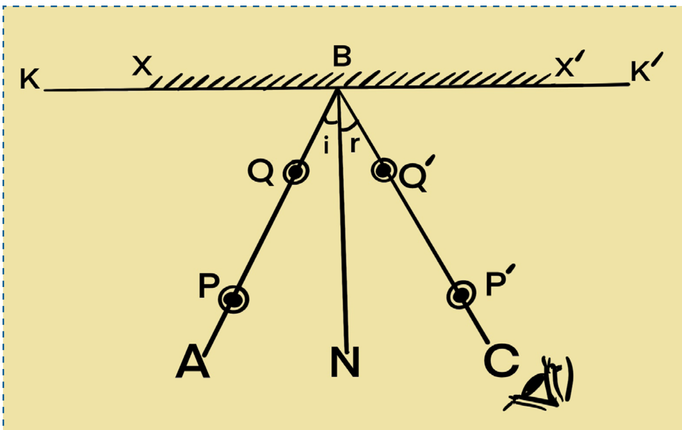


Fig.14.1: The law of reflection through a plane mirror.

Procedures

1. fix a white sheet of paper on a soft board using drawing pins.
2. In the middle of paper draw a straight line KK' and mark a point B on it.
3. Draw a perpendicular line BN. Place a mirror XX' online KK' such that the polished side of the mirror is along the line.
4. Draw the line AB at an incident angle of 30^{o} from the line BN.
5. Fix two steel pins P and Q on the straight line AB at least 10 cm apart.
6. Observe the image of the pins P and Q and fix two pins P' and Q' such that the image of P and Q are all in the same straight line.
7. Remove the pins and draw small circles around the pin picks and remove the mirror.
8. Join P'Q' and produce the straight line CB.
9. Measure and record the angle □CBN = r.
10. Repeat procedure 4 to 9 for incident angles i = 35^0, 40^0, 45^0, 50^0 and 55^0.
11. Record the results in a table below

Incident angle (i)/^{0}	Reflected angle(r)/ ^{0}
30	
35	
40	
45	
50	
55	

Questions to guide interpretation of results

1) What happened to the reflected angle when changing the angle of incident?
2) What will happen if the mirror is not silvered on one side?
3) What are the sources of error in this experiment?
4) Why where two optical pins used to construct each line instead of only one?
5) Plot a graph of Incident angle (i) against reflected angle (r).
6) From the graph determine the slope.

Experiment 14.2: Determination of the focal length of concave mirror

Rationale

Concave mirrors are used in a variety of applications, including searchlights, shaving mirrors, dental mirrors, satellite dishes, and more. Concave mirrors are used as a light beam Reflector in the torches and headlights.

Objective

In this experiment, you will determine the focal length of concave mirror

Materials:

- A lighting candle.
- A mirror holder
- Screen
- Concave mirror
- A meter rule.

Set up

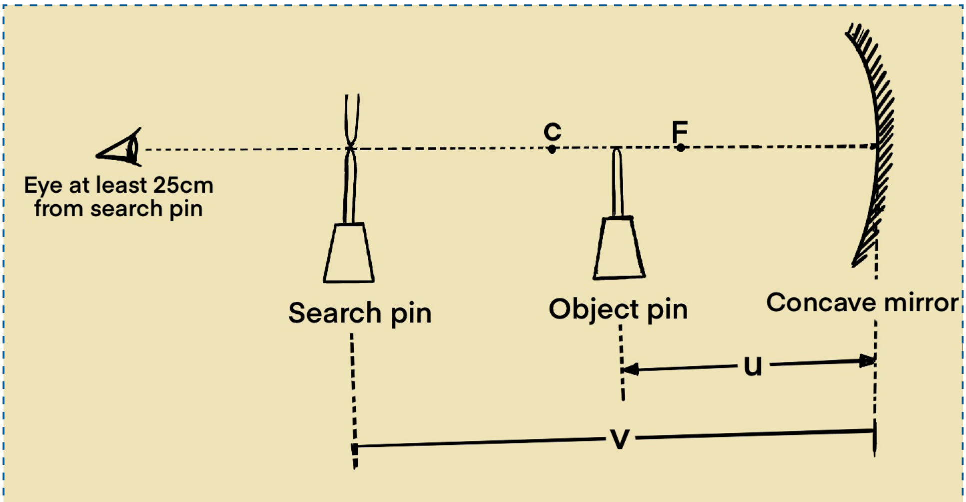


Fig.14.2: *Ray diagram for determination of focal length of a concave mirror*

Procedures

1. Arrange the set up as shown in the figure above.
2. Place the lighting candle at a distance d =10cm
3. Adjust the concave mirror until a sharp real image is formed on the screen.
4. Measure the object distance u and image distance v

Questions to guide interpretation of results

1) Using the obtained results of u and v, calculate the focal length of the mirror using

$$f = \frac{uv}{u+v}$$

2) Explain why it is good to repeat the experiment for different values of object distance.

Experiment 14.3: Determination of the focal length of a convex mirror

Rationale

These convex mirrors are used for cars because they give an upright image and provide a wider field of view as they are curved outwards. Convex mirrors are also often found in the hallway of various buildings including hospitals, hotels, schools, stores and apartment building.

Objective

In this experiment you will determine the focal length of a convex mirror, using a convex lens.

Materials

- Illuminated candle
- Stand
- Screen
- Meter scale
- Convex lens
- Given convex mirror

Set up

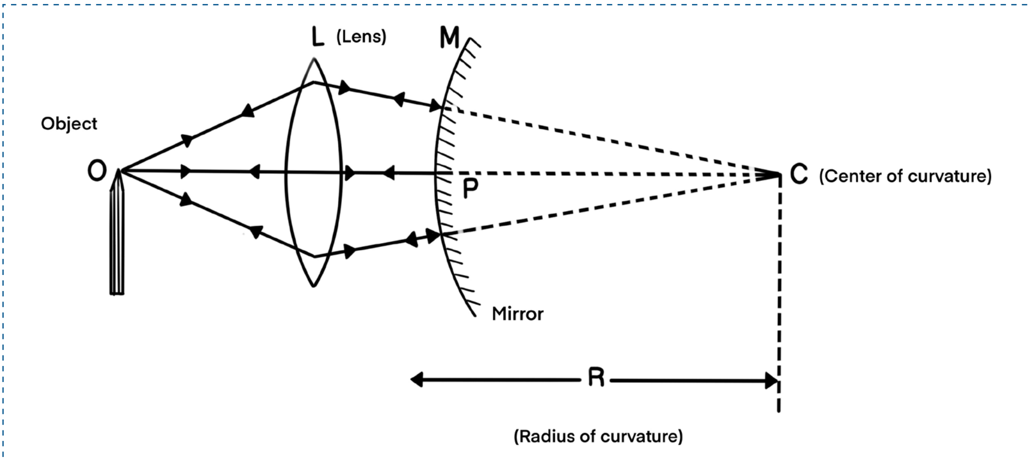


Fig .14.3: *The focal length of a convex mirror*

Procedures:

1. Place a convex lens on a lens holder facing the illuminated candle at a fixed distance, say 30 cm, away from the candle. It is taken as **u**.
2. Place a screen, at the other side of the lens so that the candle, lens, and screen are in a straight line.
3. Adjust the position of screen to get a clear image of the candle.
4. Fix the given convex mirror to another holder and place it in between the convex lens and screen with its reflecting face facing the candle.
5. Now place another screen side by side with the candle.
6. Adjust the position of the convex mirror is so that a clear image of the candle is formed on the screen placed side by side with the candle.
7. Measure the distance between the mirror and first screen and take as the radius of curvature of the mirror R.
8. Repeat the experiment by moving the convex lens towards the object by 2 cm each time and record the values in a table below.

No.	Distance from lens to		Radius of curvature, R/cm		
	Object u/cm	Image V/cm			
1					
2					
3					
4					

Questions to guide interpretation of results

1) Basing on the values of R you got for each trial, how are they related?
2) From this experiment, estimate the focal length of used mirror.

UNIT 15 BASIC ELECTRONIC COMPONENTS

Experiment 15.1. Analyzing Diodes and transistors in an electronic device.

Rationale

All electronic devices we use at home or at school are made of different components depending on their functions. For example, there are diodes and transistors in these electronic devices.

Objective

In this experiment, you will analyze diodes and transistors in any electronic device you will use.

Materials

- Any electronic device
- Screwdriver

Set up

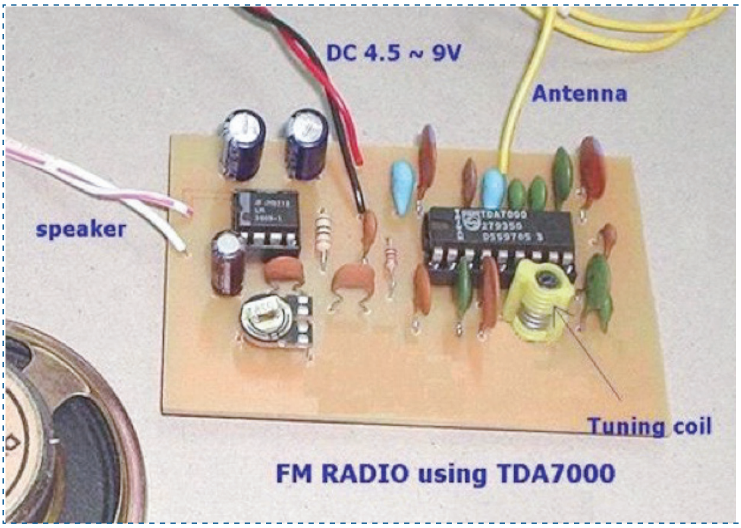


Fig.15.1: *Electronic device*

Procedures

1. Get any electronic device of your choice. Make sure it is not connected to the source of electricity.
2. Using the screwdriver (or anything you can use to open the device), open it and observe the different components in the device you opened.

Questions to guide interpretation of results

1) Were you able to see the diodes and transistors after opening the device?
2) Basing on what you observed, describe the appearance of the diodes and transistors you saw.

Experiment 15.2. Verification of working principle of Light Emitting Diode (LED).

Rationale

LEDs are currently used for a wide variety of different applications such as: residential lighting, aerospace industry, architectural, automotive, broadcasting, electronic instrumentation, entertainment and gaming, the military, traffic and transportation; They become very important tools of modern technologies.

Objective

In this experiment you verify the working principle of Light Emitting Diode (LED)

Materials:

- LED
- 2 dry cells
- Switch
- Ammeter
- Connecting wires

Set up

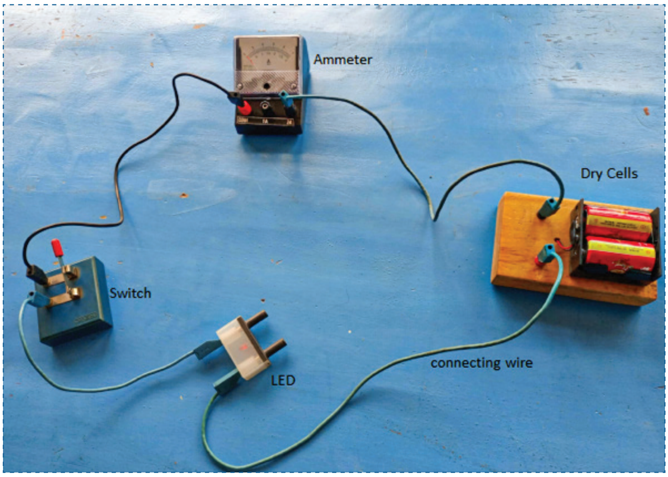


Fig.15.2: *Connecting LED to the source of electricity*

Procedures:

1. Arrange the circuit as in figure 15.2. Remember to connect the long lead/leg of LED directly to the positive terminal of the dry cells.
2. Close the switch; Note what is happening on LED and record the readings of ammeter.
3. Open the circuit.
4. Now reverse the terminals of LED by connecting short lead directly to the positive terminal of dry cells.
5. Again, close the switch. Note down what is happening on the LED and record the reading of ammeter.

Questions to guide interpretation of results

1) Explain what happened on LED when its long lead was connected on positive terminal and switch is closed. What is the reading on ammeter?
2) What did you observe after reversing the terminals of LED? What was the reading on ammeter?
3) From what you observed in this experiment, comment the working principle of LED.

SENIOR THREE EXPERIMENTS

Experiment: To verify if the distance moved by a uniformly accelerating body is directly proportional to the square time

Rationale

The motion of any moving body can be described by analyzing its change in portion in a defined time. To make the situation easier, a distance-time graph to shows how far an object has travelled can be used.

Objective

In this experiment you will verify if the distance moved by a uniformly accelerating body is directly proportional to the square time.

Materials

- Stopwatch
- Ramp
- Meter stick
- Marble ball

Set up

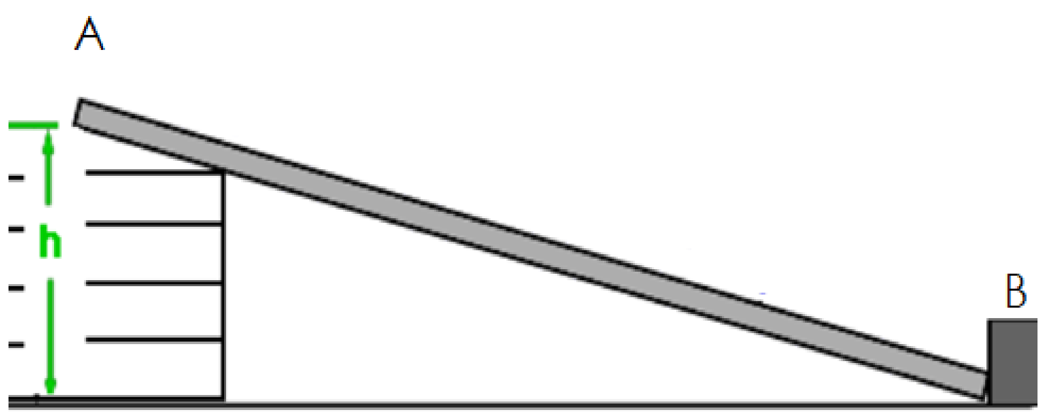


Fig.1.1 *inclined plane*

Procedures

1. Set up the ramp with h = 0.10 m above the table, (as shown in Figure 1.)
2. Using a meter stick, measure and mark on the range the distance d =1m, d = 0.8m, d = 0.60m and d =0.40m starting from A
3. Starting from A, release the marble ball from rest, to roll down the ramp and use the stopwatch to measure the time used to roll a distance d = 1.0 meter. (use the marking made in step 2)
4. Take 4 times measurements, record in data table provided below.
5. Repeat steps 3 and 4 for distances of 0.80 m, 0.60, 0.40 m
6. Tabulate your results in the table below

Distance/m	T_1/s	T_2/s	T_3/s	T_4/s	T(average)/s	T^2/s^2
1.00						
0.88						
0.60						
0.40						

Questions to guide interpretation of results

1) Using the data tabulated in the table of result, plot a graph of d (vertical axis) vs t^2 (horizontal axis).
2) Draw a "best fit" straight line through the points.
3) Is the graph linear?
4) What does it mean if the graph is linear?
5) What does a linear graph indicate about the acceleration of rolling objects?

UNIT 2

FRICTION FORCE AND NEWTON'S LAWS OF MOTION.

Experiment 2.1: Verification of friction force

Rationale

The friction between the sole of the shoes and the ground helps us to move forward when we walk. Our legs provide a backward force and in response, the force of friction propels us in the forward direction. The more friction, the better the walking experience.

Objective

In this experiment you will verify friction force

Materials.

- A block
- A table
- A spring balance

Set up

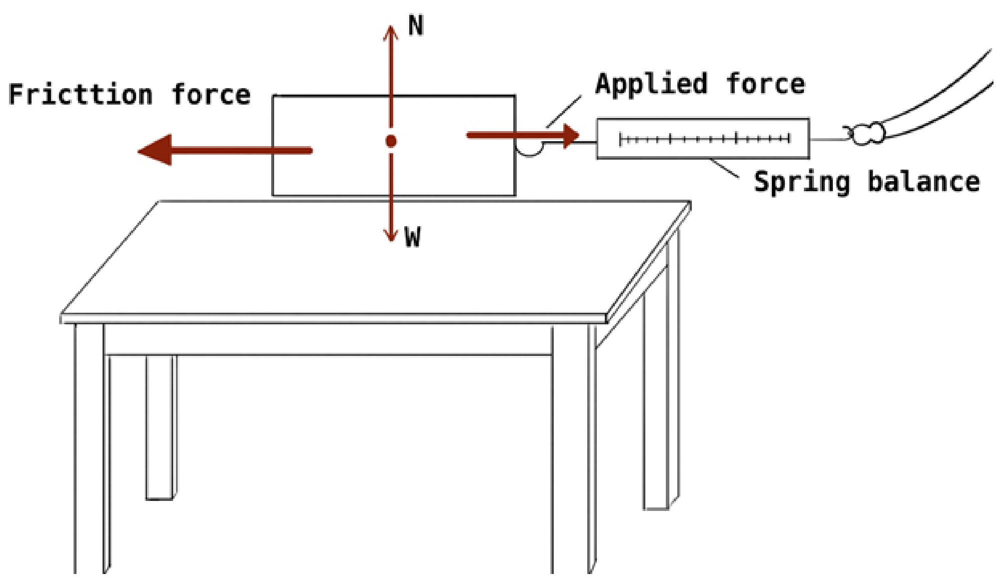


Fig. 2.1: *Verification of Newton's laws*

Procedures

1. Measure the weight of the block using spring balance.
2. Tie a thread to spring balance
3. Read and record the force that pull the block when it starts to move.

Questions to guide interpretation of results

1) What is friction force?
2) Explain how do forces affect motion?

Experiment 2.2: Illustration of linear momentum.

Rationale

Linear momentum is particularly important because it is a conserved quantity, meaning that in a closed system (without any extern forces) its total linear momentum cannot change. It is applied in launching of rockets.

Objective

In this experiment, you will illustrate the linear momentum.

Materials

- Two hammers (light and heavy)
- Four identical nails
- Wooden block

Set up

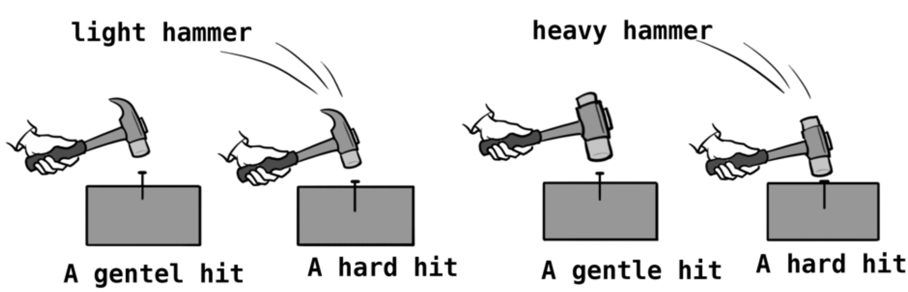


Fig. 2.2.: *Illustration of linear momentum*

Procedures

1. Take two nails and drive them into two pieces of wood using a light hammer.
2. Hit the first one gently and the second nail very hard. What happens in each case?
3. Repeat the activity using a heavy hammer in the figure above. What do you notice?

Questions to guide interpretation of results

1) Highlight two factors on which the penetration distance of the nail depends on.
2) Discuss with your classmate what the term 'linear momentum' means.

Experiment 2.3: Demonstration of Newton's second law of motion

Rationale

Newton's second laws explain how things move and how forces work on their movement, which make it an extremely important discovery if we were to place an object into space, we could observe how it behaves without any influences.

Objective

In this experiment, you will demonstrate Newton's second law of motion

Materials

- Two wooden blocks (heavier and light one)
- A string or cotton thread
- Pulley

Set up

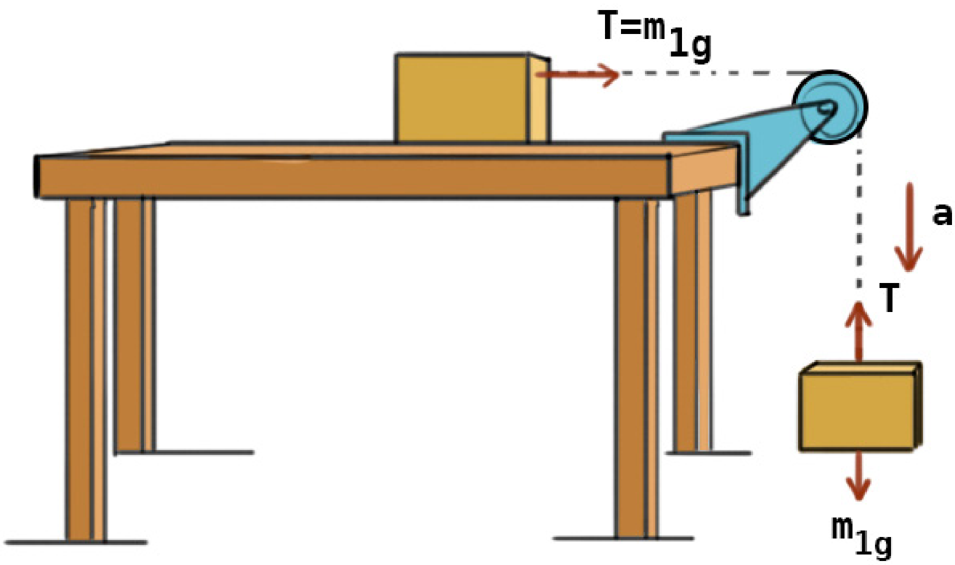


Fig.2.3: *Demonstration of Newton's second law*

Procedures

1. Place the one lighter block of unknown mass on a smooth flat surface (floor or a table surface).
2. Connect the heavier block of known mass to the lighter block using a string or cotton thread provided.
3. Pull the lighter block using the heavier one. See and note the observation.

Questions to guide interpretation of results

1) Based on your observations in this activity, suggest relationship between the applied force, mass of an object and the acceleration produced by the force on the body.
2) Explain your observation using Newton's Second law of motion in term of momentum.
3) Compare your finding with those of other classmates.

Experiment 2.4: Demonstration of action and reaction force

Rationale

It is easier to study effects of forces on an object by considering one force at a time. However, in reality, a single force cannot exist by itself. Two forces always occur when two objects push or pull each other. These forces are called action and reaction force

Objective

In this experiment you will demonstrate Newton's third law (action and reaction force)

Materials

- Two identical spring balance
- One retort stand

Set up.

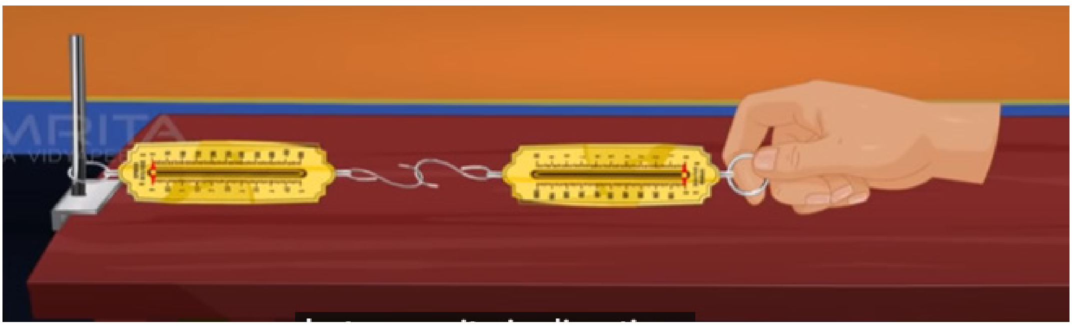


Fig. 2.4: *Demonstration of Newton's third law*

Procedures

1. Fix one spring balance to the stand
2. Take the second spring balance and attach it to the end of the first spring balance
3. Pull the second spring balance away from the stand

Questions to guide interpretation of results

1) Note your observation on the forces at each balance.
2) Are the force the same or different? Explain.
3) Give three real life situations where Newton's third law of motion is experienced

Experiment 2.7: Determination of the coefficient of friction

Rationale

In some application, a low coefficient of friction is desirable, for example, in bearings, pistons moving within cylinders, on ski runs, and so on. However, for such applications as force being transmitted by belt drives and braking systems, a high value of the coefficient is necessary.

Objective

In this experiment, you will determine the coefficient of friction

Materials

- A 50 g wooden block with rough surface.
- Four 50 g mass
- A rough bench
- A spring balance

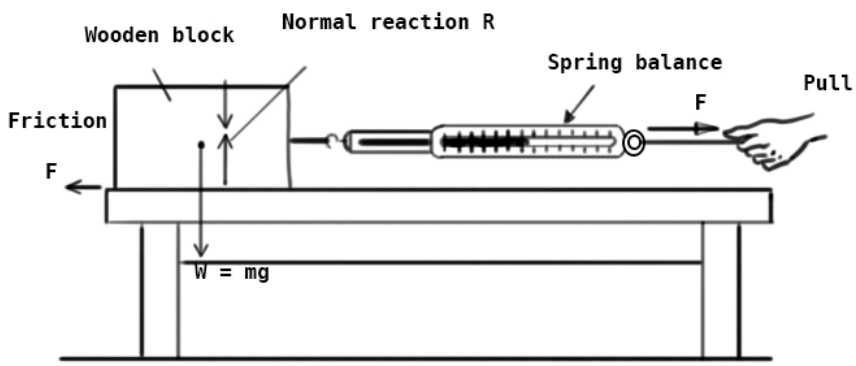


Fig. 2.7: *Determination of the coefficient of friction*

Procedures

1. Pull the string until the block is just about to move. Record the reading on the spring balance. Note that the spring balance reads the value of frictional force which is acting in the opposite direction in these experiments. (F is the frictional force between the surfaces. Frictional force = Applied force F).
2. Place one 50 g mass on the block and pull the string again. Record the reading on the spring balance.
3. Repeat steps 2 and 3 for two, three and four 50 g masses on the block masses and the record the reading of force, F on the spring balance in Table below.

Mass /g	Reaction R /N	Spring reading F /N
50		
100		
150		
200		
250		

Questions to guide interpretation of results

1) What is the relationship between weight of the block and the normal reaction?
2) Draw a graph of F(N) against R(N).
3) Find the slope of the graph and explain what it represents.

Experiment 3.1: Measurement of atmospheric pressure using mercury barometer

Rationale

Barometers measure the pressure. Atmospheric pressure is an indicator of weather. Changes in the atmosphere, including changes in air pressure and affect the weather. Meteorologists use barometers to predict short-term changes in the weather.

Objective

In this experiment, you will measure the atmospheric pressure by using barometer.

Materials

- Mercury barometer (Glass tube)
- Mercury container
- Stand
- Meter scale

Set up

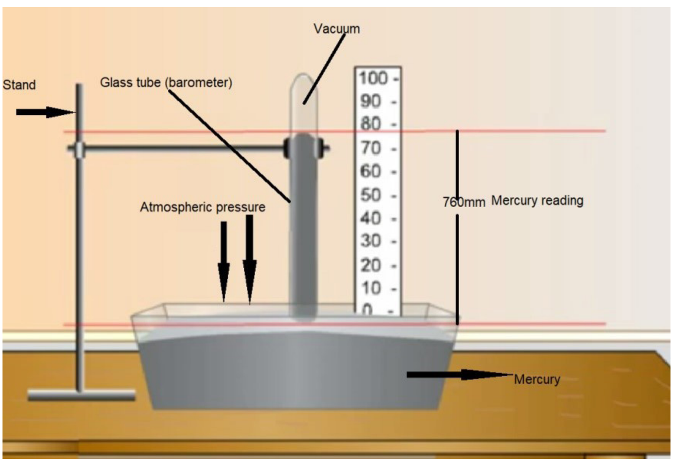


Fig. 3.1. *Mercury barometer*

Procedures

1. Take the mercury barometer provided and observe its calibrations.
2. Record the height of the column of mercury in it.
3. Why mercury is used as a barometric liquid and not water.
4. Predict what will happen to the level of the mercury as you climb up a high. Explain.
5. Fill again the tube with mercury and inverted into a trough containing mercury.
6. Read the height of mercury in glass tube and record it.

Questions to guide interpretation of results

1) Why is mercury used as a barometric liquid and not water?
2) What instrument to be used to measure atmospheric pressure?
3) Give a summarized report on your findings from a class discussion on how to measure atmospheric pressure?

Experiment 3.2: Demonstration of some applications of atmospheric pressure

Rationale

To know the common use of air pressure in daily life is inflating tires, playing musical wind instruments, drinking through straw, flushing toilet, drawing water from well, operating barometer, blowing up balloon, breathing, maintaining body shape especially abdomen

Objective

In this experiment, you will demonstrate some applications of atmospheric pressure.

Materials

- Drinking straw
- Syringe
- Glass
- Empty beakers
- Drinking water

Set up

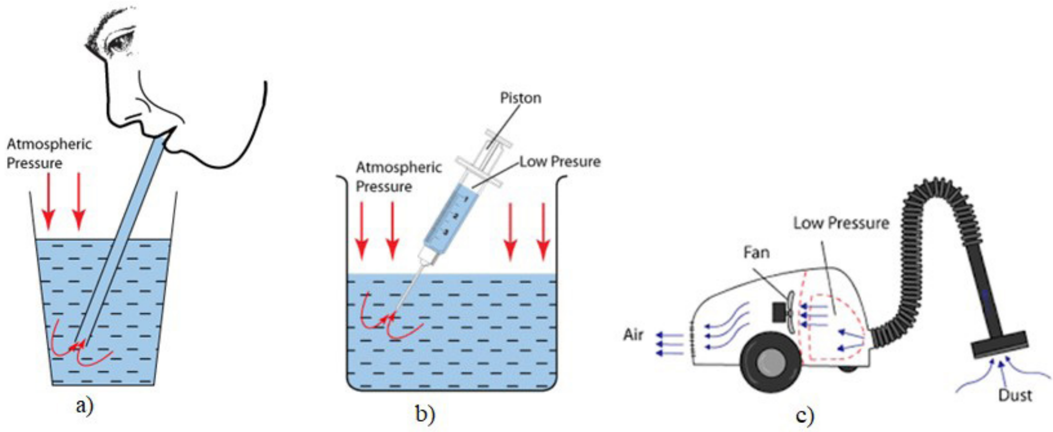


Fig. 3.2 *(a) The use of drinking straw, (b) The use of Syringe, (c) The use of Vacuum cleaner*

Procedures

1. Take a drinking straw provided to you and dip it in the glass with clean drinking water.
2. Sip the water using the straw with your mouth and note your observation.
3. Take two empty beakers and fill one with water.
4. Dip the nozzle syringe in the water. What do you observe? Explain your observation.
5. Pull up the piston. What do you observe? Explain your observation.
6. Switch on the vacuum cleaner
7. Suck out the air inside the cleaner.

Questions to guide interpretation of results

1) Discuss how a drinking straw, syringe and vacuum cleaner work.
2) Note down the main points from your discussion.

RENEWABLE AND NON-RENEWABLE ENERGY SOURCES

Experiment 4.1: Making a simple wind turbine.

Rationale

Wind turbines do not release emissions that can pollute the air or water (with rare exceptions), and they do not require water for cooling. Wind turbines may also reduce the amount of electricity generation from fossil fuels, which results in lower total air pollution and carbon dioxide emissions.

Objective

In this experiment you will make a simple wind turbine.

Materials:

- Manila paper
- A pair of scissors
- Pencil
- A nail
- Stapler or cellatope.

Set up

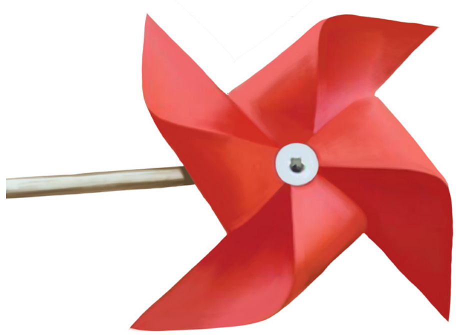


Fig 4.1. *A simple wind turbine*

Procedures

1. Cut a square piece from the Manila paper.
2. Use a ruler to draw diagonal lines from corner to corner. Make a small mark along each diagonal line about 2 cm from the center of the square piece.
3. Cut along the diagonal lines toward the centre until you reach the 2 cm mark.
4. Fold alternating corners onto the center and staple the layers together, but make sure to leave space between staples in the very centre.
5. When all four 'blades' are folded in, push a straight nail through all the layers at the centre. Remove the nail and push the pencil through the hole to act as the 'shaft'. The turbine is now complete (Fig 4.1). Make sure the turbine is free to rotate on the pencil
6. Hold the turbine in the direction of the wind. The wind currents blow the curved part of the blades, causing them to spin.

Questions to guide interpretation of results

1) On step 5, will the turbine you made blow in whichever direction?
2) Where does it apply in daily life?
3) Was the knowledge gained today helpful?
4) Do you understand the wind turbine's working principle? If yes, explain how.

Experiment 4.2: Demonstration of effects of solar energy using a convex lens.

Rationale

The convex lens focuses more amount of radiations on the solar cells, which results in the increased power production.

Objective

In this experiment, you will demonstrate the effects of solar energy using a convex lens.

Materials:

- Convex lens
- Thin piece of paper

Set up

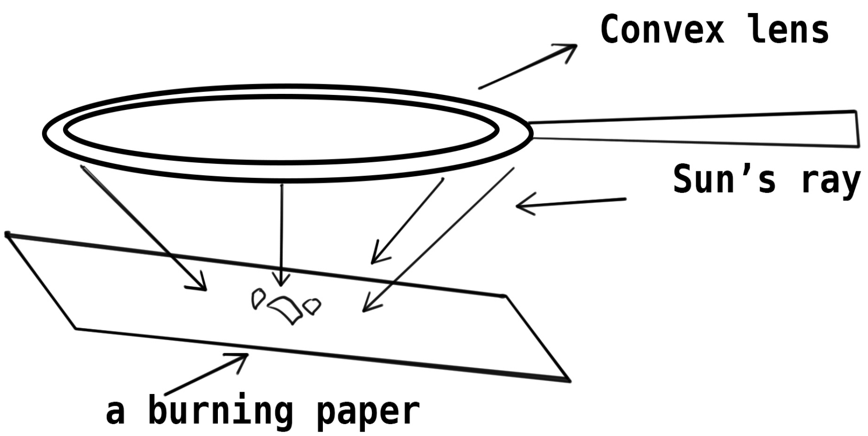


Fig. 4.2. *Solar energy's effect on a piece of paper.*

Procedures

1. Choose a clear bright day with a lot of sunshine.
2. Place a convex lens in the path of sunlight.
3. Place a thin piece of paper under the lens. Ensure that light is focused on the paper.
4. Wait for some minutes. What happens to the paper? Explain.

Questions to guide interpretation of results

1) What happens to the thin piece of paper?
2) Will the same results be obtained if you were to use a concave lens?
3) Where will it be applied or where have you seen this experiments' application in real life?

Experiment 4.3: Demonstration of the transformation of potential energy into kinetic energy.

Rationale

The electricity that fuels people's homes is supplied by potential energy turned kinetic, either in the form of an electric power plant fueled by coal, a hydroelectric dam, or other source such as solar cells.

Objective

In this experiment you will demonstrate the transformations from Potential energy to Kinetic energy and vice-versa.

Materials:

- Clamp and stand
- 1 m of thread
- Pendulum bob
- Weighing scale
- Calculator

Set up

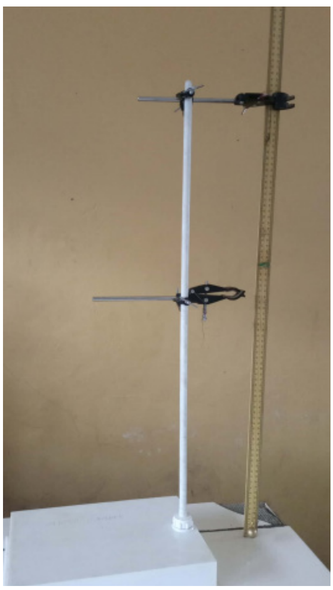


Fig. 4. 3. *A swinging pendulum*

Procedures

1. Measure and record the mass, m, of the pendulum bob.
2. Tie the bob with a string and suspend it on a clamp with the thread such that the bob is just about to touch the ground when hanging freely (Fig. 4.3).
3. Pick an arbitrary vertical height at which you will release their pendulum.
4. Measure and record this height, h. preferably it should be 40 cm from the floor.
5. Release the pendulum bob from this height.

Questions to guide interpretation of results

1) Calculate the potential energy of the bob at the height in procedure 4.
2) Observe and explain what happened on step 5.
3) Calculate the theoretical velocity, v, at the lowest point of the swing.
4) Calculate the kinetic energy at the lowest point of the swing.
5) Where will the pendulum have the greatest potential energy?
6. Where will it have the greatest kinetic energy?

Experiment 4.4: Making a simple motor.

Rationale

Electric motors are extremely important in modern-day life. They are used in vacuum cleaners, dishwashers, computer printers, fax machines, video cassette recorders, machine tools, printing presses, automobiles, subway systems, sewage treatment plants, and water pumping stations, to mention only a few applications.

Objective

In this experiment you will make a simple motor.

Materials

- Safety pins, nails (screws)
- Battery holder
- Wood block
- Disk magnet/Any available magnet
- Wire
- Scotch tape
- Sharp knife/razor blade

Set up

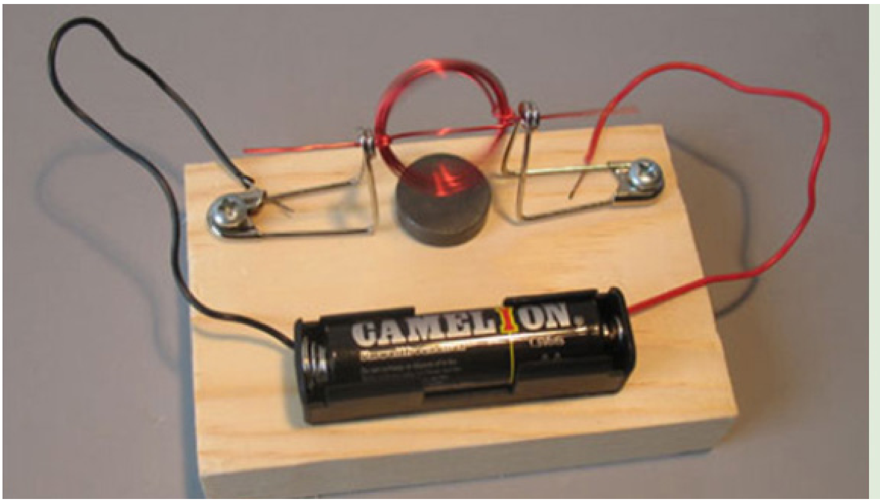


Fig. 4.4. *A simple motor*

Procedures

1. Wind a wire to form a coil (solenoid) on a pen, making 6 or 9 turns and leave some centimeters of wire free at each end.
2. Carefully, pull the coil off the pin (former) and make its shape permanently by wrapping it around the loop.
3. Hold the coil at the edge of a table so that the coil is straight up and down (not flat on the table) and one of the free wire ends lying on the table.
4. With a sharp knife, remove the top half of the insulation from the free wire end. Be careful to leave the bottom half of the wire with the enamel insulation intact. Do the same thing to the other free wire end.

5. Bend two safety pins from the middle.
6. Use nails (screws) to mount the bent safety pins on the wood block so that the loops face each other and are about 2 centimeters apart.
7. Attach the wires from the battery holder to the supports (bent safety pins).
8. Swing the safety pins apart a little and insert the coil into both rings.
9. Insert the battery into the holder. Place the magnet on top of the wood just underneath the coil. Make sure the coil can spin freely and it just misses the magnet.
10. Spin the coil (armature) gently.

Questions to guide interpretation of results

1) What do you observe? On step 10.
2) Discuss the energy transformation in the simple motor within your group and write it down.
3) How do we call that device which transforms mechanical energy into electrical energy?
4) State the concept applied in this experiment and in two sentences, explain its working principle.

Experiment 4.5: Demonstration of transformation of mechanical energy into electrical energy.

Rationale

A generator converts mechanical energy into electrical energy. A hydroelectric powerplant converts the mechanical energy of water in a storage dam into electrical energy. An internal combustion engine is a heat engine that obtains mechanical energy from chemical energy by burning fuel

Objective

In this experiment you will demonstrate energy transformation from mechanical to electrical energy.

Materials:

- Galvanometer
- Connecting wires
- Coil (solenoid)
- Bar magnet
- Insulated copper wire

Set up

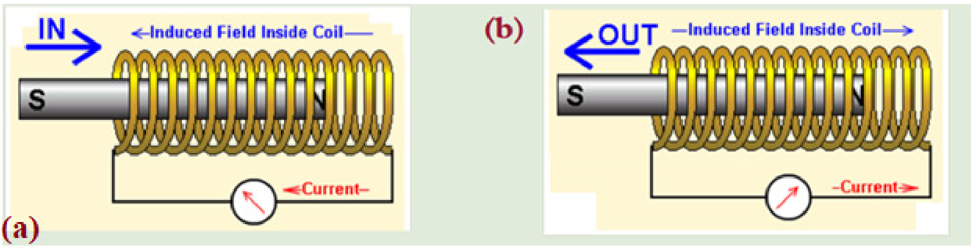


Fig. 4.5 *Mechanical energy being transformed into electrical energy.*

Procedures

1. Make a coil (solenoid) using an insulated copper wire.
2. Connect the ends of the solenoid using connecting wires to a sensitive galvanometer.
3. Quickly introduce (push) the bar magnet into the solenoid and stop (Fig. 4.5(a)).
4. Withdraw the magnet quickly from the coil and stop (Fig. 4.5(b)).
5. Move both the bar magnet and the coil at the same speed and in the same direction.

Questions to guide interpretation of results

1) Observe and explain what happens to the galvanometer while the magnet is moving through the coil.
2) Which types of energy where present? How are they related?

Experiment 5.1: Verification of thermal expansion of solid

Rationale

Railway lines require expansion gaps (similar to bridges) to avoid buckling in hot weather

Objective

In this experiment, you will investigate thermal expansion of given solid

Materials:

- Metallic ball connected to the metallic chain
- Metallic ring
- Retort stand set
- Source of heat
- Stop watch.
- Paper sheet or notebook
- Pencil and rubber

set up

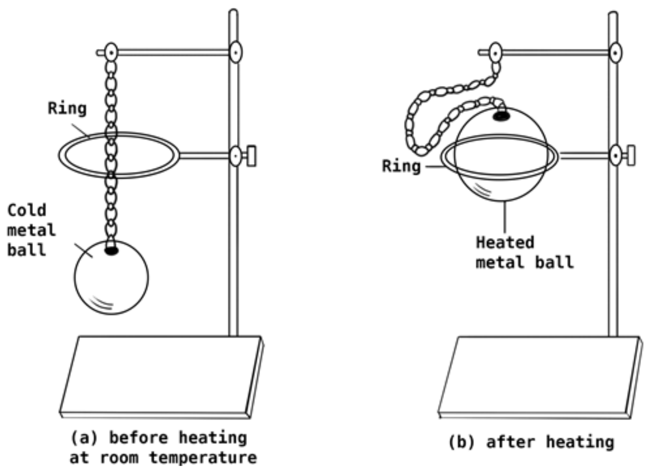


Fig. 5.1: *Verification of thermal expansion of solid*

Procedures:

1. Set up the experiment as in the above diagram (a)
2. Take a metallic ball and try to pass it through the ring. Record your observation.
3. Heat up the ball for 5 minutes and try to pass it through the ring as in figure (b). Record your observation.

Questions to guide interpretation of results

1) What did you observe when the ball is not heated and you try to pass it through the ring?
2) What did you observe after heating up the ball and you try to pass it through the ring?
3) Explain the cause of the observation noticed after heating up the ball and you try to pass it through the ring.

Experiment 5.2: Verification of thermal expansion of liquid.

Rationale

The behavior of gasoline pumped on a hot day provides an example of liquid thermal expansion in response to an increase in temperature. When it comes from its underground tank at the gas station, the gasoline is relatively cool, but it will warm when sitting in the tank of an already warm car.

Objective

In this experiment, you will investigate thermal expansion of given liquid

Materials:

- A glass flask
- Colored water
- Tripod stand
- A rubber stoppers
- Bunsen burner
- Stop watch
- Wire gauze
- Long glass tubing

Set up:

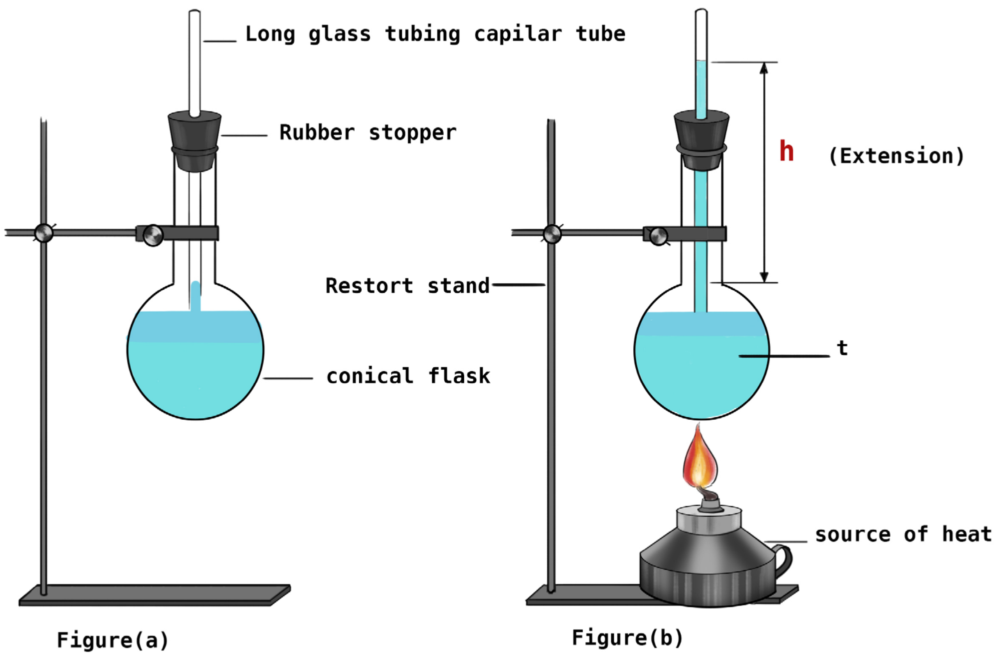


Fig 5.2: Verification of thermal expansion of liquid

Procedures:

1. Pour Colored water into conical flask
2. Place rubber stopper with glass tube.
3. Make sure that the column in the glass tube is small, as indicated.
4. Measure and record the level of water into glass tube.
5. Apply heat to the conical flask as in figure (b)
6. Measure and record the level of water after 10 minutes

Questions to guide interpretation of results

1. How much does water level changes in glass tube?
2. How do you explain your observation?

Experiment 5.3: Investigation of thermal expansion of given gas.

Rationale

Hot-air balloons are an obvious example of the practical use of the thermal expansion difference between a gas and a solid. Because the hot air inside the balloon bag increases in size faster than the container it stretches the bag so that it expands and displaces the colder (heavier) air outside the bag

Objective

In this experiment, you will investigate thermal expansion of given gas.

Materials

- Glass tube or capillary tube
- Rubber stopper with a hole
- Test tube
- Stop watch
- Test tube holder
- Source of heat such as candle.
- Colored water.

Set up:

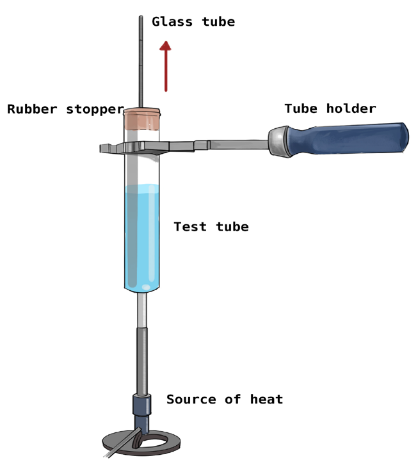


Fig. 5.3: Thermal expansion of given gas

Procedures:

1. Take an empty test tube and close its mouth with a single-holed rubber stopper.
2. Take a capillary tube in which a small amount of coloured water is trapped.
3. Insert it into the test tube through the single-holed rubber stopper.
4. Hold the test tube with a test tube holder, and heat it over a burner for 1 minute.
5. Observe the level of coloured water in the capillary tube. Record your observation.

Questions to guide interpretation of results

1) What happened when heating the test tube?
2) What is the cause of your observation?

Experiment 5.4: Demonstration of the causes of expansion and contraction.

Rationale

Railway tracks buckled on a hot summer day due to expansion if gaps are not left between sections. Bridges made of steel girders also expand during the day and contract during the night.

Objective

In this experiment, you will demonstrate causes of expansion and contraction.

Materials:

- 2 Beaker
- 1 Test tube
- 1 Balloon
- 1 stop watch
- 200cm^3 of hot Water
- 200cm^3 of cold Water

Set up:

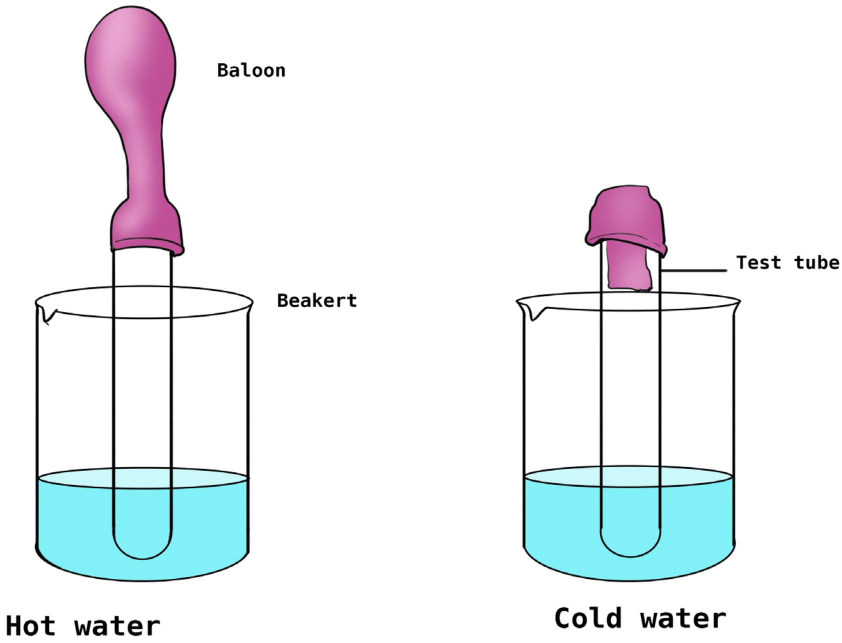


Fig. 5.4: *Expansion and contraction*

Procedures:

1. Take an empty test tube and attach a rubber balloon to its top as shown in above Fig.5.4.
2. Place the test tube on a source of heat.
3. After some 2 minutes, record your observation.
4. Take the test tube out of the hot source and put it in cold water.
5. Wait for 3 minutes, record your observation.

Questions to guide interpretation of results

1) What was initial state of the balloon before heating it?
2) What happened on the balloon after 2 minutes of heating? Explain why.
3) What was your observation after 3 minutes while test tube was in cold water? Explain the phenomenon behind your observation.

Experiment 5.5: Demonstration of heat transfer in solids

Rationale

If you leave a metal spoon propped up in a pot, it will become hot from the boiling water inside the pot. Chocolate candy in your hand will eventually melt as heat is conducted from your hand to the chocolate. When ironing a piece of clothing, the iron is hot and the heat is transferred to the clothing.

Objective

In this experiment, you will demonstrate heat transfer in solids .

Materials

- 1 wooden stirring spoon,
- 1 plastic cooking spoon,
- 1 regular metal spoon
- 1 source of heat
- 1 beaker (or pot)
- 3 laboratory thermometers
- 1 stop watch
- Stick plaster

Set up

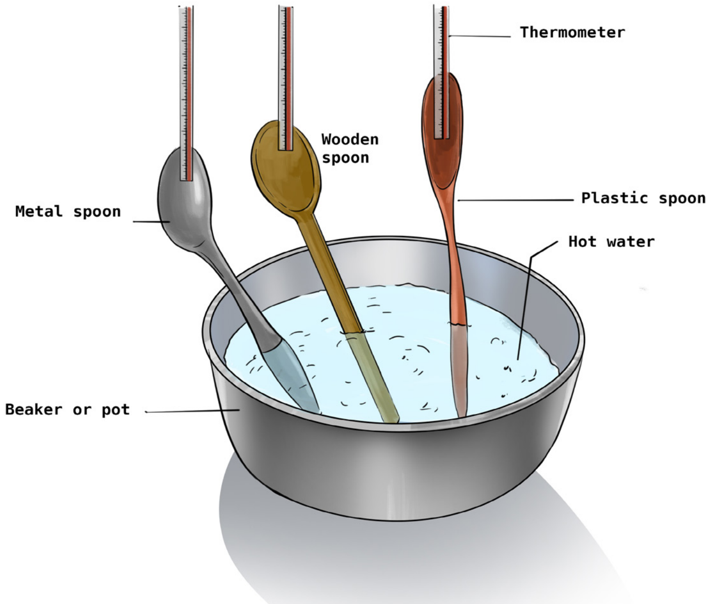


Fig. 5.5: *Heat transfer in solids*

Procedures:

1. Pour 200 cm^3 of water into beaker and Boil water by using a source of heat.
2. Wait for water to boil and switch off the source of heat.
3. Tape the thermometers to the handles of each spoon.
4. Place the spoons in the water
5. Record the temperature of each spoon and start counting the time.
6. Read and record temperature of each spoon after 10 minutes.

Questions to guide interpretation of results

1) What are initial and final temperature of Wooden, spoon and plastic spoons respectively?
2) Find the temperature raise in each spoon?
3) Explain the phenomenon behind the raise in temperature, if any, for each spoon.
4) Explain why the temperature change is not the same in all three spoons?

Experiment 5.6: Investigation of heat transfer by conduction

Rationale

As the pad heats up, it transfers heat to the part of your body that it is in contact with. The heat from a hot liquid makes the cup itself hot. If you grab a cup that has hot coffee, tea or broth in it, the cup itself will be hot and your hands will feel it.

Objective

In this experiment, you will investigate the heat transfer by conduction

Materials:

- 2 laboratory thermometers
- 1 retort stand set
- 1 beaker
- 1 test tube
- 1 test tube holder

Set up

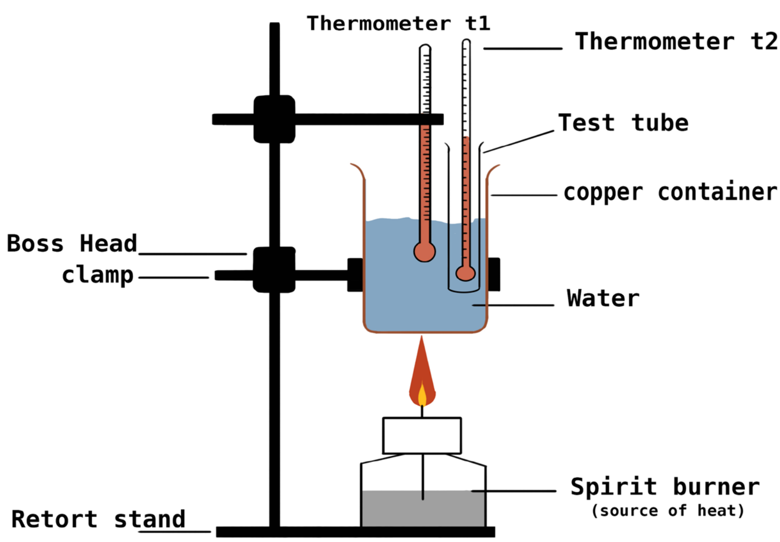


Fig. 5.6: *Heat transfer by conduction*

Procedures

1. Pour 200 cm^3 of cold tap water into a beaker.
2. Clamp the beaker and thermometer so that the bulb of thermometer is fully put in water.
3. Apply heat on 200 cm^3 of water on the source of heat.
4. When the reading of thermometer T1 is 60^0C, switch off the source of heat.
5. Put a test tube containing water with thermometer 2 into the beaker
6. Record the temperature θ_1 and θ_2 of both beaker and test tube respectively at time t = 0.
7. Start recording the temperature of beaker and test tube every 1 minute until they reach the same temperature θ.

Questions to guide interpretation of results

1) What are values of temperature θ_1 and θ_2
2) What is the value of temperature θ?
3) Explain the phenomenon behind the raise in temperature of test tube water. How to call this phenomenon?

Experiment 5.7: Investigation of heat transfer by convection

Rationale

The radiator is an everyday examples of convection. A radiator puts warm air out at the top and draws in cooler air at the bottom. Steaming cup of hot tea. The steam you see when drinking a cup of hot tea indicates that heat is being transferred into the air. Ice melts because heat moves to the ice from the air.

Objective

In this experiment, you will investigate the heat transfer by convection

Materials:

- Pyrex beaker, 600 ml containing water.
- Bunsen burner.
- Tripod
- Glass tube or a long straw
- Potassium manganate crystals

Set up

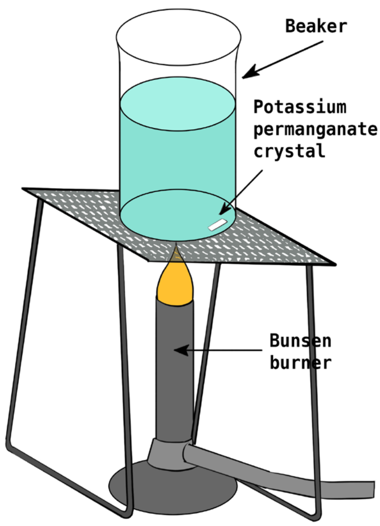


Fig. 5.7: *Heat transfer by convection*

Procedures

1. Fill the beaker with water.
2. Put a glass tube (such as drinking straw) into the beaker so that it rests on the base of the beaker.
3. Put individual crystals of potassium manganate VII on the bottom of the beaker through the tube.
4. Heat the water gently over the Bunsen burner and observe the motion of the coloured water.
5. Note the path that the coloured water takes from the heater to the top of the water and back down again.
6. When repeating the experiment, you should always start with a new batch of cold water.

Questions to guide interpretation of results

1) What did you see as the water started to warm up in the beaker that was heated? Draw a picture to show what you saw.
2) Rename and describe the phenomenon that occurred in this experiment?

Experiment 5.8: Investigation of heat transfer by radiation

Rationale

The heating of the Earth by the Sun is an example of transfer of energy by radiation. The heating of a room by an open-hearth fireplace is another example. The flames, coals, and hot bricks radiate heat directly to the objects in the room with little of this heat being absorbed by the intervening air.

Objective

In this experiment, you will investigate heat transfer by radiation

Materials:

- 2 metal cups
- 2 thermometers
- 1 source of heat
- 500ml of water
- 2 tripod stands or any stands.
- Black paint
- Pencil and rubber
- Paper sheet or notebook

Set up:

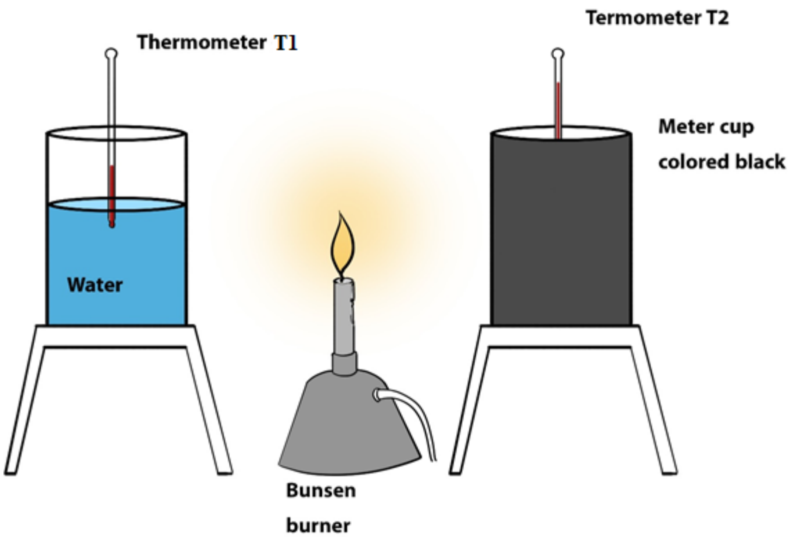


Fig. 5.8: *Heat transfer by radiation*

Procedures

1. Paint one cup with blank paint.
2. Pour 200 ml of water in each cup
3. Set up the experiment as in the above diagram.
4. Turn on Bunsen burner and record the temperatures θ_1 and θ_2 on thermometer T1 and T2 respectively.
5. Wait for 5 minutes, read and record the temperatures θ_1' and θ_2' on thermometer T1 and T2 respectively.

Questions to guide interpretation of results

1) What are the values of temperatures θ_1 and θ_2 ?
2) What are the values of the temperatures θ_1' and θ_2' ?
3) Estimate the temperature raise for each cup. Are they the same?
4) What is the cause of change in temperature for each cup?
5) Describe the process of heat transfer by radiation.

Experiment 5.9: Determination of the specific heat capacity of a solid by the electrical method.

Rationale

Substances having a small specific heat capacity, are very useful as material in cooking instruments such as frying pans, pots, kettles and so on, because, when small amount of heat is applied it will heat quickly.

Objective

In this experiment, you will determine the specific heat capacity of a solid by the electrical method

Materials:

- Electric circuit
- Heating element
- Metal cylinder
- Thermometer
- Variable resistor
- Cotton wool
- Aluminum foil
- Wooden container
- Solid metal blocks in the form of a cylinder, with 2 holes.

Set up:

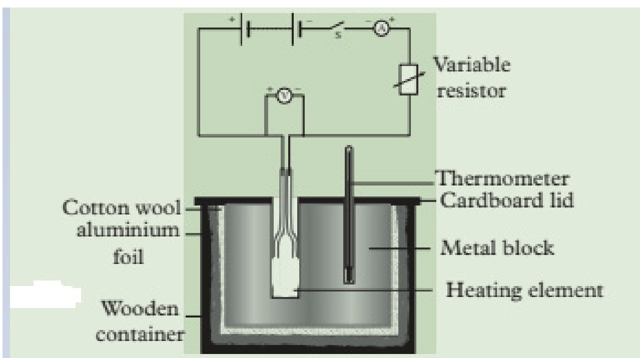


Fig. 5.9 *Determination of the specific heat capacity*

Procedures:

1. Measure and record the mass, m, of the metal cylinder.
2. Insert an electrical heater in position in the metal block through the larger hole and a thermometer through the other hole.
3. Note the initial temperature of the metal block θ_1
4. Cover the solid with cotton wool or felt material and wrap an aluminum foil around cotton wool.
5. Place the set up a wooden container. Complete the electrical circuit as shown in above diagram.
6. Close the switch S and start a stop watch at the same time.
7. Use the variable resistor to maintain a steady current passing through the heater.
8. Note the current I through the heater with the ammeter and the potential difference, V across the heater with the voltmeter.
9. Pass this steady current for some time so that the rise in temperature in the solid is about 8 °C.
10. Note the time t, when the final temperature of the solid is θ_2 .
11. Calculate the change in temperature $\theta = \theta_2 - \theta_1$.

Questions to guide interpretation of results

1) Explain the relationship between electrical energy used and the heat energy gained by the metal
2) How much electrical energy has been spent in this time? What has happened to this energy?
3) Calculate the specific heat capacity c of the metal cylinder from $Q = mc\theta$,where m is mass of metal cylinder and θ is temperature rise.
4) What is the unit of specific heat capacity c?
5) What is the purpose of cotton wool or felt material, aluminum foil and the wooden container?

Experiment 5.10: Determination the specific heat capacity of water by the method of mixtures

Rationale

Substances having a small specific heat capacity, are very useful as material in cooking instruments such as frying pans, pots, kettles and so on, because, when small amount of heat is applied it will heat quickly.

Objective

In this experiment, you will determine the specific heat capacity of water by the method of mixtures

Materials:

- A solid of known specific heat capacity (cs)
- Weighing balance
- Water bath
- Thermometer
- Beaker
- Stirrer
- Heating source
- Tripod stand

Set up:

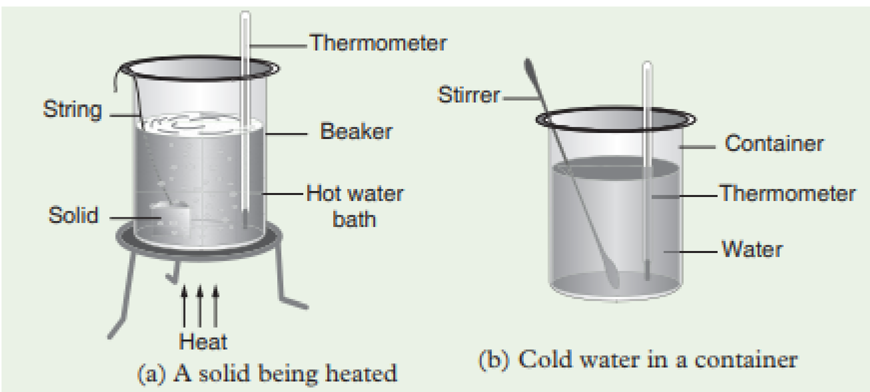


Fig. 5.10: *Specific heat capacity of water by the method of mixtures*

Procedures

1. Take a solid of known specific heat capacity (c_s) and measure its mass (m_s).
2. Heat it in a water bath till the water starts boiling, as shown in Figure (a).
3. In the meantime, take an empty, clean and dry container of known specific heat capacity (c_c) and measure its mass (m_c).
4. Put water into the container, say to half of the container, and measure the total mass.
5. Calculate the mass of water (m_w) whose specific heat capacity (c_w) is to be determined.
6. Find the initial temperature (θ_1) of water and the container (Figure (b)).
7. When water in the water bath has started boiling, note the temperature of the solid (θ_s) in the water bath.
8. Quickly transfer the hot solid into cold water in the container and observe the temperature of the mixture.
9. Stir the contents gently to distribute the heat uniformly throughout the mixture and note the final maximum steady temperature of the mixture θ_2.

Questions to guide interpretation of results

1) What happens to the cold water and the container when the hot solid is transferred into the container?
2) Find the heat Qs lost by the hot solid using the equation,

$$Q_s = m_s c_s(\theta_s - \theta_2)$$

3) Calculate the specific heat capacity of water using the equation

$$Qs = m_w c_w(\theta_2 - \theta_1)$$

4) What precautions have to be taken to ensure accuracy in the experimental procedure?

Experiment 5.11: Determination of the specific heat capacity of a liquid by electrical method.

Rationale

Substances having a small specific heat capacity, are very useful as material in cooking instruments such as frying pans, pots, kettles and so on, because, when small amount of heat is applied it will heat quickly.

Objective

In this experiment, you will determine the specific heat capacity of a water by electrical method.

Materials

- Calorimeter
- Stirrer
- Thermometer
- Heater
- A liquid
- Electrical circuit
- Variable resistor

Set up:

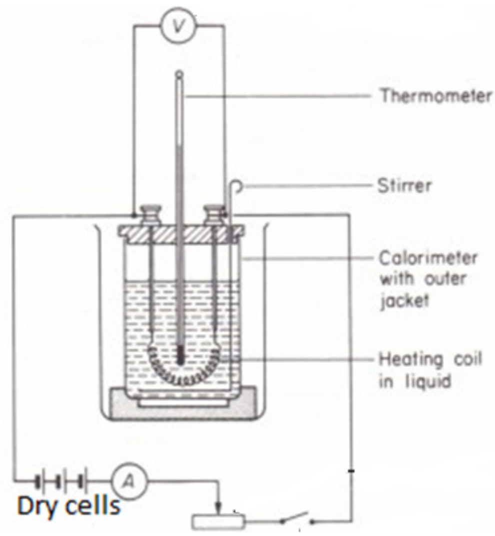


Fig. 5.11 *Specific heat capacity of a liquid by electrical method*

Procedures

1. Measure and record the mass, m_c, of an empty, clean and dry copper container with the stirrer of the same specific heat capacity, c_c.
2. Gently pour the liquid of known mass, ml , into the container. Let the specific heat capacity of the liquid be c_l
3. Note the initial temperature of the liquid and the container, θ_1.
4. Complete the electrical circuit as shown in Fig 5.12 with the heater fully immersed in the liquid without touching the base or the sides of the container.
5. Close the switch S and start a stop watch at the same time.
6. Use the rheostat to maintain a steady current passing through the heater.
7. Note the current I through the heater with the ammeter and a potential difference V across it with the voltmeter.
8. Pass this steady current for some time so that the rise in temperature of the liquid and the container is about 2°C.
9. Keep stirring the liquid gently throughout the experiment.
10. Note the time, t, taken when the final temperature of the liquid and the container is θ_2.

Questions to guide interpretation of results

1) Calculate the change in temperature $\Delta\theta = (\theta_2 - \theta_1)$.
2) How much electrical energy has been spent in this time, t?
3) Using all the data you have collected, calculate the specific heat capacity of the liquid. (Hint: Electrical energy supplied = heat energy gained by liquid)

Experiment 5.12: Determination of the specific latent heat of fusion of ice

Rationale

The latent heat of fusion is the heat required for an object to go from the solid state to the liquid state, or vice versa. Since its value is generally much higher than specific heat, it allows you to keep a beverage cold for much longer by adding ice than simply having a cold liquid to begin with

Objective

In this experiment, you will determine the specific latent heat of fusion of ice by method of mixture.

Materials

- Container with known specific heat capacity (copper calorimeter or aluminum Calorimeter).
- Warm water
- Ice
- Thermometer
- Balance
- Stirrer
- Beaker
- String

Set up:

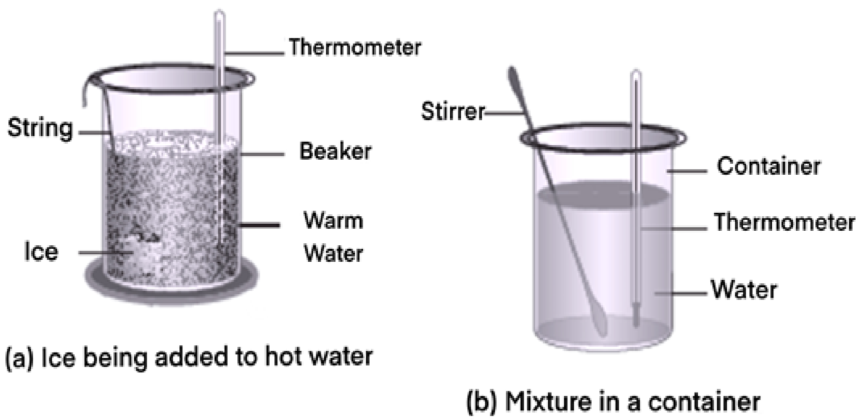


Fig. 5.12. *Determination of Specific latent heat of water by method of mixtures.*

Procedures:

1. Take an empty, clean and dry container of known specific heat capacity (c_c) and measure its mass (m_c).
2. Add some warm water at a temperature a few degrees above room temperature to the container and note its temperature (θ_1).
3. Measure the mass of the container with warm water and calculate the mass of water (m_w).
4. Dry small pieces of ice with a blotting paper and gently immerse them into the warm water, without splashing out any water.
5. Keep adding the small pieces of dried ice till the temperature of the mixture is a few degrees below room temperature.
6. Note the temperature of the mixture (θ_2).
7. Find the mass of the mixture.
8. Calculate the mass of ice (m_{ice}) which has been added.

Questions to guide interpretation of results

1. What happened when you drop ice into warm water?
2. Using the data you have collected, determine the latent heat of fusion of ice.

(**Hint:** Heat gained by ice to melt = heat lost by warm liquid water)

Experiment 5.13: Determination of the specific latent heat of Vaporization of water by electric method.

Rationale

The energy required to completely separate the molecules, moving from liquid to gas, is much greater that if you were just to reduce their separation, solid to liquid. Hence the reason why the latent heat of vaporization is greater that the latent heat of fusion.

Objective

In this experiment you will, determine latent heat of vaporization by electrical method.

Materials

- Beaker
- Heater electrical circuit
- Cold water
- Insulated container
- Tube T
- Thermometer
- Stopwatch
- Stopper

Set up:

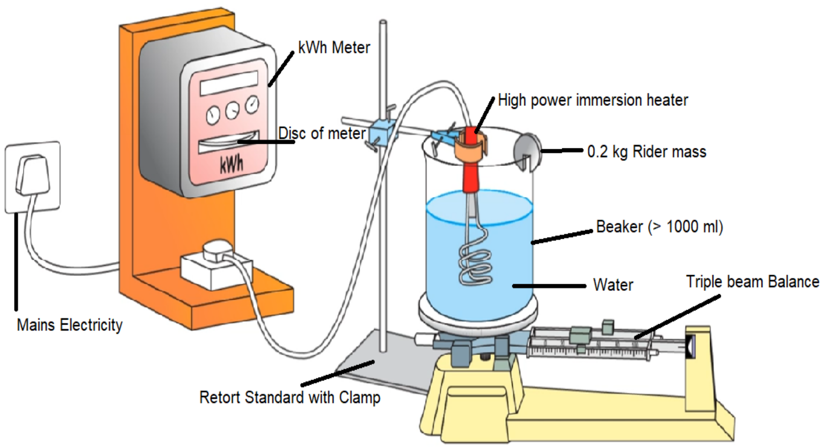


Fig. 5.13 Determination of Specific latent heat Capacity of Vaporization of water by electrical method.

Procedures:

1. Half fill the beaker with cold water
2. Place the beaker on the triple-beam balance
3. Clamp the immersion heater so that it is fully immersed inside the water
4. Connect the immersion heater to the Kilowatt-hour meter

5. Connect the meter to the mains electricity
6. Adjust the balance so that the beaker side is slightly heavier
7. Now, power on the heater.
8. Now stop the heater for a whole.
9. Put the 0.2kg rider mass onto the wall of the beaker. This will cause the beaker side heavier.
10. Now, power on the heater again and start counting the number of turns made by the disc inside the meter.
11. Start counting the number of turns made by the disc inside the meter.
12. Turn off the heater and record the number of the turns N made by the disc.

Questions to guide interpretation of results

1) The water would be heated up gradually. When boiling point starts, water will vaporize and the total mass of the beaker will fall. After some water boils away, the balance will restore equilibrium.
2) The mass of water boiled away is m = 0.2 kg. The energy used to vaporize this mass of water is Q = N x 24000. The latent heat of vaporization of water is then calculated according to:

$$L_V = \frac{Q}{m}$$

Experiment 5.14: Demonstration of working principle of bimetallic strip.

Rationale

Thermostats is one of the best examples of bimetallic strip in real life. The bimetallic strips are used as switches in thermostats.

Objective

In this experiment you will demonstrate the working principle of bimetallic strips

Materials

- Bunsen burner
- Bimetallic strips
- Stop watch

Set up

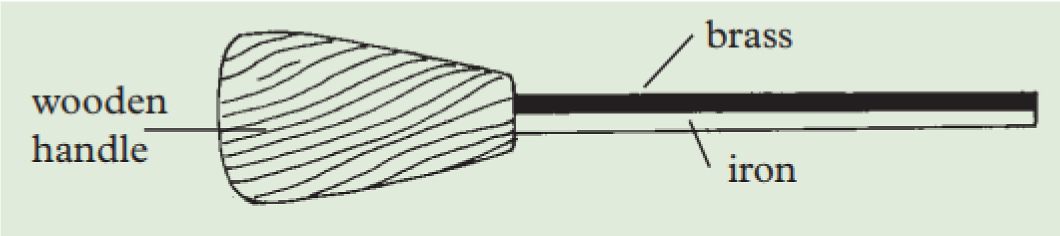


Fig 5.14: *Bimetallic strip*

Procedures

1. Observe a bimetallic strip at a room temperature
2. Take the bimetallic strip with the brass strip at the top and heat it with a bunsen burner flame for some time. Note your observation.
3. Remove the flame and allow the bar to cool to a room temperature. Note down your observation

Questions to guide interpretation of results

1) What happened when heating the bimetallic strip?
2) Explain what happened when cooling the bimetallic strip

UNIT 6 LAWS OF THERMODYNAMICS

Experiment 6.1: Demonstration of the first law of thermodynamic

Rationale

Thermodynamics is used in everyday life all around us. One small example of thermodynamics in daily life is cooling down hot tea with ice cubes. At first, hot tea has a lot of entropy. This is due to the temperature and the molecules rapidly and disorderly bouncing off one another.

Objective

In this experiment, you will demonstrate the first law of thermodynamics

Materials:

- Two balloons
- Water
- Conical flask
- Laboratory Bunsen Burner
- Tripod stand with gauze

Set up

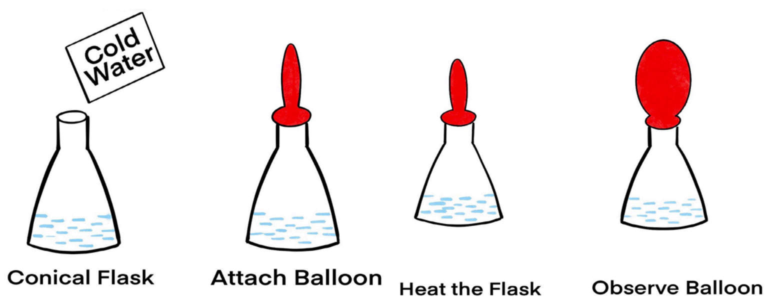


Fig. 6.1. Investigation of first law of thermodynamics.

Procedures

1. Add a half cup of cold water in the conical flask
2. Attach balloon over the mouth of the conical flask
3. Place the conical flask on the lab burner and start heating it
4. Now observe the balloon. You will notice that the balloon will inflate in some time.
5. Remove the flask from the heat and allow it to cool down.

Questions to guide interpretation of results

1) Describe energy transformation taking place in the set up during heating.
2) State the law that govern the heat energy exchange in this experiment.

Experiment 6.2: Demonstration of the Second law of thermodynamics

Rationale

Sweating in a crowded room: In a crowded room, everybody (every person) starts sweating. The body starts cooling down by transferring the body heat to the sweat. Sweat evaporates adding heat to the room. Again, this happens due to the first and second law of thermodynamics in action.

Objective

In this experiment you will demonstrate the Second law of thermodynamics.

Materials

- Beaker
- Bunsen burner
- Ice
- Thermometer

- Table

Set up

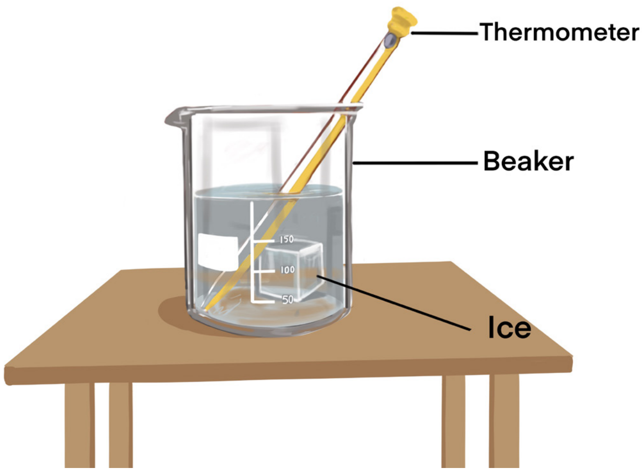


Fig. 6.2: Demonstration of Second law of thermodynamics

Procedures

1. Warm a half beaker of water up to 75^{0}C
2. Remove the beaker from the heat and place it on the table. (Note: use a support to move the beaker, hot beaker can hurt you)
3. Place the thermometer in warm water and wait until the thermometer reading shows 70^{0}C
4. Place the peace of Ice into the warm water in the beaker

Questions to guide interpretation of results

1) From your observation, explain what happened to the temperature of water as the ice eventually melts.
2) Discuss with your comrades whether the two process that took place in step (4) would be reversed in the same time if after taking place, the beaker is heated again.

Experiment 6.3: Demonstration of heat exchange using cold and hot water

Rationale

Waste heat in the exhaust of an electricity-generating gas turbine can be transferred via a heat exchanger to boil water to drive a steam turbine to generate more electricity (This is the basis for combined cycle gas turbine technology)

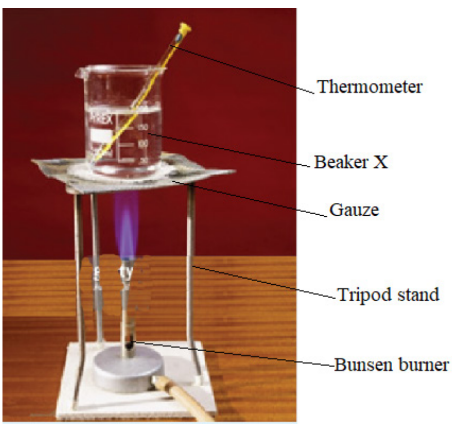
Objective

In this experiment you will demonstrate heat exchange phenomena using cold and hot water.

Materials

- Water
- Tripod stand
- Stirrer
- Beakers
- Bunsen burner
- Thermometers
- Wire gauze

Set up



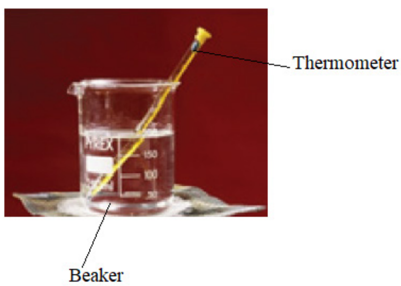


Fig 6.3: Demonstration heat exchange using cold and hot water

Procedures

1. Pour equal amounts of water into beaker X and Y
2. Measure and record the temperature of water in beaker Y
3. Set the tripod stand, wire gauze and Bunsen burner as shown in figure above
4. Place the beaker X on the burner and light the Bunsen burner for three minutes
5. Read and recorder the temperature in beaker X
6. Mix the water in X and Y and stir well
7. Measure and record the final temperature of the mixture

Questions to guide interpretation of results

1) Compare the final temperature of the mixture and the initial temperature of water in beaker Y.
2) How was the initial temperature of water in beaker Y changed?
3) During the mixing up of water in X and Y, in what direction did the heat move?
4) Summarize the direction of heat transfer between cold and hot regions

Experiment 6.4: Determination of the quantity of heat using the method of mixture

Rationale

Water is used as coolant car radiators for its high specific heat capacity, due to which it can absorb a large amount of heat energy from the engine of the car, without its temperature rising too high.

Objective

In this experiment you will determine the quantity of heat using the method of mixture

Materials

- Calorimeter
- Thermometer
- Stiller
- Water
- Steam heater
- Wooden box
- Balance
- Small piece of copper

Set up

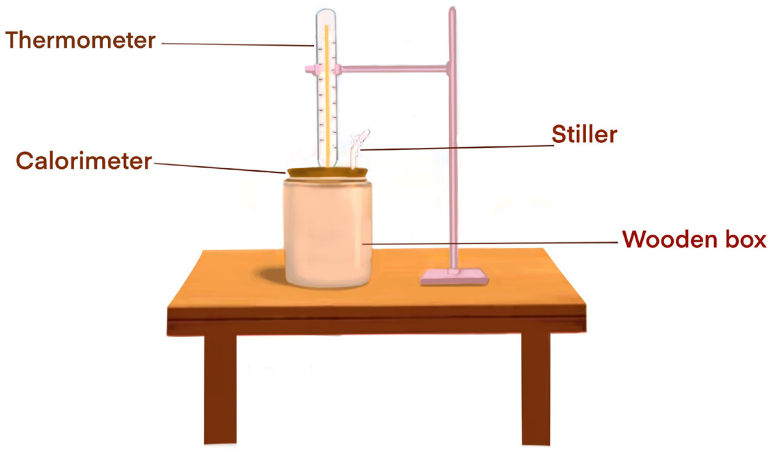


Fig. 6.4. Determine the quantity of heat using the method of mixture

Procedures

1. Measure and record the mass of calorimeter M_1
2. Pour some water into calorimeter (above the half of calorimeter)
3. Measure and record the new mass of calorimeter M_2
4. Put the calorimeter into the wooden box
5. Measure and record the temperature of calorimeter T_1
6. Measure and record the mass of copper M_3
7. Heat the copper piece in steam heater
8. Measure and record the heated copper T_2
9. Quickly transfer the heated copper into calorimeter and still the system
10. Measure and record the final temperature T

Questions to guide interpretation of results

1) What did you notice?
2) Use the relation here to calculate the specific heat capacity of copper

$$M_3S(T_2 - T) = M_1S_C(T - T_1) + (M_2 - M_1)S_W(T - T_1)$$

S_W = *Specific heat capacity of water*

S = *Specific heat capacity of copper*

S_c = *Specific heat capacity of calorimeter*

Experiment 6.5: Verification of the heating curve of ice

Rationale

A cooling curve is a type of graph used in chemistry, physics, engineering, and other disciplines to chart the progress of a cooling substance

Objective

In this experiment you will verify the heating curve of ice

Materials

- Ice (in pieces)
- Bunsen burner
- Tripod stand
- Thermometer
- Stirrer
- Wire gauze
- Beakers

Set up

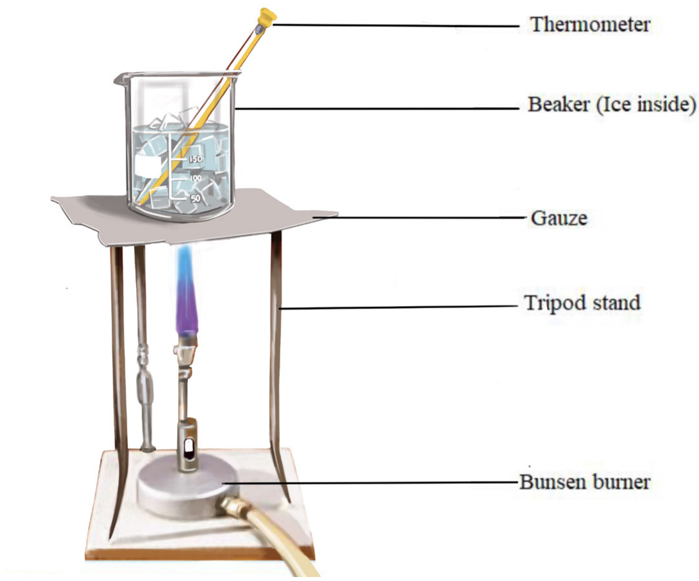


Fig. 6.5. The heating curve of ice

Procedures

1. Take pure crushed ice at about -10 °C and put it in a beaker placed on wire gauze on a tripod stand as shown in Figure above
2. Note the initial temperature of the ice.
3. Light a Bunsen burner and adjust the blue flame to a small low temperature.
4. Note the temperature of ice at 20 seconds interval until the temperature of the container is about 10 °C.
5. Record your results as shown in Table

Time/seconds	**0**	**20**	**40**	**60**	**80**	**100**	**120**	**140**	**160**
Temperature/ ⁰C									

Questions to guide interpretation of results

1) What happened to the amount of ice as heating continues?
2) Plot a graph of temperature against time
3) Explain the shape of the graph.

Experiment 7.2: Induction of an electromotive force in a straight conductor (wire).

Rationale

Two important devices depend on electromagnetic induction: electric generator and electric transformer both depends on electromagnetic induction.

Objective

In this experiment, you will induce an electromotive force in a straight conductor

Materials

- U-Shaped magnet
- Copper wire (straight conductor)
- Galvanometer

Set up

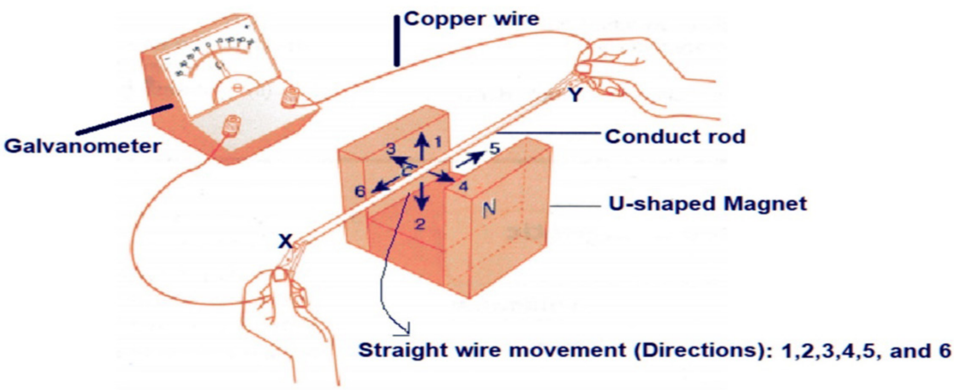


Fig. 7.2 A conductor in between the poles of a U-shaped magnet.

Procedures

1. Connect a copper wire XY to a galvanometer as shown in Fig. 7.2 above.
2. Place a conductor in between the poles of a magnet as shown in Fig. 7.2 and observe the galvanometer reading when the wire is stationary.
3. Move quickly the conductor vertically (1 and 2), horizontally (3 and 4) and move it in its horizontal position (5 and 6). Observe and explain what happens to the galvanometer pointer.
4. Re-introduce the wire in between the poles of the magnet and stop. Explain what happens to the galvanometer pointer.
5. Repeat the experiment, keeping the wire stationary and moving the magnet. Explain what happens to the galvanometer pointer.
6. Repeat the experiment by first moving the wire vertically up and down and then repeat by moving the magnet. Explain what happens to the galvanometer pointer.

Questions to guide interpretation of results

1) Does the galvanometer detect electric current? Explain.
2) When is the current produced in the copper rod?
3) What happens to the galvanometer when the copper rod stops to move?

Experiment 7.3: Demonstration of the induced current produced when there is a relative motion between the magnet and the Solenoid

Rationale

The microphone is a device that converts sound waves into electrical signals. Microphones use the generator effect to induce a changing current from the pressure variations of sound waves.

Objective

In this experiment, you will demonstrate how induced current would be produced when there is a relative motion between the magnet and the solenoid.

Materials

- Permanent bar magnet
- Solenoid of 600 turns
- Galvanometer
- Connecting wires

Set up:

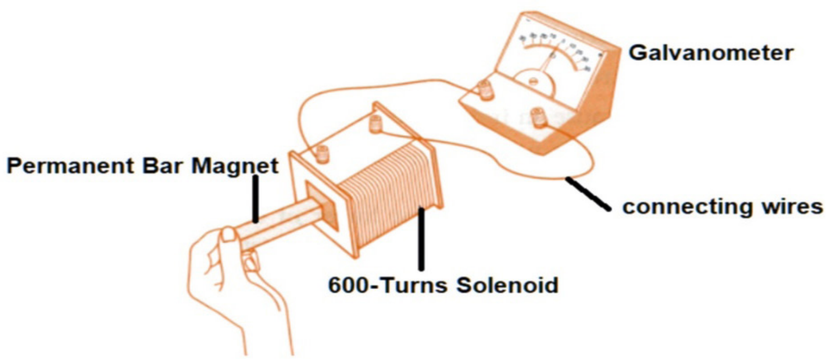


Fig. 7.3 Induced current by the moving permanent magnet through solenoid.

Procedures

1. Set up the apparatus as shown in Fig 7.3.
2. While solenoid is kept stationary push the bar magnet into the solenoid and observe the reading of the galvanometer.
3. While solenoid is kept stationary held the bar magnet in the solenoid and observe the reading of the galvanometer.
4. Pull the bar magnet out of the solenoid and observe the reading of the galvanometer.
5. Now, while the bar magnet is held stationary push the solenoid towards the bar magnet and observe the reading of the galvanometer.

6. Then pull the solenoid away from the bar magnet and observe the reading of the galvanometer
7. Complete the below table

Bar Magnet	Solenoid	Galvanometer reading
Pushed into the solenoid	Stationary	
Stationary	Stationary	
Pulled out of the solenoid	Stationary	
Stationary	Pushed towards bar magnet	
Stationary	Pushed away from bar magnet	

Questions to guide interpretation of results

1) When does the galvanometer shows a positive reading? Explain the direction of induced current.
2) When does the galvanometer shows a positive reading? Explain the direction of induced current.
3) When is a current induced in a solenoid?

Experiment 7.4: Verification of factors affecting the magnitude of the induced emf

Rationale

Hard drives utilize magnetic induction to read/write information. Other applications of magnetic induction can be found in graphics tablets, electric and hybrid vehicles.

Objective

In this experiment, you will demonstrate the factors that affect the magnitude of the induced emf

Materials

- Permanent bar magnet
- Solenoid of 600 turns
- Galvanometer
- Connecting wires

Set up

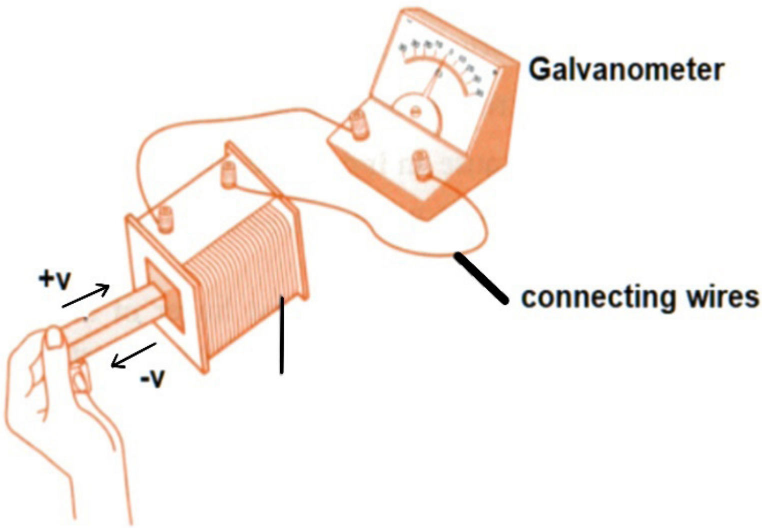


Fig. 7.4 Induced EMF through solenoid.

Procedures

1. Set up the apparatus as shown in Fig 7.4.
2. Push a bar magnet slowly into the solenoid of 600 turns. Record the maximum reading of the galvanometer.
3. Push a bar magnet quickly into the solenoid of 600 turns. Record the maximum reading of the galvanometer.
4. Push a bar magnet slowly into the solenoid of 1200 turns. Record the maximum reading of the galvanometer.
5. Tie two bar magnets together using rubber bands with like poles side by side.

6. Push slowly the two magnets into the solenoid of 600 turns. Record the maximum reading of the galvanometer.

Number of bar magnets	Speed of magnet	Number of turns of solenoid	Maximum reading of galvanometer
1	Slow	600	
1	Fast	600	
1	Slow	1200	
2	Slow	600	

Questions to guide interpretation of results

1) What does the reading of the galvanometer represent?
2) By comparing the observations in steps 2 and 3, what happens to the magnitude of the induced current when the speed of the magnet is increased?
3) By comparing the observations in steps 2 and 4, what happens to the magnitude of the induced current when the number of turns of the solenoid is increased?
4) Two bar magnets with like poles side by side produce a stronger magnetic field. By comparing the observations of steps 2 and 6, what happens to the magnitude of the induced current when the strength of the magnetic field is increased?

UNIT 8

ELECTRICAL POWER TRANSMISSION

Experiment 8.1: Verification of working principle of transformers

Rationale

In electricity distribution networks, there is always a need to increase or decrease voltage. This means that there must be appliances to either increase or decrease voltages. A device that can do this is called a transformer.

Objective

In this experiment, you will verify the working principle of transformers.

Materials

- Transformer core
- 2 copper wires
- 4 dry cells and cell holders
- 1 switch
- 2 voltmeters
- 1 bulb and bulb holder
- Pencil and rubber

Set up:

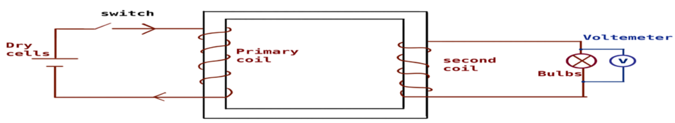


Fig 8.1 Working of transformer

Procedures:

1. Set up the circuit as shown above.
2. Keep the voltage across the primary coil constant at V_1 = 24V and keep the number of coils in the primary coil constant at N_1=1000.

3. Set the number of coils on the secondary coil to be N_2=100.
4. Measure and record the output voltage of the secondary coil V_2.
5. Find the ratio $\frac{N_2}{N_1}$
6. Repeat the procedures 3 to 5 for N_2 = 200, 300, 400, 500, 600, 700, 800, 900, and 1000.
7. Record your data in a suitable table shown here below.

Number of coils in secondary coil, N_2	Ratio, $\frac{N_2}{N_1}$	Output voltage, V_2/v
100		
200		
300		
400		
500		
600		
700		
800		
900		
1000		

Questions to guide interpretation of results

1) Plot the graph of output voltage, V_2 against ratio $\frac{N_2}{N_1}$
2) Find the slope S of the graph.
3) From the slope of the graph, find the input (Primary voltage), V_1

Experiment 8.2: Investigation of the relationship between number of coils and the induced e.m.f

Rationale

In a production or induction of voltage in a transformer, the induced voltage depends on the number of coils in the primary and secondary. Therefore, in designing a transformer, one must remember that the induced voltage, depends on the number of coils either in primary or secondary.

Objective

In this experiment, you will investigate the relationship between number of coils and the induced e.m.f

Materials

- 1 Galvanometer
- Insulated copper wire
- 1 bar magnet
- Pencil and rubber
- Paper sheet or notebook

Set up:

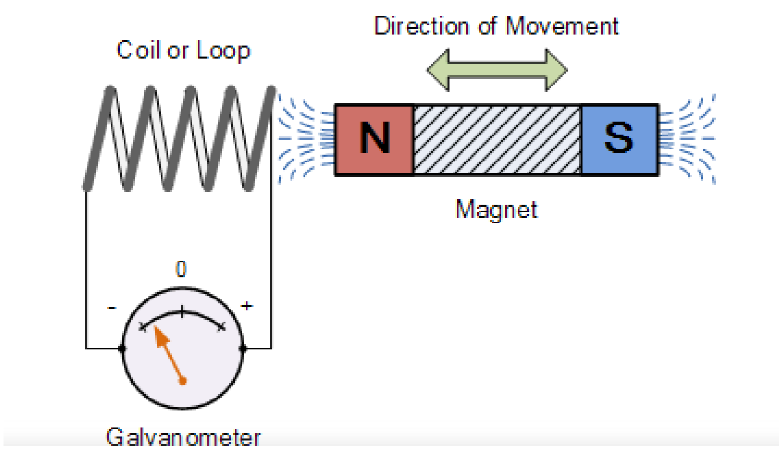


Fig. 8.2: Magnet moved through coil to induce e.m.f

Procedures

1. By using insulated copper wire, make a coil with number of turns N= 50 and a diameter of 3 cm.
2. Using connecting wires, connect a galvanometer to the coil with number of turns N =50 as in figure 8.2.
3. Move the magnet towards the coil and keep it at rest while it reaches inside the coil. Note your observation.
4. Move the magnet from the coil as quick as possible, and record your observation from galvanometer.
5. Again move the bar magnet forth and back through the coil and record your observation.
6. Repeat the procedures (1) to (5) for N= 100, and 200 turns

Questions to guide interpretation of results

1) What is the effect on galvanometer when the magnet is at rest inside the coil?
2) Explain what happened when the magnet moving through the coil.
3) From your observation, explain what happens when you increase the number of turns.
4) From this experiment, explain the relationship between number of coils and the induced e.m.f.

Experiment 9.1: Demonstration of the electrostatic law between two negatively charged polythene rods.

Rationale

When identical charges like negative and negative are put close to one another, they are seen repelling one another. This is the same case for 2 positive charges put near to one another. This signifies that there is always repulsive force between two identical charges.

Objective

In this experiment, you will demonstrate the electrostatic law between two negatively charged polythene rods.

Materials

- Two identical polythene rods A and B
- Silk cloth
- Clamp and a stand
- Thread

Set up

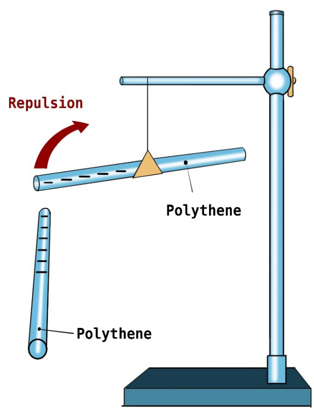


Fig. 9.1 Repulsion between two rods

Procedures

1. Charge two polythene rods negatively by rubbing them with a silk cloth.
2. Suspend rod A on a stand.
3. Bring charged rod B (touching it using a stirrup cloth) near the suspended polythene rod A.
4. While varying the distance of the rod A from B, note the magnitude of the force of repulsion.
5. Charge the two rods with the silk cloth more vigorously while maintaining the distances and repeat procedures 3 and 4. Note your observation.

Questions to guide interpretation of results

1) From your observation, comment on the relationship between the distance and the force.
2) What do you observe when the two rods rubbed vigorously?
3) State the effect of the amount of charge on the force of repulsion.

Experiment 9.2: Demonstration of the electric fields produced by charged bodies.

Rationale

There is always a force between two charges. This force is due to the lines of force that are produced by a charge. These lines are called electric field lines.

Objective

In this experiment, you will demonstrate the electric fields produced by charged bodies.

Materials:

- Glass dish
- Castor oil
- Electrodes
- Connecting wires

Set up

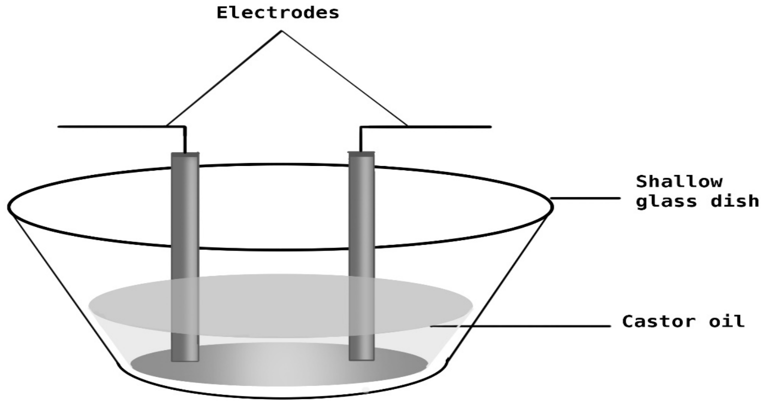


Fig. 9.2 Electric fields produced by charged bodies

Procedures

1. Assemble a pair of straight metal wires, called the electrodes, in a shallow glass dish so that their ends are just covered by a layer of an insulating liquid like castor oil or carbon tetrachloride.
2. Apply a very high potential difference, from a suitable power supply, to the two electrodes so that they have opposite charges.
3. Then sprinkle grass seeds or semolina powder on the surface of the liquid.
4. Observe what happens to the grass seeds or powder and draw the resulting pattern.
5. Repeat the activity with different charges on electrodes and observe the pattern formed.
6. Draw the various patterns and draw the various alignment of the grass seeds.

Questions to guide interpretation of results

1) Region around a charge q in which it exerts force on a test charge is called
2) Field lines always emerge from...........................
3) Direction of free test charge will be...........................

Experiment 9.3: Verification of the strength of an electric field varies with magnitude of charge and distance from the charge.

Rationale

The strength of field lines created by a charge depends on the magnitude of the of the charge and the distance of separation.

Specific Objective

In this experiment, you will show the strength of an electric field varies with quantity of charge and distance from the charge.

Materials

- a clamp and a stand
- plastic drinking straw 25 cm long
- small piece of plastic drinking straw 1 cm long
- a string

Set up

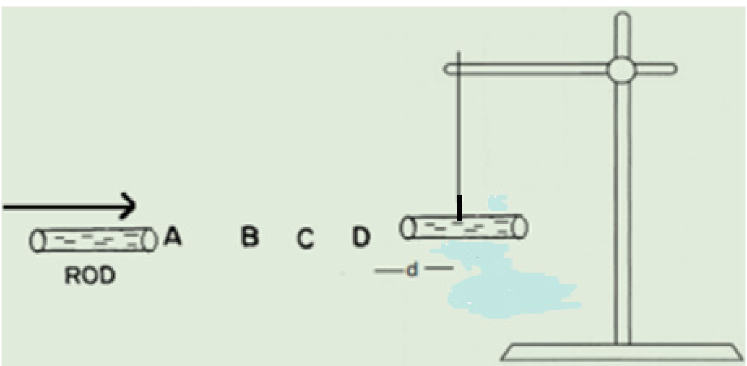


Fig 9.3. Verifying strength of electric field.

Procedures

1. Suspend a piece of plastic drinking straw with a string on a clamp in the figure above. Charge it by rubbing it with a dry cloth.
2. Charge a plastic drinking straw by rubbing it with a cloth.
3. Hold small piece of plastic drinking straw firmly with an insulating

material and bring the charged plastic drinking straw closer to the suspended piece of plastic drinking straw.

4. Measure the distance and observe what happens when you release the small piece of plastic drinking straw. Note your observation.
5. Repeat procedures 3 and 4 but this time bring the plastic drinking straw more closely to the small piece of plastic drinking straw.
6. Charge the plastic drinking straw more strongly and repeat procedures 3 and 4, trying as much as possible to maintain the same distance.

Questions to guide interpretation of results

1) Explain what happened a small piece of plastic straw released to move freely.
2) What happened when the distance of separation, that is between straw and a piece straw, is diminished?
3) What did you observe when the plastic straw is rubbed vigorously?
4) Based on your observations in this experiment, make a conclusion on how the strength of the electric field varies with the
   i) Quantity of charge.
   ii) Distance from the charge

UNIT 10 HOUSE ELECTRIC INSTALLATION

Experiment 10.1: Demonstration of simple house circuit installation

Rationale

Our houses, classes, or any other building use electricity as a source of energy and light. To allow the flow of electricity in in a domestic installation is a must. Therefore, it is good to know how electricity can be installed in buildings as a scientist.

Objective

In this experiment, you will perform installation of a 5 rooms building

Materials

- Connecting wires (Two colors)
- 5 bulbs
- Cardboards
- Switch
- 3 dry cells

Set up

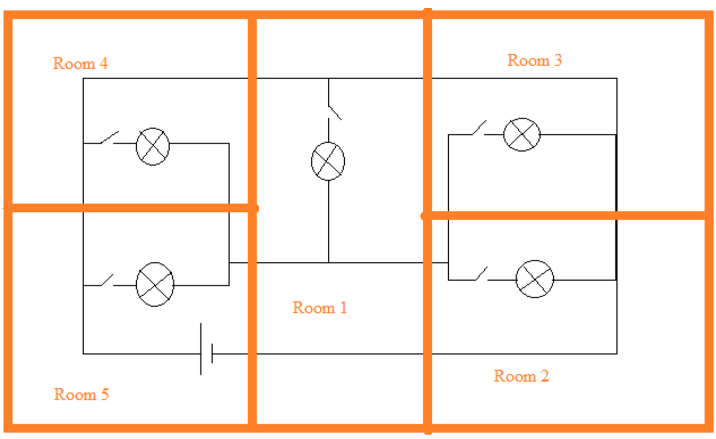


Fig 10.1 Installation of a house

Procedures

1. Assemble cardboards to construct walls so that it looks like a 5 rooms house.
2. Secure a place for bulb holder and switch in each room.
3. Connect your connecting wires to light bulb in each room (hint : use parallel connection)
4. Connect for circuit to 3 dry cells (dry cells are in series).

Questions to guide interpretation of results

1) What did you observe when you switched on the switch?
2) What happened when you remove one bulb?
3) Repeat the installation for series connection.
4) What happened when you remove one bulb in series connection?

UNIT 11 BASIC ALTERNATING CURRENT CIRCUITS

Experiment 11.1: Determination of Inductance of a coil (inductor)

Rationale

Inductors are typically used as energy storage devices in switched mode power devices to produce DC current. The inductor, which stores energy, supplies energy to the circuit to maintain the current flow during Off switch periods.

Objective

In this experiment you determine the inductance of the coil (inductor)

Materials

- Switch
- Power supply
- Bulb (or resistor)
- insulated copper wire
- 3 multimeters (or ammeter and 2 voltmeters)
- 9 pieces of connecting wire.

Set up

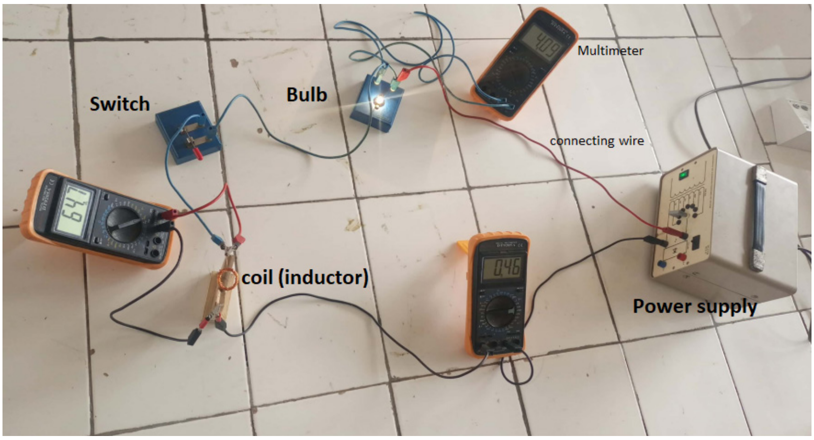


Fig 11.1 Inductance of a coil.

Procedures

1. Using an insulated copper wire, make a coil of 20 turns and diameter of 2.5cm.
2. Arrange the circuit as in the fig.11.1. by connecting coil (inductor), bulb (resistor), switch and ammeter in series to a 4.0V source of electricity.
3. Close the switch. Read and record the maximum current I of the circuit.
4. Now connect voltmeter across the inductor (coil). Read and record the voltage V_L
5. Again connect voltmeter across the resistor (bulb) Read and record the voltage V_R

Questions to guide interpretation of results

1) Estimate the inductive reactance X_L of the coil from $X_L = V_L / I$
2) Find the resistance R of the bulb $R = V_R / I$
3) Calculate the average impedance Z of the circuit from $Z = \sqrt{R^2 + X_L^2}$
4) Estimate the inductance L of the coil used in this experiment from $X_L = 2\pi f L$, where $f = 50Hz$ is the frequency of the source.

Experiment 11.2: Demonstration of an electric circuit consisting of Ac voltage and capacitor.

Rationale

The most common use for capacitors is energy storage. Additional uses include power conditioning, signal coupling or decoupling, electronic noise filtering, and remote sensing. Because of its varied applications, capacitors are used in a wide range of industries and have become a vital part of everyday life.

Objective

This experiment you will demonstrate how to design an electric circuit consisting of AC voltage and capacitor.

Materials:

- Capacitor
- Milliammeter
- Voltmeter
- Connecting wires
- A.C power supply

Set up

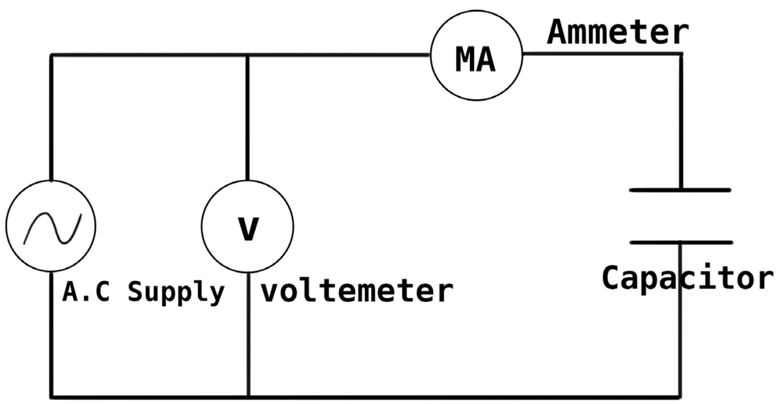


Fig. 11.2. Capacitor connected across A.C supply.

Procedures

1. Connect a capacitor using connecting wires in the circuit made in the above illustration.
2. Connect the low frequency generator to the main (make sure the generator is "off"). Switch on the generator.
3. Set the generator at a frequency where both the milliammeter and voltmeter show a reading.
4. Record the variation of current and voltage with time.

5. Repeat the experiment by increasing the frequency of a.c signal.
6. On the same axes, plot the graph of variation of current and voltage with time.

	Time (S)	Current (r.m.s)	Voltage (r.m.s)	$X = \frac{1}{2\pi fC}$	$X = \frac{V(r.m.s)}{I(r.m.s)}$
1					
2					
3					
4					
5					

Questions to guide interpretation of results

1) Find the capacitance in the circuit.
2) Find the capacitor reactance.

Experiment 12.1. Verification of the laws of refraction of light

Rationale/Purpose

Refraction is used in the working of telescopes, microscopes, peepholes of house doors, cameras, movie projectors, magnifying glasses.

Objective

In this experiment you will verify the law of refraction of light and measure the refractive index of a glass block.

Materials

- Rectangular glass slab
- white sheet of paper
- a drawing boards.
- four drawing pins
- cello tape
- Protractor, ruler and a pencil.

Set up

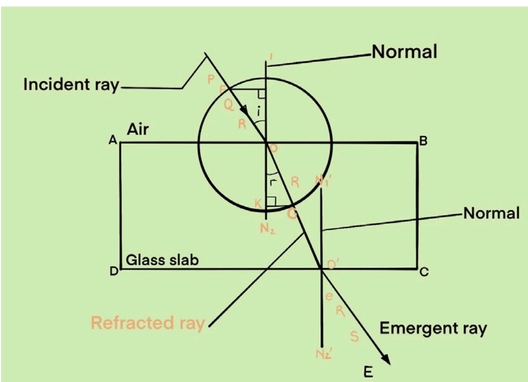


Fig 12.1. Verification of laws of refraction

Procedures

1. Place a white sheet of paper on a soft board.
2. Put a rectangular glass slab on this white sheet and trace out its boundary ABCD.
3. Remove the glass slab and draw a normal N_1N_2 at O.
4. Draw an incident ray IO inclined at an angle say 30^0 with the normal.
5. Fix two pins P and Q on the incident ray IO.
6. Place the glass slab within its boundary ABCD.
7. Looking from the other side of the glass slab, fix two other pins R and S such that P, Q, R and S appear to lie on the same straight line.
8. Remove the glass slab and the pins. Mark the pin points P, Q, R and S.
9. Join the pins R and S and produce the line on both sides.
10. Join OO'. It is the refracted ray.
11. With O as center, draw a circle of a convenient radius of 2.5 cm in such a way that it cuts the incident and the refracted rays at F and G respectively.
12. From F and G draw perpendicular to the normal N_1N_2.
13. Triangle FHO and triangle GKO are right-angled triangles.
14. Measure the length of FH and GK.
15. Repeat the experiment for different values of angle of incidence and find the value of $\frac{FH}{GK}$ for different values of i.
16. Record your results in suitable table including values of FH and GK

$i/^0$	FH/cm	GK/cm
30		
40		
50		
60		

Questions to guide interpretation of results

1) Plot a graph of FH against GK
2) Calculate the slope of the graph.
3) Deduce the refractive index of the glass block.
4) From this experiment state laws of refraction of light applied.

Experiment 12.2. Investigation the relationship between the angle of incidence and the angle of refraction

Rationale

Refraction has a lot of applications in optics and technology. Refraction of light helps us to see an object because there is a convex lens in our eyes. When we have seen an object, the light from the object, being refracted by the lens of the eye, forms an image on the retina. We can see the object when a real and inverted image of that object is formed on the retina.

Objective

In this experiment you will clearly explain the phenomenon of refraction of light by experimentally establishing the laws of refraction of light.

Materials

- Thick glass block
- Protractor
- Source of light

Set up

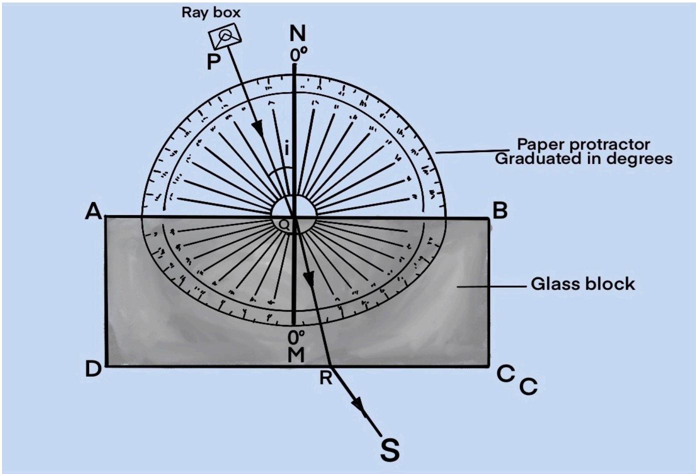


Fig. 12.2: Relationship between the angle of incidence and the angle of refraction

Procedures

1. Using drawing pins, fix a white paper on soft board
2. Place a glass slab on a white paper and draw its outline ABCD.
3. Place a thin circular "protractor" graduated in degrees such that the edge AB coincides with the 90°–90° mark of the protractor and a line along 0°–0° mark appears to be normal as shown in Fig. 12.2.
4. Remove a glass slab and draw a normal NQM at Q along 0°–0° mark.
5. Replace the glass slab on its outline.
6. Fix a pin P at angle *i*=20° and look through the glass slab on the other side and fix other two pins P_2 and P_3 such that they appear to be on the same straight line with the image of the first pin.
7. Remove glass slab and pins, then draw a line P_2P_3 to meet CD at point R.
8. Draw a refracted ray QR by joining points Q and R
9. Measure and record the angle of refraction, r.
10. Repeat procedures 6 to 9 for i=30°,40°,50°,60° and 70°
11. Record the results in a table below.

i /°	r /°	$\sin i$	$\sin r$
20			
30			
40			
50			
60			
70			

Questions to guide interpretation of results

1) Plot the graph of $\sin i$ against $\sin r$
2) Find the slope *n* of the graph.
3) Discuss the meaning of the slope in 2 above.

Experiment 12.3. Determination of refractive index of a glass block

Rationale

The refractive index tells the behavior of light in different materials. The index is used to determine the focusing power of material like lenses. It is also used to measure the number of particles that are dissolved in a solution. In many industries, a refractive index measurement is used to check the purity and concentration of liquid, semi-liquid and solid samples. Liquids and semi-liquid samples can be measured with high accuracy.

Objective

In the experiment you will determine the refractive index of the glass block.

Materials

- Rectangular glass
- Protractor
- 4 drawing pins
- 4 optical pins
- Ruler and plain A4 paper

Set up

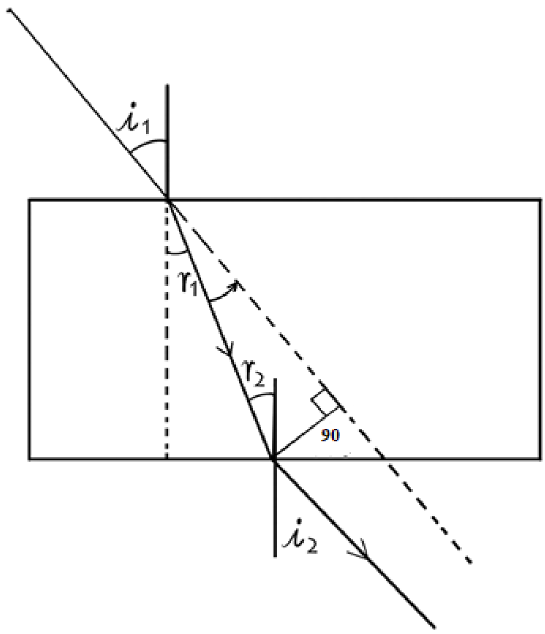


Fig 12.3. Refractive index of a glass block

Procedures

1. Place the glass block in the middle of the paper and use a pencil to draw its outline ABCD.
2. Remove the glass block and trace the normal at point of incidence O.
3. Trace an incidence ray with the angle of incidence i=50°
4. Fix two pins on the incident ray
5. Replace the glass block on its outline and look from other side to see the image of two pins.
6. Fix other two pins such that they appear on the straight line with the images of first pins.

7. Draw a line P3 P4 to meet CD at point M.
8. Trace a line OM and the angle *r* it makes from the normal.
9. Calculate the ratio $n = \frac{\sin i}{\sin r}$
10. Repeat procedures 3 to 9 for i=45°,40°, and 35°
11. Record your results in the table below

$i\,/^o$	$r\,/^o$	$n = \frac{\sin i}{\sin r}$

Questions to guide interpretation of results

1) Find the average value of refractive index of the used glass block
2) What could be happen if the incidence angle has been gradually increased?

Experiment 12.4. Investigation of the critical angle and total internal reflection

Rationale

There is a frequent application of total internal reflection of light in everyday life. The phenomenon of total internal reflection of light is used in many optical instruments like telescopes, microscopes, binoculars, spectroscopes, periscopes etc. The brilliance of a diamond is due to total internal reflection.

Objective

In this experiment you will investigate the critical angle and total internal reflection

Materials

- Semi-circular glass block
- Optical pin
- White paper
- a ruler and a pencil
- a protractor

Set up

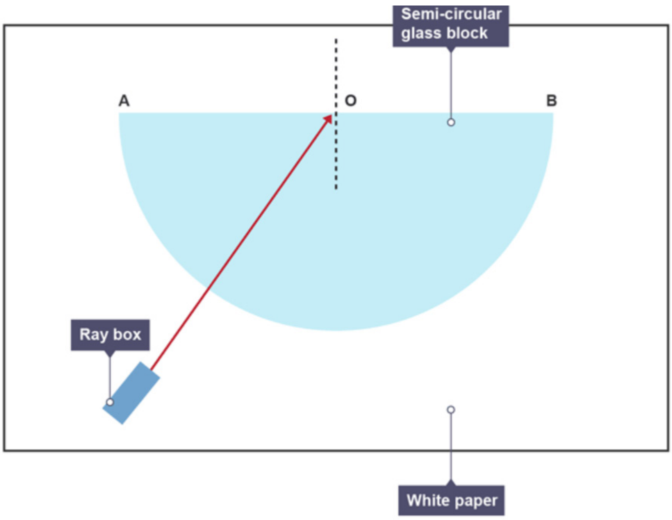


Figure 12.4. Position of Semi-circular glass block

Procedures

1. Draw around a semi-circular glass block on a sheet of white paper.
2. Remove the glass block. Locate the centre of the side AB and, using a protractor, draw a normal and label it O.
3. Replace the glass block carefully on its outline.
4. Fix pin P_1 along a radius of the block towards O. The angle of incidence at O should be $i = 15^o$.
5. Observe the image of P_1 through side AB – away from the normal into air.
6. Position your head near the edge A and slowly increase the angle of incidence, until the image of pin P_1 appears to locate at point of incidence O.
7. Fix pin P_1 and remove the block.
8. Trace line P_1O.Measure and record the angle i_c between NO and P_1O

Questions to guide interpretation of results

1) From your results, estimate the critical angle of glass block used in this experiment.
2) State two conditions necessary for total internal reflection to occur.
3) What will happen as the angle of incidence increases beyond critical angle?

Experiment 12.5. Illustration of dispersion of white light

Rationale

Well understand the phenomena of refraction of light, helps to know its significance and its applications that we meet in everyday life (eg. Petrol mixed with the water produces different colors).

Objective

In this experiment you will demonstrate dispersion of light using a glass prism.

Materials

- Triangular prism
- White screen
- Ray of white light

Set up

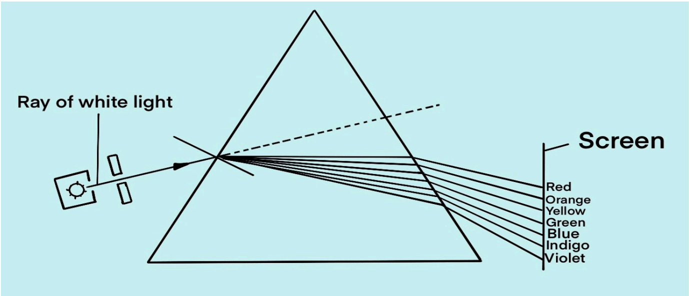


Fig. 12.5: Dispersion of white light forming a spectrum of colours

Procedures

1. Point a narrow beam of white light (such as sunlight, light from carbon arc lamp or a mercury vapour lamp) from a narrow slit, in a semi-dark room, to an equilateral glass prism.
2. Adjust the angle of incidence until a distinct band of colours is obtained on a white screen placed on the other side of the prism as shown in figure 12.5.

Questions to guide interpretation of results

1) What colours are obtained on the white screen?
2) How many of the colours can you identify?
3) Is the angle of deviation the same for each colour?

Experiment 12.6. Illustration of total internal reflection of light using a right-angled prism.

Rationale

Some examples of total internal reflection in daily life are the formation of a mirage, shining of empty test-tube in water, shining of crack in a glass-vessel, sparkling of a diamond, transmission of light rays in an optical fibre, etc

Objective

In this experiment, you will illustrate total internal reflection of light using a right-angled prism.

Materials:

- 1 soft board,
- 1 white sheet of paper,
- 4 optical pins,
- 4 drawing pins,
- 1 glass prism,
- 1 mathematical set.

Set up:

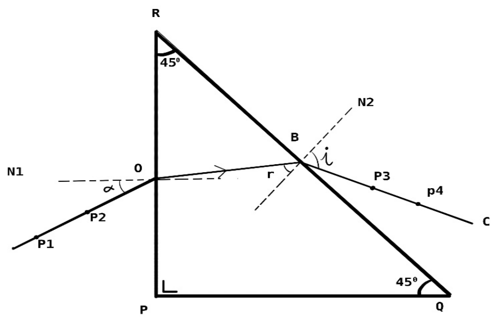


Figure 12.6. Illustration of total internal reflection of light

Procedures:

1. Fix a white sheet of paper onto a soft board.
2. Place the glass prism on the sheet of paper.
3. Trace its outline PQR.
4. Remove the glass prism.
5. Draw a normal N_1 at O.
6. Draw a line AB at angle $\alpha = 35^0$ and replace the prism.
7. Fix two pins P_1 and P_2 along AB, and by looking from side RQ, place pins P_3 and P_4 such that they appear to be in line with the images of P_1 and P_2 seen through the glass prism.
8. Remove the glass prism.
9. Draw line BC that meet side RQ at B.
10. Draw the normal line N_2 at B.
11. Draw line OB
12. Measure and record the angle r and i.
13. Repeat procedures (6) to (12) for $\alpha = 30^0, 25^0, 20^0, 15^0$ and 10^0.
14. Record your results in a table including values of $\sin r$ and $\sin i$.

Questions to guide interpretation of results

1) Plot a graph of $\sin i$ against $\sin r$.
2) Find the slope of the graph.
3) Find the critical angle of the prism from $r_c = \sin^{-1}(1/s)$
4) Explain what will happen for any value of r which is greater than r_c
5) Provide the two conditions of total internal reflection.

EXPERIMENT 12.7: Determination of critical angle of glass prism

Rationale

When a ray of light travels from denser to rarer medium it bends away from the normal and as the angle of incidence in denser medium increases, the angle of refraction in the rarer medium also increases and at a certain angle, the angle of refraction becomes 90°, this angle of incidence is called critical. It is the basis for the construction and working of fiber optic cables.

Objective

In this experiment, you will determine the critical angle c of glass prism provided

Materials:

- soft board,
- 1 white sheet of paper,
- 3optical pins,
- 4drawing pins,
- 1 glass prism,
- mathematical set.

Set up:

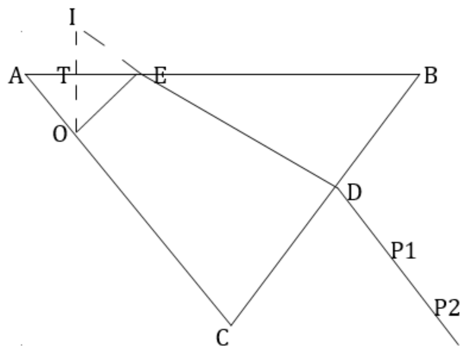


Fig 12.7. Ray diagram

Procedures:

1. Fix a tracing paper provided onto a soft board using drawing pins.
2. Place the prism on the sheet of paper and trace its outline ABC as shown in the figure.
3. Stick a pin at O, a distance t =1.5 cm from A.
4. View the image I of the pin from the side BC of glass prism.
5. Your head from left to right and vice versa, locate a point when the suddenly becomes bright.
6. With your eye in this position, fix pins P_1 and P_2 such that they are in line with the image I of the pin O.
7. Remove the glass prism
8. Draw a perpendicular line to AB passing through a point O to meet AB at T.
9. Mark a point on a perpendicular drawn in (h) above such that OT=TI
10. Draw a straight line from I to D and label the point E, where it intersects with side AB.
11. Measure and record the distances OE and OI as x and y respectively.
12. Repeat the procedures (3) to (11) for t =1.7, 1.9, 2.1, 2.3 and 2.5cm.
13. Tabulate the table of results and include the values of y^2 and x^2.

t/cm	x/cm	y/cm	x^2/cm^2	y^2/cm^2
1.5				
1.7				
1.9				
2.1				
2.3				
2.5				

Questions to guide interpretation of results

a) Plot a graph of y^2 against x^2.
b) Find the slope S of your graph.
c) Compute the critical angle c of the glass prism from the expression; $c = \cos^{-1}\left(\frac{1}{2}\sqrt{s}\right)$

Experiment 12.8. Determination of the image formed by converging lenses

Rationale

Human eye, magnifying glasses, eyeglasses, cameras, telescopes, microscopes, projectors, are all a real examples of lens application

Objective

In this experiment, you will analyze the image formed by converging lenses

Materials:

- Convex lens
- Lens holder
- Screen (you may use white wall)
- Real object (tree)

Set up

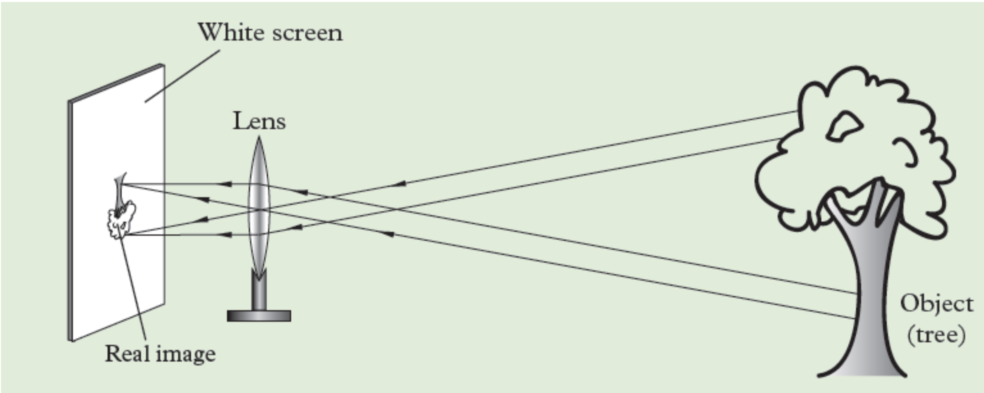


Fig12.8. Formation of image of a distant object

Procedures

1. Place the convex lens between the wall of laboratory or classroom (it is better to use white wall or white paper to maximize the view) and a far way object (tree) outside the room.
2. Adjust the distance between the lens and the wall until the image of the tree is observed on the wall.

Questions to guide interpretation of results

1) What are the characteristics of the image formed?
2) In peers, discuss how you can explain the formation of such image using ray diagram.

Experiment 12.9. Determination of the characteristics of images formed by convex lenses when the object is at infinity

Rationale

Human eye, magnifying glasses, eyeglasses, cameras, telescopes, microscopes, projectors, are all a real examples of lens application.

Objective

In this experiment, you will describe the characteristics of images formed by convex lenses when the object is at infinity

Materials

- Converging lens
- Lens holder
- Screen (you may use white wall)
- Real object (tree)

Set up

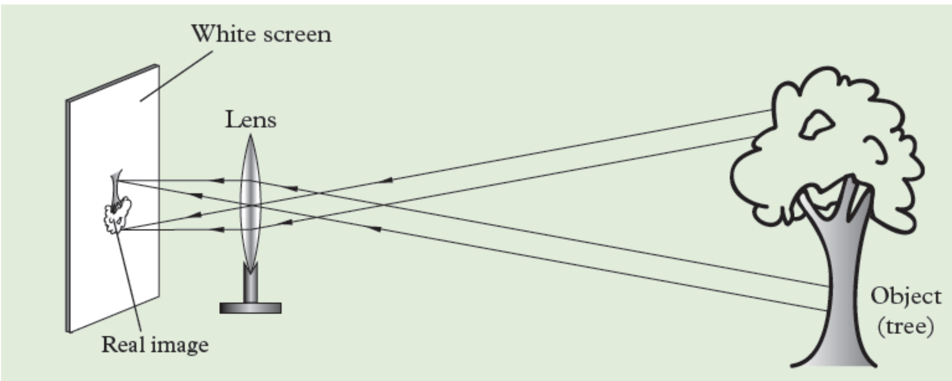


Fig 12.9 Formation of an inverted image by a convex lens.

Procedures

1. Position a convex lens vertically in front of a tree far away from the lens (through a window).
2. Place a white screen on the other side of the lens as shown in Figure above. Adjust the screen until you see a sharp image of the tree.

Questions to guide interpretation of results

1) Compare the size of the image with that of the object (tree).
2) Is image upright or inverted?
3) Measure and record the distance from the lens to the screen.
4) What does the distance from the lens to the screen represent in this set up?

Experiment 12.10: Determination of images formed by convex lens when the object is beyond 2F

Rationale

Human eye, magnifying glasses, eyeglasses, cameras, telescopes, microscopes, projectors, are all a real examples of lens application

Objective

In this experiment, you will describe images formed by convex lens when the object is beyond 2F.

Materials:

- Candle
- Converging lens
- Lens holder
- Screen

Set up

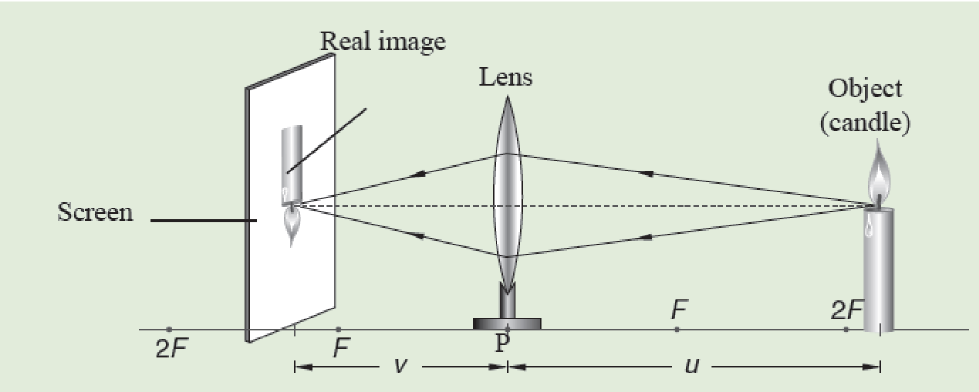


Fig 12.10. Formation of image by a convex lens when the object is beyond 2F.

Procedures

1. Mark the positions of the principal focus *F* and 2*F* on both the sides of the lens with a piece of chalk.
2. Place a lit candle on the table along the principal axis of the lens, slightly away from 2*F*.
3. Place a white screen, on the other side of the lens, perpendicular to the principal axis of the lens and adjust the position the lens to and fro to the screen and observe what happens.

Questions to guide interpretation of results

1) Estimate the values of u and v, that you have used in this experiment.
2) What are the characteristics of the image formed on the screen?

Experiment 12.11: Determination of images formed by convex lens when the object is at 2F

Rationale

Human eye, magnifying glasses, eyeglasses, cameras, telescopes, microscopes, projectors, are all a real examples of lens application

Objective

In this experiment, you will describe images formed by convex lens when the object is at 2F

Materials

- Candle
- A 10 cm focal converging lens
- Lens holder
- Screen

Set up

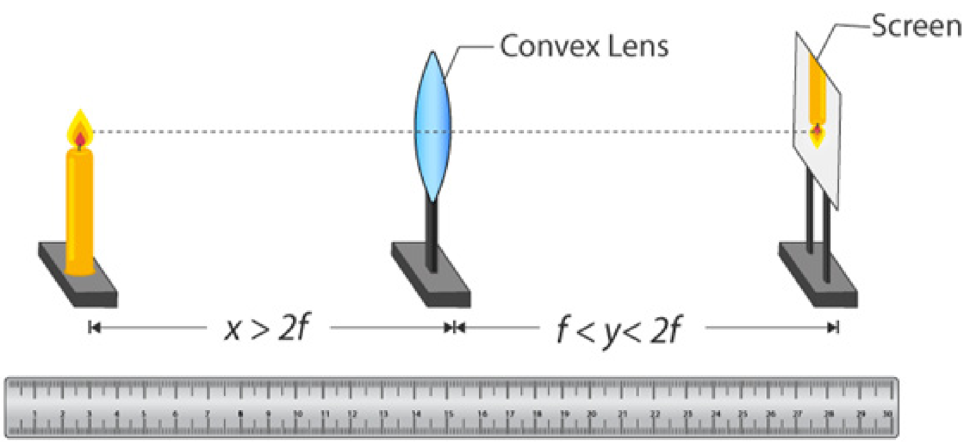


Fig 12.11. Formation of image by a convex lens when the object is at 2F.

Procedures

1. Mark the positions of the principal focus *F* and 2*F* on both the sides of the lens with a piece of chalk.
2. Place a lit candle on the table along the principal axis of the lens, at 2*F*.
3. Place a white screen, on the other side of the lens, perpendicular to the principal axis of the lens and adjust its position to and fro to the screen and observe what happens.

Questions to guide interpretation of results

1) Locate the image formed during this experiment.
2) What are the characteristics of the image formed?

Experiment 12.12: Determination of the images formed by convex lens when the object is between F and 2F

Rationale

Human eye, magnifying glasses, eyeglasses, cameras, telescopes, microscopes, projectors, are all a real examples of lens application

Objective

In this experiment, you will describe images formed by convex lens when the object is between F and 2F

Materials:

- Candle
- Converging lens
- Lens holder
- Screen

Set up

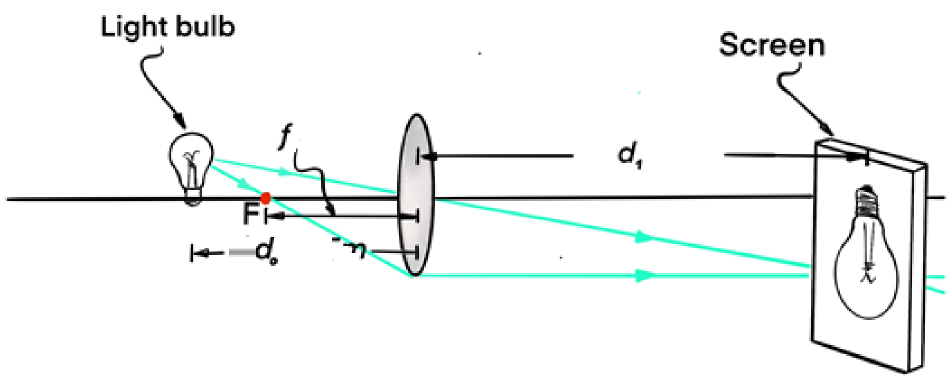


Fig 12.12 Images formed by convex lens when the object is between F and 2F

Procedures

1. Mark the positions of the principal focus *F* and 2*F* on both the sides of the lens with a piece of chalk.
2. Place a lit candle on the table along the principal axis of the lens between F and 2F.
3. Place a white screen, on the other side of the lens, perpendicular to the principal axis of the lens and adjust its position to and fro to the screen and observe what happens.

Questions to guide interpretation of results

1) What did you observe on the screen when the object was exactly placed between F and 2F?
2) From your observation, characterize the image formed on the screen.

Experiment 12.13: Characterization of images formed by convex lens when the object is between F and lens

Rationale

Human eye, magnifying glasses, eyeglasses, cameras, telescopes, microscopes, projectors, are all a real examples of lens application

Objective

In this experiment, you will describe images formed by convex lens when the object is between F and P

Materials:

- Candle
- Converging lens
- Lens holder
- Screen

Set up

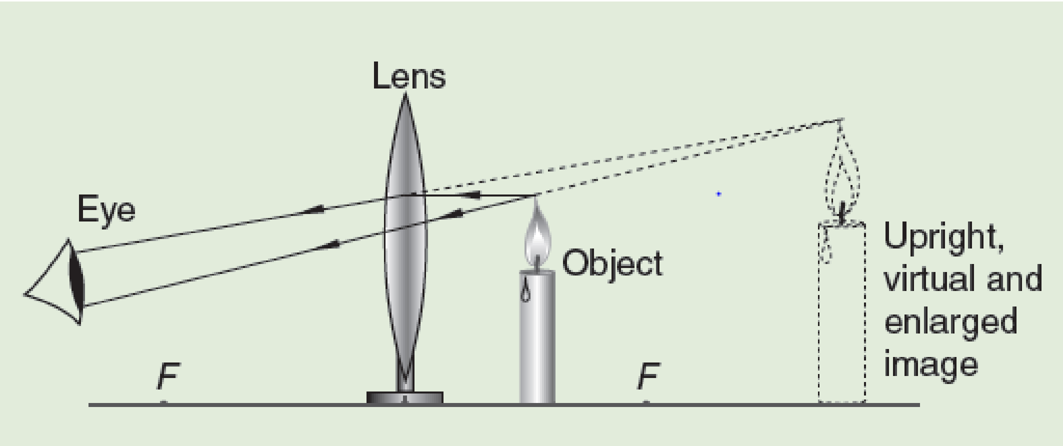


Fig 12.13. Image of an object located between lens and F

Procedures

1. Mark the positions of the principal focus *F* and 2*F* on both the sides of the lens with a piece of chalk.
2. Place a lit candle on the table along the principal axis of the lens closer to the lens and look through opposite side. Note your observation.

Questions to guide interpretation of results

1. What are the characteristics of the image formed?
2. Compare the characteristics of images formed in experiment 12.12 with that of this experiment. Explain?

Experiment 12.14. Determination of the focal length, f of a converging lens

Rationale

Human eye, magnifying glasses, eyeglasses, cameras, telescopes, microscopes, projectors, are all a real examples of lens application

Objective

In this experiment, you will describe images formed by convex lens when the object is at 2F

Materials

- Converging lens
- Lens holder
- Screen (white wall)
- Wire gauze
- Bulb
- Dry cells
- Switch

Set up

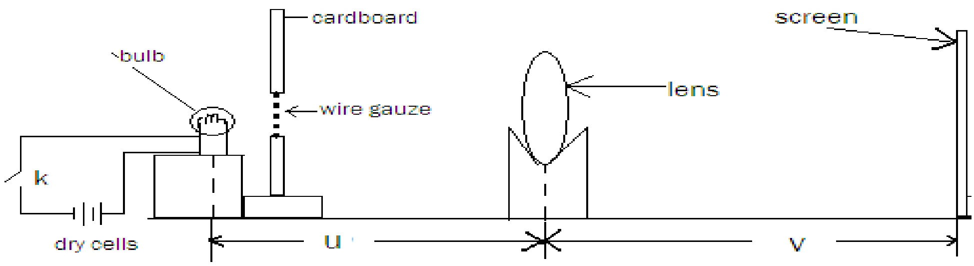


Fig 12.14. Determine the focal length, f of a converging lens

Procedures

1. Mount the lens provided in a lens holder.
2. Focus a distant object onto the screen.
3. Measure and record the distance, d between the lens and the screen.
4. Align the screen, the converging lens and the illuminated wire gauze such that the centers and the gauze are at the same height above the bench and lie in a straight line as shown in the figure 12.14.
5. Place the lens at a distance $U = 20\ cm$ from the gauze.

6. Adjust the position of the screen until a clear image of the wire gauze is formed on the screen.
7. Measure and record the distance, V of the screen from the lens.
8. Repeat procedures (5) to (7) for values of $U = 25, 30, 35, 40$ and $45\ cm$.
9. Tabulate your results, including values of $\frac{V}{U}$ in the table below.

U/cm	V/cm	
20		
25		
30		
35		
40		
45		

Questions to guide interpretation of results

1) Plot a graph of $\frac{V}{U}$ against V.
2) From your graph, find the value of V when $\frac{V}{U} = 0$.
3) Calculate the slope, S of the graph.
4) Calculate the focal length, f of the converging lens from the expression $f = \frac{1}{S}$.
5) Compare distance d measured in procedure 3 and the calculated value of focal length.

Experiment 12.15: Determination of the images formed by concave lens

Rationale

Human eye, magnifying glasses, eyeglasses, cameras, telescopes, microscopes, projectors, are all a real examples of lens application

Objective

In this experiment, you will describe images formed by concave lens

Materials:

- Candle
- Concave Lens
- Lens holder
- Screen

Set up

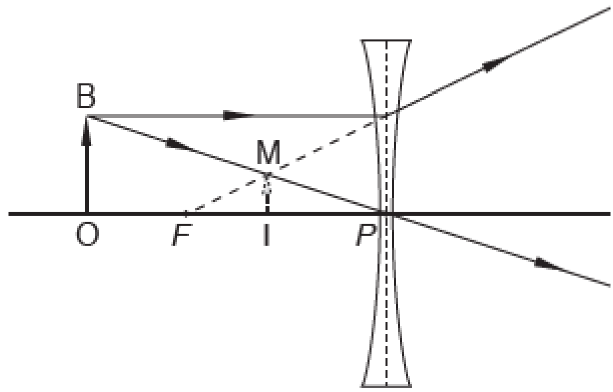


Fig 12.15: Images formed by concave lens

Procedures

1. Mark the positions of the principal focus *F* and 2*F* on both the sides of the lens with a piece of chalk.
2. Place a lit candle on the table along the principal axis of the lens slightly away from 2F.
3. What are the characteristics of the image formed?
4. Now move the candle far away from 2F.

Questions to guide interpretation of results

1) Describe what you have observed while carrying out this experiment?
2) Describe the characteristics of the image formed.

ENVIRONMENTAL PHENOMENA AND RELATED PHYSICS CONCEPTS

Experiment 13.1: Explanation of the laws that govern heat transfer in the environment

Rationale

In what ways has the global climate changed, and the causes and impact of climate change in the world, and ways in which we can control climate change

Objective

In this experiment, you will explain the laws that govern heat transfer in the environment

Materials:

- Metallic rod
- Ink
- Retort stand
- Heating source
- Candle wax
- Tripod stand
- Water (in a beaker)
- Small pins
- Steel wire

Set up

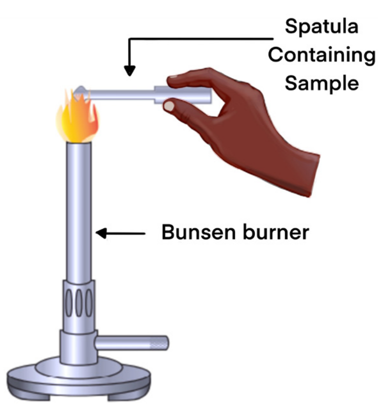


Fig.13.1. Heat transfer by conduction

Procedures

1. Stick the candle wax at different points towards one end of the metallic rod. Fix the pins on each candle wax.
2. Now hold the rod from the other end and start heating it as shown in Figure.
3. Heat the metallic rod for some time.
4. Remove the rod from the Bunsen burner and move your hands near but beside the burning flame.
5. Put one drop of ink at one side of the water in the beaker. Place the beaker on the tripod stand and start heating.

Questions to guide interpretation of results

1) Explain what happened to the pins on the candle wax when the metallic rod heated for some time?
2) What did you feel while moving your hands near but beside the burning flame?
3) After adding ink, what did you observe after 5 minutes of heating of water?
4) When heat flows between two objects, does the temperature increase in one object always equals to the temperature decrease of the other object? Discuss.
5) Describe how the thermal energy of an object changes when the temperature of an object changes.
6) Basing on experiment above, Explain the three modes of heat transfer.
7) Share your findings with your friend and then to the whole class.
8) Discuss your findings as the whole class with the help of the teacher and note them down in your notebooks.

APPENDIXES

Most of all experiments in this book were tested. These appendixes include the expected results of the tested experiments. You may not obtain the same results in the data recording; however, the final results and observations will be almost the same.

SENIOR ONE EXPERIMENTS' EXPECTED RESULTS

Experiment 1.1: Measurement of length, width, and height of a glass block (You might use any kind of block such as wooden block, a brick or even improvise your own block to use.)

Expected answers for interpretation of results

No.	Length/cm	Width/cm	Thickness/cm
Reading 1	11.8	6.6	1.9
Reading 2	11.8	6.5	1.8
Reading 3	11.9	6.6	1.7
Average reading	11.8	6.6	1.8

1. $Length = 11.8cm, \quad Width = 6.6cm, \quad Thickness = 1.8cm$
2. The least count of measuring instrument is the smallest measurement which can precisely be measured using that instrument. For a metre rule the least count is 0.1 cm or 1mm.
3. The importance of taking one measurement many times is to minimize the errors that can occur reading on the instrument due to wrong position or other fluctuations during reading.
4. The reason of differences in results obtained by different groups may have come from different source of errors in measurement such as instrumental errors in instruments used, personal issues of vision, wrong position of the eye during reading on the measuring instrument.

Conclusion

Errors in measurement can't be avoided but can be reduced. Measurement of one quantity should be made more than once and the average calculated to reduce the error that may occur in measurement due to fluctuation, wrong positioning of the reader etc. Therefore,

- The length of the measured glass block is 11.8 cm
- The width of the measured glass block is 6.6 cm
- The thickness of the measured glass block is 1.8 cm

Depending on the difference of standards of glass block used you might get a variety of results, but make sure you use the glass block of the same standards, and when the learner gets difference in results the only difference should be on the last digit of the two decimals provided.

Experiment 1.2: Measurement of diameter of optical pin by using micrometer screw gauge

Expected answers for interpretation of results

Table of results

Diameter	Measured value/mm
D1	1.04
D2	1.03
D3	1.01
Average diameter, D	1.03

1. Measured diameter of the optical pin was 1.03cm
2. The smallest division or the least count of used micrometer screw gauge was 0.01mm
3. The importance of taking the measurements many times is to minimize the errors. Calculating the average of different measurement of one quantities measured give you one typical result.

Conclusion:

The micrometer screw gauge has an accuracy of 2 decimal places (0.01mm). Before using a micrometer screw gauge, its scale must be studied to determine the zero error. The zero error must be subtracted from the subsequent measurement. The diameter of the optical pin obtained from this experiment is 1.03cm. However, depending on the difference of standards of optical pin used you might get a variety of results, but make sure you use optical pin of the same standards, and when the learner gets difference in results the only difference should be on the last digit of the two decimals provided.

Experiment 1.3: Measurement of internal diameter of the test tube by using a vernier caliper.

Expected answers for interpretation of results

Table of results

Measurements of the internal diameter of test tube.	Main scale readings/ cm	Vernier scale readings/ cm	Diameter/cm
Reading 1	1.2	0.09	1.29
Reading 2	1.2	0.08	1.28
Reading 3	1.2	0.06	1.26
Average diameter D			1.27

1. The internal diameter of the test tube is 1.27
2. The Vernier caliper gives more precision and accuracy measuring small length over meter ruler.

Conclusion

The internal diameter of a test tube obtained from this experiment is 1.27cm. However, depending on the difference of standards of test tubes used you might get a variety of results, but make sure you use the test tubes of the same standards, and when the learner gets difference in results the only difference should be on the last digit of the two decimals provided.

Experiment 1.4: Measurement of the external diameter of the test tube using a vernier caliper.

Expected answers for interpretation of results

Table of results

Measurements of the external test tube.	Main scale readings/cm	Vernier scale readings /cm	Diameter/cm
Reading 1	1.5	0.00	1.5
Reading 2	1.5	0.00	1.5
Reading 3	1.5	0.00	1.5
Average diameter D			1.5

1. The external diameter of the measured test tube is 1.5cm

2. Though you might get no deviation of results, but the cause of deviation of results might be due to error in measurement coming from the instruments used, personal vision and position of the eye reading on the measuring instrument.

Conclusion

The external diameter of a test tube obtained from this experiment is 1.5cm. However, depending on the difference of standards of test tubes used you might get a variety of results, but make sure you use the test tubes of the same standards, and when the learner gets difference in results the only difference should be on the last digit of the two decimals provided.

Experiment 1.5: Measurement of the depth of the beaker using a vernier caliper.

Expected answers for interpretation of results

Table of results

Measurements of depth of the beaker	Main scale readings/ cm	Vernier scale readings/cm	Depth/cm
Reading 1	9.0	0.00	9.00
Reading 2	9.0	0.03	9.03
Reading 3	9.0	0.04	9.04
Average readings			9.02

1. The depth of the beaker measured is 9.02cm
2. The advantage of using the vernier caliper in measuring the depth of a beaker is that it gives more precise and accurate measurement.
3. Students in different group may obtain different measurement due to different factors.
    - Having measured beakers of different standards.
    - Errors in measurement that may come from wrong position reading on the measuring instrument or different fluctuation handling the measuring instrument.

Conclusion

The depth of the beaker measured in this experiment is 9.02 cm, however depending on the different standards of beaker used, you might get a variety of results. Therefore, make sure you use the beakers of the same standards, and when the learner gets difference in results the only difference should be on the last digit of the two decimals provided.

Experiment 1.6: Measurement of the thickness of the test tube using a vernier caliper.

Expected answers for interpretation of results

Table of results

Internal diameter of the test tube/cm	External diameter of the test tube/cm	Thickness of the test tube/cm
1.27	1.5	0.23

1. The thickness of the test tube is 0.23cm
2. Some advantage of using the vernier caliper in measuring the thickness of the test tube is that it provides the accurate and precise results.
3. The possible sources of deviation from the correct measurement might be experience of the experimenter or observer, the zero mark of the vernier caliper.

Conclusion

Vernier caliper is well positioned to providing accurate and precised measurement of the thickness of the test tube, however depending on the different standards of test tube used, you might get a variety of results. Therefore, make sure you use the test tube of the same standards, and when the learner gets difference in results the only difference should be on the last digit of the two decimals provided.

Experiment 1.7: Measurement of the mass of an object by using a spring balance

Expected answers for interpretation of results

1. The S.I unit of the mass is "kg"
2. The mass is the quantity of matter in a physical body. It is not changed regardless of the measuring instrument used to measure it. However, different value can be obtained when measured using different measuring instruments due to their sensibility and calibrations.

Conclusion

The object will have almost the same mass using different types of balance. In order to be familiar with use of balances, a student might measure a range of different objects with the use of those three types of balance.

Experiment 1.8: Measurement of the time by using stopwatch

Expected answers for interpretation of results

Table of results

Number of heart beeps	Time taken
81 beeps	1 min

1. The duration between two heart beeps is 1.35 seconds.
2. Start by finding the time interval between two heart beat for each member of the group and then calculate the average.

Conclusion

For a normal child ranging from 1 to 16 years old, the heart beeps will range from 80 to 100 per 1 min. But to get an accurate result make sure that you start counting as you press on the stop watch. i.e. your counting and the timer should start at the same time.

Experiment 1.9: Determination of the volume of an irregularly shaped solid (stone) using Eureka can

Expected answers for interpretation of results

Table of results

Number of readings	Volume/ml
V1	30.5
V2	30.0
V3	30.0
Average volume	30.2

Conclusion

The water overthrown from eureka can is equal to the volume of the immersed irregular shaped stone, thus we conclude that the volume of the measured stone is 30.2ml.

Note: Depending on the different size of stone used, you might get a variety of results.

Experiment 1.10: Determination of the volume of a regularly shaped solid using a measuring cylinder.

Expected answers for interpretation of results

The diameter is 1.8cm, thus, the radius is 0.9cm. Using the formula $Vo = \frac{3}{4}\pi r^3$, $Vo = \frac{3}{4}\pi 0.9^3 = 3.05cm^3$

The result shows that V_1= 31.0cm^3 and V_2=34.0cm^3, Thus,

$$V = V_1 - V_2 = 34.0 - 31.0 = 3.0cm^3$$

1. V and V_o are almost the same and equal to the volume of the pendulum bob used.
2. A difference in result can occur due to different source of errors in measurement but if the measurement were carefully made, the difference would be very small.

Conclusion

Though we used different method of finding the volumes, we obtained the same quantitative data. So, both ways are relevant to use while calculating the volume of an irregular object.

Experiment 1.11: Measurement of density by using spring balance and a measuring cylinder

Expected answers for interpretation of results

Data: V_1= 31.0cm^3 and V_2=34.0cm^3

$$V = V_1 - V_2 = 34.0 - 31.0 = 3.0cm^3$$

m=30g

1. $\rho = m/V$

$$\rho = \frac{30g}{3cm^3} = 10\,{}^{g}\!/_{cm^3}$$

2. So, the $\rho = \frac{30g}{3cm^3} = 10\,{}^{g}\!/_{cm^3} = 10^4\,{}^{kg}\!/_{m^3}$

Conclusion

The calculated value $10^4\,{}^{kg}\!/_{m^3}$ is the estimated density of the material by which the pendulum bob is made of.

However, depending on the different standards of solid used, you might get a variety of results. Therefore, make sure you use the solid of the same standards, and when the learner gets difference in results the only difference should be on the last digit of the two decimals provided.

Experiment 1.12: Measurement of relative density of a solid

Expected answers for interpretation of results

Data: V_1= 31.0cm^3 and V_2=34.0cm^3

$$V = V_1 - V_2 = 34.0 - 31.0 = 3.0cm^3$$

m=30g

1. $\rho = m/V$

   $$\rho = \frac{30g}{3cm^3} = 10\, {}^{g}\!/_{cm^3}$$

2. So, the $\rho = \frac{30g}{3cm^3} = 10\, {}^{g}\!/_{cm^3} = 10^4\, {}^{kg}\!/_{m^3}$

3. Given that the density of water is $1000\, {}^{kg}\!/_{m^3}$, the relative density of the material of which the pendulum bob is made is given by

   the relation $\rho_s / \rho_w = \frac{10^4\, {}^{kg}\!/_{m^3}}{1000\, {}^{\mathrm{kg}}\!/_{\mathrm{m}^3}} = 10$

4. The relative density doesn't have unit

Conclusion

Because the units of the two densities are the same, we found our relative density to have no unit.

You might get a different result depending on the standards of the solid considered in your experiment. You are advised to use solid with same standard.

Experiment 1.13: Measure Density of liquid (cooking oil or water)

Expected answers for interpretation of results

Data: $m_c = 49.90g$

Volume /cm³	Mass/g	M_o/g	$\frac{m_o}{V} / gcm^{-3}$
20	69.36	19.46	0.973
30	79.13	29.23	0.974
40	89.22	39.32	0.983
50	99.75	49.85	0.997

1) The observation in the ratio $\rho = m_o / V$ is that the results are slightly the same.
2) The density of water is $1g/cm^3$

Conclusion

The density of water is around $1g/cm^3$, by using this experiment you can also determine the density of any liquid. However, you might get different result depending on the quality of water used. Therefore, make sure you use the water of the same standards, and when the learner gets difference in results the only difference should be on the last digit of the two decimals provided.

Experiment 2.1: Measurement of acceleration due to gravity by using spring balance

Expected answers for interpretation of results

Number of readings	Weight/N
W_1	1.0
W_2	0.9
W_3	1.0
Average Weight	1.0

1) m=100g=0.1kg

2) Constant "g" is equal to $g = \frac{w}{m} = \frac{1.0N}{0.1kg} = 10\,{}^{N}\!/_{kg}$

3) The unit of constant "g" is ${}^{N}\!/_{kg}$ which can be equivalent to ${}^{m}\!/_{s^2}$

4) The "g" calculated presents the acceleration due to gravity of the earth.

Conclusion

When you use the standard spring the earth acceleration due to gravity is 10N/kg, however, the errors from your readings might cause a variety of results.

Experiment 3.1: Demonstration of effects of friction force

Expected answers for interpretation of results

1. Before the block started moving, the spring balance readings increased for the block to start the moving.
2. Then after the block starts moving, the spring balance will read lower weight and it will be easier for the block to keep moving.
3. The force being applied is called "Friction force".
4. The effect of friction force is that it reduced the speed of the moving block.

Conclusion

In the first case, there is a force preventing the stationary block of wood from moving which is friction force. But as it was in the motion the velocity was low, though it was moving.

Experiment 3.2: Demonstration of upthrust force

Expected answers for interpretation of results

Data observed:

i. W_o=0.48N
ii. W=0.42N

1. When the solid was in air it had higher weight, but due to the influence of water its weight decreased.
2. The force applied by the water is called "the upthrust force"
3. $Upthrust = 0.48N - 0.42N = 0.06N$
4. The influence of water on the solid weight, is that the solid became lighter than it was before.

Conclusion

The upthrust helped the solid body to float and its weight decreases when it was submerged fully in the water.

Depending on the different size and standard of solid used, you might get a variety of results. Therefore, make sure you use the solid of the same standards, and when the learner gets difference in results the only difference should be on the last digit of the two decimals provided.

Experiment 3.3: Determination of spring constant and the verification of Hook's law

Expected answers for interpretation of results

Table of results

X_o=0cm

Mass/g	New position (X_1/ cm)	Extension $X=(X_1-X_o)$ /cm	$F=m\times g$ /N	Constant, k/ Ncm^{-1}
50	0.3	0.3	0.5	1.667
100	0.6	0.6	1.0	1.667
150	0.9	0.9	1.5	1.667
200	1.2	1.2	2.0	1.667

Conclusion

To conclude, the spring constant is 1.667 k/Ncm^{-1} and it remained the same of each mass added.

However, depending on the different standards of spring (balance) used, you might get a variety of results. Therefore, make sure you use the spring of the same standards, and when the learner gets difference in results the only difference should be on the last digit of the two decimals provided.

Experiment 3.4: Demonstration of the existence of an electrostatic force

Expected answers for interpretation of results

1. A rubbed ruler attracted the pieces of paper. And this behavior was caused by an electrostatic force.
2. Electrostatic force is created when the plastic ruler was rubbed against a dry piece of cloth.

Conclusion

When rubbed together, the ruler and dry piece of cloth exchange charges, one becoming positively charged and the other becoming negatively charged.

Experiment 3.5: Demonstration of the existence of a magnetic force

Expected answers for interpretation of results

1. In procedure 2, the bar magnets repelled one another
2. In procedure 3, there will be attraction between them.
3. For the iron rod is a metal which has magnetic material in it, it was attracted by the magnet.

Conclusion

Like pole of a magnet repel each other while unlike pole of a magnet attracts.

Metals like brass, copper, zinc and aluminum are not attracted to magnets, because they do not have magnetic properties in them.

Experiment 4.1: Demonstration of the inertia using a coin

Expected answers for interpretation of results

1. It is observed that when the card is pulled slowly, the coin moves together with the card or sheet of paper.
2. When the card is pulled suddenly, the coin is left behind and drops vertically down into the beaker.
3. Because of the inertia in the coin in procedure 2, it could not move with the sheet of paper as it did in procedure 1.

Conclusion

Inertia is the tendency of an object to resist any sudden change of state. If the pull is slow, the change of state of the coin and the card board is not sudden hence, they move together. If the pull is fast, the coin is urged to resist the sudden change of its state hence, drops vertically downwards into the beaker. A perfect example of this principle is when a car stop suddenly, the passenger tend to move forward.

UNIT 5 CENTRE OF GRAVITY

Experiment 5.1: Location of the position of centre of gravity of a regular object.

Expected answers for interpretation of results

1. It observed that the cardboard balances horizontally at point M only. This point, M, is called Centre of gravity of the cardboard.

Conclusion

The center of gravity is the average position of the total weight of an object.

Although the mass of the cardboard is distributed over the whole body, at point "M" the whole weight of the cardboard appears to be concentrated there.

Experiment 5.2: To locate the Centre of gravity of a regular lamina

Expected answers for interpretation of results

1. Yes, the plumb line pass through "M"
2. The point M is the center of gravity of the lamina.

Conclusion

Bodies with uniform cross section area and density have their C centers of gravity located at their geometrical centers.

Experiment 5.3: Determination of centre of gravity (c.o.g) of irregular lamina.

Expected answers for interpretation of results

1. Yes, it will pass through M.
2. Because the finger is at the center of gravity, the lamina will balance horizontally.

Conclusion

This activity proves that when a body is freely suspended it rests with its center of gravity vertically below the point of suspension.

Experiment 6.1: Work done in pulling an object along a horizontal surface.

Expected answers for interpretation of results

1. When the block of wood was being pulled, the spring balance registered the force applied
2. $W = f \times d = 0.6N \times 0.5m = 0.3J$

Force F/N	Distance D/M	Work done W/J
0.6	0.5	0.3

Conclusion

Since the block was on a smooth surface, we assume that friction force is negligible hence the force applied is constant along the distance of motion, d. Work done in moving the block is given by: Work = force × **distance.**

Experiment 6.2: Demonstration the law of conservation of Mechanical Energy using a swinging pendulum

Expected answers for interpretation of results

1. M = 25g = 0.025kg

   Ho = 4cm = 0.04m

   h_1 = 14cm = 0.14m

   l = 70cm

$$h = h_1 - h_o = 0.14 - 0.04 = 0.01m$$

$$PE_B = mgh = 0.025 \times 10 \times 0.10 = 0.025J$$

2. At position A, $v_A=v_{max}$ and at position B, $v_B=0$
3. $KE_B=0$, whereas the $KE_A=KE_{max}$

   So, KE_B is almost the same to KE_A.
4. $ME = PE_{max} = PE_B = 0.025J$

$$v_{max} = \sqrt{\frac{2PE_B}{m}} = \sqrt{2\left(\frac{0.025}{0.025}\right)} = 1.414\, m/s^{-1}$$

5. No, it does not change. The mechanical energy is conserved.

Conclusion

As the bob moves forth and back, at point B and C, the bob has gained the maximum potential energy due to its height above the ground while it has a minimum potential energy as it passes the point A. The bob gain maximum kinetic energy at point A and has zero kinetic energy at both point B and C. At all point the mechanical energy is conserved as the lost potential energy is converted into kinetic energy and vice versa.

Experiment 7.1: Determination of the mass of the solid provided by using principle of levers

Data recording:

1. G=50.7cm
2. GX=50.7cm
3. P_1X=46.4cm and $GP_1 = 50.7 - 46.4 = 4.3$
4. $U_1 = \frac{GP_2}{P_1X} = \frac{4.3}{46.4} = 0.09$
5. P_2X=37.0

   $GP_2 = 50.7 - 37.0 = 13.7$
6. $U_2 = \frac{GP_2}{P_2X} = \frac{13.7}{37.0} = 0.37$

Expected answers for interpretation of results

1. $m = \frac{30}{v_2 - v_1} = \frac{30}{(0.37 - 0.09)} = \frac{30}{0.28} = 107.14g$
2. Mass in kg, $107.14 \times 10^{-3} = 0.10714kg$

Conclusion

When we use laboratory ruler in this experiment, the expected mass should range between 100 to 125 g.

Experiment 7.2: Determination of velocity ratio of a system of pulleys

Expected answers for interpretation of results

Table of results

L_o=10.4cm

Distance moved by effort cm	Measured value of l_1/ cm	$l_1 - l_o$ /cm	velocity ratio
10	15.1	4.7	2.13
20	20.2	9.4	2.13
30	25.0	14.6	2.05
40	30.1	19.7	2.03

1. They are slightly equal
2. The quantity e/l has no unit
3. The approximation of VR is 2.00

Conclusion

Velocity ratio is directly proportional to the distance moved by the effort.

Experiment 7.3: Determination of the mechanical advantage of a system of pulleys

Expected answers for interpretation of results

1. $L = m \times g = 0.100 \times 10 = 1N$

   E=0.68N

   $$MA = {}^{L}\!/_{E} = \frac{1N}{0.68N} = 1.47$$

2. M.A is dimensionless.

Conclusion

The mechanical advantage determines the relationship between the load and effort. A simple machine has a great mechanical advantage if a small effort can be used to produce work. As the effort to be used decrease the mechanical advantage increases.

Experiment 7.4: Determination of the efficiency of a system of pulleys using spring balance

Expected answers for interpretation of results

L=20cm

E=0.68N

1. $MA = \frac{1N}{0.68N} = 1.47$

2. $VR = \frac{e}{l} = \frac{41.5cm}{20cm} = 2.08$

3. $\eta = \frac{MA}{VR} = \frac{1.47}{2.08} = 0.71$

4. $\eta = 71\%$
5. η has no unit.

Conclusion

The degree to which friction and other variables lower a machine's actual work production from its theoretical maximum is measured by its efficiency. A frictionless machine would have a 100 percent efficiency. The output of a machine with a 20% efficiency is merely one fifth of its theoretical output. The efficiency of a machine is the ratio of its output (resistance multiplied by distance moved) to its input (effort multiplied by distance exerted); As the effort is decreasing as the mechanical advantage and efficiency increase.

Experiment 8.1: Comparison of viscosity of two liquids (Water and cooking Oil)

Expected answers for interpretation of results

1. In cylinder A of graduation 250ml (water) time is short of 0.69 secs. Whereas, in cylinder B of graduation 250ml (oil) time is a bit longer of 1.00secs.
2. Oil is more viscous than water and it has strong cohesion force than water.

Conclusion

The marble took more time to reach the bottom of measuring cylinder B and less time to reach the bottom of measuring cylinder A. This shows that cooking oil is more viscous than water. However, when carrying out this experiment consider using the same container of the same graduations and the level of water and oil should be the same.

Experiment 8.2: Determination of melting point of water

Expected answers for interpretation of results

Table of results

Time, t/s	Temperature, T/°C
2	0
4	0
6	0
8	0
10	0
12	1
14	2
16	3

1. The value of temperature that last for a long period without changing is 0°C. It lasted for 10 minutes.
2. From this experiment, the melting point of the ice is 0°C.

4. Referred to this experiment, melting point of iced substance is that temperature at which iced substance transforms into liquid. This temperature is kept constant until all ice gets melt.
5. At 12 seconds of the process, all amount of ice got melt.

Conclusion

The melting point of water (ice) is approximated to be 0^0 C. During melting the temperature does not change. This show that the melting substance gain more heat which is used to melt it the reason why its temperature remains the same in the process.

Experiment 8.3: Determination of boiling point of water

Expected answers for interpretation of results

1. T_1=25°C
2. T_2=100°C
3. From the experiment, the Boiling point of water is 100°C.
4. There was no more change in temperature. At 100°C , the heat gained by water is used to boil it the reason why its temperature remain constant until the boiling process is finished for the temperature to change again.

Conclusion

As the temperature increases gradually, the water starts heating as the kinetic energy is increasing along with rise in the temperature. At a certain temperature, the intermolecular space increases up to such an extent that the water molecules break free from each other and vaporize. This temperature is called the boiling point of water. As the water change the state from liquid to vapor the temperature remain constant.

Experiment 9.1: Investigation of the difference between heat and temperature

Expected answers for interpretation of results

1. T_{1w}=23.5 ˚C, then temperature T_{2w} is 98˚C
2. T_{1oil}=25 ˚C, then the value of temperature $T_{2\ oil}$ is 91˚C?
3. No, the two temperatures are not the same. Therefore, two substances can have equal heat energy supplied but be at different temperatures.

Conclusion

When the tubes are heated for the same time, i.e. the same heat energy passes from the burner to the tubes, both oil and water gain equal amount of heat energy but are at different temperatures. Temperature is the measure of hotness of something while heat is energy from hot to cold substance.

Experiment 10.1: Determination of the poles of bar magnet using the earth's magnetic field.

Expected answers for interpretation of results

1. It rests in geographic north-south direction of the earth.
2. The axis is on the vertical plane, which is called the Magnetic meridian
3. The south pole of this bar is near the geographical north pole and north pole at the geographical south pole. Therefore, when a magnet is suspended freely the magnetic poles of the earth attracts the opposite pole of the magnet, which is why it comes to rest in the north-south direction.

Conclusion:

The pole that points towards the north pole of the earth is called the north seeking pole or simply the North Pole (N). The other pole is called the south seeking pole or South Pole (S). The north geographic pole holds earth's south magnetic pole which attract the north of the suspended magnet.

Experiment 10.2: Demonstration of difference in magnetic, ferromagnetic and non-magnetic materials.

Expected answers for interpretation of results

1. Some materials were attracted by the bar magnet and some others were not attracted to the magnet.
2. The classification of the substances is in the table below. And we classified them by ferromagnetic and non-magnetic

Substances attracted by a bar magnet	Substances not attracted by a bar magnet
1. Steel	1. aluminium, pen
2.cobalt	2.copper, cork
3.nickel	3.brass, paper
4.	4.zinc

Conclusion:

The materials which are attracted by a magnet are called magnetic materials while those which are not attracted are called non-magnetic materials. The magnetic materials that are strongly attracted by a magnet are called ferromagnetic materials. These include nickel, iron, cobalt and steel.

Experiment 10.3: Demonstration of poles of a bar magnet.

Expected answers for interpretation of results

1. The head of the compass needle will be attracted to the South pole of the bar magnet, and the tail of the compass will be attracted to the south of the North pole of the bar magnet.
2. According to answer in question 1, you will take a decision of which pole is which.

Conclusion:

In order to easily identify the poles of a magnet, the ends are usually painted in different colors. For example, the N-pole is painted red while the S-pole is painted blue or white.

Experiment 10.4: Demonstration of magnetic field by using a compass needle.

Expected answers for interpretation of results

1. The direction of the compass needle changes.
2. When you move the magnetic compass toward or around the magnet, the direction of the magnetic needle (compass) change to align with the magnetic field of the magnet.

3. There exist two behaviors of magnetic force. Magnetic force of attraction and magnetic force of repulsion.
4. Earth's south magnetic pole is near Earth's geographic north. Earth's magnetic north pole is near Earth's geographic south. That's why the north pole of the soldier's compass point toward north, that's where Earth's south magnetic pole is located and they attract.

Conclusion:

The space or region around the magnet is called magnetic field, and is represented by the lines of force called magnetic field lines. These field lines form a pattern called magnetic field pattern.

Experiment 10.5: Demonstration of the action of one pole of a magnet to another.

Expected answers for interpretation of results

1. The north and south pole attracts
2. The south pole repels the south pole
3. Like pole repel each other while unlike pole attracts

Conclusion

Two unlike pole of a magnet attracts each other and two like pole repel.

Experiment 11.1: Find out materials that produce static electric charges when they are rubbed together.

Expected answers for interpretation of results

1. When the glass rod and the silk are rubbed against each other, they both get charged by friction. This is confirmed when they were brought near the electroscope and the gold leaf deflect. The glass rod gains positive charges, and the silk cloth gain negative charges.
2. When the metal rod is rubbed against the silk cloth, it gains some charges but are directly conducted as the metal rod is a good conductor. This is confirmed by the fact that when the metal rod is approached to the gold leaf electroscope, no deflection is observed because no the rod is not charged.
3. when the glass rod is rubbed against the silk cloths, it is charged by friction that it can attact small papers or deflect gold leaf electroscope. However, for the metal rod, the acquired charges are directly conducted as it is a good conductor hence it is not charged and will not be able to deflect the gold leaf electroscope.

Conclusion

When two different materials are rubbed together, there is an exchange of charges between them with one loosing electrons to the other material. This cause one object to become positively charged (the electron loser) and the other object to become negatively charged (the electron gainer).

Experiment 11.2: Demonstration of charging a body by rubbing.

Expected answers for interpretation of results

1. On both cases pieces of paper were attracted to both the glass rod and pen.
2. In procedure 5, the pen repelled the glass rod.
3. Because both glass rod and pen were positively charged, they attracted pieces of paper.

But when they were again brought together, they repelled from each other due to the same charge gained from rubbing.

Conclusion:

When two objects are rubbed together, they get charged by friction by with opposite charges. The electric charge acquired by glass rod is positive while the silk cloth acquired negative charges.

Experiment 11.3: Demonstration of charging a body by conduction.

Expected answers for interpretation of results

1. Before touching the electroscope, it was neutral. And after touching it, it was negatively charged due to the negative charges in the human hands from the earth. So, the gold leaves repelled one another.
2. By attaching it with the positively charged balloon, it was also positively charged and the leaves of the electroscope were attracted to each other.
3. The name of the method used is charging by conduction.

Conclusion

The electroscope was positively charged by conduction when it was attached to the positively glass rod. And negatively charged when your hand touched it.

Experiment 11.4: Demonstration of charging a body induction.

Expected answers for interpretation of results

1. The initial charge of the electroscope was neutral.
2. After bringing the glass rod and balloon near the electroscope, it gained a positive charge. And this process is called charging by induction.
3. After some 5min, the electroscope will be neutral again.

Conclusion:

The electroscope was positively charged by induction when it was brought near a positively charged glass rod. But after some time, it will become neutral again.

Experiment 11.5: Determination of type of charge of charged body using electroscope.

Expected answers for interpretation of results

1. Because the electroscope was negatively by touching it. The glass rod was positive because the leaves of the electroscope contracted. The silk cloth and metal rod were negatively charged.
2. A pen and a drinking straw were charged by rubbing. A pen was positively charged; a drinking straw was positively charged.

Conclusion

The electroscope can be charged negatively using your hand because you are standing on the ground. And you can also charge the electroscope using any positively charged body.

Experiment 12.1: Measure electric current, potential difference, and resistance in simple circuit

Expected answers for interpretation of results

1. After closing the switch, the bulb glows. The ammeter and the voltmeter starts reading. Their needles move clockwise.
2. V=2.3v
3. I=0.53A
4. $R = \frac{V}{I} = \frac{2.3V}{0.53A} = 4.34\Omega = 4\Omega$.

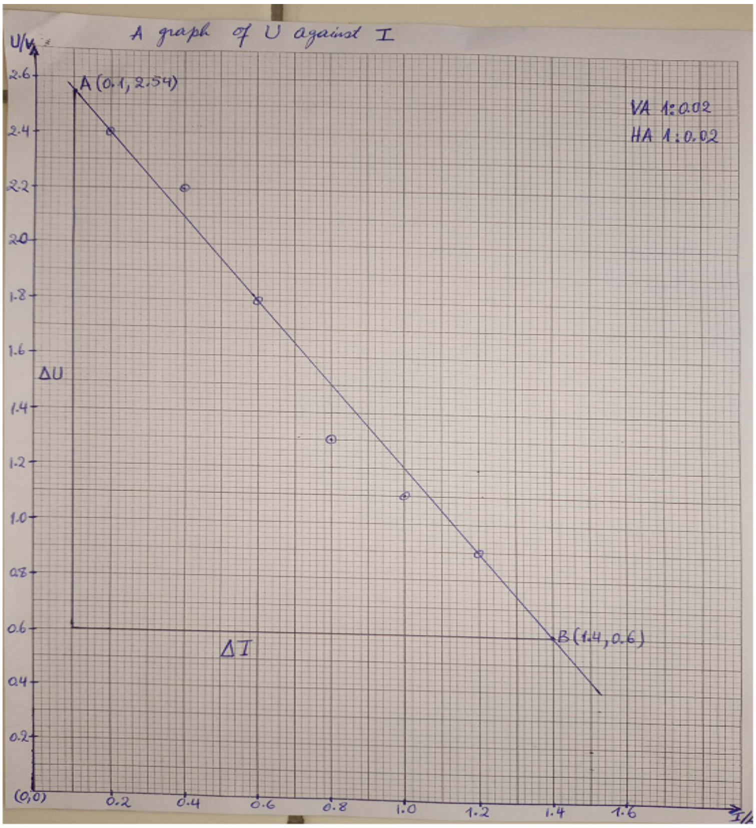
Conclusion

The cell provides electrical energy needed to light the bulb. The bulb converts electrical energy into light and heat energy. A cell is a kind of a 'pump' which provides electrical energy needed to drive charges along a complete path formed by the wire through the bulb switch and back again to the cell.

Experiment 12.2: Verification of Ohm's law.

Expected answers for interpretation of results

1) Graph of U against I



2)

Current, I/A	Voltage, U/v
0.2	2.4
0.4	2.2
0.6	1.8
0.8	1.3
1.0	1.1
1.2	0.9

Slope, $S = \frac{(0.60 - 2.54)V}{(1.4 - 0.1)A} = -1.47\Omega$, The absolute value of the slope is 1.47Ω

3) Unit of the slope is Ω.

4) For any resistor, the potential difference pd across its ends is proportional to the current flowing through it. This fact is expressed by the Ohm's law.

Conclusion.

For any resistor, the potential difference pd across its ends is proportional to the current flowing through it. This fact is expressed by the Ohm's law.

Experiment 12.3: Investigation of the chemical effect of electric current.

Expected answers for interpretation of results

1. Yes.
2. There is formation of bubbles around the nail connected to the negative terminal.

$$NaCl \rightarrow Na^{+} + Cl^{-}$$

Conclusion.

A chemical reaction takes place when an electric current passes through a conducting solution. As a result, bubbles of a gas may be formed on the electrodes. Na^{+} molecules will be attached to the negative electrodes.

Experiment 12.4: Investigate the heating effect of electric current

Expected answers for interpretation of results

1. After 4 minutes, the bulb got hot
2. The bulb got hot because of the electric current that is passing through it. Hence the bulb can convert electric current into heat and light.

Conclusion

As you carry out the experiment, you have noticed that the bulb got hot as the time increased and the electric current

Experiment 12.5: Investigation of the magnetic effect of electric current

1. When the circuit is open, nothing happens on the magnetic needle
2. When the circuit is closed, the magnetic needle deflects showing that electric current has produced magnetic field around it.

Experiment 13.1: Image formed by pin hole camera

Expected answers for interpretation of results

1. U=25cm

   V=15cm
2. I=0.9cm
3. $m = \frac{v}{u} = \frac{15cm}{25cm} = 0.6$
4. $O = \frac{I}{m} = \frac{0.9cm}{0.6} = 1.5cm$
5. The image formed by pinhole camera is:
   - Real
   - Inverted
   - Diminished

Conclusion

When an object is in front of a Pinhole camera, an image forms on the film. Since the Pinhole camera has a small hole, only a small amount of light can go through the camera and reflect on the film. The image in a pinhole camera is inverted (upside down) as compared to the object. The image in a pinhole camera is real (because it can be formed on a screen)

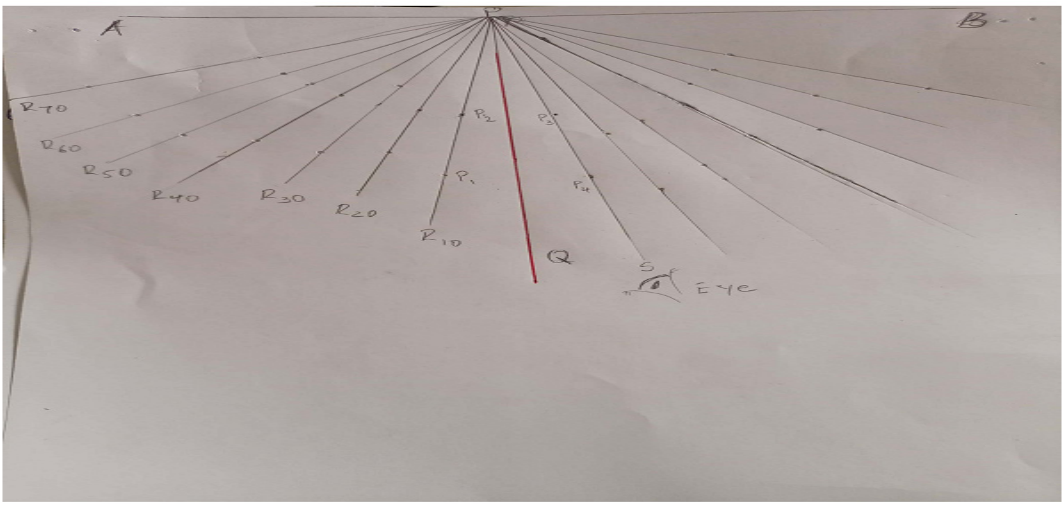
Experiment 13.2: Verification of the laws of reflection using optical pins.

Expected answers for interpretation of results

Table of results

$i/^0$	$r/^0$
10	10
20	19
30	30
40	40
50	50
60	60
70	70

1) *i:* angle of incidence, *r:* angle of reflection
2) *i* and *r* are equal *(i=r)*
3) - Incident ray, reflected ray and normal are in the same plane
   - Angle of incidence equals to the angle of reflection.



Conclusion

The observations show that the incident ray, the reflected ray and the normal, all lie in the plane of the paper.

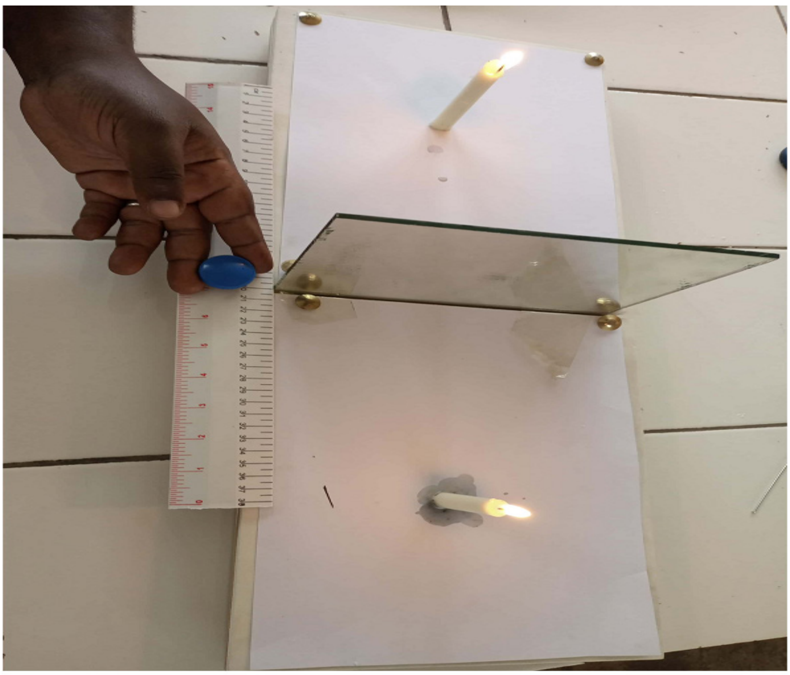
Experiment 13.3: Location of image on plane mirror

Expected answers for interpretation of results

1. x=17cm
2. y=17.2cm
3. x and y are approximately the same (x = y = 17.0cm) Note: The position of image formed by a plane is symmetric to the position of object about the mirror.
4. The image formed by a plane mirror is:
   - Virtual
   - Lateral inverted
   - Has the same size as the object.

Conclusion:

- A plane mirror always forms a virtual image (behind the mirror).
- The image and object are the same distance from a flat mirror, the image size is the same as the object size, and the image is upright.



Picture of reference.

Experiment 13.4: Verification of rectilinear propagation of light

Expected answers for interpretation of results

1. When three cardboards are all on straight line, you can see the lighting candle.
2. When cardboards are disorganized, I did not see the candle except the surface of moved cardboards.
3. From this experiment, I can conclude that the candle can be seen if and only if all cardboards are aligned such that three holes are on straight line. Hence, the light travels through straight path.

Conclusion

You should have observed that when the holes are aligned, light from the candle is seen through the three holes in a straight line. When the holes are not aligned, the light is not seen.

Experiment 13.5: Construction of a simple periscope

Expected answers for interpretation of results

1. Yes, the images were observed.
2. The characteristic of images formed
    - Virtual
    - The same size as the object
    - Upright

Conclusion

In the periscope, light hits the top mirror at 45°C and reflects away at the same angle. The light then bounces down to the bottom mirror. When that reflected light hits the second mirror, it is reflected again at 45 degrees, right into our eye. Hence, the image is due to the reflections at two mirrors.

SENIOR TWO EXPERIMENTS' EXPECTED RESULTS

Experiment 1.1: Determination of the compound errors in single measured physical quantities

Expected answers for interpretation of results.

Table of results

Number of reading	Length /cm	Width/cm
Reading 1	29.7	21.0
Reading 2	29.8	21.0
Reading 3	29.7	21.0

1. Common sources of error include instrument used, environmental issues, procedures taken, and human error. All these errors can be either random or systematic depending on how they affect the results.
2. – Check the instrument for accuracy
   – Make the measurement with the instrument that has the highest precision
   – Make sure observers are in the right position. And this position is your eyes being perpendicular to the instrument being read.
   – Take the measurement under controlled conditions.

Conclusion

There are a variety of source of errors which might lead to the deviation of the accurate results. So, when carrying out a range of experiments, try to avoid any possible mistake which might deviate the results severely.

Experiment 1.2: Investigation of the sources and types of errors

Expected answers for interpretation of results.

$$L = (29.50 \pm 0.05)cm$$
$$W = (20.30 \pm 0.05)cm$$

1. $$C \pm \Delta C = 2(L \pm \Delta Lr + W \pm \Delta L) = 2(L + W) \pm 2(Lr + \Delta L)$$
$$= 2\left[(29.50 + 20.30) \pm 2(0.05 + 0.05)\right]cm$$
$$= \left[\left(2 \times 49.84\right) \pm \left(2 \times 0.10\right)\right]$$
$$= \left(99.68 \pm 0.20\right)cm$$
$$C = 99.68cm \quad and \quad \Delta C = \pm 0.20cm$$

2. $$S = L \times W$$
$$S \pm \Delta S = (L \times W) \pm (W\Delta Lr + L\Delta Lr)$$
$$= [(29.52 \times 20.32) \pm (20.32 \times 0.05 + 29.52 \times 0.05$$
$$= [599.85 \pm (1.016 + 1.47)]cm^2$$
$$= (599.85 \pm 2.50)cm^2$$
$$S = 599.85cm \quad and \quad \Delta S = \pm 2.50cm^2$$

3. The final result is larger than the uncertainty in the individual measurement because during experiment propagation of errors were added up and multiplied.

Conclusion

The propagation of errors in measurement helps in proper treatment of unsuspected sources of error that would emerge if measurements covered a range of operating conditions and a sufficient time.

Experiment 1.3. Investigation of the sources and types of errors

Expected answers for interpretation of results.

$D = (6.30 \pm 0.05)cm$

$\Delta L = 0.05cm$

$H_1 = 2.40$ $\quad$ $H_1 = (2.40 \pm 0.05)cm$

$H_2 = 6.20$ $\quad$ $H_2 = (6.20 \pm 0.05)cm$

$H_3 = 8.50$ $\quad$ $H_3 = (8.50 \pm 0.05)cm$

1. Surface area of the base

$$S = \pi\left(\frac{D}{2}\right)^2 = \frac{22}{7}\times\left(\frac{D \pm \Delta Lr}{2}\right)^2$$

$$= \frac{22}{7}\times\left(\frac{D^2 \pm 2D\Delta Lr}{4}\right)$$

$$= \frac{22}{7}\times\left(\frac{(6.30)^2 \pm (2\times 6.30\times 0.05)}{4}\right)cm^2$$

$$= \frac{22}{7}\times\left(\frac{39.69 \pm 0.63}{4}\right)cm^2$$

$$= \left(\frac{22}{7}\times\frac{39.69}{4} \pm \frac{22}{7}\times\frac{0.63}{4}\right)cm^2$$

$$= (31.18 \pm 0.49)cm^2$$

$$S \pm \Delta S = (31.19 \pm 0.49)cm^2$$

***Volume corresponding with H_3,**

$$V_3 = S\times H_3 = (S \pm \Delta S)\times(H_3 \pm \Delta Lr)$$

$$= \left[(31.18 \pm 0.49)\times(8.50 \pm 0.05)\right]cm^3$$

$$= \left[(31.18\times 8.5) \pm (31.18\times 0.05 + 8.50\times 0.49)\right]cm^3$$

$$= \left[265.03 \pm (1.56 + 4.16)\right]cm^3$$

$$= (265.03 \pm 5.72)cm^3$$

***Volume corresponding with H_2,**

$$V_2 = S \times H_2 = (S \pm \Delta S) \times (H_2 \pm \Delta Lr)$$
$$= \left[(31.18 \pm 0.49) \times (6.20 \pm 0.05)\right] cm^3$$
$$= \left[(31.18 \times 6.20) \pm (31.18 \times 0.05 + 6.20 \times 0.49)\right] cm^3$$
$$= \left[193.32 \pm (1.56 + 3.04)\right] cm^3$$
$$= (193.32 \pm 4.60) cm^3$$

***Volume corresponding with H_1**

$$V_1 = V_3 - V_2 = \left[(265.03 \pm 5.72) - (193.32 \pm 4.60)\right] cm^3$$
$$= \left[(265.03 - 193.32) \pm (5.72 + 4.60)\right] cm^3$$
$$= (71.71 \pm 10.32) cm^3$$

2. They are the same
3. Relative error in V_1,

$$\frac{\Delta V_1}{V_1} = \pm \frac{10.32}{71.71} = \pm 0.144$$

$$or \quad \frac{\Delta V_1}{V_1} = \pm 14.4\%$$

Conclusion

The propagation of errors in measurement helps in proper treatment of unsuspected sources of error that would emerge if measurements covered a range of operating conditions and a sufficient time.

Experiment 1.4. Rounding off a number

Expected answers for interpretation of results.

Table of results

Obtained value	Round off to 2 decimal place
62.63	62.70
17.23	17.00
51.84	51.90
73.14	73.00

1) When rounding, we are creating numbers that are approximate to their original value. The advantage to rounding is that it gives us numbers that are easier to work with
2) It disadvantages of using round off numbers is that the numbers will not always be exact.

Conclusion

As humans, it is harder to use just any number to make sense of things. Rounding numbers makes simpler and easier to use. Although they are slightly less accurate, their values are still relatively close to what they originally were.

Experiment 2.1: Determination of acceleration due to gravity.

Expected answers for interpretation of results.

Table of results

Mass/g	Weight/N
20	0.2
40	0.4
60	0.6
80	0.8
100	1.0
120	1.2
140	1.4
160	1.6
180	1.8
200	2.0

1) From the figure,

$$S = \frac{W_A - W_B}{m_A - m_B}$$

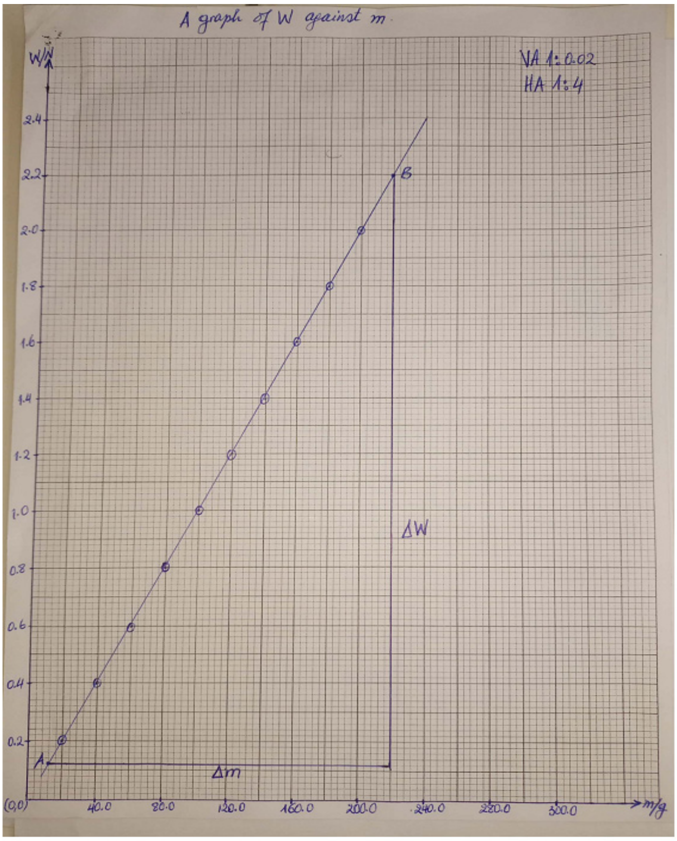
$$S = \frac{(2.4 - 0.1)N}{(240 - 10)g} = \frac{2.3N}{230g} = 0.01\,{}^{N}\!/_{g}$$

$$= \frac{0.01N}{10^{-3}kg} = 0.01 \times 10^{3}\,{}^{N}\!/_{kg} = 10.0\,{}^{N}\!/_{kg} = 10.0\,{}^{m}\!/_{s^2}$$

2) The S.I Unit of the slope is ${}^{m}\!/_{s^2}$

3) Slope is slightly equal to the average value of “g”

4) Because of the earth's pull of gravity.



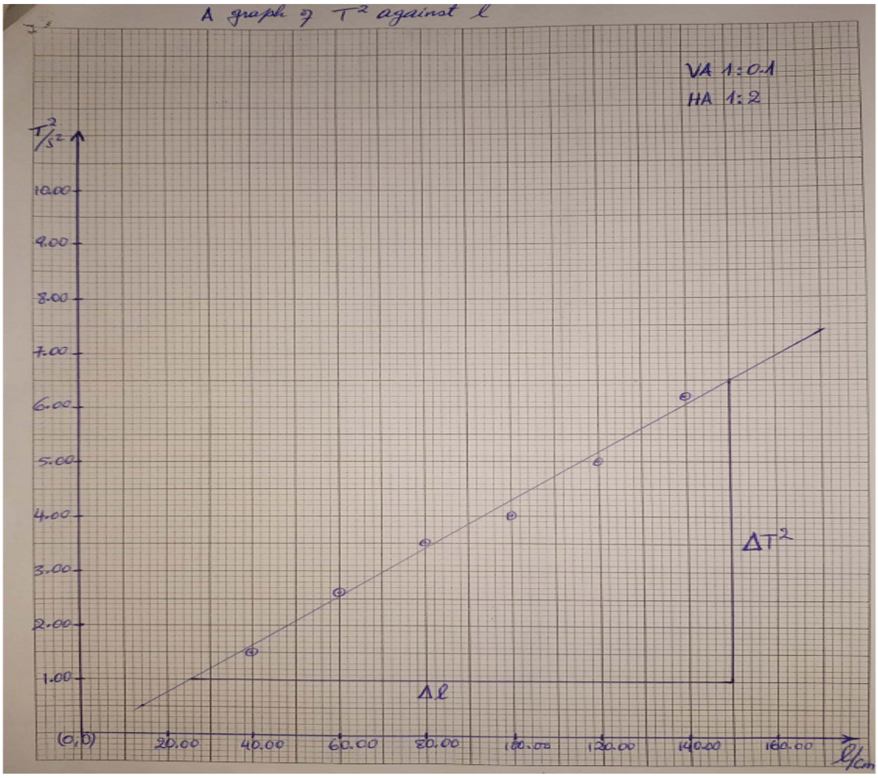
Experiment 2.2: Determination of acceleration due to gravity by using Simple Pendulum

Expected answers for interpretation of results.

Table of results

L/cm	t_{20}/s	T/s	T^2/s^2
40.00	25.00	1.25	1.56
60.00	30.00	1.50	2.25
80.00	35.00	1.75	3.06
100.00	40.00	2.00	4.00
120.00	45.00	2.25	5.05
140.00	50.00	2.50	6.25

1)



2) Slope, $m = \frac{T_B^2 - T_A^2}{l_B - l_A} = \frac{(6.50 - 1.00)s^2}{(150.00 - 26.00)cm} = \frac{5.50s^2}{124cm} = 0.04\, {}^{s^2}\!/_{cm}$

3) SI Unit of slope, $m = {}^{m}\!/_{s^2}$

$$m = \frac{4\pi^2}{g}$$

4) $$g = \frac{4\pi^2}{m} = \frac{(3.14)^2 \times 4}{0.04\, {}^{s^2}\!/_{cm}} = 985.96 cm/s^2$$

$$Thus,\ g = 985.96\, {}^{cm}\!/_{s^2} = 9.86\, {}^{m}\!/_{s^2}$$

5) Yes, he was correct, since $T = 2\pi\sqrt{\frac{l}{g}}$, then T& $\sqrt{l}$. (i.e. as *l* increases, period T increases)

6) Air resistance affects the time period T of the pendulum, by increasing.

Conclusion

As conclusion, the value of gravitational acceleration obtained in our experiment is 9.86 m/s2, the actual value of g is 9.81 m/s2. However due to errors which may be made in the experiment the value of g should vary in the range of 9.71 and 9.91.

Experiment 2.3. Determination of acceleration of a body using inclined plane and marble

Expected answers for interpretation of results.

Materials arranged with an inclined angle of 10^0

Distance, d /m	Time, t/s	Initial velocity, V_i/m/s	Final velocity, V_f/m/s
1	2.06	0	0
2	2.66		
3	3.20		

1) $v_{AB} = {}^{1m}\!/_{2.06s} = 0.48m/s$

2) $v_{BC} = {}^{1m}\!/_{(2.66-2.06)}s = 1.67m/s$

3) $v_{CD} = {}^{1m}\!/_{(3.20-2.66)}s = 1.85m/s$

4) The marble is fastest through distance CD.

5) $a_{AC} = {}^{1.85}\!/_{3.20} = 0.58m/s^2$

Conclusion:

The velocity of the marble increases as it moves down the inclined plane. At the bottom of the inclined plane the marble reaches the maximum velocity and this velocity starts decreasing as the marble moving horizontally until it will slow down.

Experiment 3.1: Determination of coefficient of friction

Expected answers for interpretation of results.

M = 808g

M= 500g

1) $$\mu = \frac{0.500\times 10 - 0.808\times 10\times \sin 20^o}{0.808\times 10\times \cos 20^o}$$

$$\mu = 0.29$$

2) No. The value of μ will increase.

Conclusion

It is clearly shown that the coefficient of friction determines the "stickiness" between two objects and many areas of everyday life are affected by friction issues.

Experiment 3.2: Investigation of tension force

Expected answers for interpretation of results.

Table of results

m/g	W/N
400	0.4
600	0.6
800	0.8

1) Tension force
2) The tension decreases the apparent weight of the stone, because it acts as the action-reaction.

Conclusion

Tension is described as the pulling force transmitted axially by the means of a string, a cable, chain, or similar object, or by each end of a rod, truss member, or similar three-dimensional object; tension might also be described as the action-reaction pair of forces acting at each end of elements. Tension could be the opposite of compression.

Experiment 4.1: Investigation of the pressure of a solid

Expected answers for interpretation of results.

L =18.0cm

w = 8.0cm

h = 4.5cm

$A_1 = l \times w = 18.0cm \times 8.0cm = 144.0cm^2$, depression caused by large side, $\delta_1 = 0.5cm$

$A_2 = l \times w = 8.0cm \times 4.5cm = 36.0cm^2$, depression caused by small, $\delta_2 = 0.8cm$

1) $P_1 = W/_{A_1} = {}^{12N}/_{0.0144m^2} = 833.3N/m^2$

2) $P_2 = W/_{A_2} = {}^{12N}/_{0.0036m^2} = 3,333.3N/m^2$

3) Pressure P_2 exerted by large, small side, is higher than the pressure P_1 exerted by large side.

4) The difference in the depression is due to the difference in pressure exerted by different sides of the brick. As the surface becomes smaller as the depression become high.

Conclusion

As the experiment run, the relationship between pressure, force and area of contact, can solve problems involving pressure, force and area in some more activities.

Experiment 4.2: Investigation of the pressure in liquids

Expected answers for interpretation of results.

1) If we connect the manometer to a process there would be variations in the liquid level of the column, and these variations will be dependent on the pressure source that is to be measured
2) The cause of that change is based on hydrostatic balance principle which state that the pressure at any point in a fluid at rest is due to the weight of the overlying fluid.

Conclusion

Pressure increases as the depth increases. The pressure in a liquid is due to the weight of the column of water above. Since the particles in a liquid are tightly packed, this pressure acts in all directions.

Experiment 4.3: Determination of the densities of two liquids by means of Hare's apparatus

1. The liquids rise until the pressures exerted at the base of each column are each equal to atmospheric pressure
2. The liquids rise until the pressure due to each liquid column is equal to the difference between atmospheric pressure and the pressure P inside the glass tube.
3.

Hence, $P_A = \rho_A gH_1 + PandP_B = \rho_B gH_2 + P$ or $P_A = P_B$

Then $\rho_A gH_1 + P = \rho_B gH_2 + P$

Or $\rho_A gH_1 = \rho_B gH_2$

Or $\rho_A H_1 = \rho_B H_2$

Or $\rho_B = \frac{\rho_A H_1}{H_2}$ or H_1=26.4cm, H_2=24.6, and $\rho_A = 1000\frac{Kg}{m^3}$

Or $\rho_B = \dfrac{1000\dfrac{Kg}{m^3} \times 26.4cm}{24.6cm} = 1073\dfrac{Kg}{m^3}$

Conclusion

This experiment shows that in Hare's apparatus, some air is sucked out of the tubes through the center limb of the T-piece and the clip closed. Removal of air causes a reduction of pressure inside, with the result that atmospheric pressure pushes the liquids up the tubes.

Experiment 4.4: Measurement of atmospheric pressure using barometer

1. Small changes in external air pressure cause the cell to expand or contract.
2. The aneroid barometer is sensitive to temperature variations, because the capsule and its linkages will expand or contract as the temperature changes.

Conclusion

An aneroid barometer has a sealed metal chamber that expands and contracts, depending on the atmospheric pressure around it. So it measures how much the chamber expands or contracts. This measurements are aligned with atmospheres or bars.

Experiment 4.5: Demonstration of the use of a Siphon

1. Liquid flows from the higher-pressure area of the jerry can to the lower-pressure(bucket) zone at the top of the siphon, over the top, and then, with the help of gravity and a taller column of liquid, down to the higher-pressure zone at the exit
2. In Siphon, liquids flow upward, above the surface of a container, with no pump, but powered by the fall of the liquid as it flows down the tube under the pull of gravity, then discharging at a level lower than the surface of the container from which it came.

Conclusion

In this experiment, a simple siphon raises water over a crest and discharges it a lower level. As water flows through a siphon, energy due to pressure is either lost to pipe friction or converted to kinetic energy.

Experiment 4.6. Investigation of atmospheric pressure using drinking straws

Expected answers for interpretation of results.

1) Air presses down equally on the water in the bottle and in the straw when there is no balloon present (or the balloon is pegged) but when the peg is removed, air from the balloon increases the air pressure (atmospheric pressure) in the bottle which pushes down on the water, forcing it through the straw.

Conclusion

Be careful as it might shoot out further than you expect.

Experiment 4.7: A can/ plastic bottle crushing (deformation) experiment

Expected answers for interpretation of results.

1) When we placed the bottle in the ice and poured cold water on it, the air inside the bottle began to cool down rapidly. The cool air exerts less pressure than hot air, therefore the air pressure inside the bottle began to decrease.
2) The air pressure inside the bottle decreased to the point where it was less than the air pressure outside the bottle. Therefore, the air pressure pushing in was greater than the air pressure pushing out, causing the bottle to be crushed!

Conclusion

You can conclude that, the coldness from ice cools the air inside the bottle. As the air temperature changes, the air pressure drops and the sides of the bottle collapse.

Experiment 4.8: Investigation of atmospheric pressure in using candle

Expected answers for interpretation of results.

1) After some time, the candle dims and goes out. Just before the candle dies, the water level rises to almost 1/10 th of pitcher height. No air bubbles are seen. The water level stays up for many few minutes more.
2) The candle heats the air and expands it. This cancels the depletion of the oxygen temporarily and the water level stays down. When the oxygen is depleted, the candle goes out and the air cools. The volume of the air decreases and the water rises. The temporary temperature change delays the rise of the water.

Conclusion

In this experiment, during the heating stage air escapes. Afterwards, the air volume decreases and pulls the water up.

Experiment 5.1: Investigation of the pressure in liquids using communicating vessel

Expected answers for interpretation of results.

1) When the liquid settles, it balances out to the same level in all of the containers regardless of the shape and volume of the containers. If additional liquid is added to one vessel, the liquid will again find a new equal level in all the connected vessels.
2) Pressure exerted on a molecule of a liquid is transmitted in full and with the same intensity in all directions. It occurs because gravity and pressure are constant in each vessel following the hydrostatic pressure

Conclusion

In this experiment, when the liquid settles, it balances out to the same level in all of the containers regardless of the shape and volume of the containers.

Experiment 5.2. Investigation of the the pressure in liquids

1. The pressure increases with increasing depth (height). With holes of the same size at three different levels in the can, the jet from the top hole reach the table nearest the can, the jet from the middle arrive further out and the jet from the lowest hole, with the biggest pressure arrive farthest out. Hence, the range reached by water depends on the pressure inside the can, where is higher at the bottom than the top
2. The water falls at different distance because the difference outpolling pressure.
3. The pressure in a liquid is different at different depths. Pressure increases as thWe depth increases. The pressure in a liquid is due to the weight of the column of liquid above. Since the particles in a liquid are tightly packed, this pressure acts in all directions.

4. To calculate the velocity *v* with which water emerges from a hole at depth *h* below the surface of the water, use:

5. $\frac{mV^2}{2} = mgh$ hence, $V^2 = 2gh$

6. Where *g* is the gravitational field strength. Then the water can be treated as a projectile moving under gravity.

Conclusion

In this experiment, we poured more water in a plastic can with holes and we have seen that the holes at the bottom squeeze water with high speed than the holes at the top. This indicates that the pressure exerted by water increases with the increase of depth.

Experiment 5.3. Determinationof the relative density using a manometer

Expected answers for interpretation of results.

1. The difference between h and h' is due to the difference in liquids' density. The denser the fluid is, the higher pressure it can support, and the lower height it produces.
2. The principle of the manometer is that the pressure to be measured is applied to one side of the tube producing a movement of liquid, as shown in **Figure 5.3.** It can be seen that the level of the filling liquid in the side where the pressure is applied, i.e. the left side of the tube, has dropped, while that in the right hand side has risen. A scale is fitted between the tubes to enable us to measure this displacement. Let us assume that the pressure we are measuring and have applied to the left hand side of the manometer is of constant value. The liquid will only stop moving when the pressure exerted by the column of liquid, h is sufficient to balance the pressure applied to the left side of the manometer, i.e. when the head pressure produced by column h' is equal to the pressure to be measured. Knowing the length of the column of the liquid, H, and density of the filling liquid, we can calculate the value of the applied pressure

3. Results from the experiment revealed that

$$M_1 = N_1 = 228mm$$

$$M_2 = 320mm$$

$$N_2 = 314mm$$

$$h' = N_2 - N_1 = (314 - 228)mm = 86mm$$

$$h = M_2 - M_1 = (320 - 228)mm = 92mm$$

$$P_A = P_B$$

$$P_A = P + \rho_{oil} gh$$

$$P_B = P + \rho_{water} gh'$$

$$P_A = P_B \Rightarrow P + \rho_{oil} gh = P + \rho_{water} gh'$$

$$\rho_{oil} gh = \rho_{water} gh'$$

$$\rho_{oil} = \frac{\rho_{water} \times h'}{h}$$

$$\rho_{oil} = \frac{1000 \frac{Kg}{m^3} \times 86mm}{92mm} = 934.7 \frac{Kg}{m^3}$$

Conclusion

In this experiment, the pressure at a certain level in liquid is the same at all points of the container on that level. Manometer is a device used to measure the pressure or comparing the densities of two liquids.

Experiment 6.1. Investigation of the variation of Pressure with Depth.

Expected answers for interpretation of results.

1) Pressure and depth have a directly proportional relationship. Pressure increases as the depth increases. This causes the water to flow with higher speed at the bottom than the top. The pressure in a liquid is due to the weight of the column of water above. Since the particles in a liquid are tightly packed, this pressure acts in all directions and cause the water to flow far.
2) As the pressure increases, water flows out with a high speed and reached a long distance.
3) To calculate the velocity *v* with which water emerges from a hole at depth *h* below the surface of the water, use:
4) $\frac{mV^2}{2} = mgh$ hence, $V^2 = 2gh$
5) Where *g* is the gravitational field strength. Then the water can be treated as a projectile moving under gravity
6) The pressure exerted by a static fluid depends upon the depth of the fluid, the density of the fluid, and the acceleration of gravity. The fluid pressure at a given depth does not depend upon the total mass or total volume of the liquid

Conclusion

In this experiment, we have seen that pressure increases as the depth increases. The pressure in a liquids is due to the height of the column of water above. Since the particles in a liquid are tightly packed, this pressure acts in all directions.

Experiment 7.1. Demonstration of the existence of atmospheric pressure

Expected answers for interpretation of results.

1) The atmospheric pressure made the card to be pushed upwards.
2) The force exerted by air (atmospheric pressure) is greater than the weight of the water inside the glass

Conclusion

From the experiment done, it implies that there is always atmospheric pressure acting on the surfaces at all points equally in all directions.

Experiment 7.2. Measurement of atmospheric pressure using barometer

Expected answers for interpretation of results.

1. The colored water was seen rising up in the capillary tube. After a certain time, colored water stopped rising.
2. From observation made in Q.1, the rising of water is due to the presence of greater pressure in water than in the capillary tube.

Conclusion

The water moves upwards in the capillary tube due to pressure difference between the free surface of water container and the capillary tube, hence liquids always move from regions of higher pressure to regions of lower pressure.

Experiment 7.3. Investigation of the the up thrust (buoyancy) of water

Expected answers for interpretation of results.

1) For each mass, there is an apparent weight and actual weights that are measured as required.
2) Some objects are denser than water that is why they sink. Thus, those that are less dense than water float.
3) Volume of solid is equal to the volume of displaced water.
4) The difference in weights is due to the up thrust that caused the decrease in the apparent weight of the immersed mass.

Conclusion

Basing on the experiment carried out, for any given mass, there is apparent weight and actual weight. Hence, their difference is the up thrust force (buoyancy of Archimedes force).

Experiment 7.4. Verification of Archimedes principle

Expected answers for interpretation of results.

1) The change are due to resistance forces that is exerted by water.
2) This is a resistive force that oppose the real weight resulting to net force being less than real weight
3) The upward force is equal to the weight of displaced water.
4) Up thrust = Difference in weight $DW = (M_1 - M_2)g$, the answer depends on the values of masses used in the experiment.
5) $W = \rho_w V g$

   $\rho_w = 1000 kgm^{-3}$

   V=depends on the volume obtained in the experiment

   $g = 10 m/s^2$

E.g= Using a mass of 100g=0.1kg. Volume of displaced water=12.5ml

$V = 12.5 \times 10^{-6} m^3$

$Then\ W = 1000 \times 12.5 \times 10^{-6} \times 10 = 12.5 \times 10^{-2} N = 1.25 \times 10^{-1} N,$

Note: Remember that you can use any mass. This means that the volume of displaced water wil depend on the mass and the nature of body used.

Conclusion

The upward force exerted by water (Called upthrust) is equal to the weight of displaced water. Basing on this, Archimedes Principle is verified.

Experiment 7.5. Determination of the density / Relative density of a solid using Principle of Archimedes

Expected answers for interpretation of results.

1) $D = \frac{Mass}{Volume}$
2) Depending on the values of mass used in the experiment and volume of displaced liquid, then the density can be easily calculated using the above formula.

Conclusion

The density of a solid object can be obtained by overflow method.

Experiment 8.1. Determination of the personal power

Expected answers for interpretation of results.

1) $Vertical\ height = 6steps \times 0.15m = 0.9m$

2) Work done in climbing the stairs = $\left(50kg \times 10 m/_{s^2} \times 0.9m\right) = 450J$

3) Time is 4s

4) $Power = \dfrac{450J}{4s} = 112.5W$

Conclusion

Work, energy and power are fundamental concepts of Physics. Work is the displacement of an object when a force (push or pull) is applied to it. We define the capacity to do the work as energy. Power is the work done per unit of time.

UNIT 9 CONSERVATION OF MECHANICAL ENERGY IN ISOLATED SYSTEM.

Experiment 9.1. Energy conversion (potential energy into kinetic energy and vice versa)

Expected answers for interpretation of results.

1) The fro and to movement results from the decrease in speed, because observations show that as the mass is released, it starts by moving in increasing the speed. While at the edge of the path it returns because its speed becomes zero.

2) The mean position (Equilibrium position) is the point where the bob was at rest when no external force was applied upon it.

3) At the equilibrium position, the body occupy lowest position relative to the horizontal surface. At that point the bob has minimum potential energy and the bob tends to move fast around this position, hence having highest (maximum) kinetic energy.

Conclusion

From this experiment, we have seen that the total mechanical energy in the system of the pendulum remains constant. This is called conservation of energy of mechanical energy. Similarly, the energy can neither be created nor destroyed. It only be changed from one form to another. This is called law of conservation of energy.

Experiment 9.2. Investigation of the open and closed system

Expected answers for interpretation of results.

1) The temperature recorded in calorimeter is greater than that recorded in cooking vessel.

2) The temperature in cooking vessel decreases rapidly because there is a high loss of heat as the hot water and vessel are in open environment. The temperature in calorimeter decreases slowly because there is no contact of hot water with the surrounding. So, the system is closed.

3) The calorimetric system is closed while cooking vessel system is opened.

Conclusion

From this experiment, we have seen that in the open system, temperature will be gradually reduced as the time increases. This means that the energy (heat) and matters (water vapor) will be transferred out of the beaker (open system). In the closed system (closed flask) the energy is exchanged but no matter transferred out the flask.

Experiment 10.1. Verification of Boyle's law

Expected answers for interpretation of results.

1) It is somehow hard to push the plunger as the lower opening is closed. The air is compressed and the balloon gradually decreases the volume. Increase of the pressure in the syringe decreases the volume of the balloon.
2) When you pull the plunger, the balloon inside the balloon increases the volume as you pull.

Conclusion

Boyle's law state that the pressure and volume of an ideal gas are inversely proportional as long as its temperature remain constant.

Experiment 10.2. Verification of Charles's law

Expected answers for interpretation of results.

1) The reason behind the inflation of the balloon is that there is a change in temperature of the air in the balloon.
2) The gas expand by heating because the volume of the gas increase or decrease by the change of the temperature.

Conclusion

Charles' law state that the volume occupied by a fixed amount of gas is directly proportional to its absolute temperature. If the pressure remains constant.

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$, V as volume and T as temperature

Experiment 11.1. Magnetization by electric current

Expected answers for interpretation of results.

1) By bringing the nails toward the steel rod before it is connected to the source of voltage, there was no effect on it (The nail was not attracted).
2) By switching on the source of current, it was observed that there was no effect of the steel rod on the nail. After 10 minutes, it was observed that the steel rod started attracting the iron nail.
3) The nail was attracted because of the existence of magnetic field which was created by the current that was passing through the copper wire wounded on the steel rod.

Conclusion

From the experiment, it is found that the current flowed through the wire created magnetic field. It intensively increases with number of turns of the copper wire.

Experiment 11.2. Magnetize a steel bar by single-touch method

Expected answers for interpretation of results.

1. Before stroking, the steel rod did not have any effect on the iron nail.
2. After stroking, it was observed that the nail was attracted to the steel rod.
3. From the results, it is observed that before stroking, the steel rod had no effect on the nail because its magnetic domain was not affected. After stroking, the magnetic domain of the steel rod was aligned leading to the magnetization of the steel rod, hence attracting the iron nail.

Conclusion

The movement of a magnet along the steel rod (or any ferromagnetic material) leads to the alignment of its magnetic domain. Thus, making the steel rod magnetized.

Experiment 11.3. Magnetization by induction

Expected answers for interpretation of results.

1) It was observed that the steel rod had no effect on the nail.
2) By putting the iron nail near or towards the steel bar, it was found out that the iron nail was attracted to it. This indicates that the steel rod became magnetized by induction process.
3) At first, the steel did not attract the iron nail because the steel was not magnetized. For the second case, the steel was brought into magnetic field of the magnet and in turn, the steel became magnetized. The magnetization of the steel rod was due to magnetic field of the strong magnet.

Conclusion

From the observations, when a ferromagnetic material is brought near a strong magnet, it becomes magnetized by induction.

Experiment 11.4. Demagnetization by Heating

Expected answers for interpretation of results.

1) The heated magnet did not attract the nail
2) A magnet subjected to heat experiences to a reduction or total loss of its magnetic properties. This is because according to kinetic theory of matter, increase in temperature leads to the increase in vibrations of particles in the magnet leading to misalignment of magnetic domain in the magnet.

Conclusion

A magnet can lose its magnetism after being heated.

Experiment 11.5. Demagnetization by Hammering

Expected answers for interpretation of results.

1) When the hammered magnet is brought near the nail, the nail is not attracted to it.
2) The nail not attracted because the hammered magnet had lost its magnetic properties during hammering. As long as hammering the magnet leads to both displacement and increase of temperature of atoms in the magnet.

Conclusion

From the observations, it is clear that hammering a magnet can lead to demagnetization of that magnet due to misalignment of magnetic atoms within the magnet.

Experiment 13.1. Investigation of the magnetic effect of the electric current

Expected answers for interpretation of results.

1) Placing a compass needle at any location indicates the geographical North and South.
2) The compass needle stays stable indicating the geographical North.
3) When the circuit is closed, the compass needle starts to deflect.

Conclusion

The observed effect is called the magnetic effect of current also known as electromagnetic effect. It is observed when a compass needle is brought near a current carrying conductor the needle of the compass get deflected because of the flow of electricity. This shows that electric current produce a magnetic effect.

Experiment 13.2. Investigation of the heat effect of the electric current

Expected answers for interpretation of results.

1) Before switching on the circuit, the bulb is cold.
2) After the circuit is closed within 1min, there is a gradually increase in bulb's temperature.

Conclusion

Passing current through an electrical conductor produces thermal energy. This effect is known as joule heating effect.

Experiment 13.3. Investigation of the Chemical effect of the electric current.

Expected answers for interpretation of results.

1) There is a formation of bubbles around the nail connected to the negative terminal
2) The bulb progressively lost its luminosity.

Conclusion

The passage of an electric current through a conducting solution causes chemical reactions. As a result, bubbles of gases may be formed on one nail (electrode). This effect is called electrolysis. Electrolysis is the process by which ionic substances are decomposed (broken down) into simpler substance when an electric current is passed through them.

Experiment 13.4: Making a simple electric circuit

Expected answers for interpretation of results.

1) When the connections are made properly, the circuit will close and the current will flow through the circuit and light the lamp. This effect is called simple circuit.

Conclusion

From this activity, we conclude that the moving electrons through the circuit will cause the change of electrical energy into light.

Experiment 13.5: Measurement of electric current using Ammeter

Expected answers for interpretation of results.

Table of results

Number of reading	**I/A**
I_1	0.22
I_2	0.22
I_3	0.23

1) The current that flow in the circuit is constant or the same
2) The brightness of the bulbs depend on the current flowing in the circuit. The higher the current, the more the brightness of the bulbs.

Conclusion

Placing the bulbs in series causes the resistance of the pair to be double that of a simle bulb because there is only one path for the electrons to flow. Therefore, the same electric current is displayed in each ammeter.

Experiment 13.6: Measurement of potential difference using Voltmeter

Expected answers for interpretation of results.

Table of results

Number of readings	V/V
V_1	2.53
V_2	0.93
V_3	1.41

1) The sum of voltage drop across the bulbs must be equal to the voltage of the battery. The difference is due to voltage dissipated within internal resistances of the component of the circuit.
2) The brightness of a bulb depend on the voltage across its terminal, however, it is affected by the internal resistance of the bulb.

Conclusion

Each voltmeter will read the potential difference (voltage) across the terminal of every component in the circuit.

Experiment 13.7. Investigation of series and parallel connections

Expected answers for interpretation of results.

a) In series

Number of readings	V/V
V_1	2.00
V_2	1.80
V_3	1.50
Source of voltage	**5.44**

I=0.27A

1) When one bulb is removed, all bulbs get switched off.
2) The p.d across each bulb are respectively V_1=2.00V, V_2=1.80V and V_3=1.50V
3) Reading of ammeters, the maximum current is 0.27A

b) In parallel circuit

1) When one bulb is removed from the circuit, other two bulbs continuous lighting up.
2) When the second bulb is removed from the circuit, the remaining bulb continuous to light.
3) The current through each bulb is I_1=0.29A, I_2=0.25A, and I_3=0.30A
4) The potential difference across each bulb is V_1=5.75V, V_2=5.74V and V_3=5.76V

Conclusion

i) A series circuit is a circuit in which resistors are arranged in a chain, so the current has only one path to take.
ii) The current is the same through each resistor.
iii) A parallel circuit is a circuit in which the resistors are arranged with their heads connected together, and their tails connected together.

iv) The current in a parallel circuit breaks up, with some flowing along each parallel branch and re-combining when the branches meet again.

v) The voltage across each resistor in parallel is the same.

Experiment 13.8: Investigation of Ohm's law

Expected answers for interpretation of results.

1)

Number of batteries	Voltage/v	Current/A	Resistance/Ω
1	1.14	0.29	3.93
2	1.76	0.36	4.88
3	2.76	0.45	6.13
4	3.34	0.49	6.81
5	4.23	0.55	7.69

2) Graph below

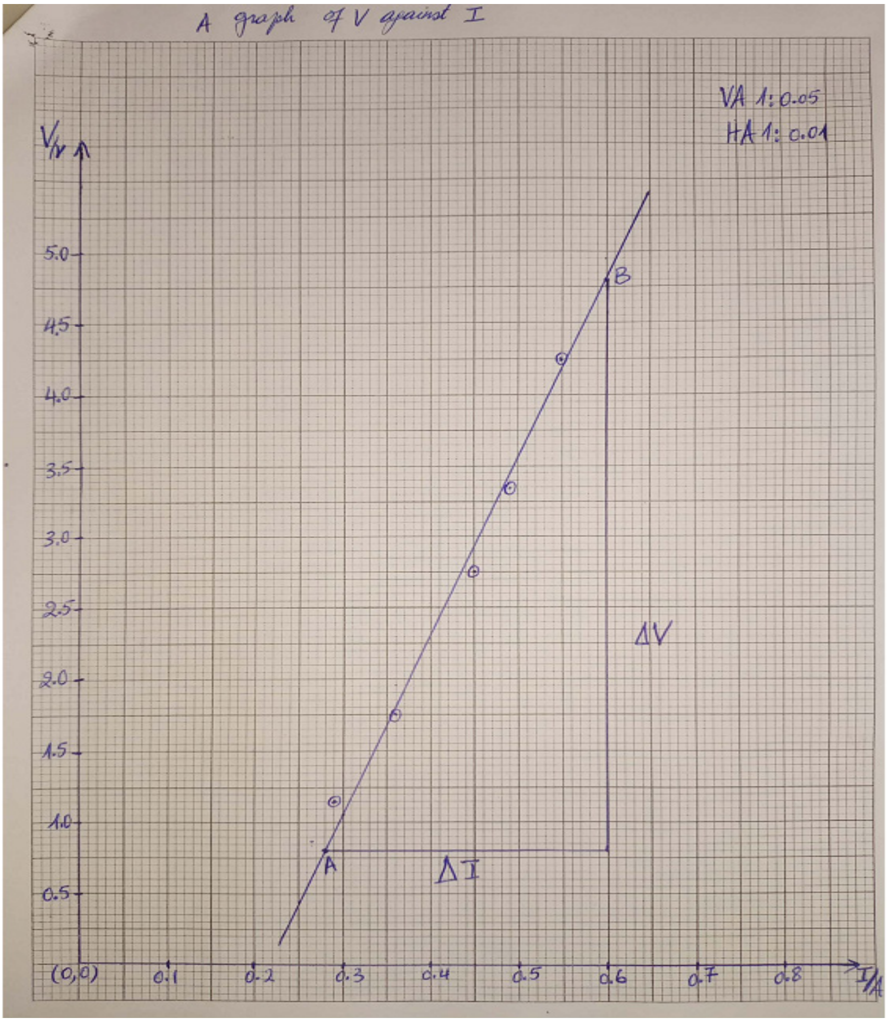
3) $S = \frac{\Delta V}{\Delta I} = \frac{(4.80 - 0.80)V}{(0.60 - 0.28)I} = \frac{4.00V}{0.32A} = 12.50\Omega$

4) The value of the slope "S" calculated from the graph has the same derived dimension as V/I calculated in the table.

5) The slope "S" expresses the resistance.

Conclusion

If the voltage is held constant, then the current is inversely proportional to the resistance. If the voltage polarity is reversed (that is, if the applied voltage is negative instead of positive), the same current flows but in the opposite direction. If Ohm's law is valid, it can be used to define resistance as: *R=VII*


A graph of V against I
VA 1: 0.05
HA 1: 0.01
V/V
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
(0,0)
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
I/A
B
A
ΔV
ΔI

Experiment 14.1: Verification of laws of reflection for plane mirror

Expected answers for interpretation of results.

Table of results

No	Incident angle $i/°$	Reflected angle $r/°$
1	30.0	32.0
2	35.0	36.0
3	40.0	40.0
4	45.0	47.0
5	50.0	51.0
6	55.0	57.0

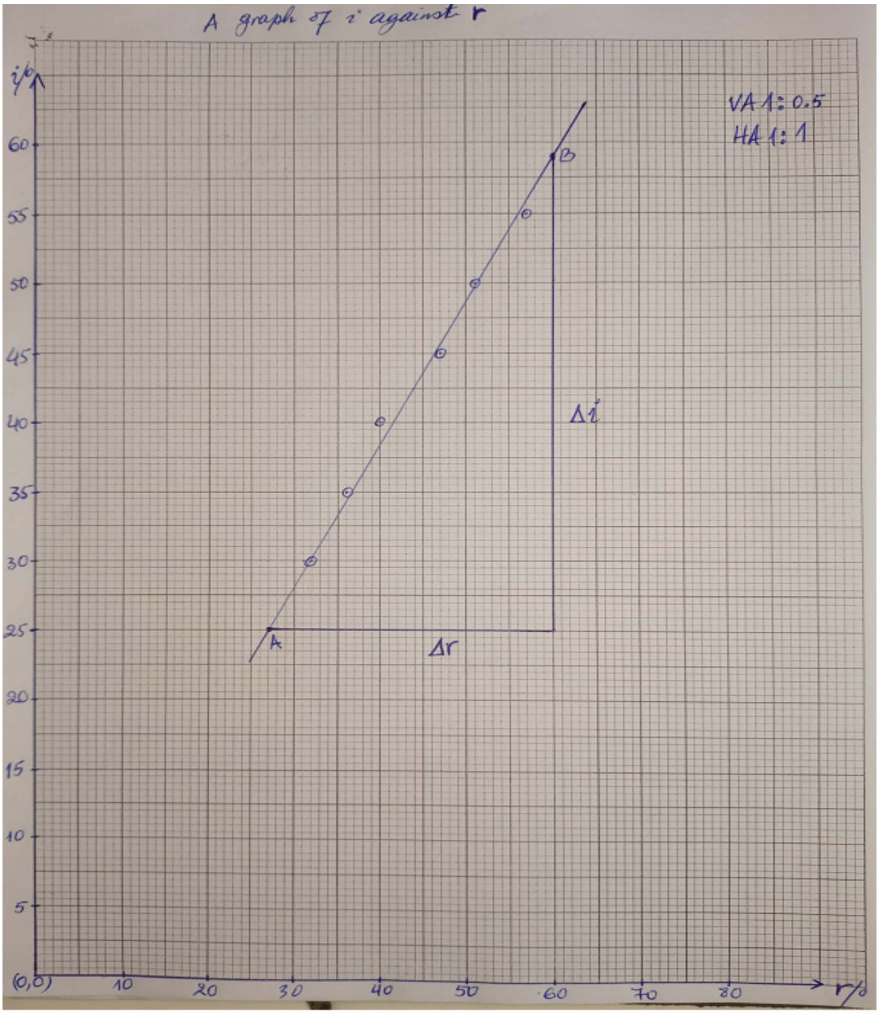
1) Changing the angle of incidence leads to change of angle of reflection. i.e. increasing the incidence angle leads to increase of the reflected angle.
2) When the mirror is not silvered on one side, part of the light is reflected and the other part is refracted. This leads to formation of unclear images of optical pins.
3) Sources of error in this experiment
    - Placing and replacing the plane mirror after trial. i.e. resetting the setups frequently.
    - Incorrect measurement of angles
    - Poor positioning of the eye.
    - Using a blunt pencil while tracing lines on a piece of paper pinned on cardboard.
4) Using two or more optical pins yield high precision

5) Graph paper below

6) From the graph

Slope, $S = \frac{Change\,in\,i\,/\,°}{Change\,in\,r\,/\,°} = \frac{(60-25)\,/\,°}{(60-27)\,/\,°} = \frac{35°}{32°}$

$Slope = 1.09$



Conclusion

Basing on the value of the slope that is almost 1, this implies that the angle of incidence is equal to the angle of reflection. This verifies the law of reflection of light.

Experiment 14.2: Determination of the focal length of concave mirror

Expected answers for interpretation of results.

1) The following are the results that we obtained after performing the experiment.

U=20cm, V=20cm

Thus, from

$$f=\frac{UV}{U+V}$$

$$f=\frac{20\times 20}{20+40}=10cm$$

Note: The value of "*f*" depends on the mirror used. Students can use concave mirrors of focal length of 15cm or 20cm.

2) Repeating the experiment for different values of distance of object leads to minimizing errors in the experiment leading to obtaining precise/exact value of focal length of the minor.

Conclusion

Basing on the obtained results in the experiment, the focal length of a concave mirror can be obtained using the method described above.

Experiment 14.3: Determination of the focal length of a convex mirror

Expected answers for interpretation of results.

Table of results

SI No.	Distance from lens to		Radius of curvature, R/cm
	Object u/cm	Image V/cm	
1	30.0	15.0	14.0
2	28.0	15.0	14.0
3	26.0	16.0	14.5
4	24.0	16.5	14.5

1) Obtained values radius R from each trial are slightly equal.

2) Radius of curvature and focal length are related through $f = \frac{R}{2}$, where R is radius of curvature while f is focal length.

3) The average value of focal length of used mirror is

$$f = \frac{(14.0 + 14.0 + 14.5 + 14.5)/4}{2} = 7.1cm$$

Conclusion

The focal length of a diverging mirror is half of radius of curvature. Thus

$$f = \frac{R}{2}$$

Experiment 15.1. Analyzing diodes and transistors in an electronic device.

Expected answers for interpretation of results.

1) On opening the device, among other parts of the device, diodes and transistors were present.
2) Appearance of diodes: They have 2 leads
3) Appearance of transistor of transistor: They have 3 leads

Note: Students can describe a transistor or a diode in terms of color or size.

Conclusion

Transistor and diodes are always connected in circuits because of their importance, for instance, a transistor can being used as a switch or amplifier, whereas, diodes are used to make current flow in one direction.

SENIOR THREE EXPERIMENTS' EXPECTED RESULTS

Experiment 2.1: Verification of friction force

Answers for interpretation of results

$$W = 0.6kg \times 10 \, {}^{m}\!/_{s^2}$$

$$F_D = 2N$$

1) Friction is a force that resists the sliding or rolling of one solid object over another
2) They may cause motion, they may also slow, stop or change the direction of motion of an object that is already moving. Since force cause changes in the speed or direction of an object, we can say that forces cause changes in velocity.

Conclusion

The force of friction depends on two factors: the coefficient of friction and the normal force. For any two surfaces that are in contact with one another, the coefficient of friction is a constant that depends on the nature of the surfaces. The normal force is the force exerted by a surface that pushes on an object in response to gravity pulling the object down. In equation form, the force of friction is $f = \mu N$ Where μ is the coefficient of friction and **N** is the normal force.

Experiment 2.2: Illustration of linear momentum.

Answers for interpretation of results

1) The penetration distance depends on two major factors: driving force (force exerted by the hammer) and the nature of the block materials.

2) Momentum can be defined as mass in motion. All objects have mass, so if an object is moving, then it has momentum and mass in motion. The amount of momentum that an object has depends upon two variables: How much stuff masses are moving and how fast the masses are moving.

Conclusion

To drive a nail into wood, a certain rate of motion (velocity) and mass of the hammer is required. The quantity involving both motion and mass of a body is called linear momentum. It is denoted by the letter p and is called momentum in short.

Experiment 2.3: Demonstration of Newton's second law of motion

Answers for interpretation of results

1) We observed that the heavier block causes the entire system to move. The whole system moves on the same rate, and the rate at which the system moves is the acceleration. Whereas this acceleration depends on all external forces acting on the system.
2) Here below,

$$F = \frac{\Delta P}{\Delta t} \text{ or } \Delta P = P_{final} - P_{initial} \Leftrightarrow \Delta P = m\left(V_{final} - V_{initial}\right)$$

$$\Delta t = t_{final} - t_{initial}$$

$$F = m\left(\frac{V_{final} - V_{initial}}{t_{final} - t_{initial}}\right) \Leftrightarrow F = m.a$$

Conclusion

We can say that one of the effects of a force is that it changes the state of motion of an object. i.e. it causes a body at rest to move and a moving body to accelerate or come to rest. Any change in the velocity of a body causes a change in its momentum.

Experiment 2.4: Demonstration of action and reaction force

Answers for interpretation of results

1) - As you pull the spring balance, you will feel that the spring balance is being pulled back
2) Both the spring balances will show the same force. When you repeat the process in different directions, the two spring balances will continue to show the same force.
3) i.) When you jump, your legs apply a force to the ground and the ground applies an equal and opposite reaction force that propels you into air.
   ii.) Pulling an elastic band
   iii.) Sitting on a chair
   iv.) Bouncing a ball
   v.) Pushing someone or pushing something you tend to move backward.

Conclusion

So we conclude that when the second spring balance exerted a force on the first which was the action force, the first spring balance also exerted an equal and opposite force on the second which was the reaction force. The action and reaction force are equal in magnitude but opposite in direction.

Experiment 2.5: Determination of the coefficient of friction

Answers for interpretation of results

Table of results

Mass /g	Reaction R /N	Spring reading F /N
50.0	0.5	0.700
100.0	1.0	1.200
150.0	1.5	1.700
200.0	2.0	2.275
250.0	2.5	2.785

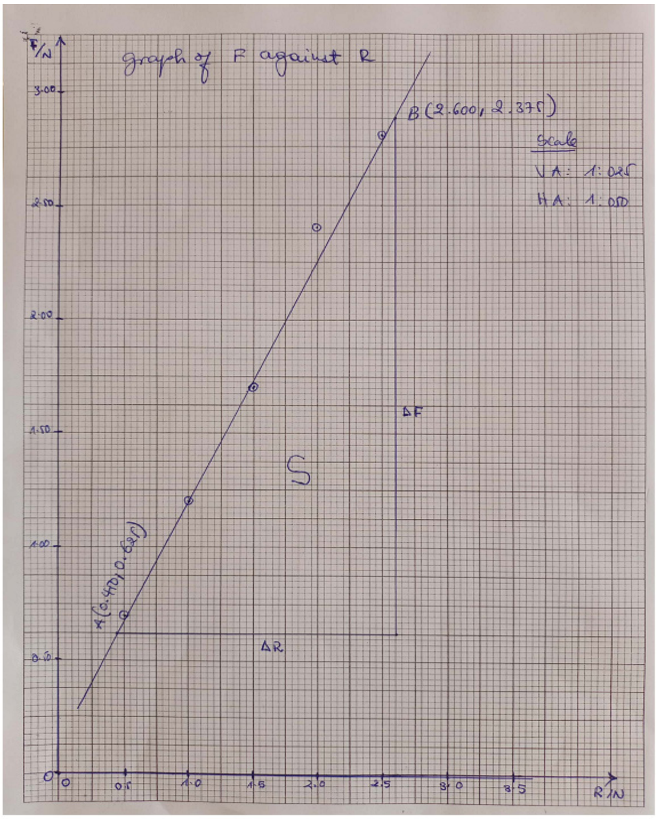
1) The normal force acting on the block is equal and opposite to the weight of the block on a horizontal surface. While when the block is on a level surface, the weight is equal to the force of gravity.
2) Check the graph

$$S = \frac{\Delta F}{\Delta R} = \frac{(2.375 - 0.625)N}{(2.600 - 0.450)N} = 0.813$$

The slope represent the coefficient of static friction.

Conclusion

The results from a similar activity showed that the readings on the spring balance increase with the increase of mass. When a column of $\frac{F}{R}$ was added and completed in the table, it was noted that the value of $\frac{F}{R}$ was constant.



Experiment 3.2: Demonstration of some applications of atmospheric pressure

Answers for interpretation of results

1) **Drinking straw:** A drinking straw works because when you suck the air out of the straw, it creates a vacuum. This causes a decrease in air pressure on the inside of the straw. Since the atmospheric pressure is great on the outside of the straw, liquid is forced into and up the straw and into your mouth.

2) **Syringe:** is a pump consisting of a sliding plunger that fits tightly in a tube. The plunger can be pulled and pushed inside the precise cylindrical tube, or band, letting the syringe draw in or expel a liquid or gas through an orifice at the open end of the tube.

3) **A vacuum cleaner:** The pressure level in the area behind the fan drops below the pressure level outside the vacuum cleaner. This creates suction, a partial vacuum, inside the vacuum cleaner.

4) The main points of discussion under this experiment is that drinking straw, syringe, and vacuum cleaner works because there is creation of vacuum, which causes a decrease in air pressure which allows the atmospheric pressure to push liquid up.

Conclusion

Air pressure is caused by weight of the air molecules above. Even tiny air molecules have some weight, and the huge numbers of air molecules that make up the layers of our atmosphere collectively have a great deal of weight, which presses down on whatever is below.

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Experiment 4.1: Making a simple wind turbine.

Answers for interpretation of results

1) The turbine moved in a direction parallel to the wings of the turbine.
2) This turbine has application in electrical generators.
3) Knowledge acquired is useful in that one can use it to design a generator that can be used to generate electricity.
4) Yes, because it converts wind energy into electrical.

Conclusion

Wind is produced as a result of giant convection currents in the Earth's atmosphere which are driven by heat energy from the sun. This means that the kinetic energy in wind is a renewable energy resource; as long as the sun exists, the winds will always be.

Experiment 4.2: Demonstration of effects of solar energy using a convex lens.

Answers for interpretation of results

1) Convex lens concentrates the light energy to one spot on the paper so that the heat energy accumulates on that one small spot of paper. As the heat increases, combustion will occur when the spot becomes too hot and the paper will burn.
2) The concave lens will diverge the rays of sunlight falling on it. Hence the paper will not burn.
3) Application of:
   - Solar electricity
   - Solar water-heating
   - Solar heating
   - Solar ventilation
   - Solar lighting
   - Etc

Conclusion:

As the concave lens might scatter away the sun's rays, it cannot be appropriate to use it when generating the solar energy. However, the convex lens will be suitable because of it will bring together all the rays focused on the paper.

Experiment 4.3: Demonstration of the transformation of potential energy to kinetic energy.

Answers for interpretation of results

Mass of the bob used, m = 30g = 0.03kg

h = 43cm = 0.43m

g = 10m/s^2

1) $PE = mgh = (0.03kg) \times \left(10 \,{}^{m}\!/\!{}_{s^2}\right) \times (0.43m) = 0.129J = 0.13J$

2) The pendulum bob moved forth and back.

3) In this case, at the lowest point of the swing

$$mgh = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{2gh} = \sqrt{2\frac{PE}{m}} = \sqrt{\frac{2 \times 0.13J}{0.03}} = 2.94 \,{}^{m}\!/\!{}_{s}$$

4) At the lowest point, $PE = KE = 0.13J$

$KE = 0.13J$

5) The pendulum bob will have the greatest PE at the releasing point. i.e. at h = 43cm

6) The pendulum bob will have the greatest KE at the lowest point of the swing.

Conclusion

At the highest point of swing, potential energy is maximum while kinetic energy is minimum (zero). When the pendulum bob is set to oscillate, the potential energy is transformed to kinetic energy. At the lowest point kinetic energy is maximum and potential energy is minimum (zero). However, in all points mechanical energy is conserved.

Experiment 4.4: Making a simple motor.

Answers for interpretation of results

1) When you spin the coil, it undergoes a continuous rotational motion.
2) In electric motor, the imparted electrical energy is transformed into mechanical energy of the rotor.
3) The device that transforms mechanical energy into electrical energy is called electrical generator.
4) The concept applied in this experiment is the interaction between magnetic field and current carrying a conductor, when the current is directed to the coil placed into magnetic field, there will be a deflecting force that causes the coil to rotate.

Conclusion

An electric motor is an electrical machine that converts electrical energy into mechanical energy. Most electric motors operate through the interaction between the motor's magnetic field and electric current in a wire winding to generate force in the form of moment applied in the motor's shaft.

Experiment 4.5: Demonstration of transformation of mechanical energy to electrical energy.

Answers for interpretation of results

1) When the magnet is moving through the coil, the needle of a galvanometer kicks. This is due to the change in magnetic field, results in the coil that induces electromotive force in the circuit.
2) Types of energy involving in this experiment are mechanical energy and electrical energy. The mechanical energy of a moving magnet was converted into electromotive force that is causing the needle of galvanometer to kick.

Conclusion

The change in magnetic field through the coil induces electromotive force. This is the working principle of electrical generators, electric guitar, ATM machine, etc.

From the experiment, it can be observed that heat was transferred from the heat source to the beaker that contained ice. This means that heat flow from higher temperature zones to lower temperature zones and not vice-versa. This verifies the 2nd law of thermodynamics.

Experiment 5.1: Verification of thermal expansion of solid

Answers for interpretation of results

1) When the ball is not heated it passes freely into the ring.
2) When you try to pass the ball into the ring after 5 minutes of heating it can't pass into the ring.
3) When the solid is heated, it increases in volume, in length, breadth and thickness.

Conclusion

Solids expand on heating and contract on cooling. The expansion (or contraction) depends on the original length, the rise in temperature, and the coefficient of linear expansion.

Experiment 5.2: Verification of thermal expansion of liquid.

Answers for interpretation of results

1) During 16 seconds of heating water level increased by 18.5cm.
2) Water expanded through capillary tube due the applied heat which broke water intermolecular forces that caused movement of water molecules. Hence water expanded through capillary tube.

Conclusion

The water in the test tube expands as it is heated. There is only one direction to expand in, the glass tube. This glass tube is narrow so that a small change in volume will result in a considerable change in height; your signal is amplified.

Experiment 5.3: Experiment on thermal expansion of given gas.

Answers for interpretation of results

1) When the test tube is heated, the trapped water in glass tube moving up.
2) The trapped water moving up because when the gas in test tube is heated it starts expanding which caused pressure to push up the trapped water

Conclusion:

On heating the test tube, the air in the test tube expands and pushes the colored water up. If the test tube is cooled, the air contracts and the level of the colored water comes down to its original level.

Experiment 5.4: Demonstration of causes of expansion and contraction.

Answers for interpretation of results

1) Before heating test, the balloon was flattened
2) After 2 minutes of heating, the balloon blown up due to the air expansion that contained in test tube. Hence, there was air expansion.
3) After 3 minutes of cooling, the balloon got flatten due to the air compression.

Conclusion

When heating test tube, the air inside expands and it fills the balloon while when test tube is placed in cold water the air contract on cooling, so the balloon gets deflated.

Experiment 5.5: Demonstration of heat transfer in solids

Answers for interpretation of results

1) Initial temperature of all three spoons was 21°C while their final temperatures were:
   - For plastic spoon :35°C
   - For Metal spoon :45°C
   - For wooden spoon :24°C
2) The temperature increase in
   - Plastic spoon :14°C
   - Metal spoon: 24°C
   - Wooden spoon:3°C
3) The caused the temperature raise is heat transfer by conduction.
4) The temperature change is not the same in all spoons because they are made from different materials. Metal spoon is made from metals which are good conductors of heat so it got hotter than other spoon while wooden spoon is made from wood that is poor to conductor of heat.

Conclusion

Metals are good conductors of heat because they have a big number of free electrons which facilitate the conduction process when the heat is applied on them. The temperatures can change depends on the size of spoons used and the room temperature of where you are carrying out the experiment.

Experiment 5.6: Investigation of heat transfer by conduction

Answers for interpretation of results

1) At t=0, Temperature in of beaker $\theta_1 = 60^o C$ while the temperature of test tube $\theta_2 = 21^o C$

2) The equilibrium temperature of beaker and test tube was, $\theta = 53^o C$

3) When the test is put in the beaker, heat energy starting transfer from hot water molecules to the walls of test tube. The molecule of test tube got hot and then transfer gained heat energy to the water contained in the tube. This phenomenon of heat transferred from walls of test tube to it is known as "conduction of heat"

Conclusion

Conduction is the mode of heat transfer that takes place into solids. In this experiment, the conduction happened while the heat was transferred through the walls of test tube which in turn caused its content getting hot.

Experiment 5.7: Illustrate heat transfer by convection

Answers for interpretation of results

1) As water started warm up, the potassium permanganate (colored water) moved up and spread out in water as the heating process continued.
2) The phenomenon that took place during this experiment is called "Convection".
3) Convection is the mode of heat transfer that takes place in fluids (liquids and gases), it involves the movement of molecules from one point to another that create convection currents in hole fluid; The direction of the convectional currents is from the bottom of container to its top.

Conclusion

Based on the results of our observation, Convection is the process of heat transfer in which transfer of heat energy occurs by the mass movement of molecules of the fluids like gases and liquids. Gases and liquids are not a good conductor of heat under normal conditions, but they can easily transfer heat.

Experiment 5.10: Determination of the specific heat capacity of water by the method of mixtures

Answers for interpretation of results

Data:

$$M_s = 0.0258kg$$

$$C_s = 375J/kg.K \ (for\ brass)$$

$$Mass\ of\ glass = 0.1kg$$

$$C_s of\ the\ glass\ used = 800J/kg.K$$

$$Mass\ of\ container + water = 0.207kg$$

$$Mass\ of\ water\ only = 0.207kg - 0.1kg = 0.107kg$$

$$From\ this\ experiment,$$

$$\theta_1 = 21°C$$

$$\theta_{s(at\ boiling\ point)} = 100°C$$

$$\theta_2 = 24°C$$

1. When the solid is put into cold water (in a container), the temperature of water rises by 3°C.
2. $From\ Q_S = M_s C_s(\theta_s - \theta_2)$

$$Q_S = 0.048 \times 375(100 - 24) = 1368J$$

3. $Q_s = M_w C_w(\theta_2 - \theta_1)$

$$1368 = 0.107C_w(24 - 21)$$

$$C_w = \frac{1368}{0.321}$$

$$C_w = 4261.68J/kg.K$$

Conclusion

The temperature of the solid decreased from θ_s to θ_2 , showing that the solid lost heat energy.

Experiment 5.11: Determination of the specific heat capacity of a liquid by electrical method.

Answers for interpretation of results

Data:

$$M_c = 0.03291kg$$
$$M_l = 0.05897kg$$
$$Q_1 = 22^\circ C$$
$$V = 0.5V$$
$$I = .82A$$
$$Q_2 = 24^\circ C$$
$$t = 18.40min = 1104secs$$

1)
$$\Delta\theta = \theta_2 - \theta_1$$
$$\Delta\theta = 24°C - 22°C = 2°C$$

2)
$$Electrical\,energy = IVt$$
$$E = (0.82)(0.5)(1104)$$
$$E = 452.64J$$

3) From Electrical energy = Heat gained by liquid supplied

4) Heat gained by liquid

$$H = M_w C_w \Delta\theta = 452.64$$
$$452.64 = M_l C_l \Delta\theta$$
$$452.64 = 0.05897 C_l \times 2$$
$$C_l = \frac{452.64}{2(0.05897)} = 3837.88J / kg.K$$

Conclusion

From the experimental results obtained above, the specific heat capacity of a liquid can be determined by electrical Method. The sampled results gives 3837.88J/kg.K which is almost 4200J/kg.K (exact specified heat capacity of water). In the experiments learners may get different results but which are around 4200J/kg.K .

Experiment: 5.12: Determination of the specific latent heat of fusion of ice

Answers for interpretation of results

1) When you drop ice into warm water, the ice melts quickly.

2)
$$M_c = mass\,of\ calorimeter = 32\times10^{-3}\,kg$$
$$\theta_1 = Temperature\,of\ warm\,water = 55°C$$
$$M_w = mass\,of\ water = 74\times10^{-3}\,kg$$
$$M_{ice} = mass\,of\ ice = 18\times10^{-3}\,kg$$

C_c = specific heat capacity of copper (calorimeter) =385J/kg.K
C_w = specific heat capacity of water=4200J/kg.K

$$M_{ice}L + M_{ice}C_w(\theta_1 - 0°C) = M_cC_c\Delta(\theta_2 - \theta_1) + M_wC_w(\theta_2 - \theta_1)$$

$$M_{ice}L = M_cC_c(\theta_2 - \theta_1) + M_wC_w(\theta_2 - \theta_1) - M_{ice}C_w(\theta_1 - 0°C)$$

$$M_{ice}L = 32\times10^{-10}kg\times385J/kg.K\times(55°C - 29°C) + 74\times10^{-3}kg\times4200J/kg.K\times(55°C - 29°C) - 18\times10^{-3}kg\times4200J/kg.K\times(29°C - 0)$$

$$M_{ice}L = (320{,}320 + 8{,}080{,}800 - 2{,}192{,}400)\times10^{-3} = 6{,}208{,}720\times10^{-3}$$
$$L = \frac{6{,}208{,}720\times10^{-3}}{18\times10^{-3}} = 344{,}928J/kg$$

Conclusion

Since pure ice melts at 0 °C under standard atmospheric pressure, the specific latent heat of fusion of ice (lice) is defined as the quantity of heat energy required to change 1 kg of ice at 0 °C to 1 kg of water at 0 °C under standard atmospheric pressure.

Normally a total of 334 J of energy are required to melt 1 g of ice at 0°C, which is called the *latent heat of melting*. At 0°C, liquid water has 334 J g^{-1}more energy than ice at the same temperature.

Experiment 5.14: Demonstration of the working principles of bimetallic strip.

Answers for interpretation of results

1) Once heated, the bimetallic strip start bending gradually, the brass expands more than the steel and the strip curves with the brass on the outside.
2) If the strip is cooled, it curves with the steel on the outside.

Conclusion

The bimetallic strip consists of two thin strips of different metals, each having different coefficient of thermal expansion. When heated, the two strips expands at different rates resulting in bending effect that is used to measure the temperature change.

Experiment 6.1: Demonstration of the first law of thermodynamics

Answers for interpretation of results

1) During heating, the applied heat energy caused evaporation of water. Produced vapor started expanding which resulted in transformation of heat into mechanical energy of the vapor.
2) The law governed in this experiment can be stated as "Whenever heat is applied to a system, it transforms into equal amount of other forms of the energy."

Conclusion

The law of conservation of energy states that energy can neither be created nor destroyed but can be converted from one form to another. This law is obeyed by all systems including thermodynamic systems. In thermodynamic systems, the law of conservation of energy governs the energy transformations involving applied heat and internal energies. In such systems, the heat applied (external energy) and the work done by the environment onto the system are converted to internal energy.

Specifically, for thermodynamic systems, the law of conservation of energy is summarized into what is known as the first law of thermodynamics. The law states that the change in the internal energy (ΔU) of a system is equal to the sum of the heat (Q) that flows across its boundaries and the work (W) done on the system by the surroundings.

Experiment 6.2: Demonstration of the Second law of thermodynamics

Answers for interpretation of results

1) On dropping the ice into the warm water, the temperature immediately dropped by 10°C. Later, when the ice completely melts, the temperature then slowly decreases.

2) On heating melted ice and warm water, the temperature slowly increases with time. The increase does not happen spontaneously. This process is not reversible.

Conclusion

From the experiment, it can be observed that heat was transferred from the heat source to the beaker that contained ice. This means that heat flow from higher temperature zones to lower temperature zones and not vice-versa. This verifies the 2nd law of thermodynamics.

Experiment 6.3: Demonstration of heat exchange using cold and hot water

Answers for interpretation of results

√ Initial temperature of beaker X and beaker Y were measured to be 19°C

√ After heating Beaker X for 3 minutes its temperature become 95°C

1) The final temperature of the mixture after stirring was 53°C which is high than the initial temperature of beaker Y.
2) The temperature in beaker Y raised by (53-19) °C= 34°C.
3) During the mixing up of water in beaker X and Y, Heat moved from hot water (in beaker X) to cold water (in beaker Y)
4) For natural process, heat transferred from hot to cold regions.

Conclusion

Heat exchange between an individual and the surrounding environment is realized through conventional heat exchange pathways of conduction, convection, radiation, and evaporation.

Experiment 6.4: Determination of the specific heat of copper using the method of mixture

Answers for interpretation of results

$M_1 = 212g,\ M_2 = 276g,\ T_1 = 19^oC,\ M_3 = 25g,\ T_2 = 96^oC,\ T = 23^oC$

1) There were heat energy exchange.

$$M_3S(T_2 - T) = M_1S_c(T - T_1) + (M_2 - M_1)S_w(T - T_1)$$

2)

Where $S_w = 4200J/kg^oC$

$S_c = 399J/kg^oC$

$$S = \frac{M_1S_c(T-T_1)+(M_2-M_1)S_w(T-T_1)}{M_3(T_2-T_1)}$$

$$S = \frac{0.212kg\times399Jkg^{-1}\,^oC^{-1}\times(23-19)^oC+(0.276-0.212)\times4200Jkg^{-1}\,^oC^{-1}\times(23-19)^oC}{0.025kg\times(96-23)^oC} = 774.5Jkg^{-1}\,^oC$$

Conclusion

– The specific heat capacity S of a material is the amount of heat required to raise the temperature of unit mass of the material by a unit. $S = \frac{Q}{m\Delta T}$

– A material with higher specific heat capacity retains its temperature for a longer duration as more energy is required to change its temperature

– When two bodies at different temperatures are brought into thermal contact, the net heat lost by the hot bodies is equal to the net heat gained by the cold bodies until they both attain thermal equilibrium.

Experiment 6.5: Verification of heating curve of ice

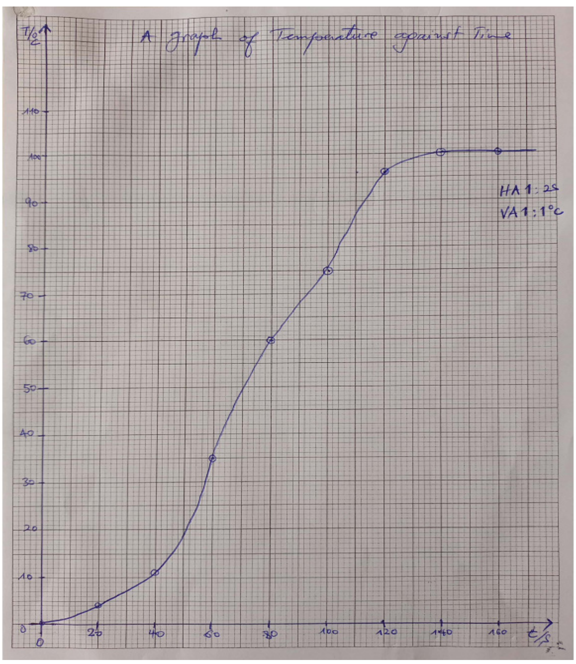
Answers for interpretation of results

Time/seconds	0	20	40	60	80	100	120	140	160
Temperature/ ^0C	0	4	11	35	60	75	96	100	100

1) On heating, the amount of ice reduces and time reaches to the point where all ice blocks/cubes turn into water/liquid.
2) Graph
3) From the graph, between 0 and 40 seconds, the curve is slowly increased i.e. the temperature is increasing slowly. Between 40 and 120 seconds, the curve increases at a high rate (thus, showing a high increase in temperature in that interval of time). Then between 120 and 140 seconds, the curve increases slowly for 20 seconds and then becomes constant for the last 20 seconds.

Conclusion

From the observation seen, it implies that as the system is heated, it absorbs heat and its temperature increases with time. However, at the boiling point of the melted ice, the temperature remains constant (100˚C).



Experiment: 7.2: Demonstration of the induced current produced when there is a relative motion between the magnet and solenoid.

Answers for interpretation of results

Bar Magnet	Solenoid	Galvanometer reading
Pushed into the solenoid	Stationary	Galvanometer needle changes direction i.e. there is induction of e.m.f
Stationary	**Stationary**	**No readings**
Pulled out of the solenoid	Stationary	Galvanometer change the direction in opposite side when you push i.e. there is induction.
Stationary	Pushed towards bar magnet	Galvanometer change the direction in opposite side when you push i.e. there is induction.
Stationary	Pushed away from bar magnet	Galvanometer change the direction in opposite side when you push i.e. there is induction.

The galvanometer shows a positive reading when a bar magnet is pushed into the solenoid or solenoid pushed towards bar magnet.

1) The galvanometer shows a negative reading when a bar magnet is pulled out of the solenoid or solenoid pushed away from bar magnet.
2) The current is induced in solenoid whenever there is a relative motion between a bar magnet and solenoid.

Conclusion

Moving the bar magnet into the solenoid induces an e.m.f. in the solenoid (according to Faraday's law), and **because the circuit is closed**, a current flows and a magnetic field is induced.

Experiment 8.1: Verification of the working of transformers

$N_{in} = 30$

$V_{in} = 4V$

$N_{out} = 600 \rightarrow V_{out} = 75.7$

$N_{out} = 200 \rightarrow V_{out} = 24.9$

$N_{out} = 400 \rightarrow V_{out} = 50.7$

Number of coils in secondary coil, N_2	Ratio, $\frac{N_2}{N_1}$	Output voltage, V_2/V
200	6.67	24.93
400	13.33	50.74
600	20.00	75.79

1) The output voltage V_2 and the ratio $\frac{N_2}{N_1}$ are directly proportional i.e. if the ratio $\frac{N_2}{N_1}$ increases also V_2 increases.
2) N_1 and N_2 must be different because, the transformer can either transform power by increasing (step up) or decreasing (step down).
3) There are two types of transformer:
   - Step-up transformer which step-up output.
   - Step-down transformer which step-down output.

Conclusion

From this experiment, the effect of the ratio of coils between the primary and secondary coil and the output voltage implied that when we increase the number of coils on the secondary transformer, then the output voltage is increased. And the output voltage will be directly proportional to the ratio of coils.

Experiment 8.2: Investigation of the relationship between number of coils and the induced e.m.f

Answers for interpretation of results

1) When the magnet is at rest inside the magnet, the needle (pointer) of galvanometer did not deflect/kick. There it read zero.
2) While magnet moved through the coil the galvanometer kicked.
3) When the number of turns increased, the rate of deflection of galvanometer increased i.e. the induced e.m.f into the coil increased.
4) From this experiment, we observed that when the number of turns increased induced e.m.f increased.

Conclusion

The magnitude of induced e.m.f is directly proportional to the number of turns of the coil.

Experiment 9.1: Demonstration of the electrostatic law between two negatively charged polythene rods.

Answers for interpretation of results

1) As you bring rod B closer to rod A, as the rod A moved away from rod B. Then as the distance between them become stronger.
2) When the two rods A and B rubbed vigorously, the force of repulsion exerted between them leads to the creation of wide deflection i.e. it becomes stronger.
3) When the two rods A and B, are rubbed strongly, they accumulate high number of charges which causes significant repulsion. Hence, as the number of charges is large, the force becomes strong.

Conclusion

The force of attraction or repulsion between two electrically charged particles is directly proportional to the magnitude of their charges and inversely proportional to the square of the distance between them.

Experiment 9.3: Verification of the strength of an electric field varies with quantity of charge and distance from the charge.

Answers for interpretation of results

1) When a small piece of straw is released, it will be attracted by charged plastic drinking straw.
2) As the plastic straw is brought very close to the other piece of straw, the force of attraction between them becomes strong. Hence, it was attracted by plastic straw strongly.

3) When plastic straw is charged vigorously, the force of attraction between straw and a piece of straw observed to become strong. If the distance of separation is maintained constant.

4) A. As the quantity of charges on the plastic straw increased by rubbing vigorously, the attraction between and the small piece of other straw became strong due to the increase in magnitude of electric field created by the charges on the rubbed plastic straw. Hence, the magnitude of electric field depends on the quantity of electric charge that creates it.

5) B. When the distance between the straw and a piece of straw became short, the force of interaction between two electrically charged object increased. This is due to the electric field of plastic straw become stronger while the distance is shortened.

Conclusion

Electric field intensity is the measure of the strength of an electric field at a specified point. It is defined as the electrostatic force per unit charge experienced by a test charge placed at a specified point in an electric field.

Thus, Electric field intensity, $E = \frac{electrostatic\ force}{charge}$

Experiment 10.1. Simple house installation

Answers for interpretation of results

1) All bulbs are lit.
2) When you remove one bulb in parallel circuit, the remaining bulb will continue to light.
3) Connect bulbs in series circuit.
4) When you remove one bulb in series, other bulbs also are switched off.

Conclusion

From this experiment, in our houses are connected to the electricity. So this experiment will help you in trial of installing your own house.

Experiment 11.1: Determination of Inductance of a coil (inductor)

Answers for interpretation of results

1) $V_R = 4.080V$

$V_L = 0.062V$

$I = 0.50A$

2) $X_L = \frac{V_L}{I} = \frac{0.062V}{0.50A} = 0.124\Omega$

3) $R = \frac{V_R}{I} = \frac{4.080V}{0.50A} = 8.08\Omega$

4) $Z = \sqrt{R^2 + X_L{}^2} = \sqrt{(8.08)^2 + (0.124)^2}\Omega = 8.081\Omega$

5) $X_L = 2\pi fL \Rightarrow L = \frac{X_L}{2\pi f} = \frac{0.124\Omega}{2\times 3.14\times 50HZ} = 3.949\times 10^{-4} H$

$or\ L = 0.395mH$

Conclusion

An inductor coil is an electrical conductor which passes electricity and generates a magnetic field and is wound in the form of a coil or spiral.

Inductance is the name given to the property of a component that opposes the change of current flowing through it and even a straight piece of wire will have some inductance.

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Experiment 12.1. Verification of the laws of refraction of light

Answers for interpretation of results

1)

$i/°$	FH/cm	GK/cm
30	2.1	1.7
40	2.8	1.8
50	3.3	2.0
60	3.7	2.4

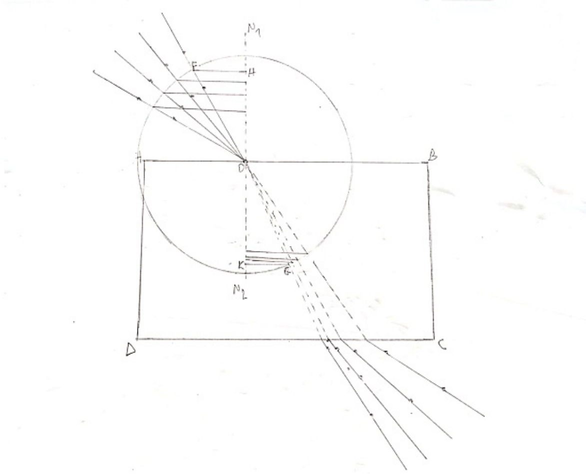
2) $S = \frac{\Delta FH}{\Delta KG} = \frac{4.0-1.6}{2.6-1} = \frac{2.4}{1.6} = 1.5$

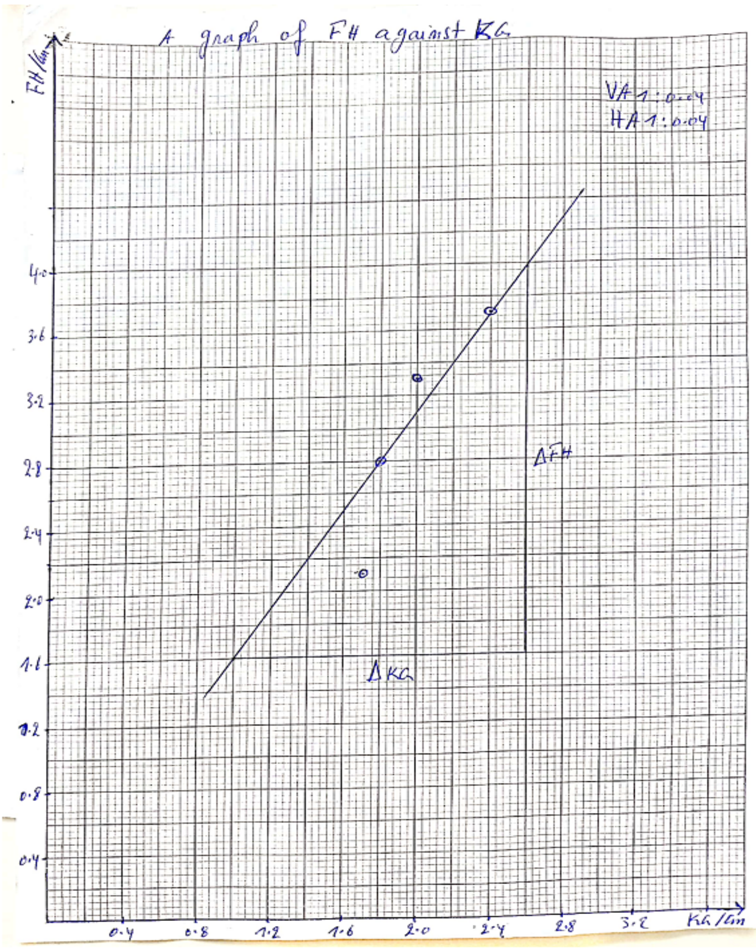
3) The incident ray, reflected ray and the normal, to the interface of any two given mediums; all lie in the same plane.
   - The ratio of the sine of the angle of incidence and sine of the angle of refraction is constant.

4) Laws of refraction state that: The incident ray refracted ray, and the normal to the interface of two media at the point of incidence all lie on the same plane. The ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant. This is also known as Snell's law of refraction.

Conclusion

The refractive index of a glass block is 1.51. Therefore, experimentally the range of the refractive index should be between 1.45 to 1.57.


N1
F
H
A
O
B
K
G
N2
D
C


A graph of FH against KG
FH/cm
VA 1 : 0.04
HA 1 : 0.04
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4
ΔFH
ΔKG
0.4
0.8
1.2
1.6
2.0
2.4
2.8
3.2
KG/cm

Experiment 12.2. Investigation of the relationship between the angle of incidence and the angle of refraction.

Answers for interpretation of results

$i\ /^o$	$r\ /^o$	$\sin i$	$\sin r$
20	15	0.34	0.26
30	18	0.50	0.31
40	22	0.64	0.37
50	28	0.77	0.47
60	35	0.87	0.57

1) Graph

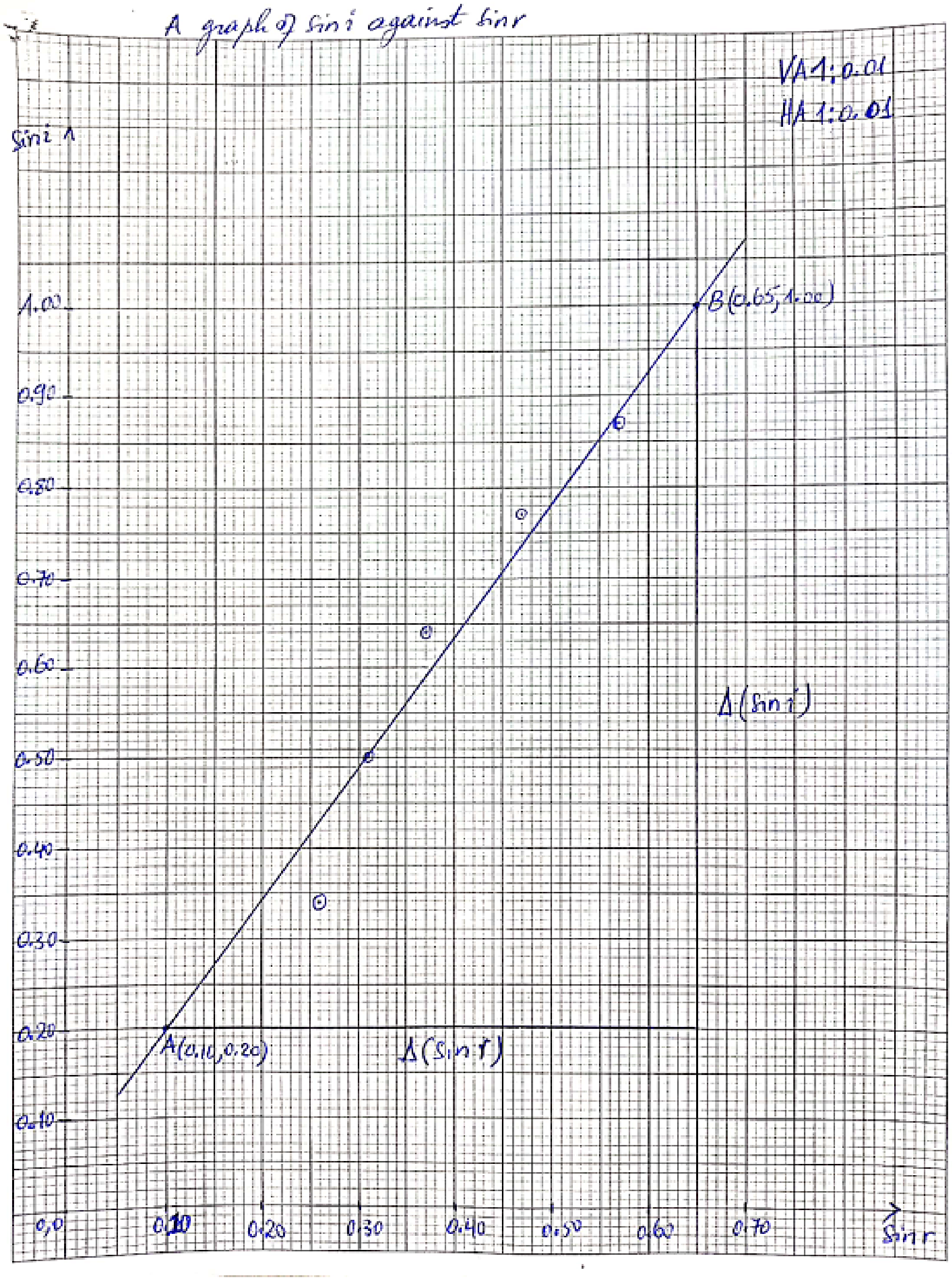
2) Slope, $n = \dfrac{\Delta(\sin i)}{\Delta(\sin r)} = \dfrac{(1.00 - 0.20)}{(0.65 - 0.10)} = 1.45$

3) The slope "n" represents the ratio of sine of the angle of incidence and sine of the angle of refraction; this ratio is always equivalent to the index of refraction of used glass.

Conclusion

From this experiment, we can conclude that:

- The incident ray, normal line and refracted ray at the point of incidence lie in the same plane.
- The ratio $\dfrac{(\sin i)}{(\sin r)}$, where *i* is the angle of incidence and *r* is the angle of refraction; it is equivalent to the refractive index of used material.


A graph of sin i against sin r
VA 1:0.01
HA 1:0.01
sin i
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.0
0.10
0.20
0.30
0.40
0.50
0.60
0.70
sin r
B(0.65, 1.00)
A(0.10, 0.20)
Δ(sin i)
Δ(sin r)

Experiment 12.3. Determination of refractive index of a glass block

Answers for interpretation of results

$i/^o$	$r/^o$	$n=\frac{\sin i}{\sin r}$
50	29	1.58
45	27	1.55
40	25	1.52

1) The average value of $n_{av}=\dfrac{1.58+1.55+1.52}{3}=1.55$

2) When you increase the value of incident angle, the value of refracted angles also increases, and vice-versa.

Conclusion

From this experiment, we can conclude that:

- The incident ray, normal line and refracted ray at the point of incidence lie in the same plane.
- The ratio $\dfrac{(\sin i)}{(\sin r)}$, where *i* is the angle of incidence and *r* is the angle of refraction; it is equivalent to the refractive index of used material.

Experiment 12.4. Investigation of the critical angle and total internal reflection

Answers for interpretation of results

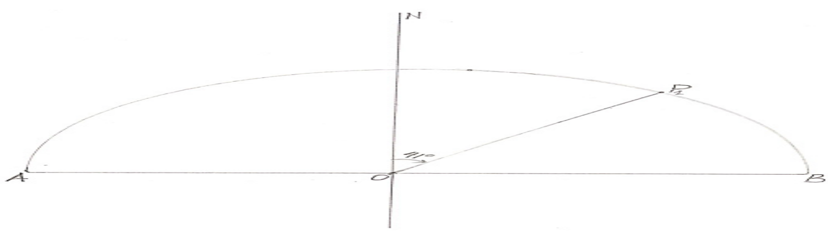
1) The value of critical angle observed in this experiment is 41°.

2) Two conditions for total internal are:
   - Incident ray must pass from denser medium to less dense medium.
   - The angle of incidence must be greater than the critical angle.

3) When the angle of incidence become greater than the critical angle, there will be total internal reflection i.e. all amount of incident light gets reflected (bounced back).

Conclusion

- The value of critical angle of glass block can be approximately ranged between 40° and 44°.
- When the angle of incidence is smaller than the critical angle refraction of light through the glass block occurs while the total interval reflection occurs when angle of incidence become bigger than the critical angle.



Experiment 12.5. Illustration of dispersion of white light

Answers for interpretation of results

1) On a white screen we observed a band of colors composed of Red, Orange, Yellow, Green, Blue, Indigo and Violet.
2) If you observe carefully, the colors identified were seven (7).
3) No, the angle of deviation is not the same on each color because red is less deviated, and violet is highly deviated.

Conclusion

Dispersion of light occurs when white light is separated into its different constituent colors because of refraction and Snell's law. So, the colors of light observed in the experiment had different wavelength, they scattered from white light into seven visible colors.

Experiment 12.6. Illustration of total internal reflection of light using a right-angled prism.

Answers for interpretation of results

1)

α /°	i/°	r/°	Sin i	Sin r
30.00	40.00	25.00	0.64	0.42
25.00	45.00	28.00	0.70	0.46
20.00	51.00	32.00	0.77	0.52
15.00	58.00	35.00	0.84	0.57
10.00	65.00	38.00	0.90	0.61

2) Slope, $S = \frac{\Delta \sin i}{\Delta \sin r} = \frac{0.95 - 0.55}{0.65 - 0.35} = \frac{0.40}{0.30} = 1.33$

r_c=critical angle

$$r_c = \sin^{-1}\left(1/s \right)$$

$$= \sin^{-1}\left(\frac{1}{1.33} \right)$$

$$= 48°$$

3) If the angle of incidence in the glass is greater than the critical angle, the total internal reflection occurs.

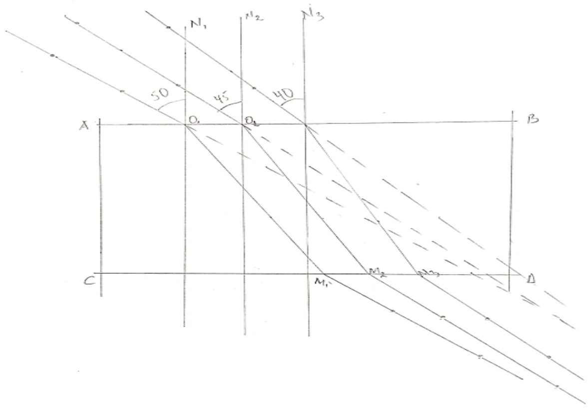
4) Condition for total internal reflection

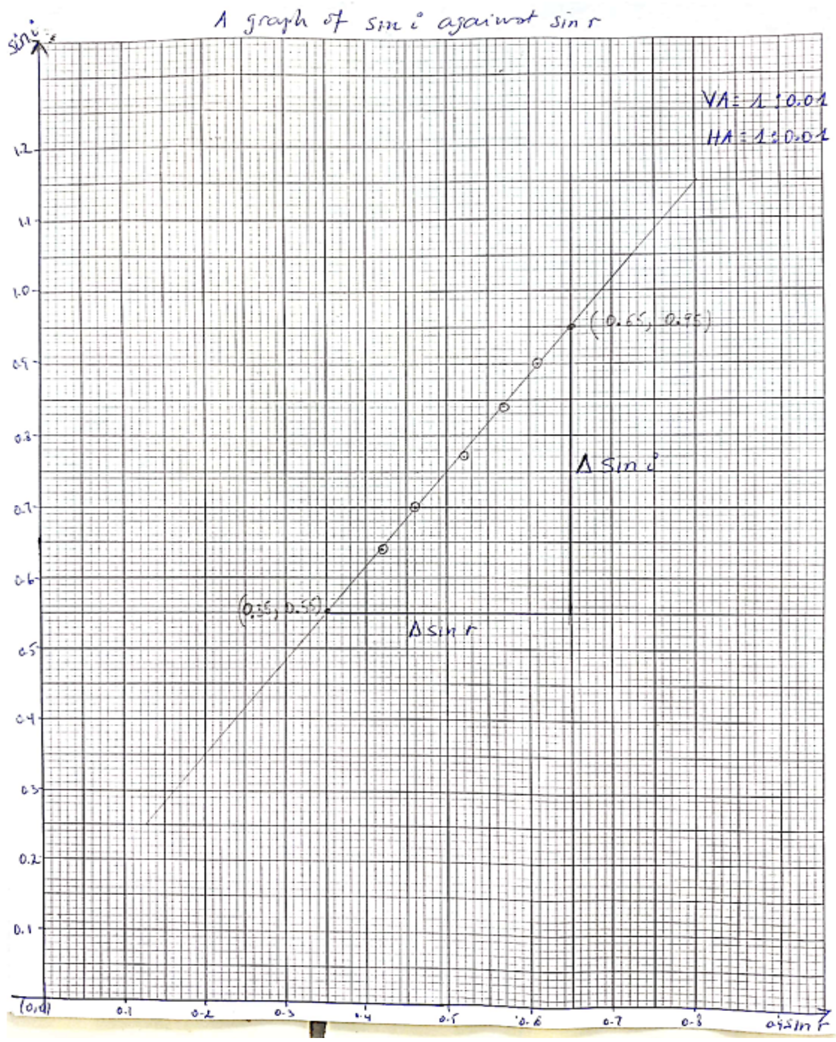
- Incident ray is from denser medium to lower dense medium.
- The incident angle is greater than critical angle.

Conclusion

Condition for total internal reflection

- Incident ray is from denser medium to lower dense medium.
- The incident angle is greater than critical angle.


N1
N2
N3
50
45
40
A
B
C
D
M1
M2


A graph of sin i against sin r
VA = 1 : 0.01
HA = 1 : 0.01
(0.65, 0.95)
(0.35, 0.55)
Δ sin i
Δ sin r
sin i
sin r

Experiment 12.7: Determination of the critical angle of glass prism

Answers for interpretation of results

1) On the graph paper

2) $S=\frac{\Delta Y^2}{\Delta X^2}=\frac{(31.5-14.0)cm^2}{(9.4-1.6)cm^2}=\frac{17.5}{7.8}=2.24$

3) $$C=\text{Cos}^{-1}\left(\frac{1}{2}\sqrt{s}\right)$$

$$=\text{Cos}^{-1}\left(\frac{1}{2}\sqrt{2.24}\right)$$

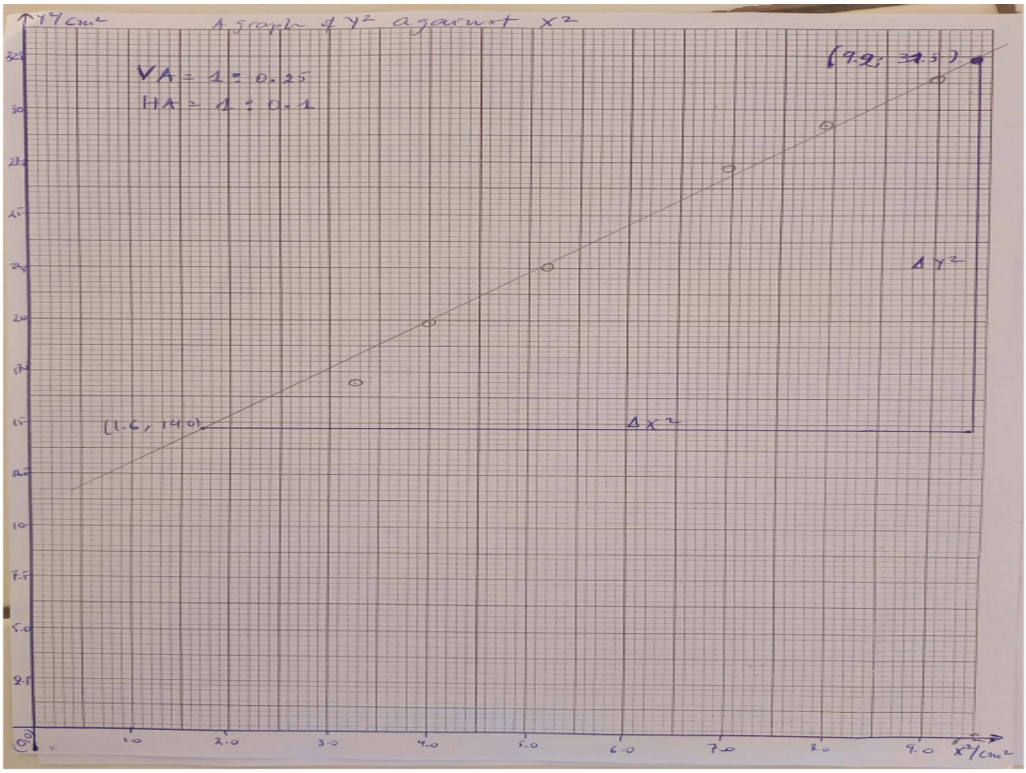
$$C=41.5°$$

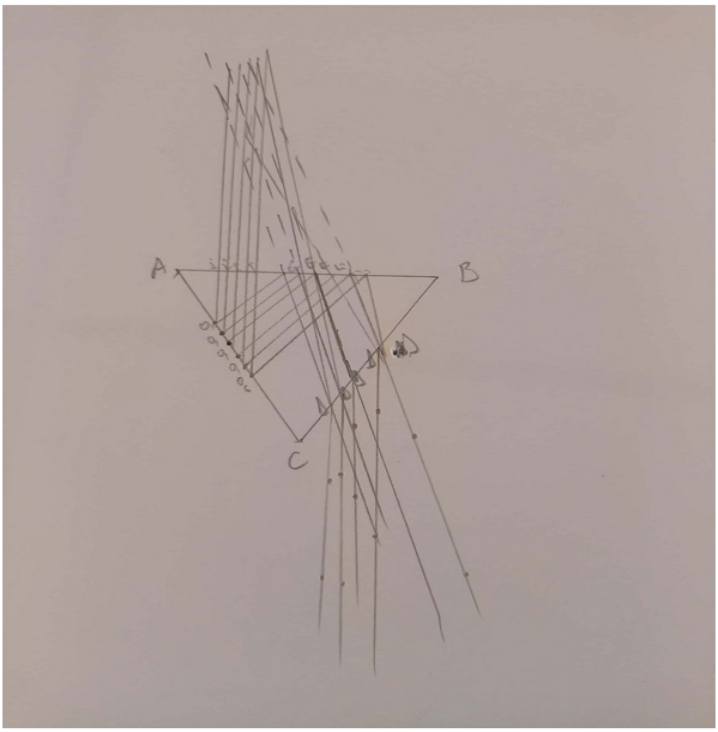
Table of results

t/cm	OE = x /cm	OI= y /cm	X^2/cm^2	Y^2/cm^2
1.50	1.80	4.00	3.24	16.00
1.70	2.00	4.40	4.00	19.36
1.90	2.30	4.70	5.29	22.09
2.10	2.60	5.20	6.76	27.00
2.30	2.80	5.40	7.84	29.16
2.50	3.00	5.60	9.00	31.36

Conclusion

The incident ray bends towards the normal when it enters the prism and while leaving the prism it bends away from the normal. With the increase in the angle of incidence, the angle of deviation decreases. After attaining the minimum value, it increases with an increase in the angle of incidence.

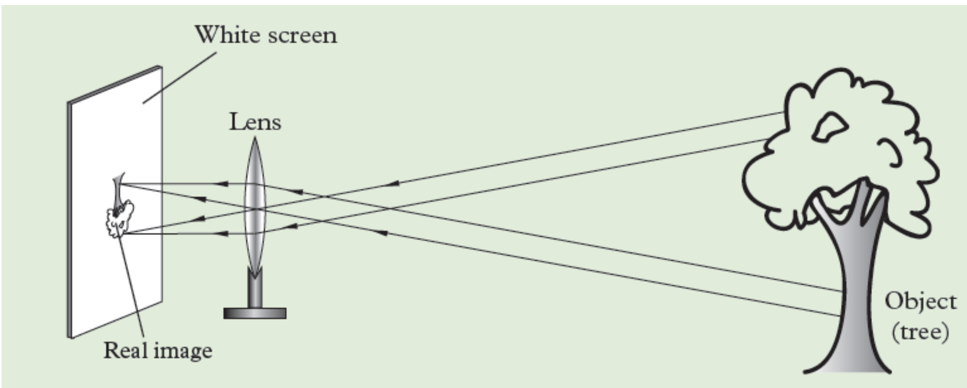

A graph of Y² against X²
Y²/cm²
VA = 1 : 0.25
HA = 1 : 0.1
(9.9; 31.5)
(1.6, 14.0)
ΔY²
ΔX²
X²/cm²


A
B
C

Experiment 12.8. Determination of image formed by converging lenses

Answers for interpretation of results

1) The image formed was:
   - Real because it was formed on the screen
   - Small than object
   - Inverted
2) To draw the image of a distant object we can use two or three important incident rays for each draw point image and thereafter we join point image.



Conclusion

- A ray of light parallel and close to the principal axis, passes through the principal focus
- A ray of light through the principal focus emerges parallel to the principal axis of refraction
- A ray through the optical centre, P, is not deviated after refraction through the lens

Experiment 12.9. Determination of the characteristics of images formed by convex lenses when the object is at infinity

Answers for interpretation of results

1) The size of formed image is smaller than the size of object
2) The image is inverted compared to the direction of an object.
3) The distance between lens and the screen was measured to be 15.0cm.
4) The distance between the lens and screen is expected to be focal length of the used lens during this experiment.

Conclusion

The image formed is real, inverted, and diminished. The distance from the centre of the lens to the screen is nearly equal to the focal length, f, of the lens.

Experiment 12.10: Determination of image formed by convex lens when the object is beyond 2F

Answers for interpretation of results

1) The object distance u = 35cm, where u>2F
2) The image distance v =15cm, where F<v<2F
   - The image formed is
   - Real
   - Inverted
   - Smaller than object

Conclusion

When the object is placed beyond 2F, it forms the image which is diminished, real, inverted and located between F and 2F.

Experiment 12.11: Determination of image formed by convex lens when the object is at 2F

Answers for interpretation of results

1) The position of the image formed is at distance *v* =20cm that is equivalent to 2F.
2) The image formed is:
   - Real
   - Inverted
   - Approximately equal size as an object
   - Located at 2F=20cm

Conclusion

When an object is placed at distance *u*=2F in front of a convex lens, it forms a real, inverted image of the same size as the object. That image is located at distance *v*=2F behind a lens.

Experiment 12.12: Determination of the image formed by convex lens when the object is between F and 2F

Answers for interpretation of results

1) When the object is placed exactly at distance *u* between F and 2F a clear and big image formed on the screen.
2) The image formed was:
   - Real
   - Inverted
   - Bigger than object
   - Located beyond 2F (20cm)

Conclusion

The image of an object placed between F and 2F in front of a converging, it is real, inverted, bigger than object and located at distance *v*>2F.

Experiment 12.13: Characterization of images formed by convex lens when the object is between F and P

Answers for interpretation of results

1) The image formed is:
   - Virtual since it can't form on the screen
   - Magnified
   - Upright compared to the direction of the candle flame.
2) The image formed Exp.12.12 is real and inverted while in this Exp. The image is virtual and upright

Conclusion

The image formed is virtual and cannot be projected on the screen. An enlarged, upright image can be seen through the lens on the same side with the object. A *magnified, upright* and *virtual* image is formed on the same side as object.

Experiment12.14. Determination of the focal length, f of a converging lens

Answers for interpretation of results

Table of results

1) Distance, d=10.0cm

N⁰	U/cm	V/cm	
1	20.0	20.0	1.00
2	25.0	17.0	0.68
3	30.0	14.0	0.47
4	35.0	13.0	0.37
5	40.0	12.0	0.31
6	45.0	12.0	0.27

2) When $v/u = 0, \quad v = 9.00cm$

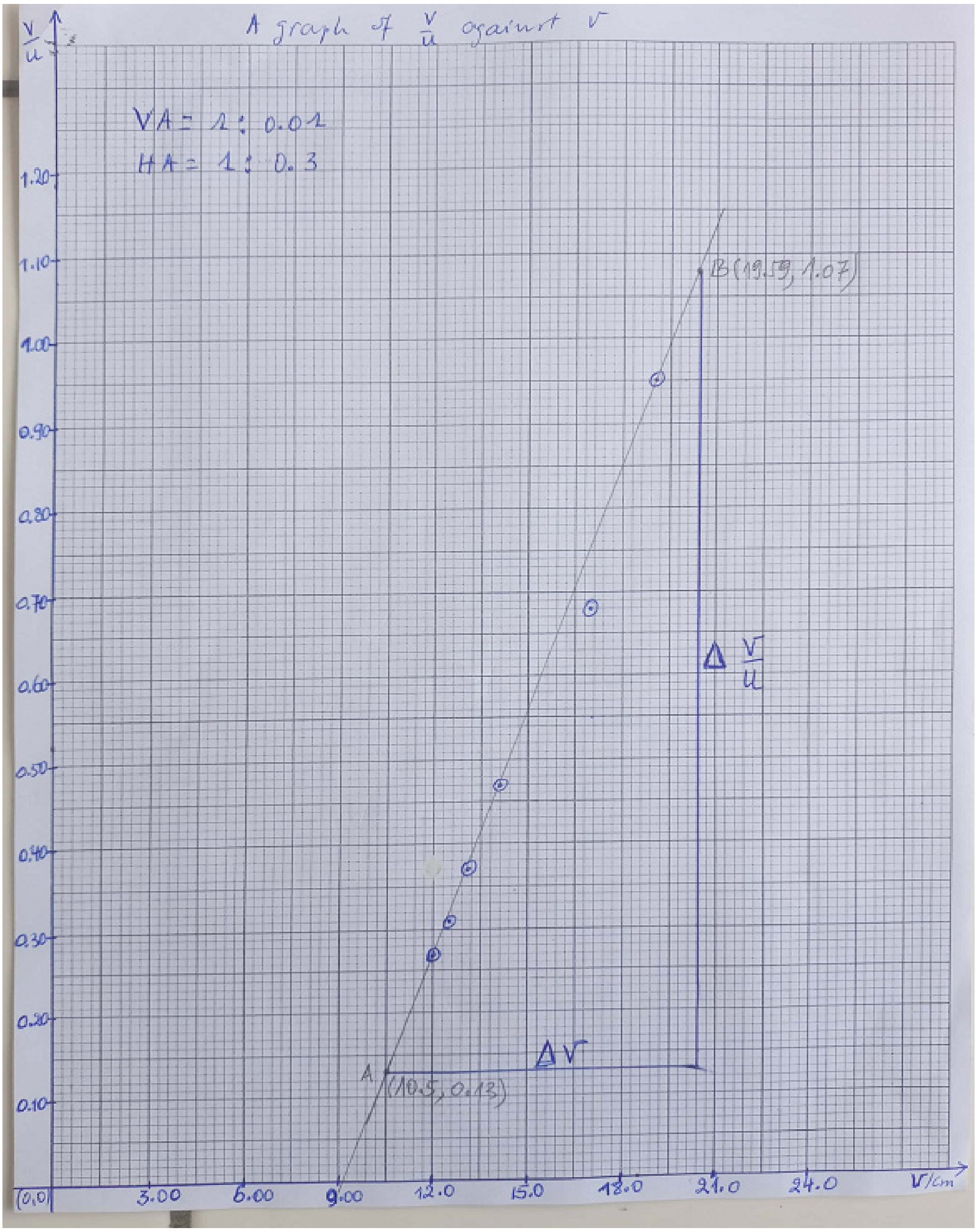
3) $S = \dfrac{\Delta \frac{v}{u}}{\Delta v} = \dfrac{1.07 - 0.13}{(19.59 - 10.5)cm} = \dfrac{0.94}{9.09} cm^{-1} = 0.103 cm^{-1}$

4) $f = \dfrac{1}{s} = \dfrac{1}{0.103 cm^{-1}} = 9.71 cm$

5) The measured distance d=10.0cm is the image distance for object place at infinity. This distance is slightly equal to the calculated value of focal length *f.*

Conclusion

Since the focal length of used lens is 10cm, then the image distance for object located at infinity is equivalent to focal length of the lens.



A graph of V/u against V
V/u
VA = 1 : 0.01
HA = 1 : 0.3
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
(0,0)
3.00
6.00
9.00
12.0
15.0
18.0
21.0
24.0
V/cm
B(19.59, 1.07)
A (10.5, 0.13)
ΔV
Δ V/u

Experiment 12.15. Determination of the image formed by concave lens

Answers for interpretation of results

1) When the object (candle) is placed in front of a concave lens, the image is formed in the same side as the object. By trying to change the position of the object (candle), the image distance also changes but it is always formed in the same side as the object (candle).
2) The image formed is:
   - Virtual
   - Diminished
   - Upright

Conclusion

When the object is placed in front of a concave lens, an upright, diminished and virtual image is formed at principal focus F. For all other positions of the object, an upright, diminished, virtual image is always formed between F and lens.

UNIT 15 ENVIRONMENTAL PHENOMENA AND RELATED PHYSICS CONCEPTS

Experiment 15.1. Explaination of the laws that govern heat transfer in the environment

Answers for interpretation of results

1) On heating the part of the metal where the candle wax and pins are attached, the wax melted, and the pins fell.
2) Putting hands near the burning flame, heat was felt i.e. the heat was transferred through air (from the bunsen flame through air and then to the hand).
3) After heating, the ink redistributed itself throughout the whole liquid making the liquid colored. The color depends on the color of the ink added.
4) When heat flows between 2 objects, the heat lost by one object is equal to the heat gained by another object. This happens in order to attain thermal equilibrium.
5) As the temperature changes, the thermal energy of the object also changes. This is because the thermal energy depends on the average temperature of individual particles in an object.
6) According to the experiment, three modes of heat transfer are:

   i. **Conduction**: the transfer of heat energy or movement of heat through a substance without the movement of the particles of the substance. Conduction also takes place between two bodies that are in contact with each other

   ii. **Convection**: the transfer of heat energy in a fluid by the movement of warmer and cooler fluid particles from place to place.

   iii. **Radiation**: the transfer of energy by electromagnetic waves. Radiation does not necessarily require a material medium for the heat energy to flow through.

Conclusion

Basing on the experiment, it is observed that heat can be transferred in different media. The medium determines the mode of heat transfer. E.g: for solids it is conduction, liquids it is convection and gases is radiation.

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HYPERTEXT BOOK

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