PHYSICS - FORM 1 CLASSICAL NOTES

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1st edition – 2020

TOPIC 01: INTRODUCTION TO PHYSICS

- Physics is the study of the relationship between matter and energy**.**
- A person who study physics is called **physicist**

Science

- **S**cience is the study of nature.

Technology

- **T**echnology is the application of science.

Branches of Physics

- **Mechanics -** This is the study of motion of bodies in the frame of reference.
- **Optics -** This is the study of physical properties of light.
- **Atomic Physics -**This is the study of atoms specifically the electrons and its properties.
- **Acoustics .It** deals with how sound is produced, transmitted ,received and controlled
- **Thermodynamics.** It deals with heat and temperature and their relation to energy and work
- **Biophysics .**It deals with the study of biological phenomena and problems using the concept of physics
- **Nuclear Physics.** The study of forces ,structure and behavior of atomic nuclei
- **Astrophysics(Astronomy) .**It deals with the study of celestial bodies in the universe
- **Electromagnetism -** This is the study of electrical and magnetic fields as two aspects of the same phenomenon.
- **Geophysics -** This is the study of physical properties of the earth.
- **Electronics -** This is the study of the flow of electrons in a circuit.

Relationship between Physics and Other Subjects

1. Chemistry

Composition and decomposing of matter involves energy.
For example,

- Cooking stoves, fuel burn to release heat energy
- Insect killers and Perfumes packed in container by compressed which comes out with high pressure

N.B

- **Matter is anything that has mass and takes up space**

2. Biology

Since biology is the scientific subject, which involves living and non-living things, which may be micro and macro organism, it uses application of physics. For example,

- Microscope which made by physicist is used to observe micro organism
- Syringe is based on pressure

3. Mathematics

Physicist should master mathematics because physics problems may involve calculations

4. Geography

Geography is the study of man and his environment. It includes soil, rainfall, mountains etc. It uses the application of physics, for example,

- Many instruments like rain gauge, wind vane developed by physicist
- Barometer which used to measure the atmospheric pressure made by physicist

Applications of Physics in Real Life

1. It is applied at home

- All tools and machinery: such as Crowbars, Hammers, door handles, cutlery, hinges, car jack, pulleys, tillage implements etc made by knowledge of physics
- Electrical appliances: such as cooker, iron, heater, electric lamps, washing machine etc made by knowledge of physics

2. It is applied in Medical field

- Machines such as laser, x-ray, incubators, ultrasound and infrared machines are used by using the knowledge and skills acquired in Physics.

3. It is applied when manufacturing different equipments of source of energy

- Batteries and generators provide electrical energy
- Bulbs they provide light energy
- Speaker gives us sound energy

4. It is used in transportation

- All vessels used in transportation is a result of concept of physics.
- For example **cars**, **ships**, **aeroplane**, **trains** etc

5. It is used in Communication

- All Devices used in communication systems is a result of concept of physics.
- For example, **telephones**, **modems**, **television**, **cables** etc

6. It is applied in entertainment

- Physics enable people to enjoy a variety of leisure activities as is evident in photography, digital appliances, exercise machines and other sport equipment.

7. It is applied in Industry

- Physicists have been able to come up with tools and process that have resulted in advanced technological equipment and new discoveries.

8. It is applied at schools

- Instruments and apparatus used at school laboratories are made from the application of the knowledge and skills acquired in Physics

Importance of Learning Physics

- It enables us to answer many questions concerned with physical properties of matter
- It enables different people to acquire skills that required in different professions. For example, engineering, teaching and architecture
- It enables us to design and manufacture different items. Eg Generators etc
- It enables us to enjoy since we study practically (**Physics is fun)**

Class Activity – 1

1. Define Physics.
2. **W**hat is science?
3. **Define the following terms (a) Matter (b) Physicist**
4. Mention and explain the branches of science.
5. How does Physics help in everyday life of an individual?
6. What are the career opportunities of a physicist?
7. Mention four transport vessels that relay on the laws of physics
8. Mention any two forms of energy and explain how they are useful in everyday life.
9. Why is it important to study Physics?
10. How does energy shape the surroundings of man?
11. Match the items in the table below

Item A	Item B
(a) Physics **(b)** Chemistry **(c)** Biology **(d)** Geography	**(i) Deals** with study of living things **(ii) Dea**ls with behavior of matter **(iii)** Study of man and his environment **(iv)** Study of matter in relation to energy

TOPIC: 02 INTRODUCTION TO LABORATORY PRACTICE

Laboratory

- Is the special room that have been designed and equipped for carrying out scientific experiments for the purposes of study or research

- **OR** Laboratory **Is a working room for scientists**

Examples of Laboratories are;
- Clinical laboratory
- Physics laboratory.
- Biology laboratory.
- Chemistry laboratory

Laboratory rules - Are the guidelines to be followed in the laboratory in order to reduce risks of accidents

The following are some of the physics laboratory rules.

1. Don't enter in the laboratory without permission from your teacher or laboratory assistance.
2. Never fight in the laboratory
3. Do not eat or drink in the laboratory
4. Do not run or play in the laboratory
5. Do not use laboratory container for drinking or storing food
6. Wash your hands with soap before you leave the laboratory
7. Don't perform any experiment in the laboratory without permission from your teacher or laboratory assistance.
8. All exits must be clear of abstraction/ obstacle.
9. Any damages that may occur must be reported immediately to the laboratory attendant technician.
10. All damaged or broken apparatus must be well deposited to a proper place.
11. Never use free hand to hold hot objects.
12. Replace immediately the cover or stopper of the particular chemical soon after use.
13. After experiment, clean the bench and leave it dry and well arranged.
14. All connections must be checked by laboratory attendant/technician in case of electrical experiments.

Features of a Laboratory

A good laboratory should have the following features

- Water supply system
- Drainage system
- Electricity supply
- Well illuminated
- Well ventilated
- Door open out ward
- Gas supply

Laboratory Apparatus

- Is a special tool or instrument commonly used to carry out the experiments in the laboratory

Laboratory Apparatus

Item	Uses
Measuring cylinder	For measuring volume of liquids
Thermometer	For measuring temperature of substances
Stop watch	To measure time
Micrometer screw gauge	For measuring diameter of a wire
Vernier caliper	For measuring depth, length, internal and external diameters of objects
A ruler	For measuring length
Relative density bottle	For measuring relative density
Microscope	For magnifying very small objects
Beaker	Used as container for chemicals and other liquids. Also can be used to estimate the volume of liquids
Spring balance	For measuring force in Newton
Slotted masses	Used for measuring for the quantity of matter.
Magnets	For demonstrating attraction and repulsion
Ball and ring apparatus	For demonstrating thermal expansion
Bar breaking apparatus	To show forces that can be exerted during thermal expansion and contraction
Tripod stand	For providing a platform for heating for stability
Wire gauze	For providing equal distribution of heat while burning
Bunsen burner	As source of heat
Retort stand	For holding/gripping materials
Triple beam balance	Measuring mass
Flasks	For holding liquids during experiment
Electronic balance	For measuring mass in more precise values

Laboratory Safety

- Is the situation in which laboratory users can be protected from danger, risk or injury

Laboratory Safety includes:-

- Laboratory should be well ventilated and his door should open outward
- Fire extinguishers should be fitted in an accessible position with using instruction
- Laboratory floors should not have polished to avoid slippery
- First aid kit must present in the laboratory
- Cabinets and drawer must present for storing apparatus
- All apparatus should have checked regularly to ensure they are safe to use
- Emergence exit should present and easy to access and use

First Aid

- Is the immediate assistance given to a victim before getting professional medical help
  OR
- Is an immediate care given to an injured person before she/he is taken to a nearby hospital for further medical treatment.

Importance of First Aid

- It helps to preserve life
- It prevents the victim's condition from becoming worse
- It promotes recovery by bringing hope and encouragement to the victim
- It helps to reduce pain and suffering
- It prevents infection

First Aid Kit

- Is a small box used to store instruments and chemicals needed for first aid.
  OR
- Is a small box containing items that are used to give help to a sick or injured person.
- Usually labeled as "**FIRST AID**" and stored in a safe and easily accessible place

The following table summarizes the items which are found in the first Aid kit

Item(s)	Uses
1.A pair of scissors	To cut adhesive tapes, bandages and gauze
2. Rolls of adhesive tape	To hold firmly into wounds, bandages , gauze and cotton wool.
3. Bandages and cotton wool	To clean and cover wounds.
4.Sterilized new razor blade	Used in treating fresh or old wounds

Item(s)	Uses
5. Sterilized gauze	To clean and cover wounds
6.Safety pin	To tighten clip bandages
7.One Jar petroleum jelly	To apply on burns
8. Iodine tincture	To clean fresh cuts and bruises
9.Antiseptic soap	To wash hand and wounds
10. Antibiotic solution	To clean wounds.
11.Painkillers	Relieving pain

Causes of Laboratory Accident

1. Slippery floor,
2. Incorrect use and handling of apparatus,
3. Gas leakages from faulty gas taps,
4. Fires,
5. Improper arrangement of laboratory instruments and chemicals.
6. Playing, fighting or quarreling in the laboratory.
7. Deviating from instruction for using chemical reagents or laboratory equipment.
8. Performing unauthorized experiment or deviating from instruction of experiment.
9. Insufficient personal protection when performing an experiment
10. Improper handling of potentially dangerous chemicals.
11. Ignoring laboratory rules.

The following are the ways used to minimize accidents in the laboratory:

- Through following laboratory rules and safety precaution.
- By using protection wears before beginning any experiment.
- Proper arrangement of laboratory instruments and chemicals.

First Aid Procedure

- Is the step by step process taken in order to help the victim when accident occurs

The following procedures may be used:-

(a) Electric Shock

When dealing with a victim of electric shock, remember to take the following actions

- Do not touch the victim who still in contact with electric current.
- BREAK the contact by switching off the current at the switch or meter box if can be reached easily
- If it is not possible to switch off the current, move the person from the current using a dry non-metallic object, for instance a piece of dry wooden plank or a bloom

- If you suspect that the area has high voltage electricity, call for professional help immediately
- If the victim is unconscious, check the breathing and pulse rate. If he or she has breathing problem, he prepared to resuscitate if necessary
- Administer First Aid for shock, burns or other injuries sustained by the victim.
- Seek medical assistance

(b) Cuts (Or Wounds)

For a small cut or wound:

- Wash your hands using soap and cleaning water.
- Put on your gloves.
- Wash your wounds using salty water and clean cloth.
- Cover the wounds or cut with an adhesive bandage or plaster.

For a large cut or wounds:

- Let the victim lay under a shade or allow her to sit comfortably.
- Wash your hands using soap and clean water.
- Put on your gloves.
- Prevent further blood loss by applying pressure over the wound using a folded but clean handkerchief or cloth.
- Use another cloth to secure the first one in place.
- Take the injured person to hospital.

(c) Fainting

- Fainting is the situation where by victim is weak and unable to stand. It is caused by too much heat and congestion

Steps to Help a Victim

- Take the person to a cool place or under a shade
- Let him lie on his back with his legs raised higher than the head.
- Loosen his clothes and ensure sufficient supply of air
- Dip a clean handkerchief in water and press on his forehead.
- Give him/her clean water to drink when he regains consciousness
- If not, take the victim to the nearest hospital

Fire
- **I**s the state (process) of combustion that results into light, heat, smokes and flame

Fire Triangle
- **Are** the components needed to start a fire.

These include

a) Fuel
b) Oxygen
c) heat

Causes of Laboratory Fire

(a) Electrical faults
(b) Smoking materials
(c) Carelessness
(d) Ignorance and negligence

Basic Principles of Fire Prevention
- No lighting of open fires near buildings
- No smoking in prohibited areas
- No interference with electrical installations
- All electrical appliances must be switched off after use
- All sources of heat should not be kept near the bench edge where they can easily be knocked down
- All flammable substances should be locked up in drawers or cabinets

Fire Extinguisher
- Is the one in which is used to fight or stop fire to continue

Types of Fire Extinguisher
- water extinguisher
- Sand extinguisher
- Fire Blanket extinguisher
- Dry powder extinguisher
- Carbon dioxide extinguisher
- Foam extinguisher
- Wet chemical extinguisher
- ABC extinguisher

Mechanism of fighting for Fire

- Fire extinguisher stop fire by preventing one among of the fire components/fire triangle

Classes of Fire

- Fire are classified according to materials burnt; therefore, we have six classes of fire namely

Class A Class B Class C
Class D Class E Class F

Fire class	Burning material	Suitable extinguisher
CLASS A	Organic solids (wood, paper plastics etc)	Water
CLASS B	**Flammable liquids** and greases (Petrol, Paraffin and alcohol)	**Dry** Powder
CLASS C	**Flammable gases** (methane , LPG ----)	**Dry powder**
CLASS D	**Combustible metals** (Magnesium or sodium)	Dry powder
CLASS E	**Electrical hazards** (damaged electrical cables, switch boards)	**Carbon dioxide**
CLASS F	**Cooking oils and fats** (deep fat fryers)	Wet chemical

- **NB: There is NO one extinguisher type which works on all classes of fire**

Warning Signs

Warning sign is the symbol established to ensure safety in the laboratory and in other fields like goods or commodities. This signs should have obeyed to avoid accidents, include the following

- **Toxic** **Irritant (harmful)** **Flammable**
- **Corrosive** **Radio Active** **Danger of electric shock**
- **Fragile** **Explosive** **Careful**
- **Flammable** **Keep away from water** **Oxidizing agent**

Toxic

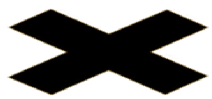
- Toxic symbol means that a substance is dangerous and can cause death within a short time.
- Toxic substances containing poisonous ingredients, examples of toxic substance is jik, mercury etc

- Toxic substance enters the body through Ingestion (by eating and drinking), Inhalation (by breathing) ,by injection and Contact

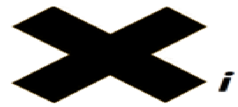
Irritant (Harmful)

- It means that a substance is dangerous and can affect our health for long time.
- Examples are alcohol, paint, insecticide, tobacco, ammonia etc

Harmful



Irritant



Flammable

- It means that the substance can catch fire easily.
- For example gasoil, kerosene, petrol, butane, methane, spirit,

Flammable

Oxidizing Agent

- It means that the substance can speed up the rate of burning.
- For example oxygen gas, chlorine gas, fluorine gas and hydrogen peroxide

Oxidizing agent

Corrosive

- The symbol means that the substance causes gradual change when in contact with various materials.
- For example, concentrated sulphuric acid, concentrated hydrochloric acid etc.

Corrosive

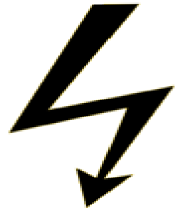
Radio Active

- It means that the substance emits harmful radiations that penetrate the human body and cause damage. For Example uranium, plutonium etc

Radio active

Danger of Electric Shock

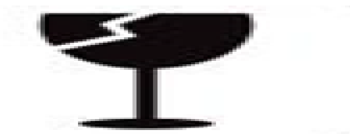
- It means that the substance has high voltage which you should not touch.



Danger of electric shock

Fragile

- It means that the substance should be handled with care to prevent them from breaking. For example, glass etc.



Fragile

Explosive

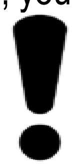
- The symbol means that the substance can erupt (explode) easily.

Corrosive

- Never store explosive material in glass container because when explode pieces of glass would fly all over and injure people

Careful

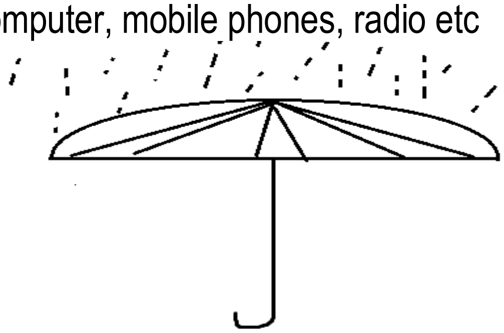
- The symbol is the caution (advice), you need to be carefully



Careful

Keep Away from Water

- Is the caution (advice) you have to keep items away from water.
- For example, computer, mobile phones, radio etc



Keep away from water

Scientific Investigation (scientific procedure)

- **S**cientific method is a set of techniques used by scientists to investigate a problem/answer question.

Steps of a Scientific Method

The following are steps followed when carrying out a scientific investigation

- Problem identification
- Asking questions
- Formulation a testable hypothesis
- Performing an experiment
- Data collection and analysis
- Data interpretation
- Data presentation
- Drawing a conclusion

Significance of the Scientific Procedure

- It helps us to solve scientific problems
- It helps us to gain new knowledge
- It helps us to conduct project work
- It helps us to carry out field study
- It helps us to solve problems or answer scientific questions

Class Activity – 2

1. Define the term laboratory.
2. Describe the common features of a science laboratory.
3. Explain why one should know the laboratory safety rules before entering or starting any activity in the Science Laboratory.
4. Mention some of the rules which ensure safety in the Science Laboratory.
5. What are warning signs?
6. Mention types of laboratory
7. State five classes of fire and their most appropriate fire extinguishers.
8. Write true for correct and false for incorrect statements for each of the following:
   (a) You should move the victim of electric shock using a metallic object ------
   (b) First Aid helps to preserve life ---------------------
   (c) Eating in the laboratory is prohibited ----------------
   (d) Thermometers are used for measuring body temperatures -------------
   (e) A micrometer screw gauge is used to measure internal and external diameters of a test tube ----------------
9. Mention safety measures that protect your body from the dangers of an experiment you are doing.
10. Draw the following apparatus and state their uses
    (a) Beaker (b) Thermometer
    (c) Micrometer screw gauge (d) Measuring cylinder
11. List down at least four accidents that are likely to occur in the science laboratory
12. What do you understand by First Aid?
13. What is the importance of first Aid?
14. List ten (10) contents of the first Aid Kit.
15. State the uses of the following instruments and chemicals in the First Aid Kit:
    (a) Petroleum jelly
    (b) Rolls of adhesive tape, plasters and bandages
    (c) Iodine tincture.
    (d) Antibiotic solution.
    (e) Methylated sprit.
16. If an accident occurs in a laboratory, what first measures are taken to accident victim?
17. What do you understand by the term scientific investigation?
18. Define the term experiment as applied in scientific investigation.
19. What do you understand by the term hypothesis as applicable to scientific investigation?

TOPIC 03: MEASUREMENT

- **Measurement** is the process of assigning numbers to observations or events

Physical Quantities

- **Physical** quantity is a property of a material that can be quantified by measurement.

There are two types of physical quantities namely.

- Fundamental quantities
- Delivered quantities

Fundamental Quantities

- Are the basic physical quantities which cannot be obtained from other physical quantities.

Fundamental Quantities and their SI Unit

Quantities	**SI unit**	**Unit symbol**
Length	Metre	m
Mass	Kilogram	kg
Time	Second	S
Electric current	Ampere	A
Temperature	Kelvin	K
Amount of substance	Mole	mol
Luminous intensity	Candela	Cd

Length

- **I**s the distance between two points.
- The SI unit of length is metre (m).
- It is measured by metre rule, tape measure, Vernier calliper and micrometer screw gauge

Metre Rule

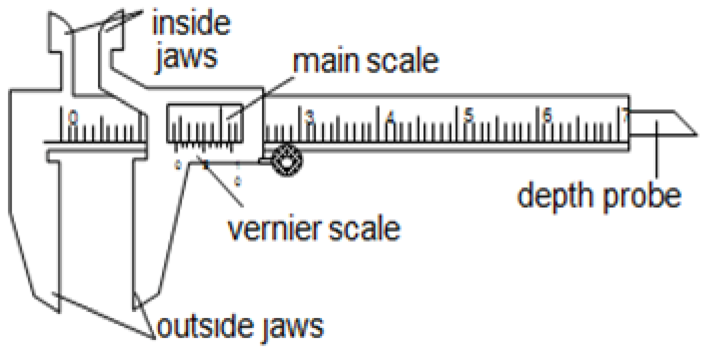
- Metre rule is a mainly wooden graduated in 100 centimeters or 1metre.
- The reading should be perpendicular to the mark otherwise the parallax error occurs

Parallax Error

- **I**s the apparent motion of one object related to another when the position of the eye is varied

Vernier Caliper

- Is an instrument used to measure length to the nearest accuracy of 0.01cm
- It is used to measure lengths to the range of 1.0 cm to about 12.0 cm



A Vernier Calliper

(a) The inside jaws are used to measure internal diameter
(b) The external jaws are used to measure external diameter

Scale of Vernier Calliper has two scales

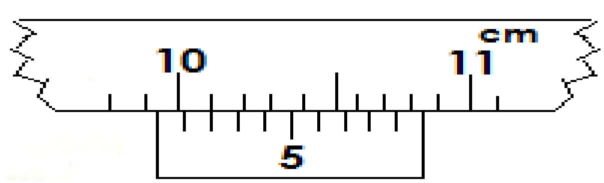
- Main (Fixed) scale
- Vernier scale

NB:

- Fixed scale gives reading in centimeter (cm) or millimeter (mm).
- Vernier scale gives reading in hundredth of a centimeter (0.01cm) or thousands of millimeter (0.001mm)
- The reading should be taken in the parallel mark between fixed scale and Vernier scale then convert it to cm or mm
- Total reading is obtained by Summing up the main scale (M.S) and Vernier scale (V.S)
- Before using a vernier caliper, close its jaws to determine if it contains zero error
- **Zero error** is the error arises when scale is not starting from zero mark

Example

1. From the fig below, determine the diameter of the object.



Solution:

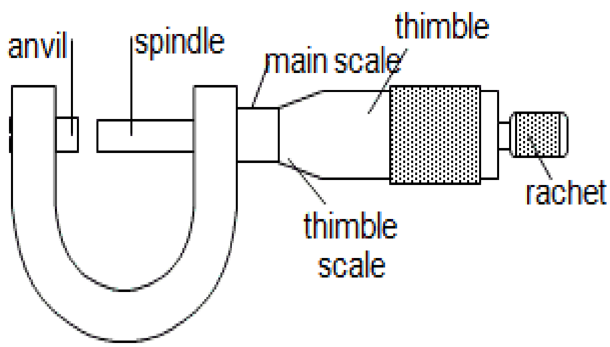
Give: Main scale, m.s = 9.9cm , Vernier scale, v.s = 2 x 0.01 = 0.02cm

$\therefore Total\ reading = 9.9 + 0.02 = 9.92\ cm$

Micrometer Screw Gauge

- Is an instrument used to measure the length to the nearest accuracy of 0.001cm or 0.01mm
- It is used to measure the diameters of wires and ball bearings
- It can measure small lengths up to about 2.5 cm

Diagram:



Scale of Micrometer Screw Gauge:-

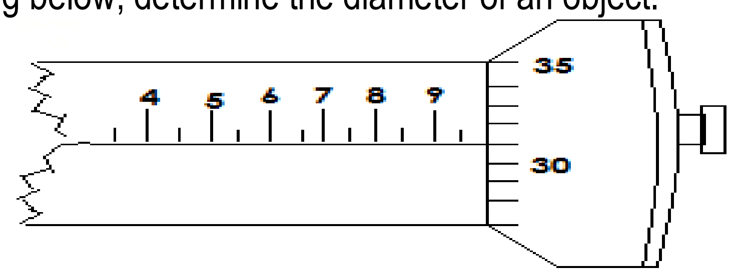
- main scale (mm)
- thimble scale

NB:

- Fixed scale gives reading in centimeter (cm) or millimeter (mm).
- Thimble scale gives reading in thousandth of a centimeter (0.001cm).
- **B**efore to use micrometer screw gauge close its jaws to determine if it contains zero error

Example

1. From the fig below, determine the diameter of an object.



Solution:

Given: Main scale, m.s = 9.5mm = 0.95cm ,
Thimble scale, v.s = 31 x 0.001 = 0.031cm

$\therefore Total\ reading = 0.95\ + 0.031 = 0.981\ cm$

Mass

- **Is** the quantity of matter in a substance.
- **The** SI unit of mass is kilogram (kg).
- It is measured by **beam balance.**
- Other units of mass are milligram, gram, tones etc
- Their equivalence: **1t = 1000kg** **1kg = 1000g** **1g = 1000mg**

Types of Beam Balance

- **Lever arm balance** (uses the principle of moments to measure the mass)
- **Triple beam balance** (uses the principle of moments to measure the mass)
- **Digital balance** (measures the mass to an accuracy of the thousandth (0.001g) of a gram

Difference between Mass and Weight

Mass	weight
Is the quantity of matter in an object	Is a force of gravity on an object
It is constant	It varies with environment
It is a fundamental quantity	It is a derived quantity
Its SI unit is kilogram (kg)	Its SI unit is Newton (N)
It is measured by beam balance	It is measured by spring balance
Is a scalar quantity	Is a vector quantity

Time

- Time is the rate at which an event happens.
- It is measured by using clock or wristwatch or stopwatch

Stopwatch

- **I**s a device that is held in the hand to show the time elapsed

Types of Stopwatch

- Mechanical stopwatch
- Digital stopwatch

N.B: Digital stopwatch is more accurate than mechanical stopwatch. They include date and time

Ways of reducing errors during measurement

- **Ta**king several readings and then find the average
- Avoiding parallax error by positioning te instrument properly on the table with eyes perpendicular to the scale
- Some instruments cab be adjusted to eliminate zero error

Delivered Quantities

- Are the physical quantities which are expressed in terms of the fundamental quantities
- Examples are area, volume ,weight ,pressure etc

Volume

- Is the quantity of space that an object occupies.
- Its SI unit is cubic meter (m^3)

N.B

1L = 1000 cm^3 **1L = 1000 ml** **1L = 1dm^3**

Volume of a solid regular object

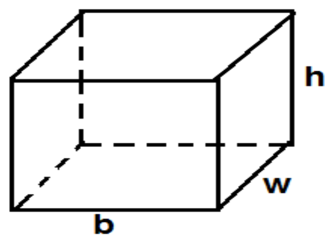
- **R**egular object is the object with known shape.
- For example, cylinder, rectangular prism, cube etc.
- The Volume of an object is given by:-

$$\boxed{V = A \times h}$$

Whereby:

A = area of a regular object h = height of a regular object

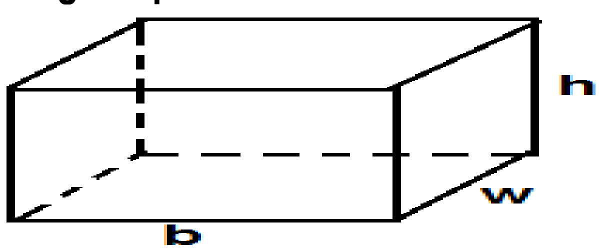
- **Volume of a Cube**



Volume of a cube , **V = w x b x h** $= \boldsymbol{w} \times \boldsymbol{w} \times \boldsymbol{w}$

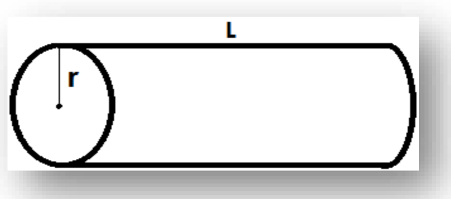
Since w = h = b

- **Volume of Rectangular prism**



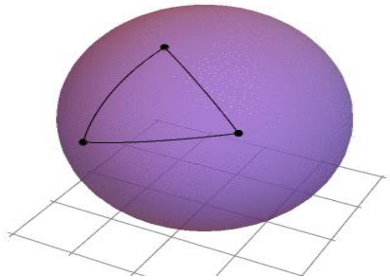
Volume of rectangular prism ,V = w x b x h

- **Volume of Cylinder**



Volume of cylinder = πr^2 h

- **Volume of Sphere (h = r)**



$$\boldsymbol{Volume\ of\ sphere\ (V)} = \frac{4\pi R^3}{3}$$

Example

1. Calculate the volume of rectangular block of sides 15cm, 8cm and 7cm

Solution:

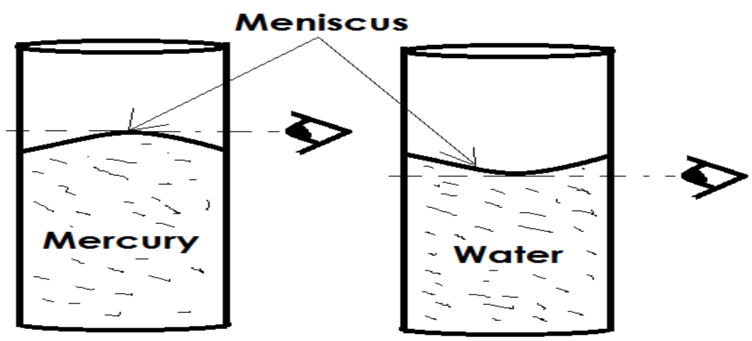
V = 15 cm x 8 cm x 7 cm **= 840 cm^3**

Individual Task – 1

1. Calculate the volume of cylinder whose radius and height are 5 cm and 14 cm respectively. Given that π = 3.14. **(ANS: V = 1099 cm^3)**

Volume of Liquid

- Litre is the standard unit used for measuring the volume of liquids.
- Burette , Pipette, measuring cylinder are examples of the instruments or apparatus used to measure the volume of liquids
- During measurement the eye should be in the same line with the meniscus of the liquid



Volume of Gas

- The volume of gas is obtained by measuring the volume of the container into which it is put
- And the volume of the container can be determined from its dimensions or by filling it with water and then pouring the water into a graduated cylinder
- Thus $\mathbf{V_{GAS} = V_{(CONTAINER + GAS)} - V_{(CONTAINER)}}$

Volume of an irregular object

- **Irr**egular object is the object with unknown shape.
- For example, stone, human body etc.
- The volume of irregular object is obtained by displacement method or immersion method

Displacement Method

- Volume of irregular object is based on the principle that when an object is completely submerged in water it displaces a volume of water equal to its own volume.
- The volume of irregular object can be measured by using:
  - **(a)** A Graduated cylinder
  - **(b)** A Eureka can or overflow can

Graduated Cylinder

- Suppose you want to measure the volume of a small stone. The following steps are necessary:-
  - Fill a graduated cylinder to known mark (let it be 300ml)
  - Carefully measure the initial volume of water (V_1)
  - Gently lower the stone into the water
  - Measure the final volume of water (V_2)
  - Lastly find the difference between the final and initial volume of water .This gives the volume of a stone. That is $\mathbf{V_{STONE} = V_2 - V_1}$

Example

1. When an irregular solid was immersed in 65cm^3 of water the water level rises to 81cm^3. What was the volume of the solid?

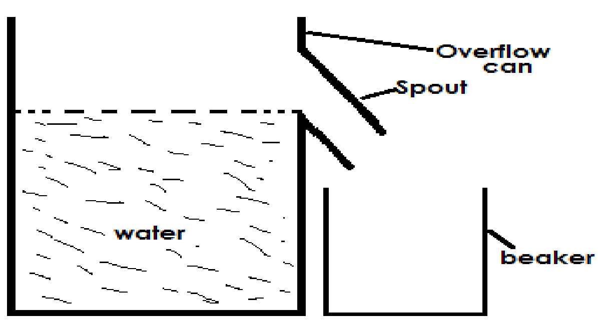
Solution:

Volume of the solid, $\mathbf{V = V_2 - V_1 = 81 - 65 = 16\ cm^3}$

Using Eureka Can (Over flow can)

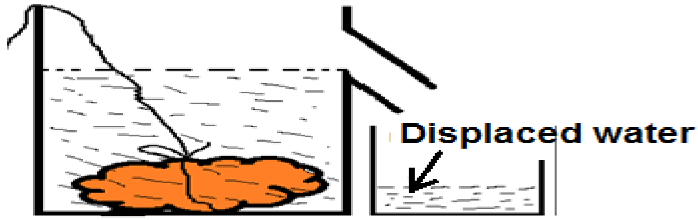
Consider the following steps:-

- Fill the overflow can with water up to the level of the spout



- Tie the irregular solid (stone) with a string

- Gently drop the irregular solid into water using a string
- The irregular solid (stone) will displace some water which will be collected in the beaker



- Transfer the displaced water into a graduated cylinder
- Measure the volume of water, which is the volume of irregular solid

Density

- Density is the mass per unit volume of a substance.
- The SI unit of density is **kg/m³ or g/cm³**

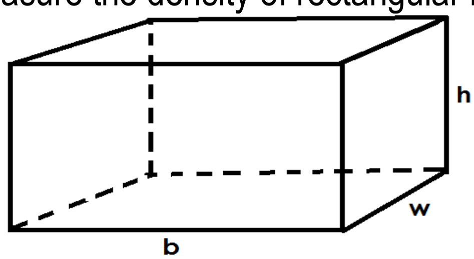
$$\therefore\ \boldsymbol{Density} = \frac{\boldsymbol{mass\ of\ an\ object\ it\ contains}}{\boldsymbol{volume\ it\ occupies}} \quad \rightarrow \quad \boldsymbol{\rho} = \frac{\boldsymbol{m}}{\boldsymbol{v}}$$

NB:

1000 kg/m³ = 1g/cm³

Density of Regular Solid Object

- The density of regular object can be found easily.
- For example, to measure the density of rectangular block



Procedure:

- Measure the mass, m of the solid
- Measure the volume, v = l x h x b
- Calculate density, ρ

Density of irregular solid Object

- The density of irregular object can be obtained by:-
  - **(a)** Measuring its mass using a triple beam balance or digital balance
  - **(b)** Determining the volume through the displacement (immersion) method
  - **(c)** Dividing the mass by the volume obtained. That is $\boldsymbol{\rho} = \frac{\boldsymbol{m}}{\boldsymbol{v}}$

Example

1. A stone has a mass of 50 g. When it is totally immersed in water of volume 60 cm^3, the final volume is read 70 cm^3. Calculate the density of the stone.

Solution:

Given: m = 50 g, V_S = 70 – 60 = 10 cm^3

$$\therefore \ \boldsymbol{Density = \frac{mass}{volume} = \frac{50}{10} = 5} \ \textbf{cm}^3$$

The Table showing Densities of Different Substance

Substance	Density (g/cm³)	Substance	Density (g/cm³)
Aluminium	2.7	Silver	10.5
Copper	8.3	Steel	7.9
Gold	19.3	Cork	0.2
Iron	7.8	Ice	0.92
Lead	11.3	Alcohol	0.8
Glass	2.5	Milk	1.03
Brass	8.5	Kerosene	1.0
Mercury	13.6	Fresh water	1.0
Sea water	1.03	Sand	2.5

Individual task – 2

1. The mass of a solid object with an irregular shape is 80 g. The solid object is totally immersed in water of volume 60 cm^3 containing in a measuring cylinder rises to 80cm^3. Calculate the density of the solid (**ANS** $\boldsymbol{\rho}$ = 4 g/cm^3)

Density of Liquids

It can be determined by using burette or density bottle by the following steps

- Measure the mass of an empty burette or density bottle, m_1
- Fill the liquid in the burette or density bottle and measure its mass, m_2
- Calculate the mass of liquid by, $m = m_2 - m_1$
- Either by graduated cylinder or overflow can Measure volume of liquid, V
- Calculate the density of liquid, $\boldsymbol{\rho}$

$$\boldsymbol{Density = \frac{m_2 - m_1}{v} \quad \rightarrow \quad \rho = \frac{m}{v}}$$

Example:

1. In an experiment to determine the density of liquid. Sophia a form one student obtained the following results.
   Mass of beaker = 500g
   Mass of beaker and liquid = 600g
   Volume of liquid, v = 25 cm^3.
   Find the density

Solution:

Mass of beaker, $m_1 = 500$ g

Mass of beaker + liquid, $m_2 = 600$ g

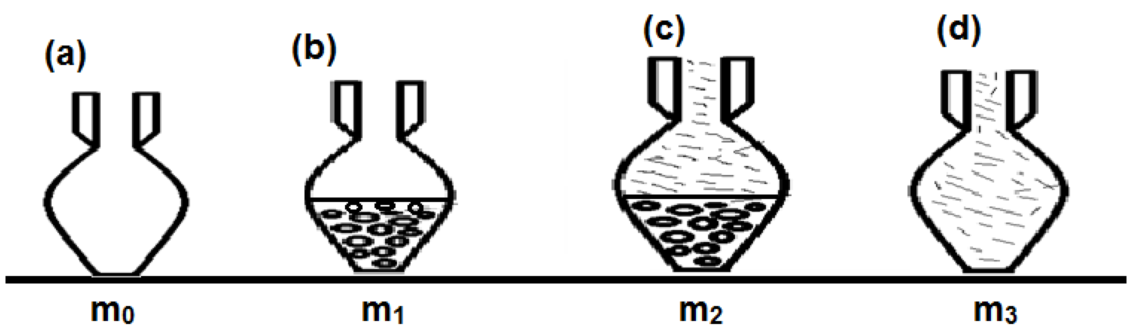
$$Density = \frac{m_2 - m_1}{v} = \frac{600-500}{25} = \frac{100}{25} = 4 \text{ gcm}^{-3}$$

Individual Task – 3

1. A clean dry beaker has mass of 400 g. 112 cm^3 kerosene is poured into the beaker with the help of burette. If the mass of the beaker and kerosene is 500 g, Calculate the density of the kerosene. **(ANS: $\rho = 0.893$ g/cm^3)**
2. The following results were obtained from an experiment:
   Mass of an empty dry density bottle = 18.9 g
   Mass of bottle full of kerosene = 70.1 g
   Volume of kerosene in the bottle = 64.0 cm^3
   Find the density of kerosene **(ANS: $\rho = 0.8$ gcm^{-3})**

Density of Granules

- It is difficult to determine the density of very small and fine particles such as sand or lead shots. Density bottle is used to determine the density of granules.
- Procedures:
  (i) Find the mass of an empty bottle by a beam balance (**m_0**)
  (ii) Put some sand in the bottle (see diagram (b))
  (iii) Record the mass of the bottle when partly filled with sand (**m_1**)
  (iv) Pour water into the bottle until it is full
  (v) Record the new mass **m_2** of the bottle with its contents
  (vi) Record the mass **m_3** when the density bottle is filled with water only



(vii) Calculate the density of granules

Given: Mass sand = **$m_1 - m_0$**
Mass of water on top of sand = **$m_2 - m_1$**
Mass of water filling the bottle = **$m_3 - m_0$**

From: $\boldsymbol{\rho} = \frac{\boldsymbol{m}}{\boldsymbol{v}}$

The volume of sand when the density of water is 1.0 g/cm³ will be

$\frac{[(m_3-m_0)-(m_2-m_1)]}{1g/cm^3}$ = **($m_3 - m_0$) – ($m_2 - m_1$) = ((m_1+ m_3) – (m_0 + m_2)) cm³**

$\therefore \boldsymbol{Density\ of\ sand} = \frac{\boldsymbol{mass}}{\boldsymbol{volume}} = \frac{\boldsymbol{m_1 - m_0}}{(\boldsymbol{m_1 + m_3}) - (\boldsymbol{m_0 + m_2})}$ **g/cm³**

Example,

1. Given that

   Mass of empty density bottle = 4.0 g
   Mass of density bottle with sand = 94g
   Mass of density bottle with sand and water = 110g
   Mass of density bottle full of water = 70g
   Find the density of sand from above readings

Solution:

M_0 = 4.0 g
M_1 = 94 g
M_2 = 110 g
M_3 = 70 g
$\boldsymbol{\rho} = ?$

From: $\boldsymbol{Density\ of\ sand} = \frac{\boldsymbol{mass}}{\boldsymbol{volume}} = \frac{\boldsymbol{m_1 - m_0}}{(\boldsymbol{m_1 + m_3}) - (\boldsymbol{m_0 + m_2})}$

$\therefore \boldsymbol{Density\ of\ sand} = \frac{\mathbf{94-4}}{(\mathbf{94+70})-(\mathbf{4+110})} = \frac{\mathbf{90}}{\mathbf{50}} = \mathbf{1.8}$ **g/cm³**

Relative Density of a Substance

- **R**elative density is the ratio of density of substance to the density of water.
- It has no SI unit.
- This shows that how many times a substance is denser than water

$$\boldsymbol{Relative\ density} = \frac{\boldsymbol{Density\ of\ a\ substance}}{\boldsymbol{Density\ of\ water}} \quad \rightarrow \quad \boldsymbol{R.D} = \frac{\boldsymbol{\rho_S}}{\boldsymbol{\rho_W}}$$

OR

$$\boldsymbol{Relative\ density} = \frac{\boldsymbol{Mass\ of\ a\ substance}}{\boldsymbol{Mass\ of\ water}} \quad \rightarrow \quad \boldsymbol{R.D} = \frac{\boldsymbol{m_S}}{\boldsymbol{m_W}}$$

Example,

1. An empty density bottle weighs 20g. When full of water it weighs 70g and when full of liquid it weighs 60g. Calculate

   (a) The relative density of the liquid (b) Its density

   Solution:

   M_0 = 20 g

   M_1 = 70 g

   M_2 = 60 g

   From: $\boldsymbol{Relative\ density = \frac{Mass\ of\ a\ substance}{Mass\ of\ water}}$

   (a) $\therefore \boldsymbol{Relative\ density = \frac{Mass\ of\ a\ substance}{Mass\ of\ water} = \frac{60-20}{70-20} = \frac{40}{50} = 0.8}$

   (b) $From$: $\boldsymbol{Relative\ density = \frac{Density\ of\ a\ substance}{Density\ \ of\ water}}$

   $$\boldsymbol{0.8 = \frac{\rho_s}{\rho_w} = \frac{x}{1} \rightarrow x = 0.8 \times 1 = 0.8}\ \textbf{g/cm}^3$$

   $$\therefore \boldsymbol{Its\ density = 0.8}\ \textbf{g/cm}^3$$

Individual Task – 4

1. In an experiment to determine the relative density of liquid x, form one physics students obtained the following results after various measurements:

   Mass of an empty relative density bottle = 15g

   Mass of bottle + liquid x = 35g

   Mass bottle + water = 40g

   Volume of bottle = 25 cm^3

   Calculate

   (a) Density of water in kg/m^3 **(ANS: $\boldsymbol{\rho_w = 1000}$ kg/m³)**

   (b) Density of liquid x in kg/m^3 (ANS: $\boldsymbol{\rho_L = 800\ kg/}$**m³)**

   (c) Relative of liquid x **(ANS: R.D = 0.8)**

Application of density and relative density in our daily Life

- It is used to design of various structures like ship, planes etc
- Used to determine density of unknown substance using known density of another
- Used to select building materials
- Used to design equipment used in swimming and diving

Importance of Measurement

- It is used in architecture and engineering for designing of bridges, flyovers and other structures
- It is used in school to determine the number of students
- Measurement for length are used for fitting clothes in the fashion industry
- In trade – exact quantities for export or import are to be known
- Helps to identify the space occupied by substance
- Helps us to know the rate of working
- Helps us to identify the size of substance
- It helps in decision making

Class Assignment

Where necessary use g = 10 m/s^2

1. What do you understand by the term derived quantities of measurement?
2. Mention at least 10 derived quantities of measurement.
3. Define the term volume of a substance
4. Calculate the volume of a cube of sides 2 cm.
5. The density of pure solid copper is 8.94 g/cm^3 .What volume does 5 kilograms of copper occupy? (**ANS: V = 559.3 cm^3)**
6. **A** beaker contains 262.5 cm^3 of a certain liquid weigh 410 g, if the mass of an empty dry beaker is 200 g. Find the density of the liquid.**(ANS: Density = 0.8 g/cm^3)**
7. A silver cylindrical rod has a length of 0.5 m and radius of 0.4 m, find the density of the rod if its mass is 2640 kg. (**ANS: Density = 10509 kg/m^3)**
8. The relative density of some type of wood is 0.8. Find the density of the wood in kg/m^3 (**ANS: Density = 800 kg/m^3**)
9. A stone has a mass 112.5 g. When the stone totally immersed in water contained in measuring cylinder displaced water from 50 cm^3 to 95 cm^3 . Find the density of the stone. **(ANS: Density = 2.5 g/cm^3)**
10. A piece of anthracite has a volume of 15 cm^3 and a mass of 27 g. What is its density (a) in g/cm^3 (b) in kg/m^3 **(ANS: a. 1.8 g/cm^3 b. 1800 kg/m^3)**
11. A 30 ml density bottle was filled with kerosene and found to weigh 86 g. If the mass of empty dry bottle was 62 g , find the density of kerosene(**D = 0.8 g/cm^3**)
12. A solid ball has a mass of 50 g and a volume of 20 cm^3. What is its density? (**ANS: Density = 2.5 g/cm^3)**
13. When a piece of wood is put in a graduated cylinder containing water, the level of water rises from 17.7 cm^3 to 18.5 cm^3. Calculate the
    (a) Mass of the piece of wood (**ANS: m = 0.8 g)**
    (b) Total volume of the piece of wood given that its relative density is 0.60
    (ANS: v = 1.33 cm^3)

14. A solid ball has a mass of 100 g and radius of 2 cm. What is the density? (**ANS: Density = 2.98 g/cm^3)**
15. A globe of steel has a mass of 12 g and a volume of 15.2 cm^3, find its relative density (**ANS: R.D = 0.79)**
16. The density of Sulphuric acid is 1.8 g/cm^3. Calculate the volume of 3.1 kg of the acid.(**ANS: v = 1722 cm^3)**
17. A block of ice with volume 5.5 cm^3 has a mass of 5060 kg find the density of **ice (ANS: Density = 920 kg/m^3)**
18. A block of glass of mass 187.5 g is 5.0 cm long, 2.0cm thick and 7.5 cm high. Calculate the density of the glass in kg/m^3. (**ANS: Density = 2,500 kg/m^3)**
19. Seawater contains approximately 3.5% salt by weight. How much seawater (in kg) contains 1 kg of salt? If the density of seawater is 1030 kg/m^3, What is the volume of seawater, in liters, containing 1 kg of salt**? (ANS: 28.57 kg, 27.74 L**)
20. Calculate the mass of air in a room of floor dimensions 10 m x 12 m and height 4 m. (Density of air = 1.26 kg/m^3) **(ANS: m = 605 kg)**
21. **W**hat is meant by the density of a substance? A spring balance has a maximum reading of 10 N and the length of the calibrated scale is 20 cm .A rectangular metal block measuring 10 cm by 3 cm by 2 cm is hung on the balance and stretches the spring by 15 cm. Calculate
    (i) The weight of the block (**ANS: w = 0.75 N)**
    (ii) The mass of the block (**ANS: m = 0.75 kg)**
    (iii) The density of the metal from which the block is made (**AN:12 500 kg/m^3)**
22. The volume of a brick is given as 60 cm^3. Given that its breadth and height are 6 cm and 4 cm respectively , calculate its length
23. What is the volume occupied by a tone of sand of density 2600 kg/m^3 **(0.385 m^3)**
24. **The** mass of an empty density bottle was 50 g . When filled with a certain liquid of volume 20 cm^3 its mass became 75 g. Find the:
    (a) Density of the liquid (b) Relative density **(ANS: Density = 1.25, R.D = 1.5)**
25. A solid cylinder of length 10 cm is placed in water. It stands upright with the top 3 cm protruding above the water surface .The density of water is 1.0 g/cm^3,What is the density of the cylinder? **(ANS: Use Archimedes principle, Equate the mass of cylinder to mass of water displaced, Density = 0.7 g/cm^3)**
26. A cylindrical tank has a diameter of 10 cm and a height of 12 cm. Calculate its volume given that $\pi = 3.14$
27. A tin containing 5000 cm^3 of paint has a mass of 7.0 kg.
    (i) If the mass of the empty tin, including the lid, is 0.5 kg .Calculate the density of the paint **(ANS: Density = 1300 kg/m^3)**
    (ii) If the tin is made of a metal which has a density of 7800 kg/m^3 calculate the volume of metal used to make the tin and the lid (**ANS: v = 6.41 cm^3)**
28. What is the volume of an irregular solid immersed in 50 cm^3 of water contained in a beaker if it raises the water level to 57 cm^3
29. A beaker contained 100 cm^3 of liquid. A 25 cm^3 pipette was used twice to transfer the liquid to another beaker. What is the volume of the liquid left in the original beaker?

30. Define density and Relative density. An empty 60 litre petrol tank has a mass of 10 kg. What will be its mass when full of fuel of relative density 0.72? **(ANS: 53.2 kg)**

31. The mass of density bottle is 19 g when dry and empty, 45 g when filled with water and 40 g when full of liquid X . Calculate the density of the liquid X. (**D = 0.81 g/cm^3)**

32. A certain piece of metal has a mass of 282.5 g, if when the block was totally immersed in overflow can displaced water in a beaker of mass 20 g . If the mass of water and the beaker was 45 g, find the relative density of the metal.**(AS: R.D = 11.3)**

33. 100 cm^3 of fresh water of density 1000 kg/m^3 is mixed with 100 cm^3 of sea water of density 1030 kg/m^3. Calculate the density of the mixture.**(ANS: Density = 1015 kg/m^3)**

34. Given the data below find the density of granules

Mass of an empty dry density bottle = 18 g

Mass of density bottle and granules = 131 g

Mass of density bottle and granules together with water on top = 171 g

Mass of density bottle full of water = 68 g. (ANS: Density = 11300 kg/m^3)

35. Differentiate between mass and weight

36. A and B, have densities of 0.75 g per milliliter and 1.14 grams per milliliter respectively. When both liquids are poured into a container, one liquid floats on top of the other .Which liquid is on top?

37. The mass of an empty bottle is 20 g .Its mass when filled with water is 40 g and 50 g when filled with liquid X .Calculate the density of liquid X if the density of water is 1000 kg/m^3 (**ANS: Density = 1500 kg/m^3)**

38. A bottle full of water has a mass of 45 g; when full of mercury its mass is 360 g .If the mass of the empty bottle is 20 g calculate the density of mercury**.**
(ANS: Density = 13.6 g/cm^3)

39. The water collected in a cylinder during an experiment using a Eureka can is 30 cm^3.When the object that displaced this volume was dried and weighed, its mass was found to be 90 g. Calculate its density

40. The mass of a density bottle is 18.00 g when empty, 44.0 g when full of water, and 39.84 g when full of a second liquid. Calculate the density of the liquid.
(ANS: Density = 0.84 g/cm^3)

41. What do you understand the following terms
   - **(a)** Mass
   - **(b)** Density
   - **(c)** Relative density

42. A piece of sealing – wax weighs 0.27 N in air and 0.12 N when immersed in water .Calculate
   - **(a)** Its relative density (**ANS: R.D = 1.8)**
   - **(b)** Its apparent weight in a liquid of density 800 kgm^{-3} (**ANS: W = 0.15 N)**

43. What is the volume of the irregular solid if when immersed in 200 cm^3 of water contained in the measuring cylinder raises the level of water to 225 cm^3?

44. What is relative density? Express relative density in terms of mass

45. The following results were obtained from an experiment:

Mass of an empty dry density bottle = 25 g

Mass of bottle full of water = 53 g
Volume of water in the bottle = 28 cm^3
Find the density of water. (**ANS: $\rho = 1.0$ g/cm^3**)

46. A block of metal of volume 60 cm^3 weighs 4.80 N in air .Determine its weight when fully submerged in a liquid of density 1200 kgm^{-3}. (**ANS: W = 4.08 N)**
47. Asher , a form 1 student at X secondary school , obtained the following results from her experiment:
Mass of an empty beaker = 48 g
Mass of beaker + liquid m = 60 g
If she had used a 25 cm^3 pipette to transfer liquid m to the beaker, calculate the density of the liquid.
48. A metal cube of side 2 cm weighs 0.56 N in air. Calculate:
   (a) Its apparent weight when immersed in white spirit of density 0.85 g/cm^3
   (b) The density of the metal of which it is made. (ANS:
   (ANS: (a) W**= 0.492 N, (b) Density = 7 g/cm^3)**
49. A river car – ferry boat has a uniform cross sectional area in the region of its water – line of 720 m^2. If sixteen cars of average mass 1100 kg are driven on board, find the extra depth to which the boat will sink in the water.**(ANS:0.024 m)**
50. A rectangular metal block has a mass of 0.**48 kg** and dimensions 5 cm x 4 cm x 3 cm. Calculate the density of the metal. The same block is now suspended from a balance so that the block is completely immersed in a liquid whose density is 1200 kg/m^3 .What will be the reading on the balance
(**ANS: Density = 8000 kg/m^3, m = 0.418 kg**)
51. Identify areas in daily life where you can find application of density.
52. Distinguish between density and relative density of a substance
53. Describe an experiment to determine the density of liquid. If a density bottle of mass 22 g weighs 109 g when filled with a liquid of density 1.3 g/cm^3, find the volume of the liquid.
54. A rectangular block of metal measuring 16 cm x 10 cm x 4 cm has a mass of 1760 g. What will the mass of a block of the same metal measuring 12 cm x 8 cm x 2 cm be?
55. An empty petrol tin has a mass of 0.75 kg. When full of petrol, the tin and petrol have mass of 7.75 kg. If the density of petrol is 700 kg/m^3, calculate the volume of the petrol in the tin.
56. A crown made of gold and silver has a volume of 60 cm^3 and a mass of 1.05kg. Find the mass of gold contained in the crown. (Given that the Density of gold is 19.3g/cm^3 and the density of silver is 10.5g/cm^3) (**ANS: m_g = 921.14g)**
57. A wooden block of dimensions 3 cm x 3 cm x 4 cm floats vertically in methylated sprit with 4 cm of its length in the sprit. Calculate the weight of the block .Given that the density of the methylated sprit = 8.0 x 10^2 kgm^{-3}
(**ANS: W = 2.88 x 10^{-1} N)**

58. The density of two liquids (A and B) is given as 1000 kg /m^3 and 600 kg/m^3 respectively .The two liquids are mixed in certain proportion and the density of the resulting liquid is 850 kg/m^3.How much of liquid B (in grams) does a 1 kg of the mixture contain? Assume that the volume of the two liquids is additive when mixed. (**ANS: m = 264.7 g)**

59. A solid of mass 1.0 kg is suspended using a thread and then submerged in water. If the tension on the thread is 5.0 N, determine the relative density of the solid. (**ANS: R_D = 2)**

60. 250ml of water are mixed with one litre of methylated spirit. Calculate the mass of mixture, assuming that there is no change of volume of mixing (relative density of methylated spirit is 0.80) **(ANS:**Mass **of the mixture = mw + ms = 800 + 250 = 1050g mt = 1050g)**

61. A ship of mass 1 200 t floats in sea – water. What volume of sea – water does it displaces? If the ship enters fresh water , what mass of cargo must be unloaded so that the same volume of water is displaced as before? (given density of fresh water = 1000 kg/m^3,relative density of sea – water = 1.03, 1 t = 1000 kg) (**ANS: $V_{SEA-WATER}$ = 1165 m^3 , m = 35 kg)**

62. What volume of brass of density 8.5 g/cm^3 must be attached to a piece of wood of mass 100 g and density 0.2 g/cm^3 so that the two together will just submerge beneath water? (**ANS: V = 53.3 cm^3)**

63. An ordinary hydrometer of mass 28 g floats with 3 cm of its stem out of water. The area of cross – section of the stem is 0.75 cm^2. Find the total volume of the hydrometer and the length of the stem above the surface when it floats in a liquid of relative density 1.4. **(ANS: V_T = 30.25 cm^3, $L_{STEM\ ABOVE\ LIQUID}$ = 13.7 cm)**

64. A material of density 8.5 gcm^{-3} is attached to a piece of wood of mass 100 g and density 0.2 gcm^{-3}. Calculate the volume of the material X which must be attached to the piece of wood so that so that the two just submerge beneath a liquid of density 1.2 gcm^{-3}. **(ANS: V = 68.5 cm^3).**

TOPIC: 04 FORCE

A F*orce:* Is a push or pull experienced by an object.
OR

Is a push or pull upon an object resulting from the object's interaction with another object

- The SI Unit of force is Newton (N)
- It is measured by spring balance.

Types of Forces
- Fundamental forces
- Non fundamental forces

Fundamental Forces
- Are the basic forces in nature that cannot be explained by the action of another force **OR**
- Are the forces in which the two interacting objects are not in physical contact with each other.

Types of Fundamental Force
- Force of gravity (weight)
- Electromagnetic force
- Strong nuclear force
- Weak nuclear force

Force of Gravity (weight)

- Is the earth's gravitational pull on a body , lying on near the surface of the earth
- For example, all objects fall down if thrown up due to force of gravity pulling the objects towards the earth surface.
- Force of gravity, F = mass (m) x acceleration due to gravity(g) → $\boldsymbol{F = mg}$
- The acceleration due to gravity (g) has a constant value of **10 m/s^2 or 9.8 m/s^2**

NB:
- The force of gravity pulls objects towards the centre of the earth.
- The force of gravity is proportional to the mass of an object
- The force of gravity is stronger when the mass is closer

Gravitational force

- Is the force of attraction acting between any two bodies of the universe

Properties of Gravitational force

- It is always attractive
- It is the weakest force among the four basic forces
- It is a central force.
- It obeys the universe square law
- It operates over very long distances.

Mass and weight.

Difference between mass and weight

Mass	Weight
It is the quantity of matter in a body	It is the pull of gravity on a body
It is measured in kilograms (Kg)	It is measured in Newton (N)
It is the same everywhere	It changes from place to place
It is measured using a beam balance	It is measured by using a spring balance
It has magnitude only	It has both magnitude and direction

Example

1. An astronaut weighs 900 N on earth. On the moon he weighs 150 N. Calculate the moons' gravitational strength. (Take g = 10 N/kg).

Solution

From: $w = mg \quad \rightarrow \quad m = \frac{w}{g} = \frac{900}{10} = 90\ kg$

Moons' gravitational strength = weight of astronaut

$$g_{moon} = \frac{weight\ in\ the\ moon}{mass\ on\ the\ moon} = \frac{150}{90} = 1.67\ ms^{-2}$$

Individual Task – 1

1. Rocket moves from the earth to a planet x. if it weighs 10, 000N and 30N on the earth and on planet x respectively determine the acceleration due to gravity on planet x (**ANS: g in a planet x = 0.03N/kg)**

Electromagnetic Force

- Is the force that associated with production field due to movement of electrons.
- It includes both electric and magnetic forces.
- For example:-
  - (a) Formation of water molecules, Atoms attract each other due to electromagnetic force
  - (b) In two charges placed near each other may attract or repel due to electromagnetic force

Properties of Electromagnetic Force

- It may be attractive or repulsive in nature
- It is a central force
- It is stronger than gravitational force
- It is a long-range force (operates over a very long distance)

Strong Nuclear Force

- Is the force which holds the constituents of the atomic nucleus
- It acts within the nucleus of the atom.
- An example of this force is the nuclear energy obtained from the splitting (fission) or the fusing together of the nucleus of the atom.

Properties of Strong Nuclear Force

- It is basically an attractive force
- It is a short-range (operates only up to a distance of the order of 10^{-14} m)
- It is a non-central force (it does not act at the centre)
- It is stronger than gravitation force

Weak Nuclear Force

- Is the force which appears only in a certain nuclear processes
- For example, in formation of water from reaction between oxygen gas and hydrogen gas weak nuclear force is used to bond the water molecules

Properties of Weak Nuclear Force

- It is Stronger than gravitation force
- It is weaker than electromagnetic force and strong nuclear force
- It Operates on small ranges of up to 10^{-17} m.

Non - Fundamental Forces

- Are the forces in which the two interacting objects are in physical contact with each other

  Examples are:- (a) Kicking a ball (b) Air resistance
  (c) Pulling a door (d) Tension
  (e) Compressing a spring (f) Friction
  (g) Elastic forces e.t.c

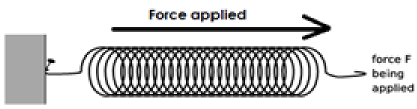
Effects of Forces

Forces have several effects on objects. These effects include:-

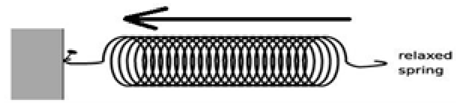
- Stretching (tensile) **Torsion** Attraction **Friction**
- Compression **Viscosity** Air resistance **Repulsion**

Stretching and Restoring

- Stretching occurs when an object increases its length when the force is applied to it.
- For some objects there is a tendency to return to their original shape and size. This is called restoring force.
- For example, when spring is pulled the stretching force elongates the spring



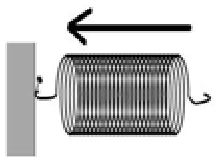
stretching force

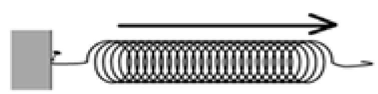


Restoring force

Compression and Restoring

- Compressional force is the force which when applied to an object results in decreasing in its volume.
- Example when you compress the spring
- Restoring force is the force which causes a body to return to its original shape and size


Compressional force

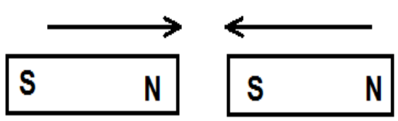

stretching force

Attractive force

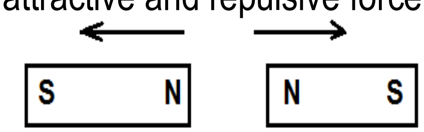
- Is the force that pulls objects toward each other.
- For example, A Magnet always attracts other objects like iron.

Repulsive force

- Is the force that pushes objects against each other.
- For example, when the same poles of magnets are closer to each other, they repel
- The figures below show an example of attractive and repulsive force



Atrractive force of a magnet



Repulsive force of a magnet

Torsional Force

- Is a force produced when a solid matter is twisted

Frictional force

- Is the force that prevents a body from sliding.
- For example, an exercise book cannot slid on top of a table due to friction exists between exercise book and table

Viscous force

- Viscosity is the resistance of a fluid to flow.
- For example water has a lower viscous force than cooking oil, since it has less resistance to flow

Air Resistance

- **Is** the force that resists the movement of an object through the air.
- Example of this force is viscosity

Factors affecting Air Resistance

- Size and shape of the body
- The speed of fluid
- The density of the fluid

Normal Force

- Is the force that acts in equal and opposite direction to the weight of a body

Applied Force

- Is the external force that causes the system or body to change position

Class activity

1. Define force
2. Why a body weighs 60 N on the earth's surface then only 10 N on the surface of the moon.
3. Explain what type of a force you can apply to stretch a rubber
4. What is restoring and stretching force
5. If an object weighs 30 N on the earth, what is its mass?
6. An astronaut weighs 900 N on earth .On the moon he weighs 150 N. Calculate the moons' gravitational strength. Take g = 10N/kg **(ANS: g_{moon} = 1.67 N/kg)**
7. If an object has a mass of 200 g ,how much would it weigh on the earth?
8. Rocket moves from the earth to a planet x. if it weighs 10, 000N and 30N on the earth and on planet x respectively determine the gravitation force on planet x (**ANS: g on planet x = 0.03N/kg)**
9. Mention types of fundamental forces
10. Match the items in the first column with those in the second column.

List A	List B
(a) Stretching	(i) Effects of magnet on iron material
(b) Attraction	(ii) Force in a string
(c) Friction	(iii) Compression of rigid material such spring
(d) Viscosity	(iv) Rough surface
(e) Restoring	(v) Motion in fluids

11. An object weighs 200 N on the earth. What would be its mass on the moon?

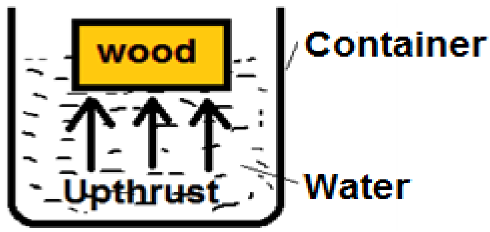
12. Differentiate between fundamental force and non – fundamental force
13. A force of 9.6 N stretches a spring 6 cm while a force of 14.4 N stretches it 9 cm .What force would be required to stretch the spring by 15 cm
14. The length of a spring is 16.0 cm. Its length becomes 20.0 cm when supporting a weight of 5.0 N .Calculate the length of the spring when supporting a weight of (a) 2.5 N (b) 6.0 N (c) 200 N

    (**ANS: (a) l = 18 cm (b) l = 20.8 cm (c) l= 176 cm)**

TOPIC: 05 ARCHIMEDES'S PRINCIPLE AND THE LAW OF FLOTATION

Archimedes's Principle

- Consider a piece of wood that is held below the surface of a liquid and then released .The wood comes to the surface immediately.

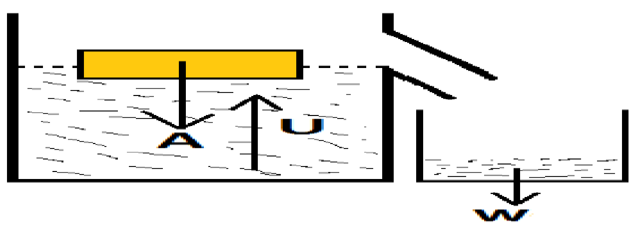


- When a piece of wood is immersed in a fluid, then it floats due to the **buoyant force or upthrust.**
- **Upthrust** is the upward force that enables the object to float or at least seem lighter
- **The** upthrust is greater than the weight of the wood, that is why the wood is pushed to the surface

Archimedes Principle (the law of buoyancy)

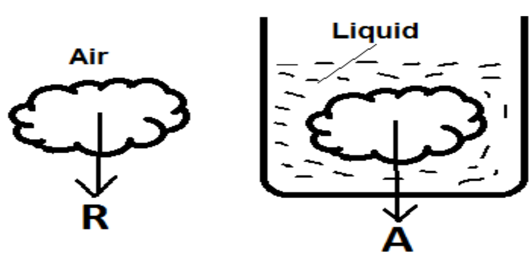
It states that:

"When a body is partially or totally immersed in a fluid it experiences an upthrust which is equal to the weight of the fluid displaced"



Relationship between Real Weight and Apparent Weight

- Consider the diagram of the mass (weight) of the object below



- **Real Weight** is the weight of an object in air
- **Apparent weight** is the weight of an object in fluid

- $\therefore$ Apparent loss in weight = Real weight – apparent weight of a body in liquid

$$\boxed{\therefore \quad U = R - A}$$

Example

1. Given that the weight of a body in air is 10.10N while the weight of the body when immersed in water is 9.2N. Find the up thrust.
   Solution:
   Weight in air (R) = 10.10 N
   Weight in water (A) = 9.2 N
   $\therefore \boldsymbol{U = R - A = 10.10 - 9.2 = 0.9\ N}$

Individual Task – 1

1. The weight of a body when totally immersed in a liquid is 4.2N if the weight of the liquid displaced is 2.5N. Find the weight of the body in air. (**ANS: R =6.7N)**
2. When an object is totally immersed in water, its weight is recorded as 3.1N if its weight in air is 4.9N. Find up thrust. (**ANS: U = 1.8N)**
3. A body immersed in water displaced 1.1N of the liquid if its weight while in water is 3.3N. Find its weight in air. (**ANS: R = 4.4N)**

Relative Density by using Archimedes Principle

- The relative density of a substance can be expressed as:

$$\boldsymbol{R.D = \frac{weight\ of\ a\ substance\ in\ air}{weight\ of\ displaced\ water} = \frac{weight\ of\ body\ in\ air}{Upthrust\ in\ water}}$$

$$\therefore \boldsymbol{R.D = \frac{R}{R-A} = \frac{R}{U}}$$

Example

1. A piece of glass weighs 5 N in air and 3 N when completely immersed in water calculate its. (a) Relative density (b) Density of glass
   Solution:
   Given: R = 5 N
   A = 3 N
   From:
   $\boldsymbol{R.D = \frac{weight\ of\ a\ substance\ in\ air}{weight\ of\ displaced\ water} = \frac{R}{R-A}}$
   $\therefore (a)\ \boldsymbol{R.D = \frac{5}{5-3} = \frac{5}{2} = 2.5}$

   (b) $From: R.D = \frac{density\ of\ substance}{density\ of\ water}$
   $\boldsymbol{R.D = \frac{x}{1000}} \rightarrow \quad \boldsymbol{1000 \times 2.4 = x} \quad \rightarrow \quad \boldsymbol{x = 2400}$ **kgm^{-3}**
   $\therefore$ The density of the piece of glass is 2400 kgm^{-3}

Relative Density of other liquid from water by solid substance in Archimedes Principle

- When a solid immersed in a liquid and water the relative density is given by liquid displaced over water displaced

Mathematically

R.D = $\frac{(weight\ of\ liquid\ displaced)}{Weight\ of\ water\ displaced}$

R.D = $\frac{weight\ of\ object\ in\ air\ -\ weight\ of\ object\ in\ liquid}{weight\ of\ object\ in\ air-\ weight\ of\ object\ in\ water} = \frac{W_A - W_L}{W_A - W_w}$

R.D = $\frac{upthrust\ on\ liquid}{up\ thrust\ on\ water} = \frac{U_L}{U_w}$

$\therefore$ **R.D** $= \frac{W_A - W_L}{W_A - W_w}$

Example

In an experiment to determine the relative density of a liquid, a solid X weighs as follows:

Weight of X in air, W_A (R) = 8.6N

Weight **of X** in water, W_A = 6.0N

Weight **of X** in liquid, W_L = 5.4N

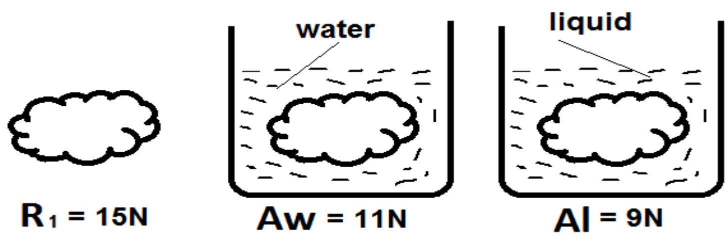
Solution:

From: R.D = $\frac{weight\ of\ object\ in\ air\ -\ weight\ of\ object\ in\ liquid}{weight\ of\ object\ in\ air-\ weight\ of\ object\ in\ water} = \frac{W_A - W_L}{W_A - W_w}$

$\therefore$ **R.D** $= \frac{W_A - W_L}{W_A - W_w} = \frac{8.6 - 5.4}{8.6 - 6.0} = \frac{3.2}{2.6} = \mathbf{1.23}$

Individual Task – 2

1. Using the data shown below and determine the relative density of the liquid



(ANS: R.D = 1.5)

2. A body weighs 0.52 N in air. When total immersed in water it weighs only 0.32N while its weight when immersed in another liquid is 0.36 N. The density of water is 1000 kg/m^3. What is the density of the other liquid? (**ANS: ρL = 800 kg/m^3)**

Sinking

- Sinking is the tendency of an object to fall or drop to lower levels in a fluid

Conditions for Sinking

- The upthrust exerted by the fluid must be less than the weight of an object
- The density of the object should be greater than that of the fluid

Floating

- Floating is the tendency of an object to remain on the surface of a fluid due to the upthrust.
- The ability of an object to float in a fluid is called **Buoyancy**

Conditions for Floating

- The upthrust due to the liquid must be equal to the total weight of the object
- The density of the body must be less than that of fluid.
- The Volume of submerged object must be large enough to displace a lot of fluid.

Difference between floating and sinking

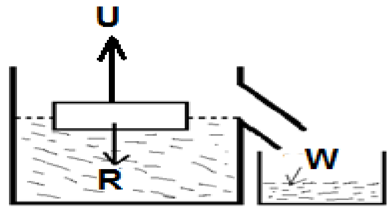
Floating	Sinking
The body stays at the surface of the liquid	The body drops to the bottom of the liquid
Takes place when the upward force is greater than the weight of the body	Takes place when the upward force is less than the weight of the object
Takes place when the density of the body is less than that of the liquid	Takes place when the density of the body is greater than that of the liquid

The following conditions can be used to determine the position of the object in the fluid:-

- If **W > U**, there is downward movement of the body (known as sinking)
- If **W < U**, there is upward movement of the body
- If **W = U**, the body is in equilibrium under the action of two equal and opposite force. (Thus the body floats)

The Law of Flotation

- It states that:
  "A floating body displaces its own weight of the fluid in which it floats"



- **For a substance to float**
  - **(a) Upthrust (U) = weight of displaced fluid (W)**
  - **(b) Real weight(R) = weight of displaced fluid (W)**
- **But: App**arent weight = Real weight – Upthrust (weight of displaced fluid)
- **For a body to float Apparent weight = 0 N**
  Therefore: R = U = W
- **To find percentage of submerged substance consider the equation**

  Real weight of a substance (R) = Weight of displaced fluid (W)

But now: **R = mass of substance (m_s) x g**
R = density (ρ_s) $\times$ volume of substance (v_s) $\times$ g
Also: U = mass of fluid (m_f) x g = density (ρ_f) $\times$ volume of fluid (v_f) $\times$ g

- But: Volume of fluid displaced = % of object submerged (S) x Volume of object (Vs)
  V_f = % Sub x V_s ---------------------- (i)

$$\therefore \textbf{ Percentage submerged (\%S)} = \frac{volume\ submerged}{volume\ of\ substance} \times 100\%$$

- Since: **R = U** (when substance floats)
- **Then**: ρs x vs x g = ρf x vf x g ---------------- (ii)
- Substitute equation (i) into equation (ii)
- **ρ**s x Vs x g = ρ_f x %Sub x V_S x g

$$\therefore \% \text{ Sub } = \frac{\rho_s}{\rho_f} \times 100\%$$

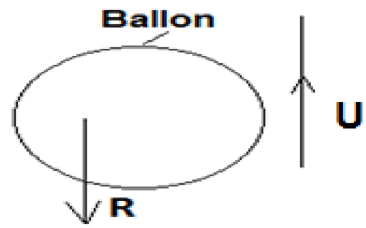
Application of Flotation

The Law of flotation is applicable in various objects like:-

- Applied when Filling Balloons (Hot air balloons)
- Submarines
- Ships
- Hydrometer

Balloons (Hot air balloons)

- A balloon is a light bag filled with hydrogen or helium gas.
- **These gases are less denser than air**. An air ship is a large balloon with a motor to make it and fins to steer it.
- The downward force in a balloon is equal to the weight of the bag plus the weight of a gas in it.
- The balloon rises if the upthrust is greater than the down ward force. That is



NB:

- As a balloon rises, the atmospheric pressure on it becomes less. The gas in the balloon tends to expands **(**$P \propto \frac{1}{V}$). **Therefore, the gas – bag must not be filled completely when the balloon is on the ground.**
- Consider the diagram below
- If the balloon is filled with some gas of known density. Then the volume of gas required just to lift the balloon into the air is given by

$$\boldsymbol{Volume\ of\ gas\ = \frac{Mass\ of\ balloon\ and\ load}{density\ of\ air - density\ of\ gas} = \frac{M}{\rho_A - \rho_G}}$$

Example

1. **A** balloon and the gas in it has a mass of 450 g and its volume is 500 cm^3. What is the maximum load it can lift in air of density 1.3 g/cm^3

Solution:

From: The Principle of floatation,

Mass of balloon + Load = Mass of air displaced
= Volume of gas x density of air
= 500 x 1.3 = 650 g

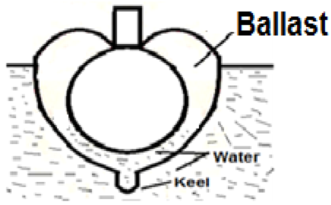
$$\therefore Maximum\ load\ = (\boldsymbol{mass\ of\ balloon + load}) - \boldsymbol{Mass\ of\ balloon}$$
$$= \boldsymbol{650 - 450 = 200\ g}$$

Individual Task – 3

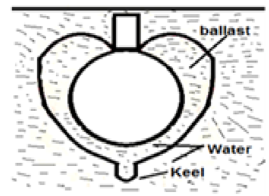
1. A hot air balloon including the envelope, gondola, burner and fuel and one passenger has a total mass of 450kg. Air outside balloon is at 20°C and has a density of 1.29kg/m^3 the air inside at temperature 120°C has density of 0.90kg/m^3. To what volume must the envelope expand to just lift the balloon into the air? (**ANS: V= 1154 m^3)**
2. A balloon has a capacity of 20m^3 and it is filled with hydrogen. The balloon fabric and the container have a mass of 2.5kg. What mass of instruments can be lifted by the balloon? (Density of hydrogen = 0.089kg/m^3 and density of air is 1.29kg/m3) (**ANS: m = 21.52kg)**

Sub Marines

- A Submarine is a watercraft capable of independent operation underwater
- A submarine has ballast tanks which can be filled with water or air
- When full of water ,the average density of the submarine is slightly greater than the density of the sea – water and it sinks



When a ballast tank is filled with air,the submarine floats

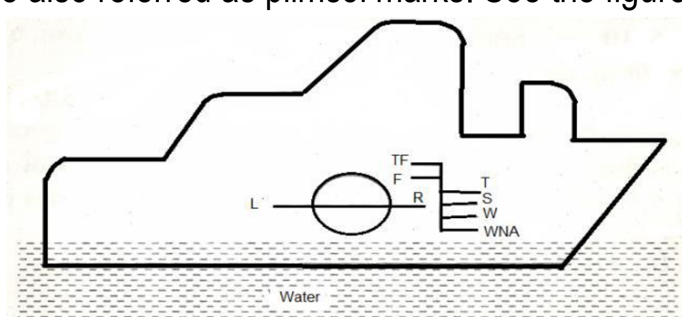


When a ballast tank is full of water ,the submarine sinks

- When air is pumped into the tanks the average density of the submarine falls until it is the same or slightly less than that of the water around it
- The submarine therefore stays at one depth or rises to the surface

Ships

- A ship is a large watercraft that travels the world's oceans and other sufficiently deep waterways
- It is used to carry passengers or goods or in supporting specialized missions such as defense, research and fishing
- A Ship is made of steel and is expected to sink due to its weight. it contains hollow which increases the volume of ship which helps on making less denser than water
- So for safety loading of the ship under different sea conditions plimsol lines (plimsol marks) are provided
- **Plimsoll lines:** Are lines which show maximum height of the ship that should be under water
- **P**limsoll lines are also referred as plimsol marks. See the figure below



Whereby:

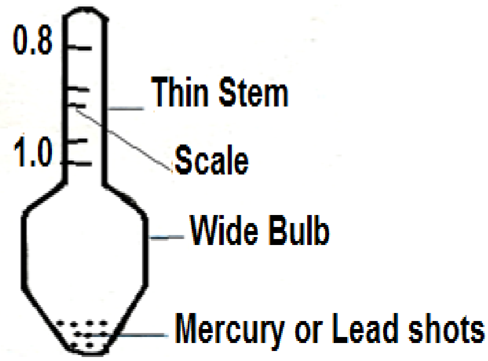
F = Fresh water
W = Winter Sea
WNA = Winter North Atlantic
S = Summer sea
TF = Tropical fresh water
T = Tropical seas

Hydrometer

- **I**s a floating instrument used for measuring the densities of liquids.

OR

- Is an instrument used for determining the relative density of liquids.



Parts (Structure) of Hydrometer

- Heavy sinker (bulb): containing mercury or lead shots that keeps the hydrometer upright when it floats
- Air bulb: it increases volume of displaced liquid and overcomes the weight of the sinker
- Stem: stem is thin so that small changes in density (height) gives large difference in reading
- **Scale: Inside stem graduated in densities**
- It is made up of glass to prevent soaking of the liquid

Mode of action of hydrometer

- A hydrometer is made to float in the liquid whose relative density is to be measured
- It sinks to different levels depending on the relative density of the liquid in which it floats
- The liquid whose relative density is to be determined is poured into a tall jar and the hydrometer is gently lowered into the liquid until it floats freely.
- **The** point where the surface of the liquid touches the stem of the hydrometer indicates the relative density of the liquid
- Example, the hydrometer sinks more in methanol than in water. This indicates that water is denser than methanol

NB:

- The greater the density of the liquid the shorter the stem of hydrometer immersed
- Hydrometer works on the principle of Archimedes

Relative Density of Liquid by Hydrometer

- When hydrometer floats over water the weight of hydrometer (w_h) must be equal to the weight of water displaced (w_w) That is $\mathbf{w_h = w_w}$
- When hydrometer floats over liquid the weight of hydrometer (w_h) must be equal to the weight of liquid displaced (w_L) That is $\mathbf{w_h = w_L}$
- Since the relative density of liquid is given by ratio of density of liquid (ρ_L) to the density of water (ρ_w) $\quad \mathbf{R.D} = \frac{\textbf{density of liquid}}{\textbf{density of water}}$

  But $\boldsymbol{Density = \frac{mass}{volume}}$

  Thus: $\boldsymbol{R.D = \frac{mass\ of\ liquid}{volume\ of\ liquid\ displaced} \div \frac{mass\ of\ water}{volume\ of\ water\ displaced}}$

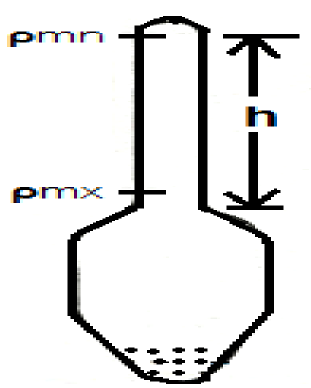
$$\boldsymbol{R.D = \frac{m_L}{V_L} \div \frac{m_W}{V_W} = \frac{m_L}{V_L} \div \frac{V_w}{M_W} = \frac{m_L}{V_L} \times \frac{V_W}{m_W} = \frac{V_W}{V_L}},\quad \textbf{Since } \mathbf{m_L = m_w = m_h}$$

$$\boldsymbol{\therefore R.D = \frac{volume\ of\ water\ displaced}{volume\ of\ liquid\ displaced} = \frac{V_W}{V_L}}$$

- Since cross-section area of the hydrometer is uniform, the volume of water and that of liquid displaced are proportional to the lengths immersed in them

$$\therefore \mathbf{R.D} = \frac{\textbf{length of hydrometer immersed in water}}{\textbf{length of hydrometer immersed in liquid}} = \frac{\mathbf{h_W}}{\mathbf{h_L}}$$

Consider the diagram below



Whereby:

Stem volume, $V_1 = Ah$

Bulb volume, $V_2 = V$

Total volume, $V_T = V_1 + V_2 = Ah + V$

But: R = U (Weight of hydrometer = Up thrust of liquid)

Whereby:
ρ_{mn} = minimum density
ρ_{mx} = maximum density
$U = V_t \times \rho_{mn} \times g$
$R = V \times \rho_{mx} \times g$

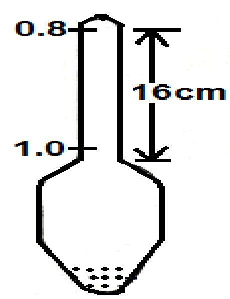
Then:

$V_t \times \rho_{mn} \times g = V \times \rho_{mx} \times g$
$(Ah + V) \times \rho_{mn} \times g = V \times \rho_{mx} \times g$
$(Ah + V) \times \rho_{mn} = V \times \rho_{mx}$
$Ah \times \rho_{mn} + V \times \rho_{mn} = V \times \rho_{mx}$ --------------- make V_2 the subject
$V \times \rho_{mx} - V \times \rho_{mn} = Ah \times \rho_{mn}$
$V \times (\rho_{mx} - \rho mn) = Ah \times \rho_{mn}$

$$\therefore V_{Bulb} = \frac{\textit{Area of stem} \times \textit{height of stem} \times \textit{manimum density}}{\textit{maximum density} - \textit{minimum density}} = \frac{Ah \times \rho mn}{\rho mx - \rho mn}$$

Examples

2. Consider the diagram below used to measure density of liquid between $1g/cm^3$ to $0.81g/cm^3$ (The area of cross section area of stem is 0.5 cm^2). Find the volume of hydrometer below 1.0 g/cm^3 graduated



Data given

Cross section area of stem, A = $0.5cm^2$
Height of steam, h = 16 cm
The volume of steam, $V_1 = Ah = 8\ cm^3$
Total volume, $V_T = (8 + V_2)\ cm^3$

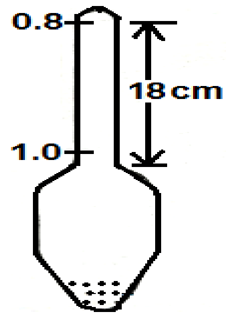
Minimum density, $\rho mn = 0.8\ g/cm^3$
Maximum density, $\rho mx = 1.0\ g/cm^3$
The volume of bulb, V_2 =?

Solution

From: $V_{Bulb} = \frac{Ah \times \rho mn}{\rho mx - \rho mn}$

$$V_{Bulb} = \frac{Ah \times \rho mn}{\rho mx - \rho mn} = \frac{0.8 \times 8}{1 - 0.8} = 32\ cm^3$$

3. The diagram below shows on form of man hydrometer used to measure the densities of liquid over the range of 0.8 to 1.00 g/cm^3. If the area of cross section of the stem is 0.5 cm^2 and the distance between the 0.80 and 100 division is 18cm determine



(a) The volume of hydrometer below 1.00 graduated
(b) The position of the 0.90 graduation

Solution:

Given
Cross section area of stem, A = 0.5cm^2
Height of stem, h = 18 cm
The volume of stem, $V_1 = Ah = 9$ cm^3

Total volume, $V_t = (9 + V_2)$ cm^3
Minimum density, $\rho mn = 0.8$ g/cm^3
Maximum density, $\rho mx = 1.0$ g/cm^3
The volume of bulb, V_2 =?

(a) The volume of bulb, V_2 = ?

From: $V_{Bulb} = \dfrac{Ah \times \rho mn}{\rho mx - \rho mn}$

$$V_{Bulb} = \frac{Ah \times \rho mn}{\rho mx - \rho mn} = \frac{9 \times 0.8}{1.0 - 0.8} = 36 \text{ cm}^3$$

(b) What height, h_2 of hydrometer when shifted to measure 0.9 g/cm^3

From: $V_{Bulb} = \dfrac{Ah \times \rho mn}{\rho mx - \rho mn}$

$$36 = \frac{0.5 \times h \times 0.9}{1.0 - 0.9} \qquad \rightarrow h = \frac{36 \times 0.1}{0.5 \times 0.9} = 8\ cm$$

Individual Task – 4

1. **(a)** Why does a solid body weigh more in air than when immersed in a liquid?
   (b)An ordinary hydrometer of mass 27g floats with 4cm of its stem out of water. If the cross section area of the stem is 0.75cm^2 .Calculate
   (i) The total volume of stem just under the surface of the liquid (ANS: V = 30 cm^3)
   (ii) The relative density of the liquid **(ANS: R.D = 0.9)**

2. A balloon of volume 2000 m^3 is filled with hydrogen of density 0.09 kg/m3. If the mass of fabric is 100kg and that of the pilot is 75kg,
   (i) What will be the greatest mass of equipment that can be carried when operation in air is 1.25kg/m^3? **(ANS: m =2145 kg)**
   (ii) How would this figure change if helium, which has twice the density of hydrogen under the same condition, were to be used?**(AN: m=1965 kg)**
3. The mass of a piece of cork of density 0.25 g/cm^3 is 20g. What fraction of the cork is immersed when it floats in water? (**ANS:** $\frac{1}{4}$ **)**
4. The mass of a piece of cork (0.25 g/cm^3) is 20g. What fraction of the cork is immersed when it floats in alcohol ?(density of alcohol is 0.8 g/cm^3) $(\boldsymbol{ANS}\colon \frac{5}{16})$
5. A uniform pencil floats upright in water with 8cm of its length immersed. What length is immersed when it floats in glycerol (density of glycerol is 1.3 g/cm^3)? **(ANS: L = 6.2 cm)**
6. A balloon and the gas in it has a mass of 500 g and its volume is 600 litres. What is the maximum load it can lift in air of density 1.3 g/dm^3? **(ANS: m=280 g)**

Daily Application of the Law of Floatation

(a) It is used in transportation by water ways: (By ships, submarines and ferry boats)
(b) It is used in transportation by air ways:(By hot air balloons and air ships)
(c) It is used in decoration: (Balloons of different colors and shapes are filled with lighter gas so that will float in air)
(d) It is used in determination of specific gravity of liquids: (By hydrometer)

Class Activity

1. **S**tate Archimedes Principle and state the Law of Floatation
2. Differentiate between floating and sinking
3. State the conditions for a body to float
4. The loose weight of a body when it is partially or totally immersed in water is called –
5. The weight of the body when in water is known as -------------------
6. A floating body experience an upthrust which is equal to the weight ------------------
7. Explain why:
   (a) A Ice floats in water
   (b) Body weighs less when submerged in a liquid
8. A body weighs 200 g in air and 100 g in water .Find its density
9. A body weighs 500 g in air and 50 g in a liquid of density 2 g/cm^3. Calculate the Upthrust and the density of the body
10. Explain concisely why a balloon full of hydrogen rises, whilst full of air sinks. Draw a well labeled diagram in each case to show the forces acting on the balloon
11. A metal cube of side 2 cm weighs 0.56 N in air. Calculate
    (a) Its apparent weight when immersed in white spirit of density 0.855g/cm^3

(b) The density of the metal of which it is made

12. **A** steel sphere of density 7800 kg/m^3 and volume 13 cm^3 floats in mercury of density 13,600 kg/m^3. What volume of the sphere remains above the surface?

13. A solid weighs 64 N in air and 48 N when totally immersed in a liquid of density 0.8/cm^3. Calculate

(a) The upthrust of the solid

(b) The volume of the solid

(c) The density of the solid

14. An empty density bottle weighs 29 g ,when full of water it weighs 70 g and when full of a liquid it weighs 60 g. Calculate (a) The Relative density (b) Its density

15. The apparent weight of the body is 6.4 N. If the weight of liquid displaced is 4.7 N. What is the weight of the body in air?

16. The mass of an empty density bottle was 50 g. When filled with a certain liquid of volume 20 cm^3 its mass became 75 g. Find the

(a) Density of the liquid (b) The relative density of the liquid

17. An object weighs 500 N in air and 400 N when immersed in alcohol. Find the Upthrust on the object

18. **A** piece of metal with a volume of 0.00012 m^3 has a mass of 0.12 kg. What is the density of metal?

19. **A** body has mass a mass of 120 kg and a volume of 100 cm^3. Will the body sink or float in water? Give reasons for your answer

20. **A** block of wood of volume 50 cm^3 and density 0.6 g/cm^3 floats in water. Find

(a) The mass of the block (**ANS: m= 30 g)**

(b) The weight of water displaced (**ANS: W_{WATER} = 0.3N)**

(c) **Vo**lume of block immersed in water and the volume of the block above the surface (**ANS: $V_{IMERSED}$ = 30 cm^3, V_{ABOVE} = 20 cm^3)**

21. A body weighs 10 N in air and 8 N when completely immersed in a liquid of density 0.8 g/cm^3, Find

(a) The volume of the liquid displaced

(b) The density of the body

22. **What** is the volume of a piece of metal with a mass of 150 g and density of 0.00 g/cm^3

23. A balloon of volume 200 cm^3 and a mass of 2 kg is filled with helium of density 0.18 kg/m^3 at ground level. If the surrounding air has a density of 1.30 kg/m^3, What is the largest mass that the balloon can lift?

24. **What** is hydrometer? And state its mode of action using a clear diagram

25. A piece of ice (0.94 gcm^{-3}) of volume 20 cm^3 floats in water. What mass of water is displaced?

26. Define the following terms

(a) Sinking

(b) Floating

(c) Up thrust

(d) Buoyancy

(e) Real weight
(f) Apparent weight
(g) Apparent loss weight

27. Write true for correct or false for incorrect
(i) Archimedes's Principle is also known as the law of submergence---------------
(ii) The relative density of an object is the ratio of its density to the density of water –
(iii) The relative density of an object cannot be used to determine the proportion of the object that will be submerged in a fluid -------------------
(iv) A spring balance can directly give the mass of an object ------------

28. When an object with a mass of 250 g is submerged in water its weight is measured to be 2.2 N.
(a) What is the up – thrust acting on the object?
(b) What is the density of the object.

29. If the ice (0.94 gcm^{-3}) of volume 20 cm^3 floats in brine (1.1 gcm^{-3}).What mass of brine is displaced and what percentage by volume is under the brine?

30. A solid wood weighs 60 N in air and when it is completely submerged in water the wood weighs 48 N. Calculate the apparent loss in weight of the wood and the volume of water displaced .

31. (a) What is hydrometer? A hydrometer of mass 24 g floats with 6 cm of its stem above oil of density 0.8 g/cm^3, the area of the cross section of the stem is 0.75 cm^2. Calculate
(i) The mass of oil displaced (**ANS: m = 24 g)**
(ii) Volume of oil displaced **(ANS: V = 30 cm^3)**
(iii) total volume of hydrometer (**ANS: V = 34.5 cm^3)**
(b) If dipped in water, what length of stem will be above water?(**ANS: h = 14cm)**

32. (a) Define the term hydrometer and draw a well labeled diagram of Hydrometer
(b) Differentiate between Plimsoll lines lords register

33. An empty density bottle weighs 30g, when full of water weighs 80 g, when full of liquid weighs 70 g. Calculate (i)The Relative density (ii)The density of the liquid

34. A car ferry with vertical sides has a water line area of 600 m^2. When fully Iden with 30 cars, their passengers and luggage, the fully laden carried is 30,750 kg. How far will the ferry sink with this load, If the density of sea water is 1025 kg/m^3

35. Why does a ship sink deeper in fresh water than in sea – water?

36. Explain how a submarine can either float or sink

37. Differentiate between Real weight and Apparent weight

38. A 300 g object weighs 2.5 N in air and 2 N in an unknown liquid. What is the density of the liquid?

39. When an object with a mass of 250 g is submerged in water, its weight is measured to be 2.2 N.
(a) What is the upthrust acting on the object?
(b) What is the density of the object?

40. Explain why an iron needle sinks in water whereas a ship made of iron floats on it

41. The mass of a density bottle is 15 g. When it is fully filled with a fluid of density 1.2 g/cm^3, its mass is 51 g. Find the volume of the bottle. (**ANS: V = 30 cm^3)**

42. **A** ship of mass 1200 t floats in sea water .What volume of sea water does it displace? If the ship enters fresh water, what mass of cargo must be unloaded so that the same volume of water is displaced as before? (Density of fresh water = 1000 kg/m^3,relative density of sea – water = 1.03; 1 t = 1000kg) (ANS:V_{SEA} =1165m^3, m = 35 t)

43. **W**hat volume of brass of density 8.5 g/cm^3 must be attached to a piece of wood of mass 100 g and density 0.2 g/cm^3 so that the two together will just submerge beneath water? (**ANS: V_{BRASS} = 53.3 cm^3)**

44. An ordinary hydrometer of mass 28 g floats with 3 cm of its stem out of water. The area of cross – section of the stem is 0.75 cm^3. Find the total volume of the hydrometer and the length of stem above the surface when it floats in a liquid of relative density 1.4. **(ANS: V_T = 28 +2.25 = 30.25 cm, h(L) = 13.7 cm)**

45. What volume of brass of density 8.5 g/cm^3 must be attached to a piece of wood of mass 100 g and density 0.2 g/cm^3 so that the two together will just submerge beneath water? (**ANS: V = 53.3 cm^3)**

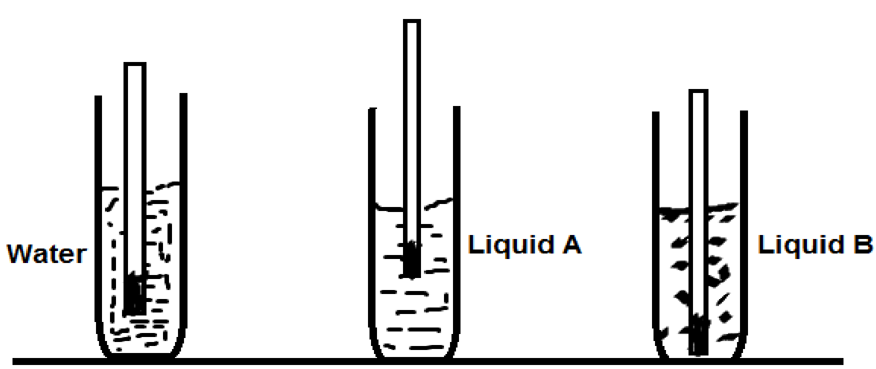
46. To measure the density of a 100 g block of wood ,a 100 g lead sinker is attached to make the block sink. When lowered into the water , the combination has an apparent weight of 1.3 N, If the density of lead is 11.3g/cm^3, what is the density of the wood?

47. When an object of mass 200 g is submerged in methanol , its apparent weight is 1.052 N. When submerged in benzene, its apparent weight is 0.951 N. If the density of methanol is 0.8 gcm^{-3}. What is the density of benzene?

48. An ice cube of density 0.9 g/cm^3 floats in freshwater of density 1.0 g/cm^3 .What fraction of volume of ice is submerged? If the same ice is floating in sea water of the density 1.3g/cm^3 What is the percentage volume of ice will be submerged? **(ANS: $\%V_{FW}$ = 90%, $\%V_{SW}$ = 69%)**

49. A balloon made up of a fabric weighing 80 N has a volume of 1.0 x 10^7 cm^3. The balloon is filled with hydrogen of density 0.9 kgm^{-3}. Calculate the greatest weight in addition to that of the hydrogen and the fabric, which the balloon can carry in air of average density 1.25 kgm^{-3}. (**ANS: W_{ADD} = 36 N)**

50. The figures below shows identical hydrometers in water and two unknown liquids ,A and B



(a) Which liquid has a relative density greater than 1?
(b) Which liquid has a relative density less than 1?

51. A material of density 8.5 gcm^{-3} is attached to a piece of wood of mass 100 g and density 0.2 gcm^{-3}. Calculate the volume of the material X which must be attached to the piece of wood so that so that the two just submerge beneath a liquid of density 1.2 gcm^{-3}. **(ANS: V = 68.5 cm^3).**

52. A ballow sphere floats with 7/8 of volume when submerged in water and 5/8 of its volume when transferred to another liquid. Determine the density of liquid

53. An object floats in water with 40% of its volume submerged.

(a) If the object were placed in methanol with a density of 0.79 g/cm^3, what percentage would be submerged?

(b) If it were placed in liquid carbon tetrachloride with a density of 1.58 g/cm^3, what percentage would be submerged?

54. A piece of cork with volume 100 cm^3 is floating on water. If the density of cork is 0.25 g/cm^3

(a) Calculate the volume of cork immersed in the water (**ANS: V = 25 cm^3)**

(b) What force is needed to to immerse the cork completely? **(ANS:F = 0.75 N)**

55. Find the fraction of the cork that partially immersed when a piece of cork of density 0.25 g/cm^3 and mass of 20 g floats in water.

56. A piece of beeswax of density 0.95 g/cm^3 and mass 190 g, is anchored by a 5 cm length of cotton to a lead weight at the bottom of a vessel containing brine of density 1.05 g/cm^3 . If the beeswax is completely immersed, find the tension in the cotton in Newton. (**ANS: T = 0.196 N)**

57. A density bottle weighs 3.4 N when empty, 5 N when filled with water and 6.4 N when filled with a substance Q. Calculate the density of substance Q (**D = 1.875 N)**

58. The apparent weight of a body is 6.4 N. If the weight of liquid displaced is 4.7 N, What is the weight of the body in air.(**ANS: W = 11.1 N)**

59. If the relative density of ice is 0.92 and that of sea – water is 1.025, What fraction of an iceberg floats above the surface? **(ANS: 21/205 or 0.1024)**

60. A type of wood has density 0.8 times that of water. If a cube made of this wood were placed in water, what fraction of the volume would be immersed? **(AN: 0.8)**

61. A block of wood of mass 24 kg floats in water.The volume of the wood is 0.032 m^3 .Find:

(a) The volume of the block below the surface of the water (ANS: V = 0.024 M^3)

(b) The density of the wood (ANS: D = 750 kgm^{-3})

62. Icebergs are hazardous to shipping because so much of their volume is below the water level. If the density of seawater is 1 025 kgm^{-3} and the density of ice is 919 kgm^{-3}, what percentage of an iceberg is below the water level?

63. A solid displaced 8.5 cm^3 of liquid when floating in a certain liquid and 11.5 cm^3 when fully submerged in the same liquid. The density of the solid is 0.8g/cm^3. Determine

(a) Upthrust on the solid when floating

(b) The density of the liquid

(c) The upthrust on the solid when fully submerged

64. A solid weighs 64 N in air and 48 N when totally immersed in a liquid of density 0.8 g/cm^3. Calculate:

(a) The Upthrust on the solid (**ANS: U = 16 N)**

(b) The volume of the solid (**ANS: V = 1600 cm^3)**

(c) The density of the solid (**ANS: Density = 4 g/cm^3)**

65. A cube of wood of volume 0.2 m^3 and density 600 kg/m^3 is placed in a liquid of density 800 kg/m^3

(a) What fraction of the volume of the wood would be immersed in the liquid?

(b) What force must be applied to the cube so that the top surface of the cube is on the same level as the liquid surface? **(ANS: a. 0.75 b. 400 N)**

66. A piece of cork of density 250 kg/m^3 has a mass of 0.02 kg. What fraction of the cork is immersed in water when it floats in water? (**ANS: ¼)**

67. An object with a volume of 150 cm^3 **is** found floating in water with 60% of its volume submerged. What is the density of the object?

68. (a) A block of metal of density 2 700 kg/m^3 has a volume of 4.0 x 10^{-2} m^3 Calculate the mass of the block (**ANS: m = 108 kg)**

(b) Apparent weight when immersed in brine of density 1 200 kg/m^3 (W_A=588 N)

69. A light spiral (helical) spring which obeys Hooke's law has unstretched length of 220 mm. It is attached at its upper end to a fixed support and, when a piece of metal of mass 2 kg is hung from the lower end, the spring extends to a length of 274 mm.

(a) Find the force in Newton needed to produce an extension of 10 mm.**(ANS: 3.7N)**

(b) When the metal is totally immersed in water, the length of the spring becomes 247 mm. What is the up thrust of the water on the metal? (**ANS:U = 10 N)**

(c) Find the mass of water displaced by the metal **(ANS: m = 1 kg)**

(d) Calculate the volume of the piece of metal **(ANS:V = 0.001 m^3)**

70. An iron cube of mass 480 g and density 8 g/cm^3 is suspended by a string so that it is **half immersed** in oil of density 0.9 g/cm^3. Find the tension in the string **(ANS: T = 4.53 N)**

71. Briefly, explain why the depth of floatation of a ship changes when it sails from the Arabian sea to the Indian ocean

72. Listed below are the dimensions and masses of various objects. Identify the ones that would float in water.

a) A 5 cm cube with a mass of 200 g.

b) A solid sphere with a radius of 5 cm and a mass of 200 g.

c) A rectangular solid with dimensions of 10 cm x 5 cm x 2 cm and a mass of 200 g

d) A solid cylinder whose height is 10 cm , base radius is 3 cm and mass is 200 g

73.x

TOPIC 06: STRUCTURE AND PROPERTIES OF MATTER

Matter

Is anything that has mass and occupies space.

State of Matter

- State of matter is defined in terms of the phase transitions which indicate the change in structure and properties.
- Matter exists in three physical states, namely
  - **(a)** Solid state
  - **(b)** Liquid state
  - **(c)** Gas (Vapor) state

Structure of matter

- Matter is made up of tiny particles.
- The particles are either atoms or molecules

Atom

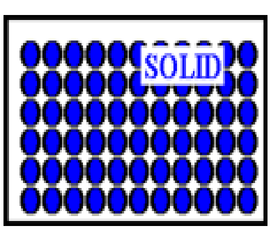
- **Is** the smallest particle of an element, which can take part in a chemical reaction.
- For example, Sodium atom (Na), hydrogen atom (H) etc

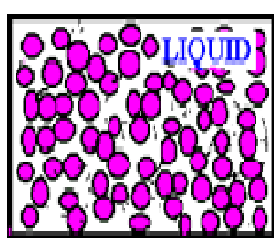
Molecules

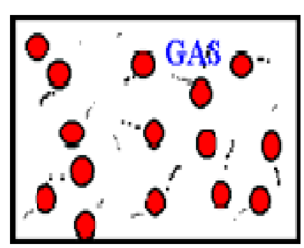
- A molecule is a group of two or more atoms held together by chemical bonds.
- For example, water molecule (H_2O), hydrogen molecules (H_2)

Particulate Nature of matter

- **Ma**tter is made up of millions of tiny particles which cannot be seen with naked eyes
- These particles are called atoms and are made up of sub – atomic particles called protons, neutrons and electrons
- Atoms join together to form molecules
- The figures below show the atoms in solid , liquid and gas respectively







Kinetic theory of matter (molecular theory of matter)

- The kinetic theory of matter describes the physical properties of matter in terms of the behavior of its component atoms or molecules

  It states that: **"All matter is made up of very small particles that are in constant motion"**
- **T**he more heat energy the particles possess the faster they move
- **In a** solid, the particles are arranged close together in a regular pattern and vibrate in fixed positions hence possess lowest kinetic energy
- **In** a liquid, the particles are still close together but in an irregular arrangement. Particles in a liquid move about and are able to slide past one another
- **In** gas, the particles are far apart, moving rapidly and bouncing off the wall of the container

The table below summarize the properties of these states of matter

Properties of three states of matter		
Solid	**Liquid**	**Gas**
Particles are closely packed together	Particles are slightly further apart	Particles are further apart
Has definite shape and volume	**Takes** the shape of the container holding it .has definite volume	**Has** neither definite shape nor volume
Has strongest inter-molecular forces	Inter-molecular forces are moderately strong	Has weak inter – molecular forces
Particles are not free to move. They just vibrate in a fixed positions instead	Particles move with a moderate speed	Particles move randomly with a high speed
Has low kinetic energy	Moderate kinetic energy, enough to '**stretch'** the intermolecular forces	High kinetic energy enough to break all inter – molecular forces

The concept of Brownian movement

- **Brownian movement** is the irregular motion of tiny particles suspended in a fluid (fluid or gas)
- Robert Brownian, an English Botanist discovered that, the random motion of the pollen grains in water was caused by the collisions between them and the molecules of water
- This motion is called **Brownian movement (motion)**

Molecular properties of matter include the following;

1. Elasticity
2. Adhesion and cohesion
3. Surface tension
4. Capillarity
5. Osmosis
6. Diffusion

Elasticity

- Is the ability of a body to return to its original shape and size after deformation.

OR

- Is the ability of a body to resist any permanent change to it when stress is applied
- A body with the ability to undergo elasticity is called **Elastic material**.Eg spring
- Materials are elastic to some degree until elastic limit is reached
- A material which does not undergo elastic deformation is called **Brittle material**. For example, glass, block etc
- When material deformed beyond the elastic limit it becomes plastic, means it will not regain its original shape even though it does not break. This type of deformation is called **PLASTIC DEFORMATION**
- A Material which does not return to its original shape and size after deformation is called **INELASTIC** or **PLASTIC** material. E.g plastic bags, plastic utensils etc

Relationship between tension and extension of a loaded elastic material

- This can be explained in Hooke's law which states that:

"Within the elastic limit, the extension is directly proportional to the force applied"

OR

"Provided that the elastic limit of a body is not exceeded, the extension is directly proportional to the force applied"

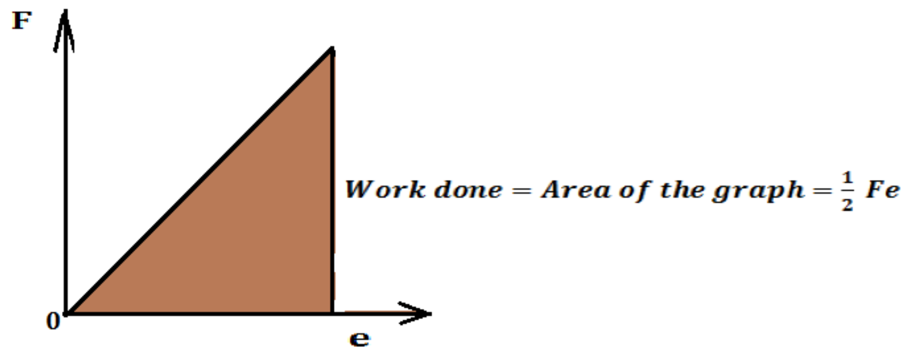
- **T**ension can be described as the force **(F)** transmitted within a string or rope or wire when it is stretched or elongated
- Extension **(e)** is an excess length obtained after stretching a wire (rope or string)
- Hooke's law describes that when a force is applied to a material, the length of the material will keeps increasing in the same proportion as the force
- If the limit of extension (elastic limit) is not reached, the material can return to its original shape and size after removing the applied force
- But when the elastic limit is reached then the body will not return to its original shape and size even after the removal of the force applied

- Mathematically Hooke's law can be expressed as:
  $\textit{applied force} \propto \textit{extension}$

  $F \propto e \quad \rightarrow F = k\ e$ $\textit{Work done} = \textit{Area of the graph} = \frac{1}{2}Fe$

  $k = \frac{F}{e}$ **(Whereby k = Force constant or spring constant)**

- **The SI unit of k is Newton per metre (N/m)**
- The area under the graph of proportionality of Load against extension gives the work done in stretching a spring, see the figure below

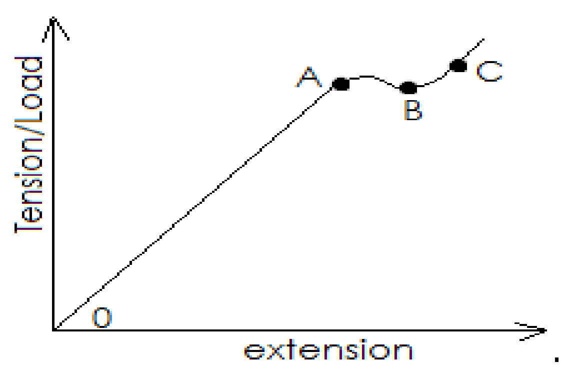


- **Therefore And the work done in stretching the spring is given by**

$$\boxed{\text{Work done} = \frac{1}{2}Fe = \frac{1}{2}ke^2}$$

- The relationship between tension and extension of a loaded elastic material can also be explained using the following graph

The graph of Tension against extension



Interpretation of the graph

- **Between point O and A (O – A)**

The tension is direct proportional to extension. This was discovered by Hooke and finally he came with a law which called Hooke's law.
At this stage, the body can regain its original shape and size if tension is removed

- **At point A**

Point A is called the limit of proportionality or elastic limit

- **Between point A and B (A – B)**

This is called the **region of elastic**. In this region a small force produces a large extension which is not directly proportional to the extension

- **Between point B and C (B – C)**

This is known as **the region of plastic deformation**. At this region material will not return to its original shape and size when applied force (tension/load) is removed

- **Beyond point C**

Beyond this point the body becomes thinner and ultimately break due to excessive application of force

Application of elasticity

At homes is applied in.

- Rubber gaskets that seal the refrigerator door
- Clothing
- Springs in furniture
- Rubber bands that holds things together
- Toys like balloons and balls

In transportation, elasticity may be applied in:

- Rubber tyres, hoses, belt and shock absorbing springs for car and trucks
- Aeroplane wings
- Supporting cables for bridges

In Industry, elasticity is applied in:

- Conveyor belts
- Measuring weight
- Steel beams used in constructions
- Insulation of vibration and sound

Surface Tension

- Is the ability of a liquid surface to behave like a fully stretched elastic skin.

OR

- **Is a force present within the surface layer of a liquid that causes the layer to behave as an elastic sheet.**

Causes of surface tension

- Surface tension is the result of inter – molecular cohesive bonding among the molecules of a liquid.
  (Surface tension occurs due to the force of attraction between molecules of a liquid)

Application of surface tension (Examples of surface tension)

- Walking of pond skater on the surface of water
- Floating of a needle on the surface of water
- Mosquito eggs can float on water because of its surface tension
- Soaps and detergents lowering the surface tension during washing of clothes
- Surface tension prevents water from passing through the pores of an umbrella
- Warm water is used for washing purpose as heating increases the surface area and reduces surface tension
- Antiseptics like Dettol have low surface tension, so that they spread faster
- Toothpaste contains soap ,which reduces the surface tension and helps it spread freely in the mouth
- Hot soup has a lower surface tension than cold soup, hence hot soup is tastier than cold soup.

Factors affecting Surface Tension

Nature of the liquid

- Different liquids have different surface tension, For example, mercury has higher surface tension than water

Contamination (impurities)

- Impurities in a liquid lower the surface tension. The substance which lowers surface tension is called **SURFACTANTS** (acronym for surface active agent). Example of surfactants is detergents

Temperature

- Surface tension of a liquid decreases with increase in temperature

Intermolecular Force

- **I**s the force of attraction or repulsion between particles of matter (atoms/ molecules)

Types of Intermolecular Forces

- Cohesive force
- Adhesive force

Cohesion

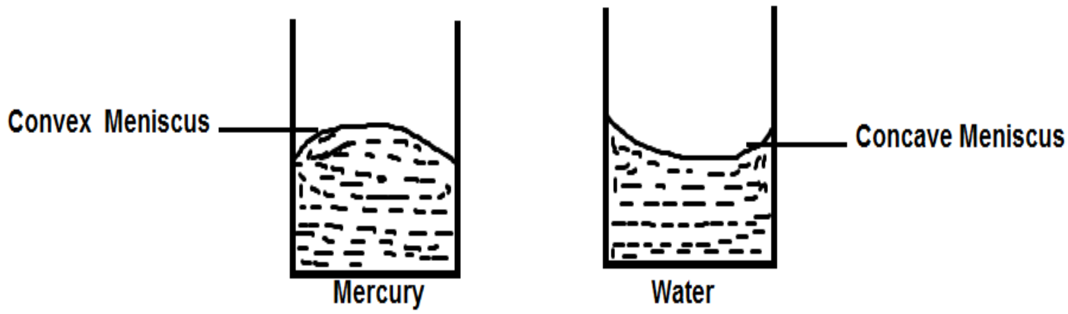
- **I**s the force of attraction between the molecules of the same substance.
- For example, water and water molecules
- Definite shapes of a solid are due to strong cohesion force among its molecules

Adhesion

- Is the force of attraction between the molecules of different substances.
- For example water to glass molecules

Effect of Adhesion and Cohesion

- Mercury forms convex (downward) meniscus because it possess strong cohesive force than adhesive force
- Water forms concave (upward) meniscus because it possess strong adhesive force than cohesive force



- Drop of water on the surface of some leaves is perfect sphere due to strong cohesive force than adhesive force
- Drop of mercury on the surface of different material is perfect sphere due to strong cohesive force than adhesive force
- Water spread over a glass because it possess strong adhesive force than cohesive force

Application of Adhesive and Cohesive force

- Adhesion is used to stick two different objects together .E.g using glue or tape
- Adhesion is used to remove harmful materials from drinking water e.g bacteria
- The bodies of Plants and animals use the cohesion of tissue to repair damage
- Ink sticks on paper because of adhesive force between the paper and ink
- Cohesion assists in transport of water in plants and animals by allowing one molecule to pull others along with it (While Adhesion occurs when the water molecules cling to the xylem tissue)

Capillarity (Capillary action)

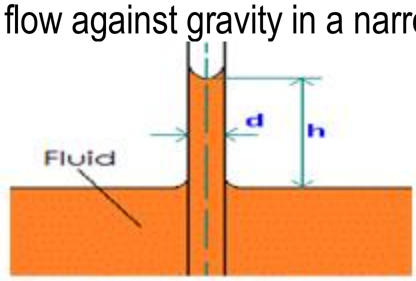
- Is the ability of liquid to rise or fall in a narrow tube.

OR

- Is the tendency of a liquid to rise in a narrow tube or to be drawn into small openings

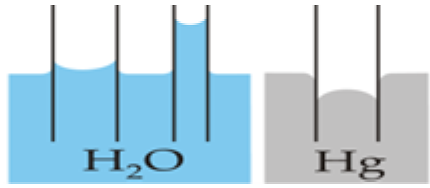
OR

- Is the ability of a liquid to flow against gravity in a narrow space (thin tube)



Capillarity in a tube

- When you dip a capillary tube in water, the water rises due to greater adhesive force
- When you dip a capillary tube in mercury, the mercury falls due to greater cohesive force



Capillary action in water and mercury

- The greater adhesive and cohesive force, the greater the capillary action

Application of Capillarity

- ❖ The raising of oil in the wicks of lamps in the cotton threads
- ❖ The absorption of water by a towel (paper or cloth)
- ❖ Water rises in the soil because the soil is composed of fine particles
- ❖ It facilitates the transport of water and nutrients from the roots
- ❖ Ink rises into the blotting paper through those fine pores
- ❖ It Promotes the movement of ground water
- ❖ Cotton clothing in hot climates uses capillarity action to draw perspiration away from the body

Osmosis

- Is the movement of a solvent from a region of low concentration to a region of high concentration through a semi-permeable membrane.

Consider the experiment below

- o Peal a potato
- o Keep over salts
- o The potato shrink due to movement of water from potato (low concentration) to salt (high concentration)

Application of Osmosis

- Removal of harmful ingredients from drinking water
- Controls the movement of water and nutrients in and out of the cell
- Removing salt from seawater so as to make it suitable for drinking and other domestic uses
- Absorption of water molecules from soil to plant
- Aquatic life is controlled by osmosis
- Filtration processes

Diffusion

- Is the movement of particles from a region of high concentration to one of low concentration.
- For example spraying of a perfume

Application of Diffusion

- Detecting harmful substance in the environment
- In the use of refreshers and other sprays
- Respiration process, oxygen diffuses into blood stream
- Balance concentration of water and nutrients in and out of the cells of living organisms.

Class Activity

1. Define the term matter. With examples, List down the states of matter.
2. State the difference between a solid, a liquid and a gas
3. What is Brownian movement?
4. Differentiate between cohesion and adhesion
5. State the kinetic theory of matter
6. State Hooke's law and identify the application of elasticity in everyday
7. A certain spring has a force constant of k = 25 N/cm.
   (a) If an object with a mass of 500 g were hung from the spring, how far in centimeters, would it stretch?
   (b) What is the mass of an object that stretches the spring 35 cm?
8. The length of a spring is 16.0 cm. Its length becomes 20.0 cm when supporting a weight of 5.0 N. Calculate the length of the spring when supporting a weight of 6.0 N **(ANS: L = 16.0 + 4.8 = 20.8 cm)**
9. What is surface tension and discuss four application of surface tension
10. What is elasticity
11. What is the essential of kinetic theory of matter?
12. Differentiate between plastic and elastic materials
13. What is elastic limit?
14. A force of 7.5 N stretches a certain spring by 5 cm. How much work is done in stretching this spring by 8.0 cm? (**ANS: W = 0.48 J)**
15. What are the uses of capillary action in everyday life
16. Sketch the graph showing how force applied in a stretched string varies with its extension
17. State Hooke's law. A scale pan of weight 0.4 N was attached on a spring balance and produced an extension of 24 mm when a load of 2 N was placed on it. Calculate the load on the scale pan when the extension is 16 mm.
18. Differentiate between Osmosis and Diffusion

19. Match the items in list A with the items in List B

List A	List B
a) Surface tension b) Elasticity c) Diffusion d) Osmosis e) Capillarity f) Adhesion g) Cohesion	(i) The ability of a body to regain its shape and size after deformation (ii) Movement of particles from the region of high concentration to one of low concentration (iii) **I**s the ability of a liquid to flow against gravity in a narrow space (iv) Is the ability of the surface of a liquid to behave like a fully stretched elastic skin (v) **I**s the force of attraction between the molecules of the same substance. (vi) Is the force of attraction between the molecules of different substances (vii) Movement of solvent from a region of low concentration to one of high concentration through semi permeable membrane

20. Explain how adding soap to the water would cause the oil and water to mix
21. Which phenomena is taking place when kerosene rises up a wick?
    A. Surface tension B. Elasticity C.Meniscus D.Capillarity
22. A force of 4 N causes a certain copper wire to extend to 1.0 mm. Find the load that will cause a 3.2 mm extension on the same wire.(**ANS: L = 12.8 N)**
23. A body of 200 g was hung from the lowerend of a spring which obeys Hooke's law. Given that the spring extended by 100 mm, what is the spring constant for this spring? (**ANS: k = 20 N/m)**
24. Is surface tension due to cohesive or adhesive forces, or both?
25.

TOPIC 07: PRESSURE

- Pressure is the force acting normally per unit area.

$$\boldsymbol{Pressure} = \frac{\boldsymbol{Force}}{\boldsymbol{Area}} \quad \rightarrow \boldsymbol{P} = \frac{\boldsymbol{F}}{\boldsymbol{A}}$$

- The SI units of pressure is Newton per metre square (**N/m²)**
- **Other units of pressure are** Pascal (Pa), Atmosphere (atm)**,** Millimeter of mercury (mmHg) and Torre bar (bar).

NB.

1Pa = 1N/m^2
1atm = 760mmHg
1atm = 100000N/m^2
1atm = 1bar

Pressure due to Solid

- Pressure on solid depends on force applied and the surface area.
- That is $\boldsymbol{Pressure(P)} = \frac{\boldsymbol{Force(F)}}{\boldsymbol{Area(A)}}$

Example.

4. Find the pressure exerted when a force of 640N acts in the area of 16m^2

Solution:
Force (f) = 640N
Area (A) =16m^2
Pressure (p) =?
∴ Pressure = $\frac{F}{A} = \frac{640}{16}$ 40 Pascal

Individual Task – 1

1. A pressure of 75N/m^2 is resulted from a certain force acting on an area of 0.8m^2. Calculate its force acting on it. (**ANS: F= 60N)**
2. Find the pressure exerted when a force of 3600N act on the area of 36m^2 (**ANS: P = 100N/m^2)**

Maximum and minimum pressure

- **Maximum pressure** is the value of high pressure and it is determined when a force acts perpendicular to the smallest area.

$$P_{max} = \frac{Force}{Minimum\ Area}$$

- **Minimum Pressure** is the value of low pressure obtained when a force acts normally per largest area

$$P_{min} = \frac{Force}{Maximum\ Area}$$

N.B

- Pressure depends upon the area **(The smaller the surface area the greater the pressure and vice verse)**
- **For example** it is easy to cut the meat using a sharp knife than a blunt one, this is because the sharp knife has smaller area which produces the larger pressure than the blunt one.

Examples

1. A rectangular block weighting 320 N has dimensions 4 m by 2 m by 10 m. what is the greater pressure and the least (minimum) pressure it can be exerted on the ground
   SOLN
   Maximum area = 4 x 10 = 40 m^2
   Minimum area = 2 x 4 = 8 m^2
   Maximum pressure = $\frac{Force}{Minimum\ area} = \frac{320}{8} = 4$ N/m^2

   Minimum pressure = $\frac{Force}{Maximum\ area} = \frac{320}{40} = 8$ N/m^2

Individual Task – 2

1. A woman weighting 500N wear a pair of shoes with heels of area 250 m^2, what is the pressure exerted on the floor by a heel of her shoes? (**ANS: P = 2 N/m^2)**
2. Calculate the pressure under the feet of Fatima if the area of contact of her foot is 80 cm^2 and her mass is 43.8 kg
3. The tip of the needle with cross section area of 0.000001m^2, if a doctor applied a force of 20N to a syringe that is connected to the needle. Find the pressure exerted at the tip of the needle **ANS: P = 20000000 N/m^2**
4. **A** rectangular metal block with sides 1.5 m by 1.2 m by 1.0 m rests on a horizontal surface .If the density of the metal is 7000 kg/m^3, calculate the

maximum and minimum pressure that the block can exert on the surface.(Take the weight of 1 kg mass to be 10 N)

5. **T**he mass of cuboid is 60 kg. If it measures 50 cm by 30 cm by 20 cm. What is the maximum pressure that it can exert?
6. A rectangular block of weight 15 N rests on a horizontal table. If it measures 40 cm by 30 cm by 20 cm, calculate the greatest and least pressure

Examples of Solid Pressure in daily life

- We experience pain discomfort when we lift a bucket of water made by thin handle
- Sharp edges of knife or razor cuts easily than blunt knife or razor
- Sharp pointer of nail, screw, push pin, spear and an arrow has high penetrating power
- Wide wooden or concrete (large area) sleepers are placed below the railway track to prevent railway track to penetrate on ground.
- Buildings are constructed with wide (large area) foundation to increase surface area so as to prevent wall from penetrating on ground
- Feet of elephant cannot sink into soft soil even if it is very heavy due to large surface area over elephant feet
- A tractor works on soft ground cannot sink due to wide tyres
- Duck cannot sink on soft mud due to large surface area on his webbed feet
- Potter puts some soft material on his/her head for heavy load to increase surface area
- It is painfully to walk on barefoot on a road that is covered by pebbles

Pressure in Liquids

- A liquid will exert pressure on an immersed object as well as on the walls of the container holding it
- The pressure in the liquid increases with the increase in depth of the liquid
- Pressure in a liquid acts equally in all directions
- Pressure in a liquid increases with the increase in density of the liquid
- From pressure:

$$\boldsymbol{P = \frac{F}{A}}$$

- **But:** $\boldsymbol{F = mg = \rho \times v \times g = \rho \times A \times h \times g}$

Now: $\boldsymbol{P = \frac{\rho h A g}{A} = \rho \times h \times g}$ = ρhg

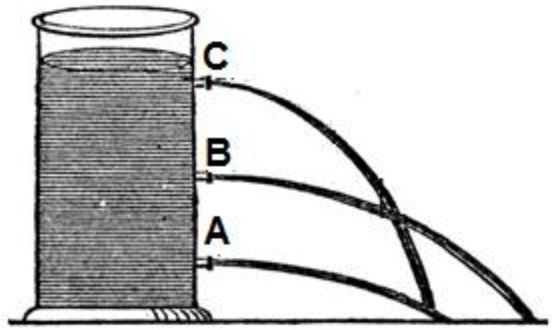
- **The pressure in liquids is given by**

$$\boxed{\therefore\ \boldsymbol{P = \rho h g}}$$

- The pressure at any point in a liquid at rest depends on:
  - **(a)** Depth (**height through which the liquid rises**)
  - **(b)** Density of the liquid

Variation of pressure with depth

- The pressure in a liquid increases with depth (**the greater the height above a point , the greater the pressure at that point)**
- **This** can be demonstrated by the following experiment
  - (a) Take a tall vessel and make three holes of the same diameter from the top downward
  - (b) Fill the vessel with water up to the brim, and observe the way in which water spurts from each hole (See the fig. below)



Water spurting from holes at different levels

Observations:

- **Water** is pushed through the holes at different speeds. More water is pushed through hole A than hole B, and least water is pushed through hole C
- The pressure at hole A is greater than that at hole C due to different in heights (ie. Pressure in a liquid increases with depth)
- That is why the bottom of a dam is made thicker than the top **because the pressure at the bottom is much greater than at the top**

Question

1. Explain why a diver at the bottom of the dam experiences greatest pressure

ANS: At the bottom of the dam the depth is greatest and therefore the diver experiences greatest pressure due to the weight above him

Examples of Pressure in liquid in real life

- The water bubbles increase in its volume if moves from the bottom of the pond to the top of the pond (depth decreases)
- Water tanks have their outlets fixed at the bottom (high depth)
- A person at great height suffers from nose bleeding
- A hole at the bottom of a ship is more dangerous than one near the surface
- A dam is thicker at the bottom than at the top

Communicating Vessel

- Communicating vessel finds its own level even though each part has different shape, the liquid will be at the same level in all parts

Pressure in a communicating vessel

Spirit Level

- Is an instrument used to test whether a surface is horizontal or vertical.
- It consists of a slightly curved glass tube which is not completely filled with a liquid (yellow in color) leaving a bubble in the tube

A Sprit Level

Mechanism

- A spirit level works on the fact that a liquid in a vessel will always find its own level.

A Spirit level is used by

- Masons
- Carpenters
- Surveyors e.t.c

Examples

1. What will be the pressure due to column of water of height 4m?

Data given

Height, h = 4m
Density of water, ρ = 1000kg/ m^3 = 1g/cm^3
Gravitation force, g = 10N/kg
Pressure exerted, P =?

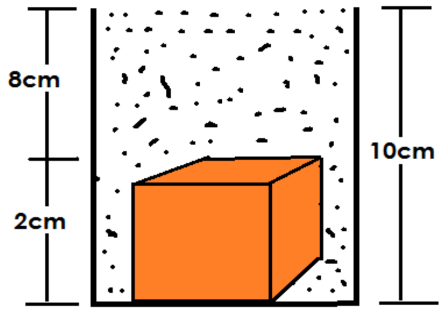
Solution

From: $P = \rho hg$
$\therefore$ **$P = 1000 \times 4 \times 10 = 40000\ N/m^2$**

2. A cube of sides 2cm is completely submerged in water so that the bottom of the cube is at depth of 10cm. Find
   (a) Different pressure between top and bottom of the cube
   (b) Different force between top and bottom of the cube
   (c) Weight of water displaced by the cube

Solution

Consider the diagram below



(a) Different pressure between the top and bottom of the cube, ΔP =?

Data given

Water density, ρ = 1000kg/ m^3 = 1g/cm^3
Gravitation force, g = 10N/kg
Height at top, h_2 = 8cm = 0.08m
Height at top, h_1 = 8cm = 0.1m

Solution

$\Delta P = P_2 - P_1$
But: $P = \rho hg$
Then: $\Delta P = P_2 - P_1 = (\rho \times h_2 \times g - \rho \times h_1 \times g)$
$\Delta P = \rho g (h_2 - h_1) = 1000 \times 10 \times (0.1 - 0.08)$
$\therefore \Delta P = 1000 \times 10 \times 0.02$ **= 200 N/m²**

(b) Different force between top and bottom of the cube, ΔF =?

From: $\boldsymbol{Pressure = \frac{Force}{Area}}$

But: A = 2cm x 2cm = 4cm^2 = 0.0004 m^2

$\therefore$ **Δ Force = ΔP x A = 200 x 0.0004 = 0.08** N

(c) Weight of water displaced, w =?

The volume of water displaced = Volume of the cube

Then: volume of water (cube) = (2 x 2 x 2) cm^3 = 8cm^3
Mass of water displaced = volume x density = 8 cm^3 x 1 g/cm^3 = 8 g

$$\therefore \boldsymbol{Weight\ of\ water\ displaced\ = m \times g = \frac{8}{1000} \times 10 = 0.08\ N}$$

Individual Task – 3

Where necessary use g = 10 N/kg, density of water = 1000 kg/m^3 (1g/cm^3)

1. The pressure at a bottom of a well is 98000 N/m^2. How deep is the well
2. Calculate the pressure exerted on a diver at a depth of 20m below the surface of water in a sea **(ANS: P = 200000 Pa)**
3. A rectangular tank measures 5 m by 3 m at its base .It contains water to a height of 3m. Calculate the pressure on the base of the tank .
4. A small submarine has an area of 1 000 m^2. What force would be exerted on the submarine by the water if it was submerged to a depth of 50 m?
5. Given that there is a considerable decrease in atmospheric pressure of 1.2 x 10^3 Pa for every 100 m increase in height ,determine the density of air

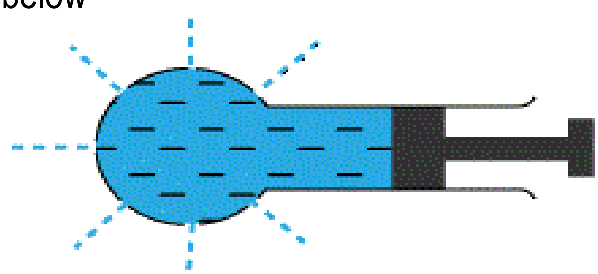
Pascal's Principle of the hydraulic Press

It states that: **"Any external pressure applied to the surface of an enclosed liquid will be transmitted equally throughout the liquid"**

OR

"Pressure applied at a point in a fluid at rest is transmitted equally to all parts of the fluid"

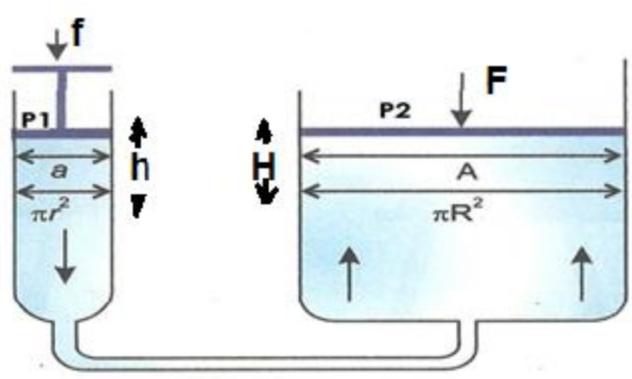
Consider the diagram below



Hydraulic Press

- Is a machine press using a hydraulic cylinder to generate a compressive force
- Hydraulic press uses Pascal's principle to multiply an applied effort using the pressure of a liquid or gas. This allows the lifting of a heavy load by applying little effort

See the fig below



- According to Pascal's principle, pressure will be transmitted equally through the fluid(oil) **($P_1 = P_2$)**

From: $P = \frac{F}{A}$ $\rightarrow$ **$P_1 = \frac{f}{a}$,** **$P_2 = \frac{F}{A}$**

$$\therefore \quad \frac{F}{A} = \frac{f}{a} \qquad \text{OR} \qquad \frac{F}{R^2} = \frac{f}{r^2}$$

Since: Area **$A = \pi R^2$, $a = \pi r^2$**

Also, From: The principle of moment

Anticlockwise moment = clockwise moment

F x H = f x h

Since: $f = P_1 \times a$

$F = P_2 \times A$

But: $P_1 = P_2 = P$ ………………………………. According to Pascal principle

$P \times A \times H = P \times a \times h$ …………………….. Divide by P

Therefore: **AH = ah**

Example

1. In a hydraulic press the area of the piston to which the effort is applied is 5 cm^2. If the press can raise a weight of 2 KN when an effort of 400N is applied, what is the area of the piston under the load?

Solution:

Given: Small Piston Force, f =400 N

Large Piston Force, F = 2 KN = 2000 N

Small piston area, a = 5 cm^2

Large piston area, A =?

From: $\frac{F}{A} = \frac{f}{a}$

$A = \frac{Fa}{f} = \frac{2000 \times 5}{400} = \mathbf{25}$

$\therefore$ The area of the piston A = 25 cm^2

Individual Task – 4

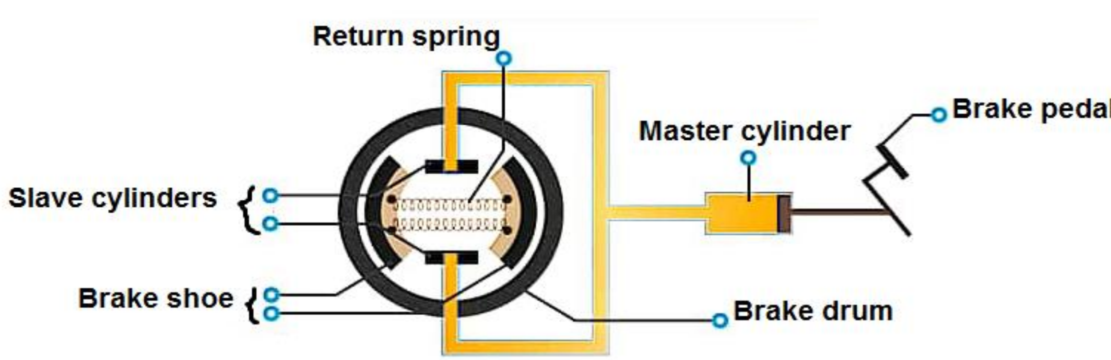
1. Hydraulic press has a large circular piston of diameter 0.7 m and circular piston to which the effort is applied of diameter 0.21 m. A force of 300N is exerted on the small piston. Find the force required to lift a heavy load (**ANS: F = 3333.33N)**
2. Pistons of hydraulic press have their areas given as 0.0003 m^2 and 0.02 m^2 respectively. A120 N is required to push down the small piston, find the force required to push the large piston (**ANS: F = 8000 N)**
3. A hydraulic lift has piston with areas of 0.02 m^2 and 0.1m^2. A car with a weight of 5000 N sits on a platform mounted on the large piston
   a) How much force applied on small piston **(ANS: F = 1000 N, h = 1.5 m)**
   b) How for must small piston fall when large piston raise the car at 0.3m?
4. A car of mass 8000kg, one of its tyres having an area of 50 cm^2 in contact with ground. Find the pressure of the four wheel car exerted on the ground by the car **(ANS: P = 4000000 N/m^2)**

Uses of Hydraulic Press in Daily Life

- Used in lifting heavy loads to the required height
- In ginneries to compress a lump of cotton into small bales
- In industries to form car bodies into the required shapes
- Extraction of oil from the oil seed
- Cranes used during construction of any project
- Office chairs use hydraulic systems to lift or lower or lean back the seats
- Brakes of cars use hydraulic systems
- Hydraulic jack for lifting car up for any repair

Hydraulic brake system

- When force is applied on the brake pedal, it exerts pressure on the master cylinder
- Then this pressure is transmitted by the brake fluid to the slave cylinders which cause the pistons of the slave cylinders to open the brake shoe and hence the brake lining presses the drum.
- The rotation of the wheel is then resisted and when the force on the brake pedal is withdrawn the return spring pulls back the brake shoe which then pushes the slave cylinders piston back

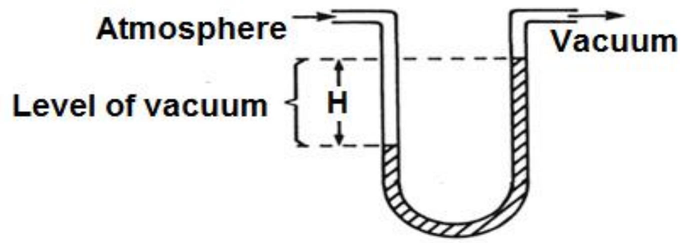


The hydraulic brake system

NB: Advantage of this system is that**: The pressure exerted in master cylinder is transmitted equally to all other parts in the liquid.**

Manometer

- Is a device used for measuring fluid (gas) pressure



A manometer

- It is a **u** shaped glass tube, open at both ends and holding liquid (water/mercury)

Mechanism of Manometer

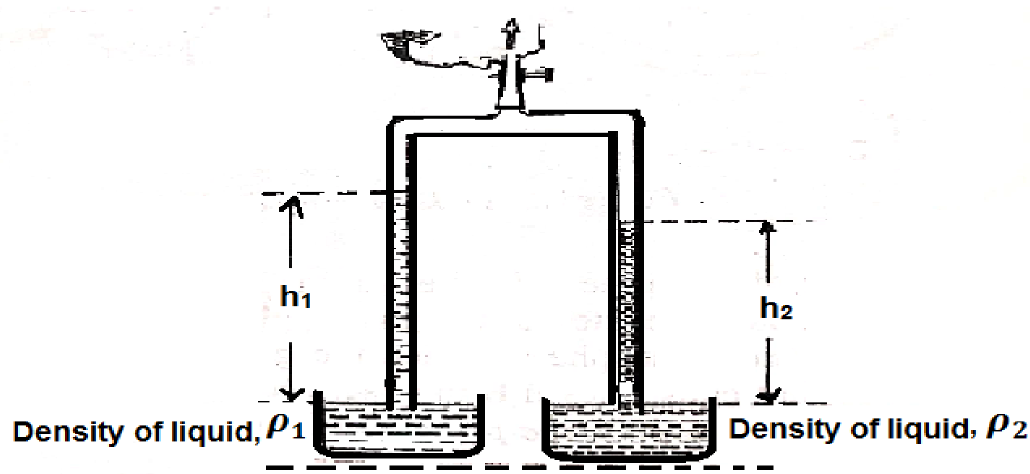
- One limb is connected to the fluid supply and the other limb is opened to the atmosphere. The pressure exerted on a fluid causes the level of water or mercury on manometer to rise at a certain height as shown in the figure above.
- The difference in level (h) of the liquid in the two limbs records the pressure and the height h is called **"the liquid head"**

Liquids Densities

- Hare's apparatus is used to compare the densities of two liquids
- When the air at the top as shown in the fig. below is sucked out, the atmospheric pressure pushes the liquid up the tubes **(This is because the atmospheric pressure acting on the surface is now greater than the pressure inside the straw)**
- On closing the openings when the liquids have reached a convenient height for measurement, the liquids produce the same pressure at X and Y

That is: $P_1 = P_2$ $\rightarrow h_1 g = \rho_2 h_2 g$ $\rightarrow \rho_1 h_1 = \rho_2 h_2$

$$\boxed{\therefore\ \rho_1 h_1 = \rho_2 h_2}$$



The hare's apparatus

N.B:

- At sea level the atmospheric pressure supports approximately 76 cm of mercury column or approximately 10 m of water column
- This difference in height column between mercury and water is that **"Mercury is much denser than water"**

Example:

1. The air pressure at the base of a mountain is 75 cm of mercury while at the top is 60 cm of mercury. Given that the average density is 1.25 kg/m^3 and density of mercury is 13 600 kg/m^3. Calculate the height of the mountain.

   Solution:

   Density of air, $\boldsymbol{\rho_1 = 1.25}$ **kg/m^3**

   Density of mercury, $\boldsymbol{\rho_2 = 13\,600}$ **kg/m^3**

   $\Delta h_2 = \boldsymbol{h_{base} - h_{top} = 75 - 60 = 15\ cm = 0.15\ m}$

   Height of mountain (h_1) =?

From:

Pressure difference due to column of air = Pressure difference due to mercury column

$$\boldsymbol{\rho_1 h_1 = \rho_2 h_2} \qquad \rightarrow \quad \boldsymbol{h_1 = \frac{\rho_2 h_2}{\rho_1} = \frac{0.15 \times 13600}{1.25} = 1632\ m}$$

Atmospheric Pressure

- **Is the pressure within the atmosphere of the earth**

OR

- **Is the pressure exerted by the weight of the atmosphere**

N.B:

- Atmospheric Pressure decreases with the increase in altitude
- At high altitudes, where the pressure of the air is less , nose – bleeding may occur due to the greater excess pressure of the blood which causes blood capillaries to burst

How Gas exerts Pressure?

- **G**as exerts pressure when its molecules are continually colliding with each other and with the walls of the container causing a small force on the wall. The pressure exerted by the gas is due to the sum of all these collision forces. The more particles that hit the walls, the higher the **PRESSURE**

Atmospheric pressure can be observed in several areas.

Example: -

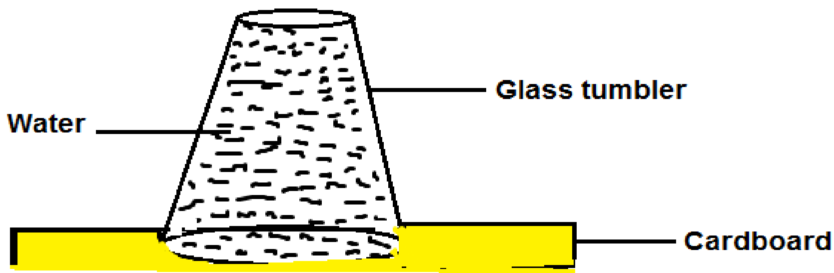
- In a glass tumbler
- In a crashing can

Experiments to demonstrate effects of Atmospheric Pressure

(a) In a glass tumbler
(b) In a crashing can

In a glass tumbler

- Fill the glass tumbler with water and place the card firmly on top of the glass so that there is no air between the glass and the glass
- With your hand on the card, gently turn the tumbler upside down , then remove your hand



A glass tumbler experiment

Observations

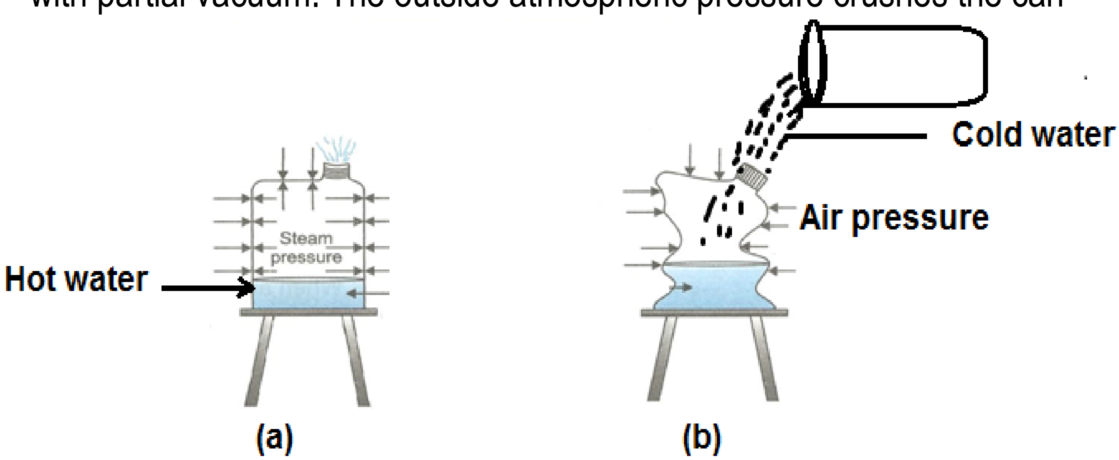
- **The** card holds on the tumbler when it is turned upside down. **This is because the atmospheric pressure acting upwards on the card is greater than downward pressure of water acting on the card**

In a crashing can

- Put a little water in a can. Boil the water while the can is open in order to drive off the air (fig.(a))
- Remove the heating source and quickly close the hole tightly
- Poor cold water over the can

Observations

- When the can is closed and the cold water is poured on it, the can collapses. This is because the steam is condensed into water leaving the inside of the can with partial vacuum. The outside atmospheric pressure crushes the can



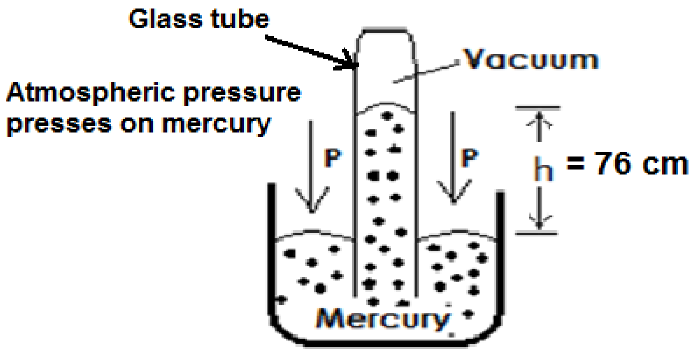
Effect of air pressure on a can

Barometer

- Is an instrument used to measure atmospheric pressure

Simple Barometer

- This is the most fundamental of the other types of barometer.
- It uses mercury instead of water **because mercury is denser than water**
- It has a height of 76 cm at sea level. Therefore, the atmospheric pressure at sea level is 76 cm of mercury **(76 cmHg)**

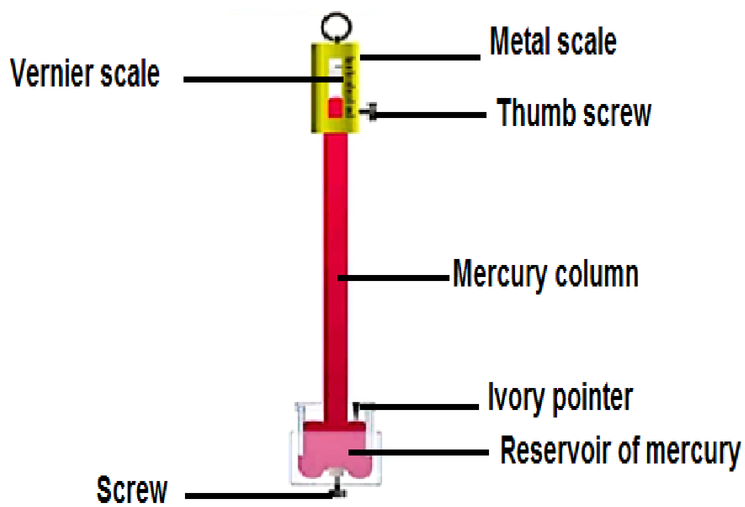


A simple barometer

- Atmospheric pressure is given by: $\mathbf{P = \rho h g}$

Fortin Barometer

- Fortin Barometer is a modified simple barometer. It is a very accurate type of mercury barometer for measuring air (atmospheric) pressure.
- It performs functions like that of simple barometer

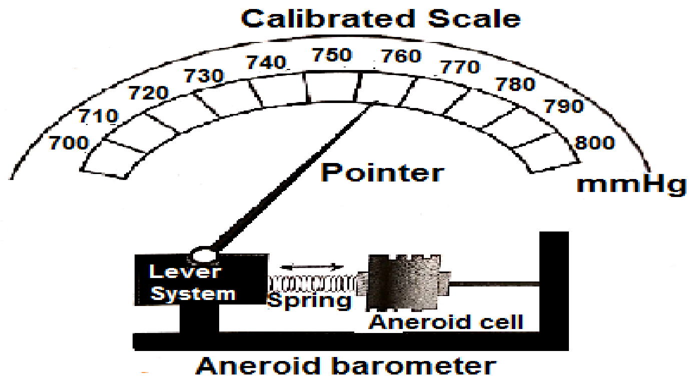


Fortin Barometer

Aneroid Barometer

- Is a barometer which is mostly used in aeroplanes to record the air pressure at a certain altitude
- Aneroid Barometer **does not use any liquid**. It consists of an evacuated metal box connecting a system of levers and a pointer. It is compacted and portable

- Aneroid barometer which is used in aircraft to show the height at which the plane is flying is called **Altimeter**



Advantages of Aneroid Barometer over Fortin's Barometer

Aneroid Barometer

- It is used to measure air pressure in confined spaces
- It is compact and portable
- It is used in aircraft to show the height at which the plane is flying **(The barometers used are called Altimeters)**

Disadvantages of using Fortin barometer

a) Mercury is expensive and toxic
b) It is not portable (it is approximately 1 m tall and contains liquid)
c) It must be mounted in a vertical position

NB:

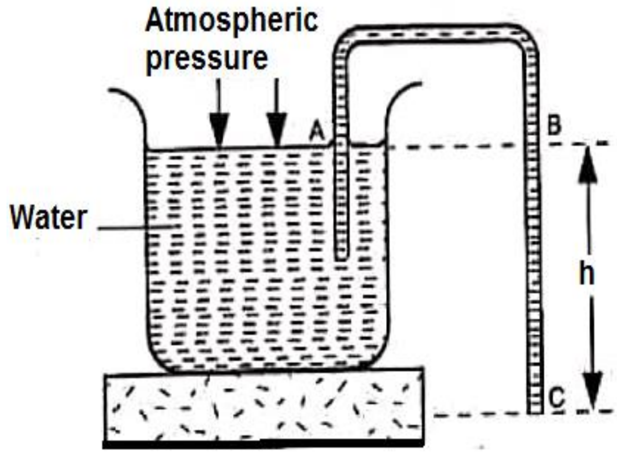
Aneroid barometer which is used in aircraft to show the height at which the plane is flying is called **Altimeter**

Application of Atmospheric Pressure

- There are a variety of common and even simple devices that work under atmospheric pressure (working under the Principle that **air exerts pressure**). These include
    1. Siphon
    2. Lift pump
    3. Force pump
    4. Syringe
    5. Bicycle pump

Siphon

- Is a tube or pipe that allows liquid to flow from the higher level to the lower level
- Siphon is a tube or pipe used to transfer liquid from one container to another container by using atmospheric pressure to make liquid flow



The siphon

- **The** pressure on the surface of the liquid is atmospheric pressure.
- Since end C of the tube is below the surface A by height h, thus the pressure at C is greater than that at the surface.**(ie. Pressure at C = pa + ρhg)**

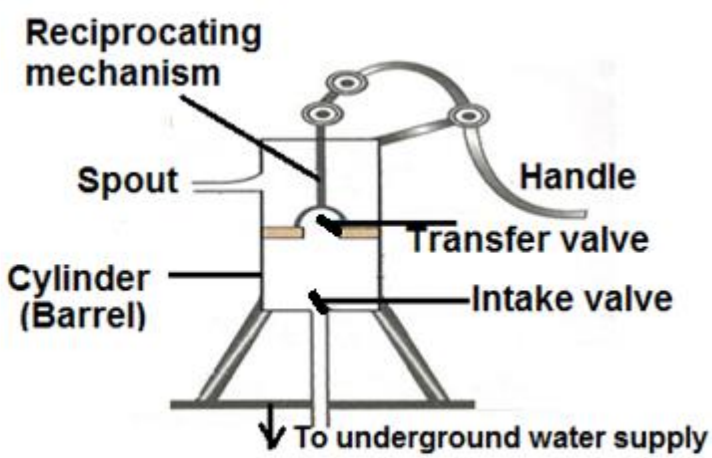
NB: Siphon can lift water about 10 m below the ground

Application of Siphon in everyday life

- It is used in the toilet flushing cisterns (Chain and ball flushing tank)
- It is used in Siphon rain gauge to automatically drain out the excess water
- A siphon cup is a reservoir attached to a gun
- It is used in some drainage systems to drain water to another point

Lift Pump

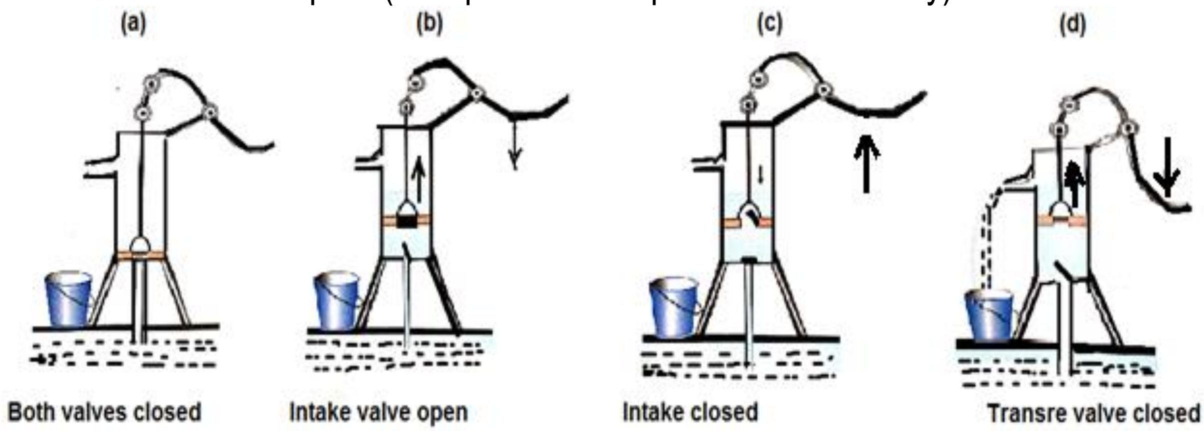
- Is used to raise water from underground water sources.
- Lift pump is a pump that is used to lift the liquid rather than force liquid up



The lift pump

How it works

- **Th**e pump starts with the piston at the bottom of the empty cylinder and both valves closed (fig.(a))
- **The** pump handle is then pushed down lifting the piston upwards (upstrokes).The transfer valve remains closed and the intake valv opens to allow water from the external source to fill the lower chamber(fig.(b)). This is due to the low pressure region created between the valve A and the Piston
- **T**he handle is then lifted upwards pushing the piston down (Down strokes).The intake valve now closes and the transfer valve opens (fig.(c)).This allows water to pass into the upper chamber
- **Fi**nally the pump handle is pushed down again lifting the piston upward. Transfer valve closes and Intake valve opens to allow water from the external source to fill the lower chamber .The water in the upper chamber is lifted and flows out of the spout (This process is repeated continuously)



Limitation of Lift Pump

- ✓ It can lift water up to height of 10 m
- ✓ Few strokes are required

Force Pump

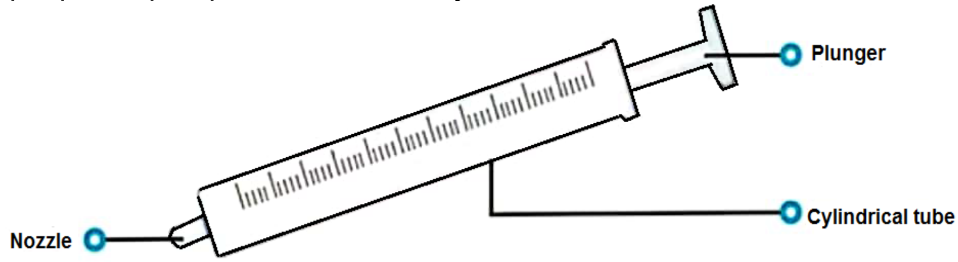
- Is a modified of a lift pump which can be used to raise water to a height of more than 10 m

Advantages of a force pump over a lift pump

- Force pump enables continuous flow of water
- Force pump is able to move water from greater depths than the lift pump
- Height to which water can be raised does not depend on the atmospheric pressure

Syringe

- Is a simple piston pump that is used to inject fluid into or withdraw fluid from the body



The Syringe

How it works

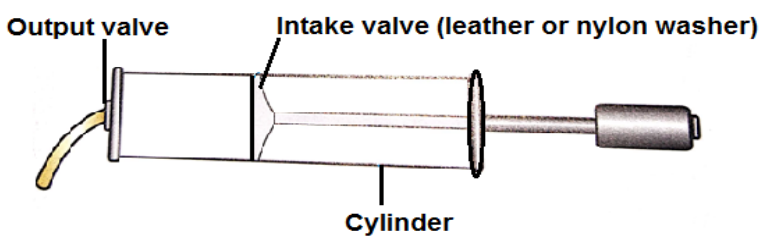
- It consists of a plunger that fits in a tube. The plunger is pulled and pushed while inside a cylindrical tube or barrel. This action enables the syringe to take in or expel fluid through the opening (nozzle) at the end of the tube

Uses of the Syringe

- ❖ Used for medical purpose e.g. Injecting vaccines
- ❖ They are used to measure liquids and gases in the laboratory
- ❖ Used to apply in a certain compound such as glue or lubricant

Bicycle Pump

- Is a type of force pump that consists of a hollow metal cylinder and a movable piston
- It is specifically designed for inflating bicycle tyres



The bicycle pump

Mechanism

- When piston is pulled out, a low pressure is created in the region just below the piston. The atmospheric pressure then forces air into the pump trough the space between the piston and the metal cylinder
- And when the piston is pushed in, the trapped air below the piston is compressed and the tube of the bicycle is then inflated using a valve

N.B:

Other examples (applications) of atmospheric pressure in our daily life are:-

- Detecting altitude of hills and mountains
- Drop ink through ink dropper
- Drinking straws
- Inflate vehicle tires
- Cleaning house using vacuum cleaners
- Enhance passage of air for breathing etc.

Class activity

Use acceleration due to gravity, $g = 10\ m/s^2$

Atmospheric pressure = $101\ 325\ N/m^2$

1. Define the term pressure and state its SI units
2. State two factors on which the pressure exerted by a fluid depends.
3. Calculate the pressure at the bottom of the pond 10 m deep if the density of water is $1000\ kg/m^3$
4. With the application of the same force, a sharp knife cuts more easily than a blunt knife. Explain why?
5. A glass slab of density $2500\ kg/m^3$ measures 20 cm x 10 cm x 50 cm. What is
   (a) Maximum pressure
   (b) Minimum pressure it exerts on a flat horizontal surface?
6. Why can't water be used as a barometric liquid?
7. Explain why a diver at the bottom of the dam experiences greatest pressure
8. Briefly explain how a bicycle pump works
9. A 40 N block exerts 20 Pa of pressure on a table. What is the area of the block that is touching the table? **(ANS: $A = 2\ m^2$)**
10. Explain the principle of a lift – pump
11. Briefly explain how drinking by using a straw is achieved
12. A diver is 5 m below the surface of water in a dam. If the density of water is 1000 kg/m^3. Determine the pressure due to the water on the diver **(ANS: $P = 50000\ N/m^2$)**
13. The density of mercury is $13600\ kg/m^3$. Determine the liquid pressure at a point 76 cm below mercury level (**ANS: $P = 103,360\ N/m^2$)**
14. Calculate the pressure due to water experienced by a diver working 15 m below the surface. Given that density of sea water is $1.03\ g/cm^3$ **(ANS:P =154500 Pa)**
15. Explain the following
    (a) A hole at the bottom of a ship is more dangerous than one near the surface
    (b) The bottom of the dam is made thicker than the top?
16. A submarine has a surface area of approximately $82\ 000\ m^2$. If it is travelling at a depth of 300 m in the ocean, what is the total force on the submarine's outer hull?
17. A rectangular tank which measures 5 m by 4 m contains water to a height of 10 m . Calculate (i) Pressure on the base (ii) Thrust on the base
    (ANS: P = 100,000 Pa, Thrust (Force) = 2,000,000 N)
18. A red cube with sides of 3 m and a blue cube with sides of 2 m are on a table. They both weigh the same .Which cube exerts more pressure on the table?
19. A rectangular brick of weight 24 N, measures 60 cm x 20 cm x 30 cm. Calculate the value of the maximum and minimum pressure
    (ANS: $P_{Max} = 400\ N/m^2$, $P_{mini} = 133\ N/m^2$)

20. A can holds water with a constant depth of 0.5 m. The surface of the water is exposed to the atmosphere .What is the pressure on the bottom of the can?
21. A can holds water with a constant depth of 1 m. Hole A is punched in the can 0.2 m below the surface of the water and hole B is punched 0.8 m from the surface. From which hole will the water spurt the furthest? Explain your answer
22. What are the advantages of using Aneroid barometer over Fortin barometer
23. Pressure in liquids depends on --------------------- and -----------------------
24. State the Pascal's principle
25. Calculate the area of a surface of an object which exerts a pressure of 0.2 N/m^2 when a force acting on it is 2 N (**ANS: A = 10** m^2)
26. Mention any two devices which apply Pascal's Principle
27. Given that both liquid A and liquid B exert the same amount of pressure, what would be height of column of liquid A if density of liquid A is twice density of liquid B and height of column of liquid B is 10 cm? (**ANS: h = 5 cm)**
28. **A** rectangular box whose dimensions are 1.2 m by 0.5 m by 2m has a density of 25 kg/m^3 . Calculate the maximum pressure which it can exert when placed on flat ground. (**ANS: P_{max} = 500 N/m^2)**
29. A hydraulic press has a large circular piston of radius 0.8 m and a circular plunger of radius 0.1 m. A force of 200 N is exerted by a plunger
    (a) Find the force exerted on the piston .(**ANS: F = 12,977 N)**
    (b) If the plunger is moved through a distance of 0.64 min exerting its force, through what distance is the piston raised? (**ANS: d = 0.01 m)**
30. A rectangular log of wood of density 200 kg/m^3 has dimensions 0.3 m x 0.5 m x 6.0 m.
    (a) Calculate the maximum pressure it can exert on the ground.**(ANS: P = 12000 N)**
    (b) Calculate the minimum pressure it can exert on the ground (**ANS: P = 600 N)**
    (c) How can (a) and (b) be experienced?
31. In a hydraulic brake system the piston in the master cylinder has a diameter of 2.0 cm and the pistons in the slave cylinders have a diameter of 3.5 cm. The brake pedal is pushed down 10 cm with a force of 50 N. How far do the brake shoes move and with what force do they press against the brake drum?
32. If pressure of a liquid is 1000 Pa and height of liquid is 20 cm, calculate the density of liquid **(ANS: Density = 5 g/cm^3)**
33. (a) Name the devices that are used for measuring pressure
    (b)How can you measure the pressure of a gas?
34. An open end of a rubber tubing of a manometer is placed in a fluid of density 1.2 g/cm^3. The mercury in the manometer rises by 3.0 mm. What is the depth of the fluid at the rubber tubing end? (Density of mercury = 13.6 g/cm^3)

35. Match the items in List A with the correct ones from list B. Items A can be used more than once

List A	List B
(a) Atmospheric pressure **(b)** Pressure **(c)** Pascal principle **(d)** Application of atmospheric pressure **(e)** Razor blades and knife blades	(i) Minimum force (ii) Hydraulic press (iii) N/m^2 (iv) Pascal (v) Maximum force (vi) Manometer (vii) High pressure (viii) Low pressure (ix) Aneroid barometer (x) Bicycle pump

36. A girl in a school situated in the cost (sea level) plans to make a barometer using a sea – water of density 1030 kg/m^3. If atmospheric pressure is 103 000N/m^2, what is the minimum length of the tube that she will require? (ANS**: h =10 m)**

37. The air pressure at the base of a mountain is 75 cm of mercury while at the top is 60 cm of mercury. Given that the average density is 1.25 kg/m^3 and density of mercury is 13,600 kg/m^3. Calculate the height of the mountain.**(ANS: h = 1632 m)**

38. A sea diver is 35 m below the surface of sea water. If the density of the sea water is 1.03 g/cm^3. Determine the total pressure on him(**ANS: $P_T = P_{atm} + P_L$ = 463,500 N/m^2)**

39. The barometric height at sea level is 76 cm of mercury while that at a point on a highland is 74 cm of mercury. What is the altitude of the point? Take density of mercury = 13 600 kg/m^3 and density of air = 1.25 kg/m^3

40. A student in a place where the mercury barometer reads 75 cm wanted to make an alcohol barometer, if alcohol has a density of 800 kg/m^3, what is the minimum length of the tube that could be used?

41. The area of the smaller piston of a hydraulic press is 0.01 m^3 and that of the bigger piston is 0.5 m^2. If the force applied to the smaller piston is 2 N, what force is transmitted to the larger piston? (**ANS: F = 100 N)**

42. **T**he master cylinder piston in a car braking system has a diameter of 2.0 cm. The effective area of the brake pads on each of the four wheels is 30 cm^2. The driver exerts a force of 500 N on the brake pedal. Calculate

(a) The pressure in the master cylinder (**ANS: A = 3.14 cm^2)**

(b) The total braking force in the car. (**ANS: F = 1.91 x 10^4 N)**

43. Atmospheric pressure on a particular day was measured as 750 mmHg .Express this in N/m^2 Take density of mercury = 13600 kg/m^3

44. The height of the mercury column in a barometer is found to be 67.0 cm at a certain place. What would be the height of a water barometer at the same

place?. Given that density of mercury and water are 13600 kg/m^3 and 1000 kg/m^3. (**ANS: h = 9.11 m)**

45. A man blows into one end of a U – tube containing water until the levels differ by 40.0 cm. If the atmospheric pressure is 1.01 x 10^5 N/m^2 and the density of water is 1000 kg/m^3, Calculate his lung pressure**.(ANS: P =1.05 x 10^5 N/m^2)**
46. In an experiment using Hare's apparatus, the lengths of methanol and water columns were found to be 16 cm and 12.8 cm respectively
    (a) Find the relative density of methanol **(ANS: R.D = 0.8)**
    (b) If the length of methanol column was altered to 21.5 cm what would be the new height of the water column? **(ANS: h = 17.2 cm)**
47. A roof has a surface area of 20 000 cm^2. If atmospheric pressure exerted on the roof is 100 000 N/m^2. Determine the force on it
48.

TOPIC 08: WORK, ENERGY AND POWER

WORK

- Is the product between force applied and the distance in the same direction

Mathematically:

Work done = Force x distance $\rightarrow$ $\boldsymbol{W.d = F\,x\,d}$

- **The SI unit of work is Joule (J)**
- **Joule** is a force of 1N that moves an object through a distance of 1m in the same direction of the force
- Equivalent Units of Work are: **1Nm = 1Joule = Kgm²S⁻² = 0.001 KJ**

Examples of work done in daily life

- When a person pushes a wall (No work is done since d = 0 m)
- When a farmer carrying a hole (No work done since d = 0 m)
- Lifting a pen (Work is done since d > 0 m)
- Lifting a cup (Work is done since d > 0 m)

Example

1. A sack of maize which weights 800N is lifted to height of 2 m. What work done against gravity

Solution:

Wight, w = 800 N
Distance, d = 2 m
Work done, W.d =?

From:

W.d = F x d
W.d = 800 x 2 **= 1600 J**

Individual Task – 1

1. How much work is done to lift a 7 kg object a distance of 2 m and then hold it at that height for 10 s (**ANS: work done to lift = 140 J, Work done to hold = 0 J)**
2. A force of 80N pulls a box along a smooth and level ground a distance of 5m. Calculate the work done by force. (**ANS: work done = 400J)**
3. How much work is done by a force of 10 N in moving an object through a distance of 4 m in the direction of the force. **(ANS: Work done = 40 J)**
4. Calculate the work done in lifting 200 kg of water through a vertical height of 6 m **(ANS: Work done = 1200 J)**

Energy

- Energy is the ability of doing work.
- The SI unit of energy is **Joule (J).**

Forms of Energy

Energy can exists in various forms such as:

- Chemical energy
- Heat energy
- Electromagnetic energy
- Sound energy
- Electrical energy
- Nuclear energy
- Mechanical energy

Chemical Energy

- Is the energy stored in the food and other fuels. Human get energy from the food that they eat

OR Is the energy that results from chemical reactions between atoms or molecules

- Example of chemical energy is an electrochemical cell or battery

Thermal (Heat Energy)

- Is the energy that reflects the temperature difference between two system
- Example, A cup of hot coffee has thermal energy.

Electromagnetic Energy (Radiant energy)

- Is the energy from light or electromagnetic waves
- Examples are Infrared radiation, Light energy, Ultraviolet radiation, radio waves, x-rays, Solar energy etc

Sound Energy (Sonic Energy)

- Is the energy that transfers in the form of waves.
- Examples, your voice, Microphone converts sound energy to electrical energy. Loud speaker convert electrical energy to sound energy

Electrical Energy

- It is due to the kinetic energy of the moving electric charge in a current

Nuclear Energy

Is the energy resulting from changes in the atomic nuclei or atomic reactions

OR Nuclear energy is the energy from the weak and strong nuclear force.

Examples are Nuclear fission, Nuclear fusion and Radioactive decay

Mechanical energy

- Is the energy that results from movement or location of an object
- Mechanical energy exists as **kinetic and potential energy**
- Examples, A book sitting on the table (PE), A Moving car (KE) etc

Types of Energy (Mechanical energy)

- Kinetic energy
- Potential energy

Kinetic Energy

- Is the energy possessed by a body due to its motion.
- Examples of kinetic energy are wind energy, Moving water ,Ocean Waves ,Ocean Tides ,Moving Machines, Falling bodies

  Mathematically:

  Kinetic energy is given by

  $$\boxed{\mathbf{K.E} = \tfrac{1}{2}\mathbf{mv^2}}$$

Example

1. An object has a mass of 5kg. What is its kinetic energy if its speed is
   (a) 5m/s (b) 10m/s

Data given

Mass, m = 5kg

Speed, v_a = 5m/s

Speed, v_b = 10m/s

Solution

(a) Kinetic energy, $\boldsymbol{K.E = \frac{1}{2} \times 5 \times 5^2 = 62.5\, J}$

(b) Kinetic energy, $\boldsymbol{K.E = \frac{1}{2} \times 5 \times 10^2 = 250\, J}$

Individual Task – 2

1. What is the kinetic energy of a 12g bullet travelling at 320m/s? (**K.E = 6144J)**
2. Anna has a mass of 80kg. If she runs at a speed of 10m/s. calculate her kinetic energy (**ANS: K.E =** 4000J)

POTENTIAL ENERGY

- Is the energy possessed by a body due to its state or position.
- The potential energy is given by**;**

  Potential Energy = mass x height x acc. due to gravity

  $$\boxed{\therefore \mathbf{PE = m\,g\,h}}$$

The PE can be observed into the following areas;

- A boy sitting on a bench
- A pen put on the table
- A man sleeping on a bed
- A book placed onto a table
- A ruler put on the table
- A man standing on a bus stop
- A brick put on the ground etc.

Example

1. A stone of 2kg falls from a height of 25 m above the ground. Calculate potential energy possessed by the stone

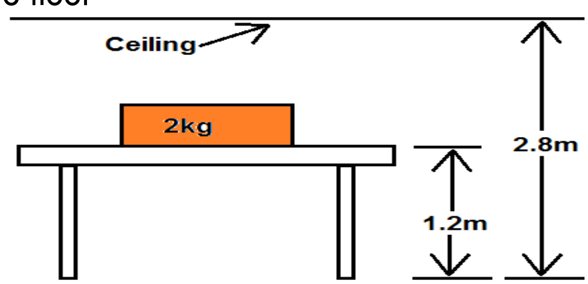
Solution:

Mass, m = 2kg
Height, h = 25 m
Gravitational force, g = 10N/kg
∴ Potential energy, P.e = $\boldsymbol{mgh = 2 \times 10 \times 10 = 200\,J}$

Individual Task – 3

Use: **Acceleration due to gravity, g = 10 m/s²**

1. A ball of mass 0.5 kg is kicked vertically upwards and rises to a height of 5 m. Find the potential energy acquired by the ball. (**ANS: P.E = 25 J)**
2. A body of mass 0.5 kg is projected vertically upwards such that it attains a height of 40 m. What is the potential energy at its highest point?
3. A 2kg object is at rest on a table 1.2 m above the floor. The ceiling in the room is 2.8m above the floor



What is the potential energy of the object relative to?

a) Top of the table **(ANS: P.E = 0 J)**
b) The floor **(ANS: P.E = 24 J)**
c) The ceiling (**ANS: $\boldsymbol{P.E_{LOST}}$ = 32 J)**

Transformation of Energy

- Energy can be changed from one form to another by the device known as transducer

Transducer

- Is a device used to convert energy from one form to another form

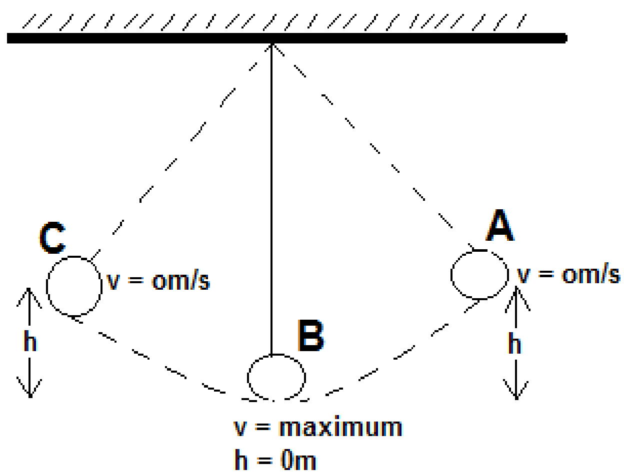
For Example,

- **Battery** convert chemical energy to electrical energy
- **Generator** convert mechanical energy to electrical energy
- **A motor** convert electrical energy to mechanical energy
- **A microphone** converts sound energy to electrical energy
- **Solar panel** convert solar energy to electrical energy
- **Heater** convert electrical energy to heat energy
- **A fan** convert electrical energy into mechanical energy
- **The green plants** convert light energy into chemical energy by the process of photosynthesis
- **Thermal power stations** convert heat energy to electrical energy
- **A torch** converts chemical energy to light and heat energy
- **A bulb** converts electrical energy to light and heat energy
- **Heat engines** convert heat energy to mechanical energy
- **A blender** convert electrical energy into mechanical energy
- **A natural gas stove** converts chemical energy from burning into thermal energy

The law of conversation of energy

States that: "***Energy can neither be created nor destroyed but can be transferred from one form to another***"

Consider the diagram below



At point A and C

- The body is momentarily stationary (zero kinetic energy) and has maximum potential energy as it starts swinging to position B (**At maximum height, $P.E_{max}$ = mgh)**
  Since: energy cannot be destroyed (**E_T = K.E + P.E= 0 + mgh = mgh)**

At point B

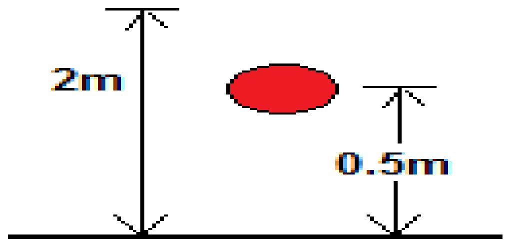
- **Th**e bob has maximum kinetic energy which takes it to position C**.**
  That is $K.E_{max} = \frac{1}{2}$ **mv^2**

NB: At any point the total energy (mechanical energy) is equal to the sum of kinetic energy and potential energy i.e **E_T = P.E + K.E**

Example

1. A stone of mass 2 kg is released from a height of 2m above the ground. Find
a) Total energy
b) Potential energy at heat of 0.5m
c) Kinetic energy at height of 0.5m
d) Velocity acquired at 0.5m

Diagram:



(a) Total energy, E =?

Maximum height, h = 2 m
Mass of object, m = 2 kg
Gravitation force, g = 10 N/kg
Minimum velocity, v = 0 m/s
From: E = P.E + K.E
E = mgh + $\mathbf{0} = 2 \text{ x } 10 \text{ x}2 = 40 \text{ J}$

(b) Potential energy, P.E =?
Height, h = 0.5m
From: P.E = mgh
P.E = mgh = = 2 x 10 x 0.5 = 10 J

(c) Kinetic energy, K.E= ?
From: E = P.E + K.E ---------- make K.E, the subject
K.E = E – P.E = 40 – 10 = 30 J

(d) Velocity acquired at 0.5m

Velocity acquired at 0.5m, v =?
From: **K.E =** $\frac{1}{2}$ **mv²** --------------- make v the subject

$$\therefore \boldsymbol{v} = \sqrt{\frac{\boldsymbol{2K.E}}{\boldsymbol{m}}} = \sqrt{\frac{\boldsymbol{2x30}}{\boldsymbol{2}}} = \mathbf{5.48}\ \boldsymbol{m/s}$$

N.B

- When the ball rebounds, it rebounds to the height less than the original height. This is due to:-
(a) Some energy is used to overcome air resistance as the ball falls
(b) The collision between the ball and the ground is not perfectly elastic
(c) As the ball hits the ground, some energy is converted into other forms of energy causing its energy to be reduced

Individual task – 4

1. A ball of mass 0.2kg is dropped from a height of 20m. On impact with the ground it loses 30J of energy. Calculate the height which it reaches on the rebound (**ANS: h = 5 m)**
2. A its highest point A 1.2 m a pendulum of mass 0.8kg is reached what.

(a) Velocity swings at lowest point (**ANS: v = 4.85 m/s)**

(b) Velocity at 0.9m **(ANS: v = 2.4 m/s)** (c) Height at 2m/s **(**ANS: h = 0.98 m)

Power

- **P**ower is the rate of doing work

OR

- Power is the rate at which energy is consumed.
- Its SI unit is Watt (W)

Mathematically:

$$Power(P) = \frac{work\ done(W.d)}{time(t)} \quad \rightarrow P = \frac{w.d}{t} \quad \rightarrow P = \frac{E}{t}$$

Equivalent units

1W = 1J/s, 1h.p = 750W or 746W, 1kW = 1000W 1MW = 1,000,000 W

Whereby:

h.p = horse power used by engineering, kW = kilowatt, MW = megawatt

Example

1. A pump raises 100kg of water through a height of 30m in 10s. What is the power developed by the pump

Solution

Given: Mass, m = 100kg
Height, h = 30m
Time taken, t = 10s
Gravitation force, g = 10N/kg
Power, p =?

From:

$$Power(P) = \frac{work\ done(W.d)}{time(t)}$$

$$\therefore P = \frac{mgh}{t} = \frac{100\ x\ 10\ x30}{10} = 3000\ W$$

Individual Task – 5

1. How much power is required to accelerate a 1000kg car from rest to 26.7m/s in 8s? (**ANS: P = 44500 W)**
2. A 50kg girl runs up a staircase of 50 steps each step is 15cm in height in 5s. Find
   a. Work done against gravity by the girl (**ANS: W.d = 37.5 J)**
   b. Power she use to run (**ANS: P = 7.5 W)**

Class Activity

Where necessary use acceleration due to gravity, g =10 m/s²

1 horsepower hp = 746 Watts

1. **De**fine the term work and give its SI unit
2. What happen when force and distance are in the same directions?
3. (a) Define the term power and states how it is measured

   (b) Express 6900 J/s in Horsepower
4. **A man** exerts a force of 200 N for 6 minutes pushing his car 60 m along a horizontal road to reach a garage
   a) **Calculate** the work done by the man. (**ANS: E = 12 000 J)**
   b) **Calculate** the power of the man when he was pushing the car**(P = 33 W)**
5. Calculate the power of a pump which can lift 200 kg of water through a vertical height of 6 m in 10 s (Assume $g = 10\ m/s^2$) (**ANS: P = 1.20 kW)**
6. **A** boy whose mass is 40 kg finds that he can run up a flight of 45 steps, each 16 cm high ,in 5.2 s. (Assume $g = 10\ m/s^2$**)** **(ANS: P = 0.55 kW)**
7. A steady force of 30 N is used to move a small crate across a factory floor. The energy used in moving the crate is 450 J. Calculate the distance moved by the **crate** **(ANS: d = 15 m)**
8. Define potential energy and kinetic energy and then state the principle of conservation of energy
9. State four of the transfers of energy which occur at a power station which uses coal as its fuel
10. Define the term energy. A ball of mass 0.2 kg is dropped from a height of 20 m. On impact with the ground it losses 30 J of energy. Calculate the height it reaches on the rebound.(**ANS: h = 5 m)**
11. **A** force of 40 N is applied on a body .The body moves a horizontal distance of 7 m. Calculate the work done on the body. (**ANS: Wd = 280 J)**
12. A bowling ball is lifted to a height such that its gravitational potential energy is 20 J relative to the ground. If released from rest, how much kinetic energy does the ball have just before striking the ground? Ignore air resistance (**ANS: K.E = 20 J)**
13. **A** man whose mass is 75 kg walked up 12 steps of 20 cm each in 5 seconds .Find the power that was developed. (**ANS: P = 360 W)**
14. A gust of wind shakes loose a football that was stuck in a tree. Ignoring air resistance, if the football falls from a height of 10.8 m, what is its speed just before hitting the ground? **(ANS: v = 14.5 m/s)**
15. A ball of mass 0**.5 kg** is dropped from a height of 10 m and on impact with the ground it loses 30 J of energy. Calculate the height it reaches on the rebound (**ANS: h = 4 m)**
16. Explain why in trying to move a rigid wall, a person is said to be doing no work
17. Define the term work and state its SI unit.

18. A crane is used to lift a body of mass 30 kg through a vertical distance of 6.0 m

a) How much work is done on the body? **(ANS: Wd = 1 800 J)**

b) What is the P.E stored in the body? (**ANS: Wd = 1 800 J)**

c) Comment on the two answers **(ANS: Wd against the gravity is stored as PE in the body)**

19. Name one device which converts:

(a) Heat energy into electrical energy

(b) Mechanical energy into heat energy

(c) Electrical energy into heat energy

(d) Electrical energy into sound energy

20. A car of mass 2000 kg is travelling along a straight road at a constant velocity of 10 m/s developing 3.0 kilowatts .If the engine of the car is switched off;

(i) Calculate the energy lost by the car in coming to rest (**ANS K.E =10^5 J)**

(ii) Briefly the energy changes in the process stated in (i) above

21. How kinetic energy distinguished from potential energy?

22. If a red ball is higher than a blue ball and both balls have the same mass, which ball has more potential energy?

23. What is the gravitational potential energy of a 3kg ball that is 1 meter above the floor? (**ANS: P.E = 30 J)**

24. If a 2 kg rock has 200 J of gravitational potential energy, how high is it? (**h = 10 m**)

25. What is the gravitational potential energy of a 1 kg ball that is 2 meters above the floor? **(ANS: P.E = 20 J)**

26. A spring constant k = 100 Nm is stretched to a distance of 20 cm. Calculate the work done by the spring. (**ANS: W = 2 J)**

27. A person weighs 500 N takes 4 seconds to climb upstairs to a height of 3.0 m. What is the average power in climbing up the height? (**ANS: P = 375 w)**

28. A box of mass 500 kg is dragged along a level ground at a speed of 12 m/s. If the force of friction between the box and floor is 2000 N .Calculate the power developed.**(ANS: P = F x v = 24 kW)**

29. A bullet of mass 3.0 g moving at 400 m/s hits a tree trunk and comes to rest inside the tree after penetrating a depth of 60 mm. Calculate the:

(i) Kinetic energy of the bullet as it hits the tree (**ANS: K.E = 240 J)**

(ii) Average force of retardation as it passes through the tree **(ANS: F = 4 000 J)**

30. A driver stopped his car by pressing the brakes to avoid a collision with a lorry that had suddenly stopped in front of him. What was the energy change that took place in this process?

31. A rubber ball of mass 0.12 kg is held at a height of 2.5 m above the ground, and then released.

(a) Calculate the kinetic energy of the ball just before it hits the ground **(ANS 3J)**

(b) Calculate the velocity of the ball just before it hits the ground **(V = 7.07 m/s)**

(c) Give one reason why the ball rebounds to a height of less than 2.5 m above the ground.

32. A girl of mass 50 kg walks up a flight of 12 steps. If each step is 30 cm high, Calculate the work done by the girl climbing the stairs (**ANS: W =1,800 J)**

33. A force of 7.5 N stretches a certain spring by 5 cm . How much work is done in stretching this spring by 8.0 cm (**ANS: W.d = 0.48 J)**

34. An apple of mass 0.3 kg falls to the ground from a height of 21.9 m. If the acceleration due to gravity is 10 m/s^2

(i) Mention all energy changes that take place in this process

(ii) Find the energy it possesses before falling (**ANS: P.E = 65.7 J)**

(iii) Find the energy possessed by the apple when it just reaches the ground.(**ANS: K.E = 65.7 J)**

(iv) Comment on the answer in (ii) and (iii) above

35. How much is done in stretching a spring of spring constant 25 N/m when the length is increased from 0.10 to 0.20 m. **(ANS: Wd = 1.25 x 10^{-1} J)**

36. Calculate the work done by a stone mason lifting a stone of mass 15 kg through a height of 2.0 m. (**ANS: work done = 300 J)**

37. A jet aircraft climbs at an increased speed , using a large amount of fuel to provide energy .Write brief notes on the energy transformations which occur

38. Which of the following device converts chemical energy to electrical energy?

A. Battery B. Loud speaker C. Solar cell D. Electric motor

39. What happens to the body on which work is done

A. It loses energy B. It gains energy C. No change in the energy

D. First it loses then gain (**ANS: B)**

40. When an object falls freely towards the ground , then its total energy:

A.Increases B. Decreases C.Remains constant

D.First increases then decreases (**ANS: C)**

41. In one minute how much energy does a 100 w electric bulb transfers? (**6000 J)**

42. A boy of mass 42 kg is standing at a height of 2.1 m above the ground on a climbing frame. The boy jumps to the ground.

a) Calculate the potential energy lost by the boy during his jump.

b) Hence calculate the speed of the boy when he lands

c) State any assumption you make to solve part (b)

ANS: (a) E_P = 880 J (b) V = 6.5 m/s (c) All of the P.E is converted to K.E

43. A pendulum consists of a small metal sphere suspended at the end of a long string. The metal sphere is pulled to the side and then released from a point 35 mm higher than the lowest part of its swing. Calculate the maximum velocity of the metal sphere. **(ANS: v = 0.84 m/s)**

44. State the energy changes which occur when a moving car is brought to rest by its brakes , and the car is then driven to top of a hill

45. A ball of mass 1 kg is dropped from a height of 7 m and rebounds to a height of 4.5 m .Calculate:

a) Its kinetic energy just before impact (**ANS: KE = 70 J)**

b) Its initial rebound velocity and kinetic energy. Account for the loss of kinetic energy on impact **(ANS: v = 9.5 m/s, KE = 45 J)**

46. What is meant by power? Explain the meaning of kilowatt? A car of mass 1500 kg is driven from rest with uniform acceleration and reaches a speed of 50 km/h in 30 s. Find:

a) The useful force exerted by the engine in Newton (**ANS: F = 690 N)**

b) The power developed in kilowatts at 50 km/h (Assume all friction forces are constant) **(ANS: P = 9.6 Kw)**

47. A stone of mass 500 g is thrown vertically upwards with a velocity of 15 m/s. find

a) the potential energy at greatest height **(ANS: PE_E = 56.25 J)**

b) the kinetic energy on reaching the ground (**ANS: KE_E = 56.25 J)**

48. **Define** momentum and Kinetic energy. A car is moving at 36 km/h. Express this velocity in m/s. What velocity will: (**ANS: 36 m/s = 10 m/s)**

a) Double its momentum (ANS: v = 20 m/s)

b) Double its kinetic energy? (ANS: v = 14 m/s)

49. A motor car of mass 1000 kg travelling at 90 km per hour is brought to rest by the brakes in 100 m. Calculate

a) The car's initial momentum (**ANS: p = 25 000 kgm/s)**

b) Its initial kinetic energy **(ANS: KE = 313 KJ)**

c) The average braking force required **(ANS: F = 3130 N)**

50. The electric motor of a crane uses 42 000 J of electric energy lifting a pack of eight 25 kg bags of cement through a distance of 15 m from the ground to the fourth floor of a block of flats. Calculate the efficiency of the motor during the lifting process **(ANS: efficiency = 71 %)**

51. When does a force do work? How is the work it does measure? What is meant by the term "Power"?

52. A pendulum bob of mass 50 g is pulled aside to a vertical height of 20 cm from the horizontal and then released

(a) The maximum potential energy of the bob **(ANS: P.E = 0.098 J)**

(b) The maximum speed of the bob **(ANS: V= 1.98 m/s)**

(c) Suppose the length of the thread of the pendulum in discussion was 1.0 ,what its periodic time of oscillation be? **(ANS: T= 2.0)**

(d) State the principle applied by the pendulum experiment

53. Define the watt and kilowatt. A man whose is 75 kg walks up a flight of 12 steps each 20 cm high in 5 s. Find the power he develops in watts (**P = 360 W)**

54. A body of mass 50 kg is raised to a height of 2 m above the ground . What is its potential energy? if the body is allowed to fall ,find its kinetic energy:

a) When half – way down
b) Just before impact with the ground.

What has become of the original energy when the body has come to rest?

(ANS: PE = 1000 J (a) KE = 500 J (b) KE = 1000 J)

55. **Define the** Newton and the joule. A mass of 8 kg is pulled by a force of 20 N along a smooth floor. Find:

a) The acceleration **(ANS: a = 2.5 m/s^2)**
b) The velocity after 4 s **(ANS: v = 10 m/s)**
c) The distance moved in 4 **s** **(ANS: d = 20 m)**
d) The work done by the force **(ANS: Wd = 400 J)**

56. A cable car is pulled up a slope by a constant force of 5000 N at a uniform speed of 6 metres per second. It takes the car 4 minutes to complete the journey. (**ANS: (a) Wd = 7.2 MJ (b) Wd = 7.2 MJ (c) Power is doubled)**

a) How much work is done in getting the car to the top of the slope
b) How much work would be done if the speed were 12 m/s (the force remaining the same)?
c) How does the power developed compare in (a) and (b)

57. 400 kg of air, moving at 20.0 m/s impinge on the vanes of a windmill every second .At what rate in kilowatts is the energy arriving at the windmill? What is the maximum mass of water that could be pumped each second through a vertical height of 5.0 m? (**ANS: P = 80 Kw, m = 1600 kg)**

58. A boat travels at a constant speed of 6.**0 m**/s for 15 minutes. The input power of the boat engine is 12 000 W. The efficiency of the engine is 30%.

a) **C**alculate the energy used by the boat engine (**ANS: E_i = 1.08 x 10^7 J)**
b) Calculate the useful energy output of the engine. **(ANS: E_O = 3.2 x 10^6 J)**
c) Calculate the force exerted by the engine (**ANS: F = 600 N**)

TOPIC 09: LIGHT PART I

LIGHT

- **Is** an invisible form of energy that causes the sensation of vision in us through eyes

Sources of Light

- Sources of light is the original of light in which the light are comes from whether natural or artificial

Types of Sources of Light

- Natural sources of light. For example, sun, star and lighting
- Artificial sources of light. For example, torch, candle, kerosene lamp etc

Properties of Light

- Light radiates (spread out) from its source
- Light travels in straight line
- Light transfers energy.
- Light travels in vacuum
- Light travels at the fast speed, about 300,000,000m/s (300,000 km/s)

NB:

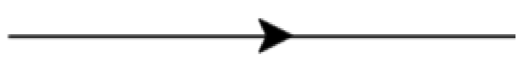
- All objects which give out their own light are called **Luminous Objects**. e.g. star, sun, torch, candle, electric bulb etc
- All objects that do not emit their own light instead became visible when they reflect light from another source are called **Non Luminous Objects**. E.g. moon
- All objects that emit light as a result of being heated are called **Incandescent Objects**. e.g. light bulb, fire flame, candle flame etc
- The spreading of light from its source to the environment in straight lines is referred as **Rectilinear Propagation Of Light**

Propagation of Light

- Light travels in a straight line

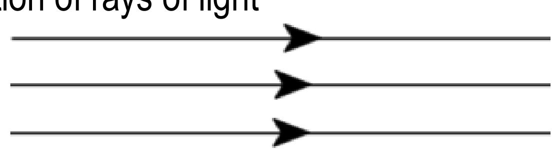
Ray

- Ray is the path travelled by light .
- Ray is represented in a diagram by full straight line with an arrow to show the direction of light.



Beam

- Beam is a collection of rays of light

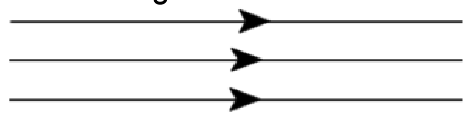


Types of Rays

- Parallel rays
- Converging rays
- Diverging rays

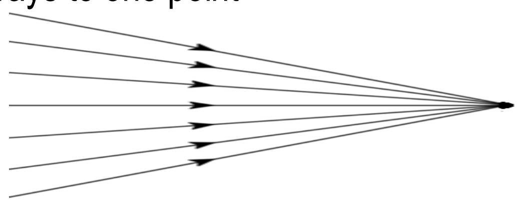
Parallel Rays

- The collection of rays in a straight line which can never cross each other



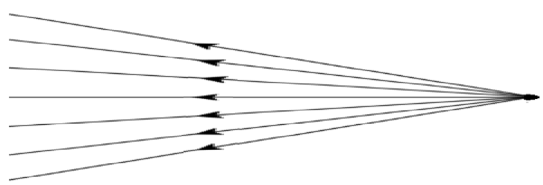
Converging Rays

- The collection of rays to one point



Diverging Rays

- The spreading out of rays from one point



Transmission of Light

Bodies (**objects)** can be grouped according to transmission of light through them such as:-

a) Opaque bodies
b) Translucent bodies
c) Transparent bodies

Opaque bodies

- Are the bodies which do not allow light to pass through them.
- For example, stone, wood, concrete walls, books etc

Translucent Objects

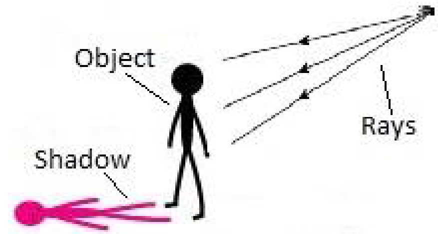
- Are the objects which allow small amount of light to pass through them.
- For example, oiled paper, tinted glass, some plastic materials etc

Transparent Objects

- Are the bodies which allow all light to pass through them.
- For example, glass, pure water, air etc

Shadow

- Is a dark area where light from a light source is blocked by an opaque object



Types of shadow

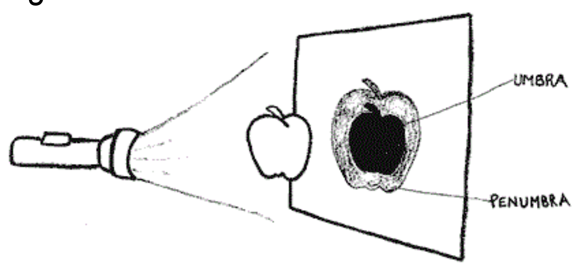
- Umbra shadow
- Penumbra shadow

Umbra Shadow

- Is the total shadow formed behind the opaque bodies.
- It receives no light at all from the source.

Penumbra Shadow

- Is the partial shadow formed behind the opaque bodies.
- It receives some light from the source



NB:

- When source of light are small than opaque only umbra are formed

Eclipse

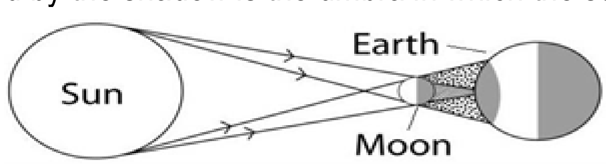
- Is the shadowing or shading of one heavenly body in the shadow of another.

Types of Eclipse

- Solar eclipse
- Lunar eclipse

Solar Eclipse

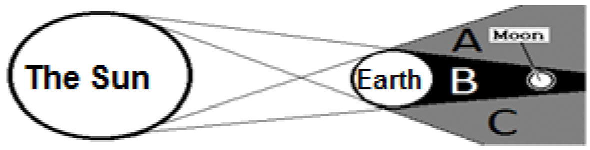
- Is the kind of eclipse in which the moon is between the earth and the sun.
- Always occurs during the day.
- The area covered by the shadow is the umbra in which the sun cannot be seen at all



Solar Eclpse

Lunar Eclipse

- Is the kind of eclipse in which the earth is between the sun and the moon and the shadow of the earth is cast on the moon.



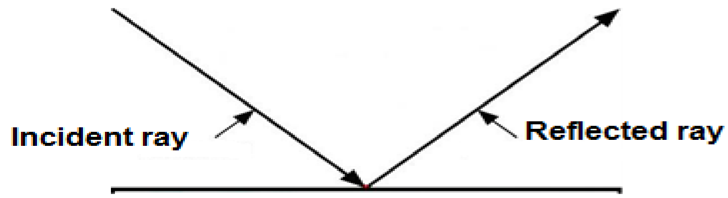
Lunar Eclipse

Reflection of Light

- **Is** the bouncing back of light rays when they meet an obstacle in their path

Terms used

- **Incident ray** is the ray of light which strikes a surface
- **Reflected ray** is the ray that represents the light reflected by the surface

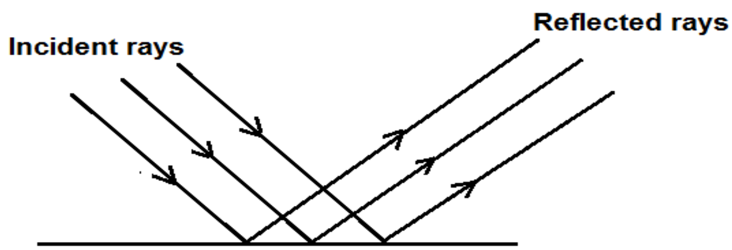


Types of Reflection

- Regular reflection
- Diffuse reflection

Regular Reflection

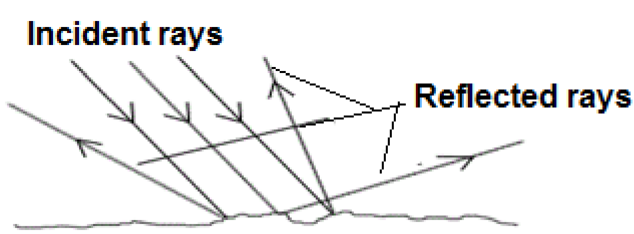
- Is the reflection where by all reflected rays reflected in one direction.
- The rays are in parallel to each other. Occurs at smooth surface



Regular reflection

Diffuse (Irregular) Reflection

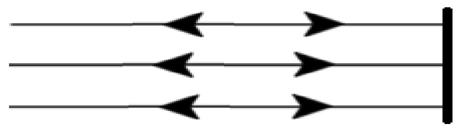
- Is the reflection where by all reflected rays reflected random or in different directions.
- It Occurs at a rough surface



Irregular reflection

NB:

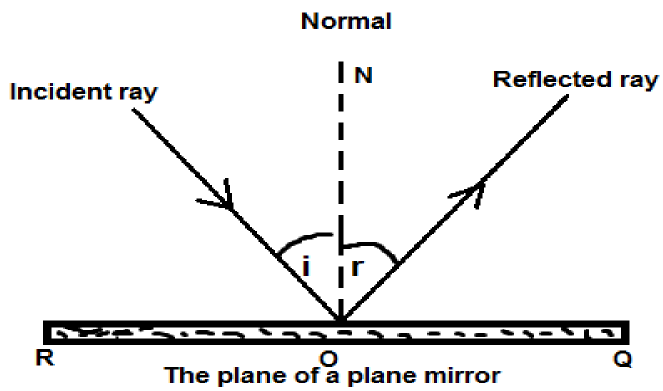
- We can see our images clear in a plane mirror as a result of regular reflection.
- If light falls in polished surface at right angle, it is reflected back into the air on the same pass



- Diffuse reflection also called **scattering/ irregular reflection**
- When the sun rays enter the earth's atmosphere, it begins to be scattered by molecules of nitrogen and oxygen.
- The sky looks blue on a clear sunny day because **these molecules scatter the blue light more than other colors due to its shorter wavelength**

Laws of Reflection

Consider the figure below



From the figure above

- **ON** is a perpendicular line to the surface of the mirror (It is called the Normal)
- Normal is the line which divides the angle of incidence and angle of reflection into two equal angles
- **Angle of incidence (i)** is the angle between the incident ray and the normal
- **Angle of reflection (r)** is the angle between the reflected ray and the normal
- **Thus** the laws of reflection states that

1st. "*The incident ray, the reflected ray and the normal all lie in the same plane*"

2nd "*The angle of incidence equals to the angle of reflection*" (i = r)

Images Formed by Plane Mirrors

- When an object is kept in front of plane mirror the image is formed due to the reflection of light

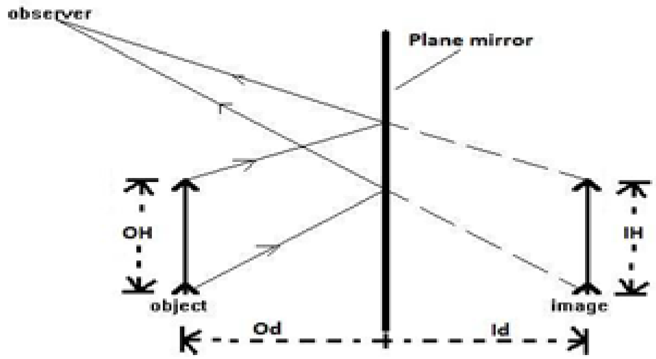


Image formed by a plane mirror

Whereby:
M = magnification
Id = image distance
Od = object distance
IH = image height
OH = object height

Characteristics of Image formed in a Plane Mirror

- ✓ The image is virtual (not real)
- ✓ The image is upright
- ✓ The Image and object has the same size
- ✓ The image distance is the same as the object distance from the plane mirror
- ✓ The image has a left-right reversal (laterally inverted)

Magnification

- Magnification is given by the formula

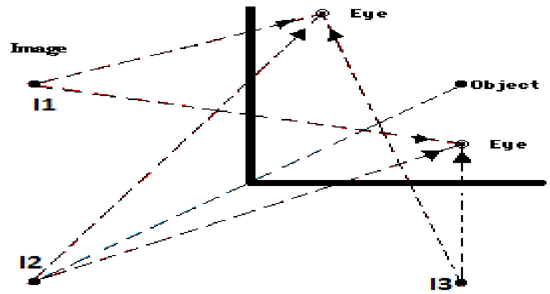
$$\boldsymbol{Magnification} = \frac{\boldsymbol{image\ distance\ from\ the\ mirror}}{\boldsymbol{object\ distance\ from\ the\ mirror}} = \frac{\boldsymbol{image\ size}}{\boldsymbol{object\ size}} = \frac{\boldsymbol{Id}}{\boldsymbol{Od}} = \frac{\boldsymbol{IH}}{\boldsymbol{OH}}$$

Rotating a mirror

- The reflected ray moves through an angle twice the angle of rotation
- If the mirror was rotated through certain angle θ, then the reflected ray would be rotated through an angle of 2θ

Multiple Mirrors

- Is the system which consists of two or more mirrors and produce several images of the same object.
- Right – angle mirrors refers to two mirrors that are joined at their edges at an angle of 90^0



- Image in parallel mirrors (two mirrors joined at 0^0). The image formed is at infinite in each mirror **because there is a repetition of images**

NB:

- The number of images increase as if the angle between the mirrors decreases i.e $\boldsymbol{n} \propto \frac{\mathbf{1}}{\boldsymbol{\theta}}$
- Parallel mirrors are commonly used in saloons and barber shops
- The number of images (n) formed between mirrors placed at $\boldsymbol{\theta}^{\mathbf{0}}$, is given by the formula:

$$\boldsymbol{n} = \frac{\mathbf{360^0}}{\boldsymbol{\theta}^{\mathbf{0}}} - \mathbf{1}$$

Application of Reflection of Light

- **It is applied in Periscope**
- Periscope is a device used for seeing objects that are above the eye level of the observer

Class Activity

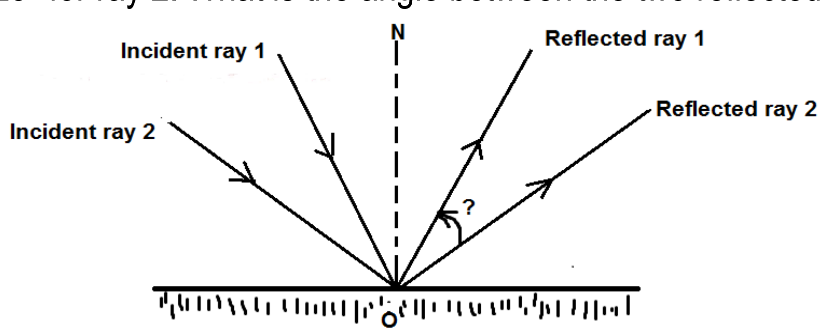
1. Define the following terms (with examples)
   (a) Natural sources of light.
   (b) Artificial sources of light
2. What is reflection? Distinguish between the angle of incidence and the angle of reflection
3. State the laws of reflection
4. List characteristics of an image formed on a plane mirror
5. Images formed by plane mirrors are laterally inverted. What does this mean?
6. Outline some of the uses of plane mirrors
7. State the difference between umbra and penumbra
8. An image that is formed in a plane mirror is always

A. Smaller than the object B. Larger than the object C. Virtual D. Real

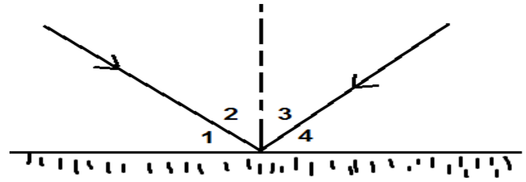
9. Differentiate between a ray of light and a beam of light
10. With the help of sketches, show the difference between parallel, diverging and converging beam
11. Define with examples the terms opaque, transparent and translucent as used in light
12. What factors do shadows formed on a screen when opaque object blocks out light depend on?
13. Discuss the application of a periscope
14. How lunar eclipse differ from soar eclipse
15. Match each item in list A with an Item from List B

List A	List B
(a) Bulb **(b)** Light **(c)** Plane mirror **(d)** Umbra **(e)** Semi – transparent **(f)** Right angle mirror **(g)** Diffuse **(h)** Used in submarines **(i)** Eyes see images due to	(i) Flat surface (ii) Luminous (iii) Translucent (iv) Periscope (v) Partial shadow (vi) Non – luminous (vii) 3×10^8 m/s (viii) Glow (ix) Full shadow (x) Images are infinities (xi) Reflection of light (xii) Incident (xiii) Scattered (xiv) Telescope (xv) Inverted images (xvi) Upright images (xvii) Dark room (xviii) Reflected ray (xix) Images are three

16. Two different incident rays reflect off a mirror. The angle of incidence for ray 1 is 60^0 and 25^0 for ray 2. What is the angle between the two reflected rays?



17. Explain the formation of multiple images in mirrors inclined at 90^0
18. The diagram below shows a ray of light reflecting off a mirror. Which is the angle of incidence? Which is the angle of reflection?



19. Distinguish between regular and diffuse reflection
20. A house building contractor fitted window glass panes which someone cannot see through, but the rooms are fully illuminated with light. These types of glass pane materials are said to be:
    A. Dim B. Opaque C. Translucent D. Transparent
21. Give two examples which illustrate that light travels in a straight line
22. The formation of a shadow is evidence that light travels in--------------------
23. Draw a diagram showing a plane reflecting surface, incident ray, reflected ray, the normal, angle of incidence and angle of reflection. What is the relationship between angle of incidence and angle of reflection
24. Describe With the aid of labeled diagrams, the formation of umbra and penumbra shadows. How are they distinguished?
25. Two mirrors are inclined at an angle of 40^0 to each other. How many images are seen when an object is placed at the centre?
26. Differentiate between Opaque and transparent bodies
27. Differentiate between translucent and transparent objects
28. Explain how solar eclipse occurs
29. How many images can be formed if two mirrors are set
    (a) At angle of 60^0 (b) Parallel to each other (c) At angle of 180^0
30. What number of images formed by mirrors at 90^0?
31. Explain how lunar eclipse occurs