LOWER SECONDARY CURRICULUM

Competency Based
Physics Learner's Work Book

WRITTEN BY

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Preface

This Learner's workbook has been written in line with the revised Physics syllabus for the lower secondary curriculum. The activities of integration together with the research assignments embedded in each chapter will enable the learner to produce new knowledge, values and skills required in the present world of innovation and creativity.

This work book provides a range of class activities, activities of integration and research assignments which will enable the learner to interact and discuss with fellow learners, research and discover more through the internet and textbooks in order to understand the applicability of knowledge acquired at his or her respective school.

The learner is expected to be able to work as an individual, in pairs or groups according to the nature of the activities in order to be able to develop personal confidence and communication skills as they share learning experiences with their colleagues.

This Learner's workbook is one of the materials that are to be used to facilitate the teaching and learning process of the lower secondary curriculum.

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Physics and Mathematics tutors

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We welcome any suggestions for improvement to continue making our service delivery better. Please get to us through katoivans001@gmail.com or contact me on +256788463703 or +256750463703

SENIOR TWO PHYSICS TOPICS AND THEIR LEARNING OUTCOMES

TERM 1

TOPIC1: WORK, ENERGY AND POWER

Competency: Understand and use the relationship between energy, work done, force and power in the operation of simple machines.

Learning outcomes

a) Know that the sun is our major source of energy, and the different forms of energy (k)
b) Know that energy can be changed from one form into another and understand the law of conservation of energy (k, u)
c) Understand the positive and negative effects of solar energy(u)
d) Understand the difference between renewable and non-renewable energy resources with respect to Uganda. (u, v/a)
e) Know and use the relationship between work done, force, distance moved, and time taken (k, s)
f) Understand that an object may have energy due to its motion or its position and change between kinetic and positional potential energy (u, s)
g) Know the mathematical relationship between gravitational potential energy and kinetic energy, and use it in calculations (k, u, g, s)
h) Understand the meaning of machines and explain how simple machines simplify work (u, s)
i) Understand the principles behind the operation of simple machines (u, g, s)

TOPIC 2: TURNING EFFECTS OF FORCES, CENTRE OF GRAVITY AND STABILIY

Competency: The learner should be able to investigate the relation between turning effect of forces and stability of bodies.

Learning outcomes

The student should be able to:

a) Understand the turning effect of forces and its applications (u, s, v/a)
b) Understand and apply the concept of centre of gravity (u, s,v/a)

TERM 2

TOPIC 3: PRESSURE IN SOLIDS AND FLUIDS

Competency: The learner should able to explain pressure in solids and fluids and identify their applications in everyday life.

Learning outcomes

The learner should be able to:

a) Understand that pressure is the result of a force applied over an area (u, s)
b) Understand the effect of depth on the pressure in a fluid and the implications of this (u, s)
c) Understand the nature of the atmosphere and how atmospheric pressure is measured (u, s)
d) Know the structure of the atmosphere and the significance of the different layers (k, u, v/a)
e) Understand the use of the Bernoulli effect in devices like aerofoils and Bunsen burner jets (u)
f) Understand the concept of sinking and flotation in terms of forces acting on a body submerged in a fluid (u)
g) Understand and apply the Archimedes' principle in different situations (u, s, v/a)

TOPIC 4: MECHANICAL PROPERTIES OF MATERIAL; HOOKE'S LAW

Competency: The learner should investigate and understand how the mechanical properties of different materials are related to their applications.

Learning outcomes

The learner should be able to:

a) Understand how the mechanical properties of common materials can be utilised in physical structures (u, s, v/a)
b) Understand that the tensile strength of materials is determined by the properties of the substances they are composed of (u)
c) Understand that heating changes the structure and properties of some materials

TOPIC 5: REFLECTION OF LIGHT BY CURVED SURFACES

Competency: The learner should understand how concave and convex mirrors form images, and also be able to describe the uses of these mirrors in everyday life.

Learning outcomes

The learner should be able to:

a) Understand reflection of light and the formation of images by curved mirrors (u)
b) Use ray diagrams to show how images are formed by curved mirrors and the nature of the images (s)
c) Determine the focal length of concave mirrors using a variety of methods. (s, g, s)

TERM 3

TOPIC 6: MAGNETS AND MAGNETIC FIELD

Competency: The learner should investigate and understand the properties of magnets and explain how the earth behaves as a magnet.

Learning outcomes

The student should be able to:

a) Know that a small number of materials are magnetic, but most are not (k)
b) Know how magnets can be made and destroyed (k, s)
c) Understand the behaviour of magnets and magnetic fields (u)
d) Know that the earth is a magnet and how a compass is used to determine direction

TOPIC 7: ELECTROSTATICS

Competency: The learner should understand electrostatics and use electrostatics to explain lighting and other phenomena.

Learning outcomes

The student should be able to:

a) Understand everyday effects of static electricity and explain them in terms of the build-up and transfer of electrical charge (u, s)
b) Apply knowledge of electrostatic charge to explain the operation of devices like lightening conductors (u, s, v/a)

TOPIC 8: THE SOLAR SYSTEM

Competency: The learner should understand the relative movement of the earth and moon in relation to the sun and explain the consequences for the Earth.

Learning outcomes

The student should be able to:

a) know the relative sizes, positions, and motions of the earth, sun and moon (k, u)
b) understand how day and night occur and demonstrate the phases of the moon (u, s)
c) understand the roles of the sun, earth and moon in explaining time, seasons, eclipses, and ocean tides (k, u, g, s)
d) know the components of the solar system and their positions (k)
e) know the main characteristics of the inner and outer planets in the solar system (k)
f) understand the various views about the origin and structure of the universe

THEME: **MACHINES AND PROPERTIES OF MATTER**

CHAPTER 1: **WORK, ENERGY AND POWER**

Learning outcomes;

By the end of this chapter, learners should be able to;

1. Know that the sun is our major source of energy and the different forms of energy.
2. Know that energy can be changed from one form to another and understand the law of conservation of energy.
3. Understand the positive and negative effects of solar energy.
4. Understand the difference between renewable and non- renewable energy resources with respect to Uganda.
5. Know and use the relationship between work done, force, distance moved and time taken
6. Understand that an object may have energy due to its motion or its position and change between kinetic energy and potential energy.
7. Know the mathematical relationship between gravitational potential energy and kinetic energy and use it in calculations.
8. Understand the meaning of machines and explain how simple machines simplify work.
9. Understand the principles behind the operation of simple machines.

Key words

- Work done
- Power
- Energy
- Potential energy
- Kinetic energy
- Joule
- Load
- Efficiency
- Mechanical advantage
- Velocity ratio
- Work input
- Work output
- Energy wasted.

1.1 Introduction

This chapter will introduce us to work, energy, power and how they apply in simple machines. We always engage in many activities such as playing, digging, cutting among others. We need tools in order to carry out these activities. However, as we conduct these activities, through the use of energy, we eventually perform work. At times we employ machines to do for us the work, what do you understand by machines? How do they simplify work? In this section we will learn all the above mentioned concepts.

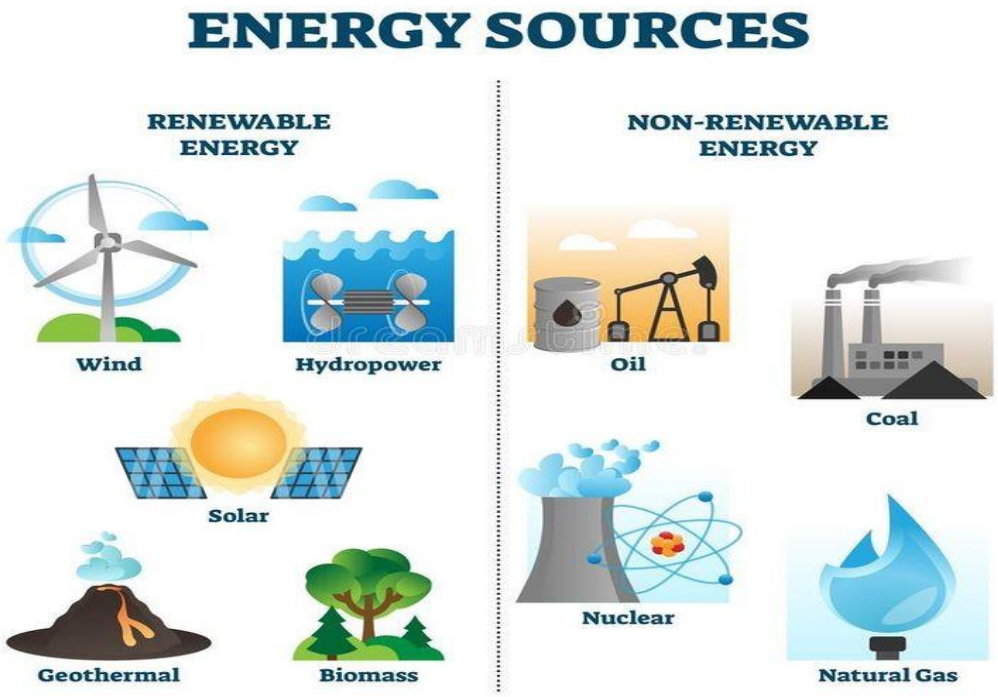
ENERGY

Energy is the ability or capacity to do work. The S.I unit of work done and energy is a **joule** (J).

SOURCES OF ENERGY (ENERGY SOURCES)

The raw material for the production of energy is called the energy source. There are two types of energy sources.

- Renewable sources of energy
- Non-renewable sources of energy



RENEWABLE ENERGY SOURCES

These are energy sources which can be replaced when they get used up. They can never get exhausted. They include;

1. Solar Energy

Source: Energy from the sun captured using solar panels or photovoltaic cells.

Advantages:

- Abundant and inexhaustible source
- Low operating costs after installation
- No greenhouse gas emissions during operation

Disadvantages:

- Unreliable energy supply (dependent on weather and time of day)
- High initial installation costs
- Requires significant space for large-scale installations

2. Wind Energy

Source: Energy from wind captured using wind turbines.

Advantages:

- Renewable and abundant
- Low operating costs after installation
- No greenhouse gas emissions during operation

Disadvantages:
- Unreliable energy supply (dependent on wind availability)
- Noise and visual impact concerns
- Requires suitable locations with consistent wind

3. Hydropower
Source: Energy from moving water, typically harnessed using dams on rivers.
Advantages:
- Reliable and consistent power generation
- Can provide large-scale power
- No greenhouse gas emissions during operation

Disadvantages:
- Ecological impact on aquatic ecosystems
- Displacement of communities and wildlife
- High initial construction costs

4. Biomass Energy
Source: Energy from organic materials (plant and animal matter), including wood, agricultural residues, and biofuels.
Advantages:
- Can use waste materials, reducing landfill use
- Renewable if managed sustainably
- Can reduce greenhouse gas emissions if replacing fossil fuels

Disadvantages:
- Air pollution from burning biomass
- Land and water resource competition with food production
- Can contribute to deforestation if not managed sustainably

5. Geothermal Energy
Source: Energy from heat stored within the Earth, harnessed using geothermal power plants or heat pumps.
Advantages:
- Reliable and consistent power generation
- Low greenhouse gas emissions
- Small land footprint compared to other renewables

Disadvantages:
- Limited to regions with accessible geothermal resources
- High initial capital costs

6. Hydrogen Energy
Source: Energy from hydrogen, used in fuel cells to generate electricity or as a direct fuel.
Advantages:
- High energy density
- Can be produced from various resources (including water and renewable energy)
- No greenhouse gas emissions when used in fuel cells

Disadvantages:
- High production and storage costs.
- Infrastructure for widespread use is still scarce.
- Energy-intensive production process if not using renewable sources.

7. Tidal and Wave Energy
Source: Energy from ocean tides and waves captured using specialized turbines and generators.
Advantages:
- Predictable and reliable energy source
- High energy potential in coastal areas
- No greenhouse gas emissions during operation

Disadvantages:
- High initial capital costs
- Environmental impact on marine ecosystems
- Limited to suitable coastal locations

NON-RENEWABLE SOURCES OF ENERGY
These are energy sources, which cannot be replaced when they get used up.
Examples of non- renewable sources of energy include;
1. Fossil fuels; these are formed from plant remains that died million years ago. They include;
Coal: A solid fossil fuel used primarily for electricity generation and steel production.
Oil: A liquid fossil fuel used for transportation, heating, and generating electricity.
Natural Gas: A gaseous fossil fuel used for heating, electricity generation, and as a raw material in chemical industries.
Advantages:
- High energy density
- Established infrastructure and technology
- Reliable and consistent power generation

Disadvantages:
- Significant greenhouse gas emissions
- Air pollution and health impacts
- Causes resource exhaustions, leading to depletion concerns

2. Nuclear Energy
Generated through nuclear fission, where atomic nuclei (typically uranium-235 or plutonium-239) are split to release energy.
Advantages:
- Low greenhouse gas emissions during operation
- High energy density and reliable power generation
- Long-term energy supply with abundant fuel resources

Disadvantages:
- Radioactive waste disposal issues
- High initial capital costs
- Risk of nuclear accidents (e.g., Chernobyl, Fukushima)

Questions

1. Are the sources given above natural sources or artificial sources or both? Explain how you were able to differentiate the two kinds of sources.

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2. What is the major source of energy for all living things on earth? Explain your response.

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3. What do plants use the energy from the sun for?

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4. Imagine that the sun goes down for a week, how would life be? Explain your response.

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NOTE;

On earth, all the energy we use comes originally from the sun. For example all plants get their energy from the sun in order to manufacture their own food and we are able to get food because plants got energy from the sun.

RESEARCH ASSIGNMENT.

1. In your groups, discuss and make a presentation on how wind mill, waterfalls, nuclear power stations and tides generate energy.
2. Think about daily activities we engage in that require use of energy and include them in your presentation.

FORMS OF ENERGY

Energy cannot be touched because it has no mass, neither does it occupy space. We define energy by what it does or what it can do. Therefore energy is defined as the ability to do work and can exist in the following forms;

a) Chemical energy:

Chemical energy is the form of energy a body has due to the nature of its atoms and molecules and the way they are arranged.

In the combination of atoms to form compounds, there is gain or loss of energy. This energy is stored in the compound as chemical energy.

If the atoms in such compounds are rearranged to form a new compound, this energy is released. E.g If sugars in the human body are burnt, a lot of chemical energy is released.

b) Nuclear energy:
This is the energy released when atomic nuclei disintegrate during nuclear reactions. In nuclear reactions, the energy, which holds the nuclear particles together (Binding energy), is released.
There are two types of nuclear reactions i.e. fission (Where large nuclei break to form smaller ones) and fusion (Where smaller nuclei combine to form larger ones). In both cases, large amounts of energy are released.

c) Electrical energy (Electricity):
This is the form of energy which is due to electric charges moving from one point of a conductor to another.
This form of energy is most easily converted to other forms, making it the most useful form.

d) Light energy:
This is the form of energy which enables us to see. Light is part of a wider spectrum of energy called the electromagnetic spectrum. Light consists of seven visible colours, of red, orange, yellow, green, blue, indigo and violet. We are able to see because the eye is sensitive to the colours.

e) Heat energy:
Heat is a form of energy, which results from random movement of the molecules in the body. It is responsible for changes in temperature. When a body is heated or when heat energy of the body increases;
(i) The internal kinetic energy of the molecules increases leading to a rise in temperature.
(ii) The internal potential energy of molecules increases leading to expansion and change of state of the body.

f) Sound energy:
This is the energy which enables us to hear. Like light, sound is also a form of wave motion, which makes particles to vibrate. Our ears are able to detect sound because it produces vibrations in the ear.

g) Mechanical energy:
Mechanical energy is classified into two major categories; potential energy and kinetic energy. In other words, mechanical energy is the sum of kinetic energy and all forms of potential energy associated with an object. That is;
Mechanical energy = kinetic energy + potential energy
M.E = K.E + P.E

Potential energy
Potential energy is the energy possessed by an object due to its position in reference to the ground or condition. A bicycle on top of a hill, a book held over your head, and a stretched spring all have potential energy.
Gravitational Potential Energy (P.E) = mgh where m is the mass of the body and g is acceleration due to gravity and h is the height at which the body is above the ground.

Types of potential energy
There are three main types of potential energy and these are;
- Chemical potential energy
- Elastic potential energy
- Gravitational potential energy

Kinetic energy

This is energy a body possesses because of its motion. The kinetic energy is given by K.E = $\frac{1}{2}$ mv^2, where m is mass of the body and v is its velocity.

Assignment.

1. Research about the above types of potential energy and write brief notes about each.

2. Research and write brief notes about the types of kinetic energy.

Trial Questions

1) A ball of mass 2kg is kept on a hill of height 3km. calculate the potential energy possessed by the body.

2) 145g spear is thrown at a speed of 25ms^{-1} to kill a wild animal. What is its kinetic energy? How much work was done on the spear to make it reach this speed, if started from rest?

3) If you a 3kg ball from a height h of 10m, ignoring frictional forces, what is;

a) The velocity when the ball hits the ground?

b) The kinetic energy of the body as it hits the ground (take g = $10ms^{-2}$)

ENERGY TRANSFORMATION

As we saw earlier that all energy in the universe comes from the sun, using both natural and man-made systems, we can transform it into many forms.

For example, Green plants change sun energy into chemical energy and the solar panel transform sun energy into electrical energy and light we use.

Group discussion work (Energy transformation)

1 (a) Discuss the energy changes that take place in the bulb, flat iron and loud speaker.

(b) State the energy transformation in the following devices/events.

i. A torch using dry cells

ii. A man running

2. In groups, discuss the energy transformations that take place in:

a) a mango falling from a tree

b) A swinging pendulum

c) Using a catapult

d) A ball is thrown vertically upwards

CONSERVATION OF ENERGY.

One of the major features of energy is that it can be changed from one form to more forms of energy. For example;

1. When lighting a match box

Chemical energy ⟶ Heat + Light

2. When a boy compresses the spring

Mechanical energy ⟶ Elastic potential energy

3. When lighting a lamp connected to a battery
Chemical energy ⟶ Electrical energy ⟶ heat + light
4. Catapult pulled by a person to propel a stone
Mechanical energy ⟶ Elastic potential energy ⟶ kinetic energy

N.B: The following devices can be used to carry out the following energy changes;
i) Electrical energy to mechanical energy ⟶ Motor
ii) Mechanical energy to electrical energy ⟶ Dynamo
iii) Electrical energy to sound energy ⟶ Loudspeaker
iv) Sound energy to electrical energy ⟶ Microphone
v) Heat energy to electrical energy ⟶ Thermopile
vi) Electrical energy to heat energy ⟶ Electrical heater
vii) Electrical energy to light energy ⟶ Electric lamps
viii) Light energy to electrical energy ⟶ Photocells
ix) Chemical energy to electrical energy ⟶ Cell
x) Electrical energy to chemical energy ⟶ Battery charging
xi) Nuclear energy to heat energy ⟶ Nuclear reactor
xii) Electromagnetic to electrical energy ⟶ Aerial

Note: For a body falling freely its kinetic energy before impact is equal to potential energy above the ground.
In an electrical bulb, electrical energy is transformed into light energy and heat energy. As energy changes from one form to another, the overall amount must remain constant. Hence during transformation, energy is conserved.
The **law of conservation of energy** states that energy can neither be created nor destroyed but transformed from one form to another. For example, if a fruit falls freely from a tree, the potential energy of the fruit before falling is conserved into kinetic energy as it hits the ground.
Therefore;
Loss in potential energy = gain in kinetic energy

$$mgh = \frac{1}{2}mv^2$$

NOTE: Don't confuse the expressions "conservation of energy". And "energy conservation". Conservation of energy is law of nature while energy conservation refers to the wise use of energy resources aimed at saving energy by reducing the length of use.

ACTIVITY (group work)

1. In groups, discuss different ways a man has innovated to save the amount of energy used.
2. A bride of mass 3kg resting on a wall fall freely to the ground through a vertical height of 3m.calculate the;
   a) Kinetic energy of the brick as it hits the ground.

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_____
_____
_____
_____
_____

b) Velocity with which the brick hits the grounds. (take g =10ms^{-2})

3. Using internet and other sources,
   a) Suggest and explain ways in which energy can be stored.

   b) How are the ways suggested above useful to the environment and the society?

POSITIVE AND NEGATIVE EFFECTS OF SOLAR ENERGY

The sun is a powerful energy source, it supplies the universe with its energy all the time. The solar energy has various advantages and disadvantages for creatures living on earth.

Research assignment

Make a comprehensive research and write down the advantages and disadvantages of solar energy.

Advantages:

Disadvantages:

RELATIONSHIP BETWEEN WORK, ENERGY AND POWER

When we walk, push a wheel barrow or even ride a bicycle, we say we have done work. Therefore, in our everyday life, work describes any activity that a person does. **Work** is defined as a product of force and distance moved in the direction of the force. The S.I unit of work is joules (J) If the object is moved through a distance of 1m by a force of IN, the from the definition for work,

Work done (W) = Force (F) x Distance (D)
S.I unit of work is **Joule**. Thus IJ= IN x IM
Therefore a **joule** is defined as the work done when a force of 1 newton moves the point of application through a distance of 1m.

Trial questions

1. Jane pushes a trolley in a super market full of goods with a force of 150N through a distance of 10m. How much work did Jane do?

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2. Isaac pushes a concrete wall in his room with a force of 300N. How much work does he do? Explain your answer.

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POWER

We normally use the term "power". It always requires a powerful person to accomplish any work on time. We all do work but at different rates. For example: The power developed by Isaac whose weight is 750N is different from the power developed by Ivan whose weight is 650N if they are climbing the same stair case in the same time.

Power is defined as the rate at which work is done. The S.I unit of power is the watt (**W**). From the definition

$$\text{Power} = \frac{\text{Work done}}{\text{time taken}}$$

$$\text{Power} = \frac{\text{Force X distance}}{\text{time taken}}$$

$$P = \frac{F \times D}{T}$$

But $\frac{D}{T}$ = V (velocity)

Therefore $P = F \times \frac{D}{T}$

$P = F \times V$, Where V is Velocity

Examples

1. An engine raises 200kg of sand through the height of 50m in 20 seconds, Calculate the power of the engine.

Solution

$$\text{From the power} = \frac{\text{work done}}{\text{time taken}}$$

$$\text{Power} = \frac{\text{Force x distance}}{\text{time}}$$

$$P = \frac{m \times g \times d}{t}$$

$$P = \frac{200 \times 10 \times 50}{20} = 5000W$$

2. Joseph of mass 60kg walks up a flight of 15 steps each of height 20cm. Calculate the power he develops in 30secs.

$$\text{From, } P = \frac{F \times d}{t}$$

$$\text{Force, } F = m \times g$$

$$F = 60 \times 10$$

$$F = 600N$$

Distance, d = number of step (n) x height (h)

$= n \times h$

$= 15 \times 20cm$

$= 300cm$

$$\text{Distance} = \frac{300}{100} = 3m$$

$$\text{Therefore } P = \frac{m \times g \times d}{t}, \; t = 30\text{seconds}$$

$$P = \frac{F \times d}{t}$$

$$P = \frac{600 \times 3}{30} = 60W$$

3. At what average velocity can a motor rated 400W raise a load of mass 80kg?

Solution

$$\text{From power} = \frac{\text{Force x distance}}{\text{time}}$$

$$400 = \frac{m \times g \times d}{t}$$

$$400 = 80 \times 10 \times \frac{d}{t}$$

$$400 = 800 \times V$$

$$\frac{400}{800} = \frac{800V}{800}$$

$$V = 0.5ms^{-1}$$

TRIAL QUESTIONS

1 a) Define a watt

_____

_____

b) Convert 2.5 kilowatts to watts.

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c) A crane lifts 20 bricks per minute through a height of 15m. Calculate the power that is expended if each brick weighs 5N.

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2. A block of mass 2kg falls freely from rest through a height of 20m above the ground. Find,

a. The potential energy of the block above the ground.

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b. The velocity with which the block hits the ground.

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SIMPLE MACHINES

Machines are all around us. They help us to do a lot of work with ease. Machines are simplified into two that is simple machines and complex machines. Both work in the same way however complex machines like bicycles, tractors and others are made out of many simple machines put together and perform work more easily and quickly than simple machines.

Note: A machine is an appliance which eases work by using a small force (effort) applied at one point to overcome a large force (load) at another point.

Research assignment

In groups, using textbooks or the internet connected device, prepare a presentation to explain the principle of moments of a force, where possible, use of diagrams on a poster.

Terms used in simple machines,

For easy understanding of machines, one must first understand the following terms.

1. **Fulcrum (F) (Pivot)**. This is a point on a lever about which the lever turns.
2. **Effort (E)**.

This is the force applied on a machine so that it can perform work.

3. **Load (L)**

This refers to the force (weight) of an object on which the machine has to overcome as it performs work.

4. **Mechanical Advantage (M.A)** This is the ratio of load to effort i.e.

$$\text{Mechanical advantage (M.A)} = \frac{\text{Load(L)}}{\text{Effort(E)}}$$

Note; Mechanical advantage is a measure of how much the machine easies the work for which it is used. The bigger the mechanical advantage, the easier the machine makes the work.

Mechanical advantage has no units because it is a ratio of the same quantities.

5. **Velocity ratio (VR)**

This is the ratio of the distance moved by the effort (effort distance) to the distance moved by the load (load distance) i.e.

$$\text{Velocity ratio (VR)} = \frac{\text{Effortdistance}}{\text{Load distance}}$$

Velocity ratio has no units because it is a ratio of the same quantities.

6. **Efficiency of a machine**

This refers to the ratio of the useful work done by a machine to the total work put into the machine expressed as a percentage I.e.

$$\text{Efficiency} = \frac{\text{Work output}}{\text{Work input}} \text{ X } 100\%$$

$$\eta = \frac{Wo}{WE} \text{ X } 100\%$$

Where η is efficiency, W_O is the useful work done by the machine and W_E is the total work done by the machine.

Efficiency of a machine can also be expressed as;

$\eta = \frac{Eo}{Ei}$ x 100% where n is efficiency, E_o is energy output and E_i is energy input

Efficiency is the measure of how well the machine works.

Note; No machine can ever be more than 100% efficiency because the energy output of the machine can never be more than energy input. Machines are always less than 100% efficiency because of the energy wasted.

Energy wasted is the difference between the work input and the work output which makes the machine less than 100% efficient

Energy wasted = work input – work output

= Effort x Effort distance – Load x Load distance

Energy Wasted is work done against friction when using the machine and also work done on useless loads.

WORK INPUT AND WORK OUTPUT OF A MACHINE

It is possible to determine how effective the machine is simplifying work when you compare the work you put into the machine and its work output.

Activity; (Determining work input and work output of a machine)

What you need;

- A pulley block
- 150g mass (on a mass hunger)
- Knitting thread
- Metre rule
- Ten 20g slotted masses (on a mass hunger)
- Retort stand with a clamp

What to do;

1) Tie the 150g mass (load) at one end of the knitting thread.
2) Fix the single pulley block in the clamp of the retort stand and pass the free end of the thread over the groove in the pulley.
3) Tie the 20g mass hanger (effort) at the other end of the thread and adjust the arrangement such that the 150g rests on the surface of the table.
4) Measure and record the distance between the bottom of 20g mass hanger and the table surface as d_a.
5) Add 20g masses on the effort pan, one at a time unit the 150g mass moves upwards as the 20g masses move downwards until it rests on the table.
6) Measure and record the distance between the bottom of the 150g mass and the surface of the table as d_b.
7) Determine the force F_a corresponding to the 20g masses used to lift the 150g mass.

8) Calculate the work input (Wi) and work output (Wo) from, $W_i = d_a \times F_a$ and $W_o = d_b \times F_b$
9) Why do you think the work output and work output are different
10) Determine the energy wasted

Trial assignment

1. A machine has a velocity ratio of 6. It is used to lift a load of 480N using an effort of 40N. Calculate
a) Mechanical advantage of the machine.
b) Efficiency of the machine.

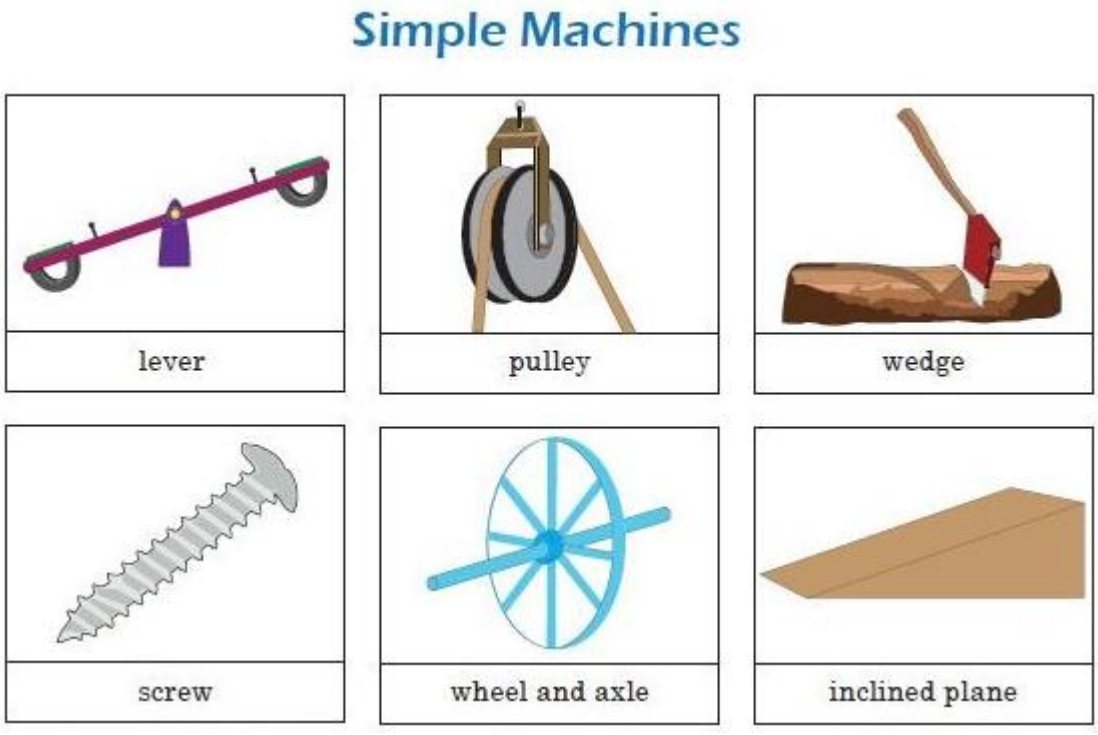
3. A machine lifts a stone of mass of 15kg through a height of 10m. An effort of 750N applied passes through 15m so as to overcome the load. What is the efficiency of the machine? (Take g = $10ms^{-2}$)

3. The effort of 750N raises a load of 1200N through 8m when using a simple machine. The effort moves through 25m. What is the;
a) Work input of the machine
b) Work output of the machine
c) Efficiency of the machine

4. a) Derive the relationship. Efficiency = $\frac{M.A}{V.R}$ X100% for a perfect machine.
b) Explain why machines are ever less 100% effective.

TYPES OF SIMPLE MACHINES

There are six simple machines namely; Pulleys, Levers, Wedges, Wheel and axel, Inclined planes, and, Screws.



However, the wheel and axel combination is similar in principle to the lever, while the wedge and screws are similar to the inclined planes. Thus, simple machines are categorized in three i.e.

- The levers
- The pulleys
- Inclined planes

THE LEVERS

A lever is a simple machine that makes work easier by applying the principle of moments. It involves moving the load around the fulcrum or pivot using an effort. A lever is a rigid bar that rests on a support called pivot (fulcrum). Levers are commonly used in our homes and these include;

- Pairs of scissors Pliers
- Claw hummer Nut cracker
- Pair of tongs Forceps
- Wheelbarrows

NB; Lever are called force multipliers because they amplify a small effort to produce greater force which is used to overcome loads

CLASSES OF LEVERS

Activity

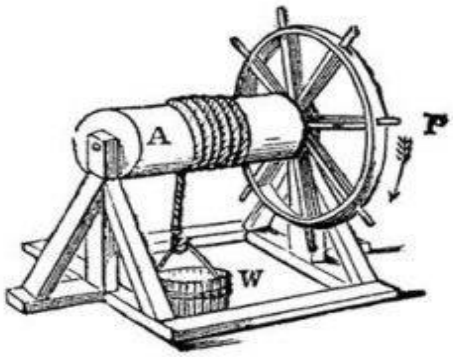
a. In groups, discuss and write short notes about three classes of levers including definitions and examples with their applications,

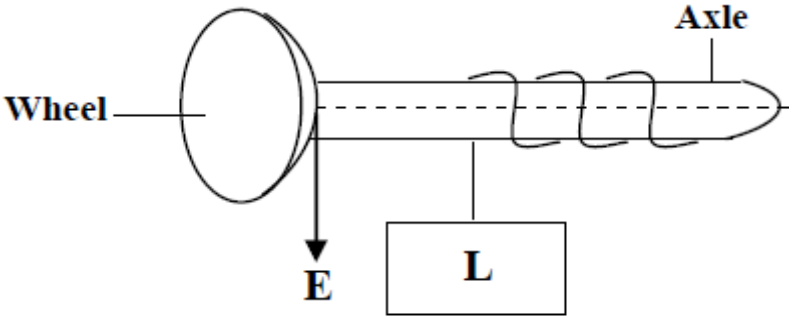
WHEEL AND AXLE (WINCH)

Wheel and axle uses the principle of levers and is commonly used in removing soil of latrines during construction or putting bricks on top of a tall building.

A wheel with a rod, known as an axle, through its center lifts or moves loads. It consists of a rope wound around an axle which is connected to a large wheel with another rope attached to its rim.

Pulling on the wheel rope lifts a load attached to the axle rope. The velocity ratio of the machine is equal to the ratio of the wheel radius to the axle radius.
The wheel and axle are fixed on the same axis. The effort is applied to the wheel and the string attached to the axel rises the load.





For a complete turn;
The effort moves through a distance equal to the circumference of the wheel
C = 2πR where R is the radius of the wheel.
The load moves through a distance equal to the circumference of the axel C = 2πr where r is the radius of the axel.

This is from V.R = $\frac{\text{Effort distance}}{\text{Load distance}} = \frac{2\pi R}{2\pi r} = \frac{R}{r}$

Activity:

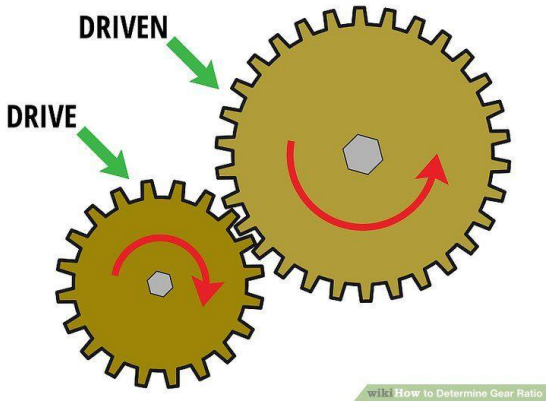
1. In a wheel and axle system, a wheel of radius 40cm uses an effort of 300N to rise a load of 900N using an axle of radius 10cm. Calculate the;
   a). Velocity ratio.
   b). Efficiency of the system

2. A common windlass is used to raise a load of 480N by application of an effort 200N at right angles to the handle. If the prank is 33cm from the axis and the radius of the axle is 11cm, calculate the;
   a). Velocity ratio.
   b). Efficiency of the windlass.

THE GEAR SYSTEM

Gears are modified wheel and axel. A gear is a wheel with equally spaced teeth around it along its circumference which can rotate about its center. The small gear wheel (driving wheel or effort gear) with **n** teeth drives the bigger wheel (driven wheel or load gear) with **N** teeth.

The direction of the driven gear is opposite to that of the driving gear and the number of rotations of the gear wheel depends on the number of teeth and the radii of the wheels.



A large velocity ratio is obtained only when the effort is applied on a smaller gear so that it drives the large gear.

$$\text{Velocity ratio} = \frac{\text{Number of teeth in the driven gear (N)}}{\text{Number of teeth in the driving gear (n)}} = \frac{N}{n}$$

Activity:

1. A gear system is 30% efficient. The number of teeth on the driven wheel is 100 while that on the driving wheel is 20. Calculate;

a). velocity ratio of the system

b). mechanical advantage

c). load which can be raised by the effort of 200N

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Research assignment:

In groups, using the internet and text books, research about:

a). the examples and applications of wheel and axel machines

b). why it is easier to undo a tight nut using a spanner with long handle than one with the short handle.

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WEDGE

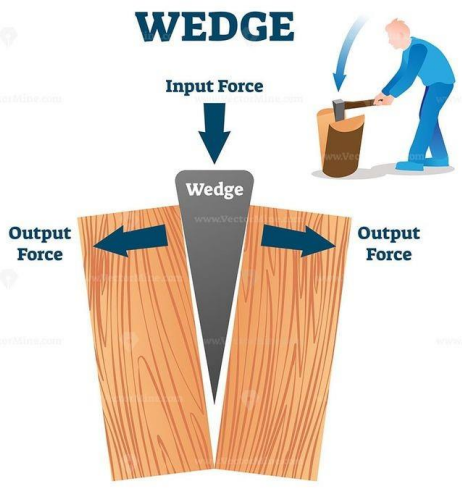
A wedge is an object with at least one slanting side ending in sharp edge, which cuts materials apart.

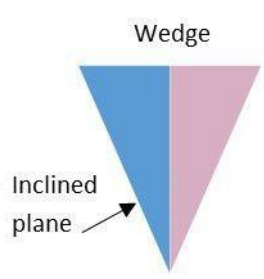
A wedge is simply a triangular tool, often made up of materials such as metal, wood, stone or plastic. It is thick at one end and tapers to a thin or sharp edge at the other end.

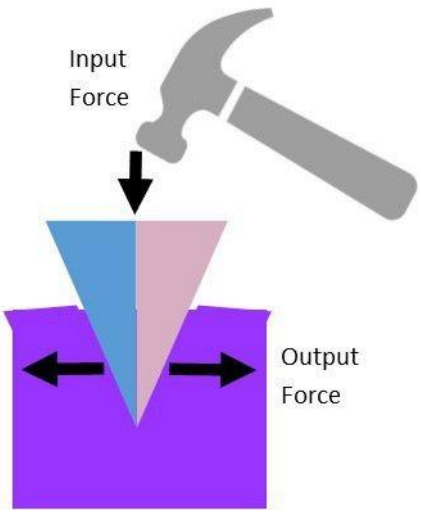
A wedge may be attached to a handle to make it easier to use.

Examples of wedges include;

- Nails Knives
- Axes teeth







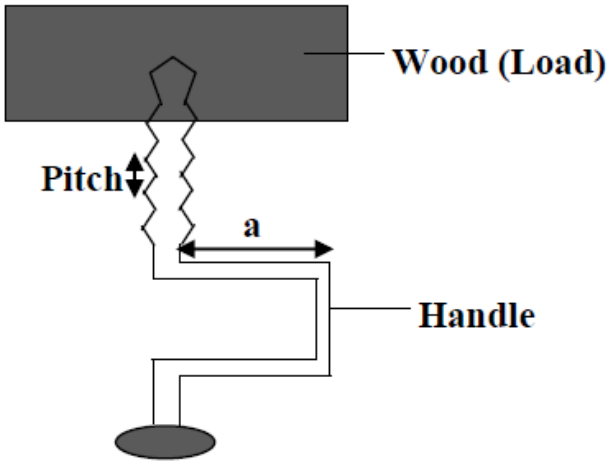
Wedges may be used in many ways which include;

- Cutting (knives)
- Splitting (axes)
- Holding together (nails)
- Tightening and holding back (door stoppers)

Wedges work by changing direction and the force applied to it.
Note: Longer And thinner wedges give more mechanical advantage compared to shorter and wider wedges.

SCREWS

A screw is a long inclined plane wrapped around an axel, with the axel rotated by a handle used as a lever.



When a screw is rotated through one complete turn, it moves through a distance equal to its pitch.
A pitch is the distance between one thread and the next measured along the axis of the screw

$$\text{Velocity ratio} = \frac{\text{circumference of the screw head}}{\text{Pitch}}$$

$$\text{V.R} = \frac{2\pi a}{P}$$, Where a is the radius of the screw head

Activity

1) A load of 800N is raised using a screw jack whose lever arm is 49cm has a pitch of 2.5cm. if it is 40% efficient, find the;
a. Velocity ratio
b. Mechanical advantage

2) A certain screw machine has a pitch 3.5mm, the effort is applied using a handle, which is 44cm long. Calculate its velocity ratio

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Assignment

Research and write brief notes about;

a. Why the efficiency of a screw jack is always less than 50%

b. Daily life applications of screws

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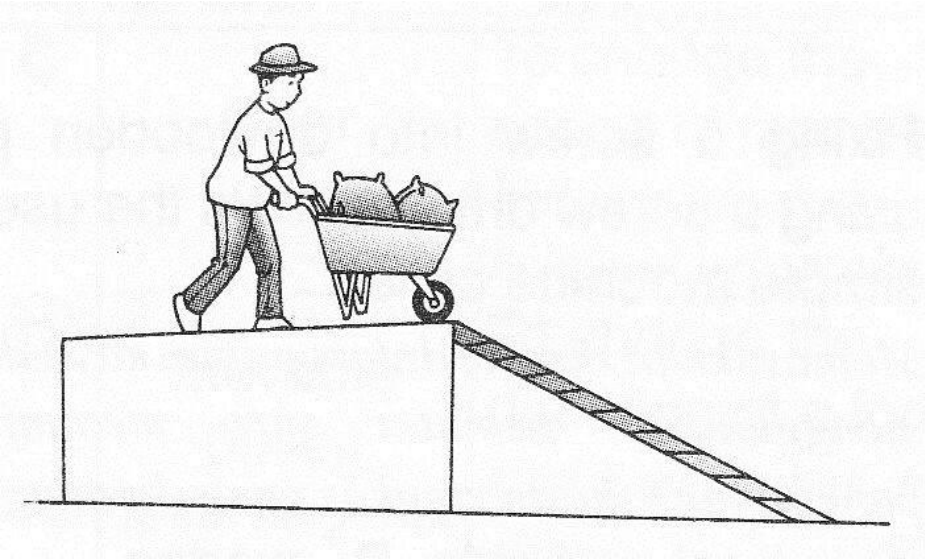
INCLINED PLANE

An inclined plane is a slanting surface raised at an angle to the horizontal over which a heavy load is lifted to a certain height easily by pushing or pulling

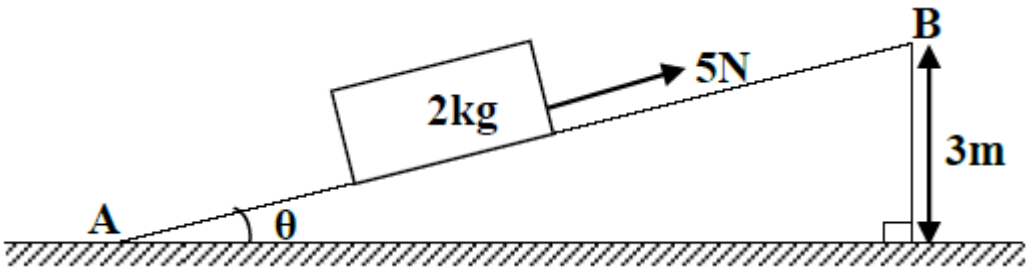


Therefore velocity ratio = $\frac{\text{Effort distance L}}{\text{Load distance H}}$, V.R = $\frac{L}{H}$

Note; the steepness (angle) of the inclined plane determines the effort needed to raise the weight. More effort will be required when the angle is steeper

Activity

A brick of mass 2kg is lifted to a height of 3m a long a smooth inclined plane 15m long by applying an effort of 5N as shown below.



Calculate;

i) Its velocity ratio

ii) Its mechanical advantage

iii) The efficiency of the incline

PULLEYS

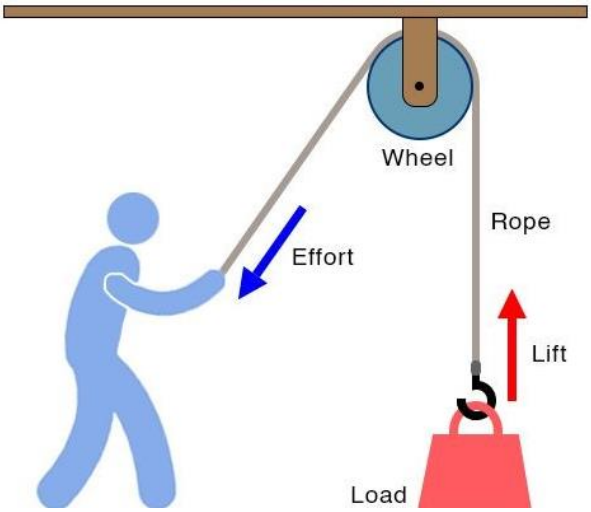
A pulley is a simple machine that uses grooved wheels and a rope to rise, lower or move a load.

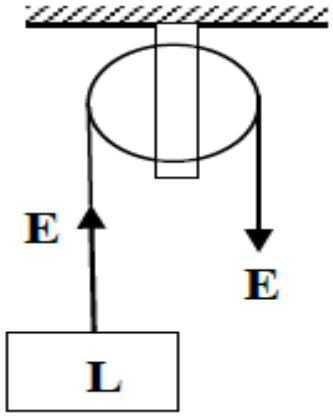
A simple pulley serves only to change direction of the applied force (**effort**). The use of more than one pulley results into a higher mechanical advantage, so that a given effort can raise a higher load.

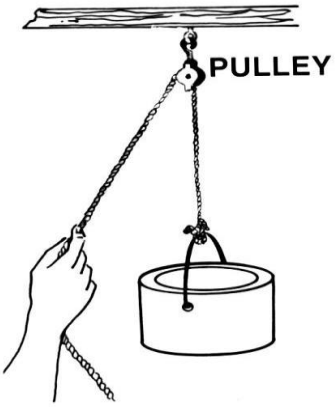
TYPE OF PULLEYS

1. Single fixed pulley

A single fixed pulley has a fixed axel. It is used to change the direction of the force on a rope (belt).







A fixed pulley has a mechanical advantage of 1 which means that the applied effort is equal to the load being overcome by the pulley. If there is no friction and the rope is weightless then at equilibrium; Load, L = Effort, E

$$M.A = \frac{L}{E} = 1$$

In practice the rope has weight and there is friction in the groove, therefore the effort is always greater than the load. Hence mechanical advantage is always less than 1.

However the distance moved by the effort is always equal to the distance moved by the load

$$\text{Thus V.R} = \frac{\text{effort distance}}{\text{load distance}} = \frac{E.D}{L.D} = 1$$

Question;

Suggest any daily life applications of a single fixed pulley.

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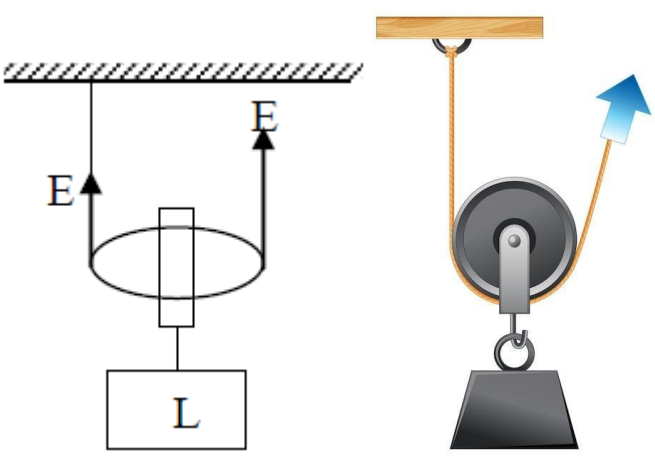
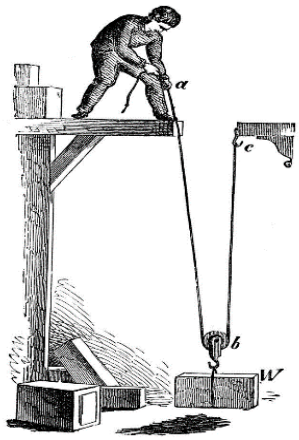
2. **Single movable pulley**

This is a simple pulley with a rope passing around the groove of a movable wheel. In a single movable pulley one end of the rope is fixed and the effort is applied on the other end but the load is tied to the wheel as shown below.





A movable pulley is used multiply forces and has a mechanical advantage of 2

Note; the effort distance is twice the load distance i.e. E.D = 2L.D

$$\text{Thus } V.R = \frac{E.D}{L.D} = \frac{2L.D}{L.D} = 2$$

If no friction is considered, the load = 2(effort) i.e L = 2E

$$\text{Thus } M.A = \frac{2(E)}{E} = 2$$

Therefore for a single movable pulley, the mechanical advantage and velocity ratio is 2. In practice the rope has weight and there is friction in the groove, therefore the effort is always greater than the load. Hence mechanical advantage is always less than 2.

Questions

Explain why a single movable pulley is more advantageous than a single fixed pulley.

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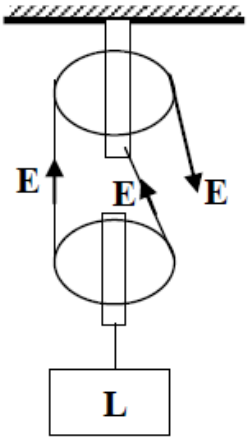
BLOCK AND TACKLE PULLEY SYSTEM

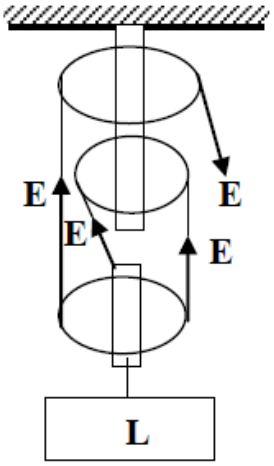
This is the system consisting of two or more pulleys combined to form a machine of large velocity ratio and higher mechanical advantage.

In the block and tackle pulley system, two or more pulleys are mounted on the same axle to form a block. The block and tackle pulley system uses very little effort. One block is fixed and the other block is movable. The two blocks are joined by a single rope known as the tackle that passes through each pulley as shown below

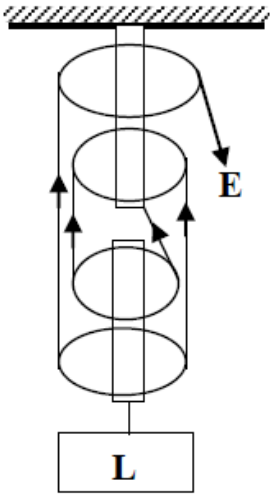
i) V.R = 2



ii) V.R = 3



iii) V.R = 4



Note:

If the number of pulleys is odd, then the fixed block has more pulleys by one than the movable block and the sting (tackle) starts from the movable block as shown in (ii) above.

If the number of pulleys is even, the blocks will have equal number of pulleys and the string starts from the fixed upper block as shown in (i) and (iii) above.

The velocity ratio is equal to the number of pulleys of the pulley system or the number of strings supporting the movable block.

Uses of pulley systems:

- Construction pulleys lift heavy materials from the ground.
- Curtains at the theatre are moved using pulley systems.
- Flag poles use pulleys in order to raise or bring down the flag.
- A crane is a pulley system used in construction.
- Engines utilize pulley systems in order to function.
- Fans with chains use pulley systems in order to be turned on or off.
- Timing belts in cars use pulley systems.
- Escalators utilize pulley system to function.
- A lift uses pulley system to move items to higher floors.
- Bulldozer uses a pulley system.
- Rock climbers use pulley systems.
- Oil drillers use pulley systems.
- Garage doors close and open using pulley systems.

Assignment

1. Differentiate between a single fixed pulley and a single movable pulley.

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2. In the space provided below, draw two pulley system of velocity ratio 5 and 6.

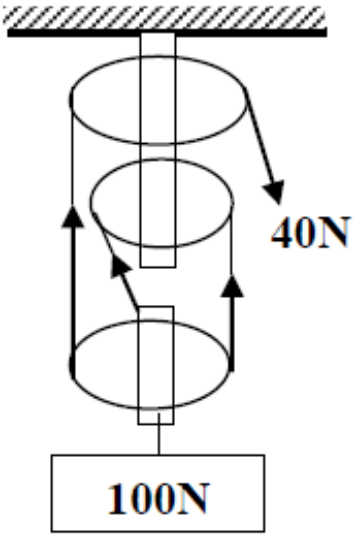
V.R = 5	V.R = 6

3. The minimum effort required to raise a load of 100N is 40N as shown in diagram below. Calculate

i) The mechanical advantage

ii) Efficiency

iii) Work done by the load if it is raised through 6m.



4. A block and tackle pulley system with a velocity ratio of 5 and 60% efficiency is used to a lift a load of mass 60kg through a vertical height of 2m. What effort must be exerted?

MECHANICS AND PROPERTIES OF MATTER

CHAPTER 2

TURNING EFFECTS OF FORCES, CENTRE OF GRAVITY AND STABILITY

Learning out comes:

1. Understand the turning effect of forces and its applications
2. Understand and apply the concept of Centre of gravity.

Key words:

- Centre of gravity
- Centre of mass
- Equilibrium
- Force pivot
- Stable, unstable and neutral equilibrium
- Turning effect and torque

Competency

To investigate the relationship between turning effect of forces and stability of bodies.

Introduction

Every time we open a door by turning the handle, turn on a tap, turn a steering wheel of a car or even tighten up a nut with a spanner, we exert a turning force. The turning effect of force also plays a big role in stability of all things around us. In this chapter, you will understand how the turning effect of forces affects stability of bodies.

TURNING EFFECT OF A FORCE

We usually apply forces on bodies during different activities. Some forces may cause a pulling or a pushing effect on the body while others may cause a turning effect on bodies.

Elements of Turning of a Force:

Force (F): The push or pull applied to the object.

Pivot (Fulcrum): The fixed point around which the object rotates.

Distance (d): The perpendicular distance between the point where the force is applied and the pivot or axis of rotation. This distance is called the moment arm or lever arm.

The turning effect of a force is called **moment of a force** or a **Torque (T),** Moment of a force is defined as the product of force and the perpendicular distance of the line of action of the force from the turning point (Pivot/Fulcrum).

From the definition, we can deduce the formula,

Moment (Torque) = Force × Perpendicular distance from the pivot

$$\tau = F \times d$$

Where: τ is the moment or torque (measured in newton-metres, Nm), F is the force (measured in newtons, N), d is the perpendicular distance from the pivot (measured in metres, m)

Clockwise Moment: When a force causes an object to rotate in the direction of a clock's hands, it is a clockwise moment.

Anti-clockwise Moment: When a force causes an object to rotate in the opposite direction to a clock's hands, it is anti-clockwise moment.

Principle of Moments Formula:

For an object to be in equilibrium (not rotating), the sum of the moments in the clockwise direction must equal the sum of the moments in the anti-clockwise direction.

Practical Examples:

Opening a Door: When you push a door, the door rotates around its hinge (the pivot). The further from the hinge you apply the force, the easier it is to open the door, because the turning effect (moment) increases.

Using a Wrench: Applying force on the handle of a wrench at a greater distance from the bolt gives more torque, making it easier to turn the bolt.

Factors Affecting Turning of a Force:

Magnitude of the Force: A larger force will produce a greater turning effect.

Distance from the Pivot: The farther the force is applied from the pivot, the greater the moment.

Direction of the Force: For maximum turning effect, the force must be applied perpendicular to the object. If it's not, only the perpendicular component of the force contributes to the turning effect.

Activity; determining moment of a force

Required materials

- A metre rule
- A knife edge
- One 100g mass on a hanger
- One piece of knitting thread (30 cm long)

What to do;

1. Balance the metre rule provided on a knife edge with its scale facing upwards and record its balancing point G.
2. Hang a mass, m = 100g using a thread at the 10.0cm mark from one end of the metre rule.
3. Adjust the position of the metre rule along the knife edge until it balances horizontally.
4. State the balancing point of the ruler

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5. State the perpendicular distance d, from the balancing point.

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6. Find the force F due to the mass suspended on the metre rule.

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7. Calculate the moment of the force from M = F x d and state its S.I unit.

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8. Define moment of a force on the body and share your findings with the class.

Examples

1. While opening a screw, the torque used is 180 Nm when the force used is 45 N. What is the perpendicular distance of the force from the turning point?

Solution

From torque (τ) = F x d

180 = 45 x d

$d = \frac{180}{45}$

d = 4 m

2. Ivan applies a force of 25.2 N to open their gate at home for his grandma to drive out. The gate handle is at 8.5 m from the hinges. Calculate the torque created by his force.

Solution

Force = 25.2 N, distance = 8.5 m

From torque (τ) = F x d

= 25.2 x 8.5

= 214.2 Nm

Principle of moments

The principle of moments states that when an object is in equilibrium, the sum of anticlockwise moments at a point is equal to the sum of clockwise moments about the same point. This means that the net torque on a system in equilibrium at any point is zero.

Application of the Principle of Moments:

Seesaw: On a seesaw, two children sit on either side of the pivot (the fulcrum). If one child is heavier, they will sit closer to the pivot, while the lighter child will sit further away to balance the seesaw. The clockwise moment from the heavier child is balanced by the counterclockwise moment from the lighter child. This keeps the seesaw level. If the moments are not equal, the seesaw will tip toward the side with the greater moment.

Lever: When using a lever to lift a heavy object, the effort force applied on one side must create a moment equal to the moment created by the weight of the object on the other side for the system to balance. This explains how levers can be used to lift heavy loads with smaller forces, by increasing the distance from the pivot where the force is applied.

Balancing Beams: In mechanical structures, such as bridges or cranes, the principle of moments is used to ensure that all forces acting on the structure are balanced to prevent rotation or collapse.

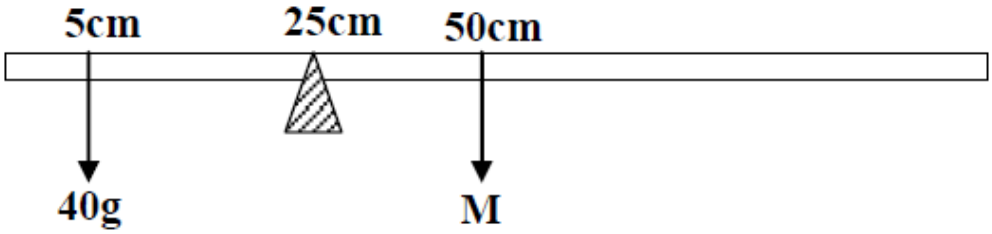
Assignment (Group work)

In groups, using materials in the laboratory, carry out research and write a report on how you can;

(a) Verify the principle of moments using a suspended metre rule and attached weights.
(b) Use the principle of moments and equilibrium to determine an unknown mass using a metre rule of known mass.
(c) Determine the mass of a metre rule.
(d) Present your findings to the class.

Examples

1. Uniform metre rule is pivoted at 25cm mark and balances horizontally when a body of mass 40g is hung at 5cm mark. Calculate the mass of the metre rule.



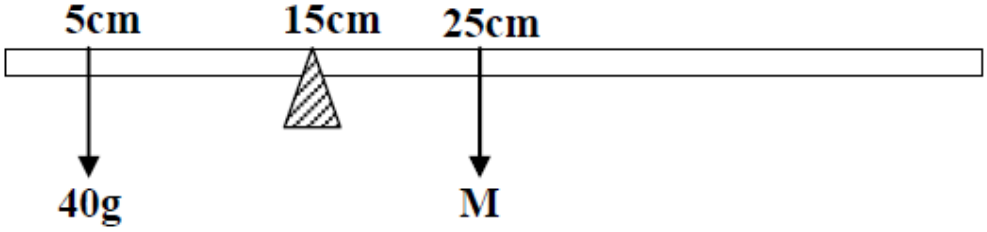
Taking moments about point P

Clockwise moments = anticlockwise moments

M x 25 = 40 x 20

M = 32g

2. A uniform half metre rule is pivoted at 15cm mark and balances horizontally when a body of mass 30g is hung at 3cm mark. Calculate the mass of the metre rule.



Taking moments about point P

Clockwise moments = M x 10

Anticlockwise moments = 40 x 12

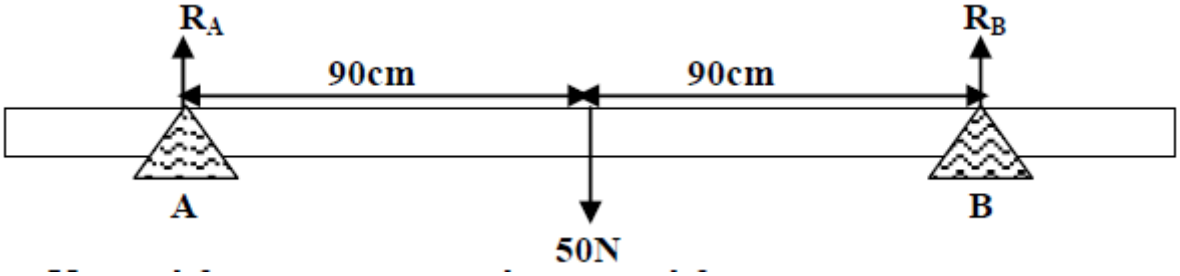
At equilibrium,

clockwise moments = anticlockwise moments

10M = 480

M = 48g

3. Two laborers A and B carry a uniform pole of weight 50N. If the pole is 2m long. Find the reactions at A and B. Given that each labourer is 10cm from each end.



Sum Upward forces = sum down ward forces

$R_A + R_B = 50$.....(i)

Taking moments about A

$R_B \times 180 = 50 \times 90$

$R_B = 25N$

From (ii) $R_A = 50 - 25$

$R_A = 25N$

Trial task

1. A uniform half metre rule is pivoted at 10cm mark and balances horizontally when a body of mass 90g is hung at 4cm mark. Calculate the mass of the metre rule.

2. A man weighing 90kg walks along a uniform plank resting on two supports 1.2m from each end. Plank is 10m long and weighs 60kg. Find the force on each support when the man is at one end of the plank.

3. A uniform log of wood AB is 7m long and weighs 300N. It is supported horizontally at two points P and Q. P is 1.5m from end A while Q is 2m from end B. Calculate the reactions at points P and Q.

4. A uniform metal rod of length 6m is suspended horizontally from two vertical strings P and Q. String P is attached at 1.2m from one end while Q is attached at 2.4m from the other end. Given that the weight of the metal rod is 180N, calculate the tension in each of the strings.

Conditions for Equilibrium:

There are two conditions for an object to be in static equilibrium:

Translational Equilibrium: The net force acting on the object must be zero, meaning there is no linear motion.

Rotational Equilibrium: The sum of the clockwise moments must equal the sum of the counterclockwise moments, ensuring there is no rotation.

Importance of the Principle of Moments:

Engineering and Construction: Ensures structures like bridges, cranes, and buildings are stable and balanced.

Mechanical Systems: Helps in designing levers, gears, and other rotating systems for effective functioning.

Daily Life: From using wrenches to balancing scales, the principle of moments is applied in various practical situations.

In summary, the Principle of Moments governs rotational equilibrium, ensuring that when forces act on a system at different distances from a pivot, the system remains balanced if the clockwise and counterclockwise turning effects (moments) are equal.

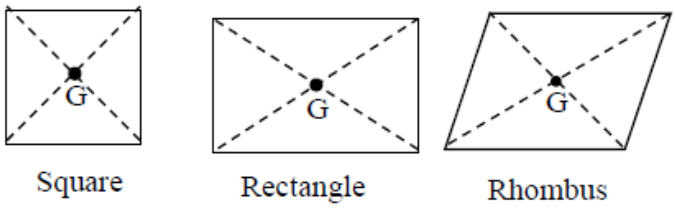
CENTRE OF GRAVITY

This is the point of application of the resultant force due to the earth's attraction on it. It is where the resultant force of gravity (mg) on the body is acting. Hence it is the point on the body where gravity seems to act OR it is a point on the body where its mass/weight is concentrated. Understanding the center of gravity is crucial for maintaining balance and stability in structures and moving objects.

Key Concepts of Center of Gravity:

Definition: The center of gravity is the point at which the weight of an object is evenly distributed in all directions, and around which the object balances in any orientation. It is the theoretical point where the gravitational force acts on an object.

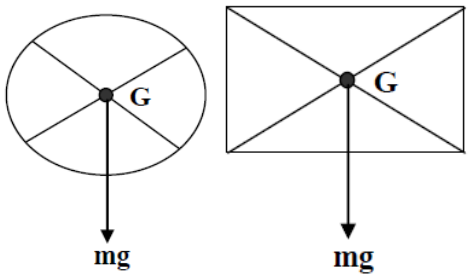
For Symmetrical Objects: In objects with uniform density and symmetrical shape (such as a sphere or cube), the center of gravity **G** is located at the geometric center of the object as shown below.



For Asymmetrical Objects: In objects with irregular shapes or non-uniform density, the center of gravity may be closer to the heavier part of the object. The center of gravity is not necessarily located inside the object — for example, in hollow or irregularly shaped objects; the **C.O.G** may lie outside the physical material.

How to Find the Center of Gravity:

For simple shapes with uniform mass, the center of gravity can be found geometrically. For example: For a rectangle or cube: The center of gravity is located at the intersection of the diagonals. For Circle or Sphere: The center of gravity is at the geometric center.



For more complex or irregular objects, the center of gravity can be determined experimentally by balancing the object at different points or through calculation, often using integration for continuous mass distributions.

Balance and Stability:
If the center of gravity is low and close to the base of an object, the object tends to be more stable. If the center of gravity is high or located away from the base, the object is less stable and more prone to tipping over.

Practical Examples of Center of Gravity:

1. Balancing Objects: For a seesaw to balance, the center of gravity of the entire system must be located directly over the pivot point.

2. Vehicles: In cars and trucks, a lower center of gravity improves stability and reduces the risk of rollover. That's why race cars are designed with low profiles to keep the center of gravity close to the ground.

3. Athletics and Sports: In gymnastics, athletes must keep their center of gravity within their base of support to maintain balance during movements. In sports like high jump, athletes manipulate their body position to raise their center of gravity for better jumps.

4. Construction: Cranes and tall buildings need careful design to ensure that their center of gravity remains within their base of support, preventing them from toppling over.

Center of Gravity and Center of Mass:
In many situations, center of gravity and center of mass are used interchangeably because the force of gravity acts uniformly across the object. However, they can differ in cases where gravitational fields vary across the object, such as very large objects or in astrophysical scenarios.

Center of Mass: This is the point where the mass of an object is evenly distributed, regardless of external forces (like gravity).

Center of Gravity: This is the point where the gravitational force effectively acts on an object. The center of gravity is the point where the total weight of an object appears to act.

Application of the Center of Gravity in Physics and Engineering:

1. Aviation: The center of gravity is critical in aircraft design. The position of the C.O.G affects an airplane's stability and control. If it's too far forward or backward, the plane could become unstable or difficult to control.

2. Robotics: Robots are designed with low centers of gravity to avoid toppling over when moving or carrying objects.

3. Construction Equipment: Cranes and heavy lifting machines are designed with counterweights to adjust the center of gravity for stability during operation.

For uniform objects, it is typically located at the geometric center, while for irregular objects; it is closer to the heavier side.

Stability and balance are directly related to the position of the center of gravity relative to the base of support. A lower center of gravity typically increases stability, while a higher one decreases it.

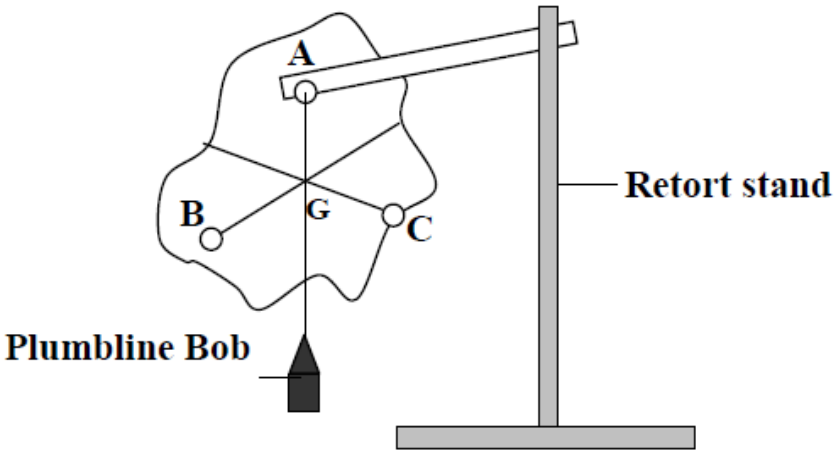
Activity:
In your groups, determine the Center of Gravity of an Irregular Object:

Required Materials:

- The irregular object (e.g., a cardboard cut-out)
- A piece of string
- A plumb line (a string with a weight at the end)
- A pin or nail
- A marker

Procedure:

1. To determine center of gravity of irregular object three holes A, B and C are made on an irregular object in different corners.



2. The object and plumbline bob are made to swing through hole A and when swinging stops a line is marked along the string on the object
3. The experiment is repeated with holes B and C and where the three lines meet is the Centre of gravity, G of the object.

The stability of a body refers to its ability to maintain equilibrium and resist disturbances that might cause it to tip, fall, or rotate.

Key Concepts of Stability:

1. **Equilibrium:** A body is in equilibrium when the sum of the forces and the sum of the moments acting on it are zero. There are three types of equilibrium:

(a) Stable Equilibrium: If the body is slightly disturbed, it returns to its original position. This usually occurs when the center of gravity is low and the base of support is wide.

(b) Unstable Equilibrium: If the body is disturbed, it moves further away from its original position. This occurs when the center of gravity is high or the base of support is narrow.

(c) Neutral Equilibrium: If the body is disturbed, it remains in its new position. This is typical for objects that have a flat surface, like a sphere on a flat plane.

Note; The stability of the body can be increased by;

i) Lowering its centre of gravity

ii) Increasing the area of the base of the body

This explains why a bus carrying luggage on its roof racket wobbles more than a bus when its luggage is below its seats.

Comparison of states of equilibrium

Stable Equilibrium	Un-stable Equilibrium	Neutral Equilibrium
• Wide base • Low centre of gravity • When pushed centre of gravity is raised from the base • When pushed slightly it falls back to its initial position	• Narrow base • High centre of gravity • When pushed the centre of gravity is lowered. • When pushed slightly it falls	• Base is a straight line • Centre of gravity at its lowest point • When pushed the centre of gravity remains at the same level • When pushed it remains at rest in its new position

2. **Center of Gravity:** The location of the center of gravity plays a crucial role in stability. A lower center of gravity typically increases stability, while a higher centre of gravity decreases it. This is because a lower center of gravity means that the object has a greater resistance to tipping.
3. **Base of Support:** The area beneath an object that includes all points of contact with the ground. A wider base of support generally leads to greater stability. If the center of gravity falls within this base, the object will be stable; if it falls outside, the object will topple.

Factors affecting Stability:

1. **Height of the Center of Gravity:** A high center of gravity increases the likelihood of tipping. For example, tall vehicles (like trucks) are more prone to rollovers than lower vehicles (like sedans).
2. **Width of the Base of Support:** A wider base increases stability. For example, a tripod has three points of contact, making it more stable than a two-legged structure.
3. **Position of the Center of Gravity Relative to the Base:** When the center of gravity is directly above the center of the base of support, the object is more stable. If it shifts outside this area, the object becomes unstable.
4. **Distribution of Mass:**

How mass is distributed affects stability, for example, a low and wide shape is generally more stable than a tall and narrow shape because the mass distribution lowers the center of gravity.

Applications of Stability:

Engineering and Architecture: Structures like bridges, buildings, and towers must be designed to ensure that their center of gravity remains within their base of support to prevent collapse.

Vehicles: Car designs focus on lowering the center of gravity to improve handling and reduce the risk of rollover.

Sports and Physical Activities: Athletes and performers often use techniques to lower their center of gravity to maintain balance during dynamic movements, such as in gymnastics or martial arts.

Robotics: Robots are designed with stability in mind to prevent tipping during movement or when carrying loads.

Research Assignment

Using internet or other sources research about the following

(a) Examples in everyday life where stability is applied
(b) Why the bus chassis is made heavier than other parts?
(c) Why does the luggage compartment in a bus designed below the passenger's seats instead of the roof rack?
(d) Why racing cars are low and have wide wheel base?
(e) Why does someone lean in the opposite direction when carrying a load?
(f) Why it is not advisable for people in a small boat on water to neither stand nor lean over its sides.

Responses:

Discuss your findings with the whole class

Activity of intergration

Bukonte is a village of farmers who rely on selling agricultural produce such as maize, beans, millet within the community. However the community has a challenge of measuring the exact amount of agricultural produce between 1kg to 10kg to be sold to each other as it has no access to weighing scale. The community does a lot of estimation in measuring the products for sale.

Task

As physics learner, discuss how you would help the community to measure their agricultural produce without using a weighing scale

CHAPTER 3:

PRESSURE IN SOLIDS AND FLUIDS

Learning outcomes:

By the end of this chapter, the learner should be able to;

1. Explain that pressure is as a result of a force applied over an area
2. Examine the effect of depth on the pressure in a fluid and the implications of this
3. Describe the nature of the atmosphere and the significance of the different layers
4. Discuss the structure of the atmosphere and the significance of different layers
5. Explain the Bernoulli effect in devices like aero foils and Bunsen burner jets
6. Explain the concepts of sinking and floating in terms of forces acting on a body submerged in a fluid
7. State and apply the Archimedes principle in different situations

Introduction

Have ever thought of the reason why tractors have wide tyres and cutting tools have sharp edges or why it is advisable to walk on muddy surfaces with flat shoes than high heeled shoes?

To understand these and others, we need the concept of pressure

In this chapter, we will be able to explain pressure in solids and fluids, and identify their applications in everyday life.

Pressure in solids

Pressure of a solid occurs only due the weight of the solid. When a force acts on a given surface experiences pressure.

Solids exert pressure on the surfaces which support them in one direction depending on the area of the solid in contact with the surface.

Note; Pressure exerted by a body depends on the force (weight) and the area of contact with another body or surface where the force is applied. Therefore Pressure is defined as the force acting normally per unit area.

$$\text{Pressure} = \frac{\text{Force (N)}}{\text{Area (m)}} = \frac{F}{A} \ (Nm^{-2})$$

The S.I unit of pressure is Nm^{-2} or Pascal (Pa). Pressure is also measured in mmHg, atmospheres (atm)

Minimum and maximum pressure

The pressure exerted by an object on another varies depending on the area of contact between the two objects. The pressure increases when the surface area is decreased and vice versa. This can be demonstrated using a needle and a nail, sharp panga against blunt panga, high-heeled shoe against gumboots, bicycle tyre against tractor tyre, etc. The increase in pressure when the surface area is decreased explains why a tractor can easily move in a muddy area than the bicycle.

Activity: Investigating maximum and minimum pressure

Required materials

- Wooden block or brick
- Working table
- Sponge
- Metre rule
- Weighing scale

What to do

(1) Measure and record the dimensions of the wooden block
(2) Calculate the weight of the wooden block
(3) Determine the areas of the faces of the wooden block
(4) Place the sponge on the table
(5) Place the block on the sponge with different faces and state the observations and calculate the pressure on the sponge
(6) Measure the depth created by the block in the sponge
(7) State the areas that exert a minimum and a maximum pressure on the sponge
(8) State the relationship between pressure and area.

Note; For a given amount of force, the smaller the area of contact between the two bodies, the greater the pressure exerted. i.e.

$$\text{Maximum Pressue} = \frac{\text{Force or weight}}{\text{Minimum Area}} \quad \text{and} \quad \text{Minimum Pressue} = \frac{\text{Force or weight}}{\text{Minimum Area}}$$

This explains why;

i) A nail has a pointed end so that the driving force is applied on a very small surface area hence pressure is very high and this makes it to penetrate the material easily.
ii) An elephant has toes made of flat surface area which makes the pressure to decrease hence exerting a small force on the ground.
iii) A tractor has very broad wheels and though very heavy, it doesn't sink into the soft ground because of the large areas of the wheels which cause the tractor to exert a small pressure on the ground.
iv) Bridges are thicker at the base than at the top so that it doesn't sink in the ground.

Assignment

Research and make brief notes about the applications of minimum and maximum pressure.

Examples

1. A metallic block of mass 40kg exerts a pressure of 20Nm^{-2} on the surface. Find the area of contact between the block and the surface

Solution

$$\text{From pressure} = \frac{\text{Force}}{\text{Area}} \quad \text{but Force} = \text{weight}$$

$$\text{Pressure} = \frac{\text{weight}}{\text{Area}}$$

$$P = \frac{mg}{A}$$

$$20 = \frac{40 \times 10}{A}$$

$$\frac{20}{1} = \frac{400}{A}$$

$$20A = 400$$

$$A = 20m^2$$

Therefore the area of contact between the block and the surface is 20m^2

2. A metallic block of weight 100N rests on a surface. Find the pressure exerted on the surface if the area of contact between the block and surface is 0.01m^2

Solution

Weight = 100N, area = 0.01m^2

$P = \frac{F}{A}$, F = weight = 100N

$P = \frac{100}{0.01}$ = 10,000Nm^{-2}

3. The dimensions of a cuboid are 5cm x 10cm x 20cm and weight of the cuboid is 60N. Calculate;

i) Maximum pressure it exerts
ii) Minimum pressure it exerts

Solution

$$\text{Maximum Pressue} = \frac{\text{Force or weight}}{\text{Minimum Area}}$$

$$P_{max} = \frac{60}{(5X10)X10^{-4}} = 12{,}000\text{Pa}$$

$$\text{Minimum Pressure} = \frac{\text{Force or weight}}{\text{Maximum Area}}$$

$$P_{min} = \frac{60}{(10X20)X10^{-4}} = 3{,}000\text{Pa}$$

Task

1. A rectangular block of dimensions 4cm x 2cm x 1cm exerts a maximum pressure of 2000Nm^{-2} when resting on a table. Calculate the mass of the block.

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2. A rectangular block of mass 50kg measures 8cm by 10cm by 20cm. What is the minimum pressure it can exert on a given surface?

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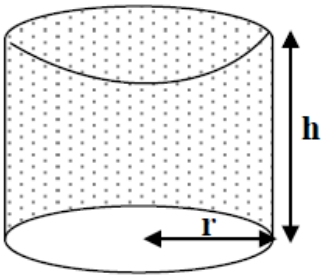
PRESSURE IN FLUIDS

A fluid can be a liquid or a gas. Fluids (liquids and gases) also exert pressure on surfaces and objects in contact with them. Pressure in fluids occurs due to both weight and movement of fluid molecules and act in all directions.

Consider a liquid in a cylindrical container of radius **r** and height **h**. Liquids take up the shape of the container; hence the volume of a liquid filling a cylindrical container is equal to the volume of that cylindrical container.



Volume of the liquid = Area of the base x height

$$V = Ah$$

From Mass = density x volume $= \rho Ah$

From weight = mass X acceleration due to gravity

Weight = Ahρg

From Pressure = $\frac{\text{Force}}{\text{Area}}$ but Force = weight

Pressure = $\frac{\text{weight}}{\text{Area}}$ $= \frac{Ah\rho g}{A}$ = hρg

Note that pressure at any point in a liquid is the same in all directions and depends on the following factors

i) Depth (height) below the surface of the liquid

ii) Density of the liquid

iii) Acceleration due to gravity

Examples:

1. Find the pressure in a liquid of density 1000kgm^{-3} at a height of 80cm

   Pressure = hρg

   = 0.8 x 1000 x 10

   = 8,000Nm^{-2}

2. The pressure of in a liquid is 10,000Nm^{-2}. What is the height if its density is 1000kgm^{-3}

   Pressure = hρg

   10000 = h x 1000 x 10

   10000 = 10000h

   h = 1m

3. The pressure at the bottom of a column of mercury is 106000 Pa. How high is the mercury column? Density of mercury is 13600 kgm^{-3}

   Pressure, P = hρg

   106000 = 13600 x h x 10

   106000 = 136,000h

   h = $\frac{106{,}000}{136{,}000}$ = 0.78m

Task

1. Calculate the pressure due to water experienced by a diver working 15m below the surface of the sea.

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2. A paraffin reservoir tank contains paraffin of density 800kgm^{-3} to a depth of 5m. What is the pressure at the base of the reservoir?

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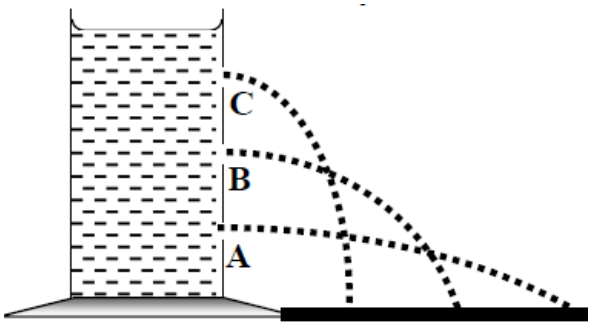
Experiment to show variation of pressure in a liquid:

- Three holes **A**, **B** and **C** of the same diameter are made using a nail on a tall tin along a vertical line on one side.
- The tin is then filled with water and observe the jets of water from holes **A, B** and **C** as shown below.



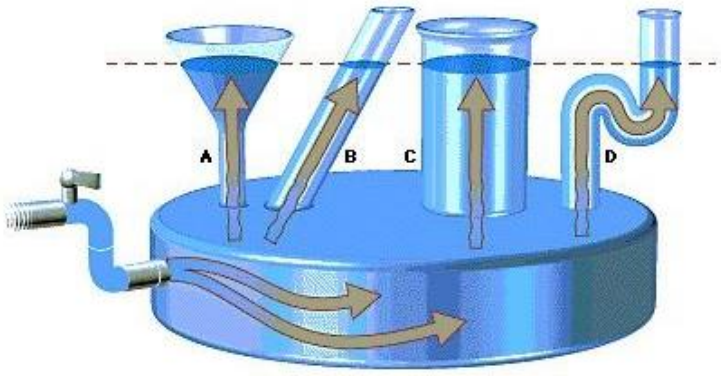
- The lower hole, **A** throws water farthest followed by hole, **B** and lastly **C**.
- Hence pressure at **A** is greater than pressure at **B** and is greater than pressure at **C.**
- Therefore pressure increases with depth.

Research assignment

Using the internet or other sources, research about how water flows from a reservoir (dam or storage tank) to a house and share your findings with the class.

Note:

- Naturally, water flows from upland sources such as crater lakes in mountain to sources in low land due to differences in pressure. To lift water from a lower level to a storage tank at upper levels, you need extra power using a water pump.
- Pressure in fluids is considered when designing overhead water tanks and in construction of dams. The thickness of the dam increases from top to bottom in order to counteract the increasing water pressure.
- Static fluid pressure does not depend on the shape and cross-sectional area of the container. When water is filled in differently shaped containers, it will attain the same level implying that pressure in fluids does not depend on the shape of the container.



We experience fluid pressure in the following ways;

(1) If you dive down to the bottom of a deep swimming pool, you feel water pressure pressing on you from all sides. For this reason, deep sea divers wear a reinforced diving suit if they are to work safely at great depths.
(2) Sometimes water from taps at home may come out slowly if the water supply tank is not much higher than the top.
(3) Dam walls are thicker at the bottom than they are at the top because there is high pressure at high depth.
(4) Hydraulic jerks work on the principle of fluids and can be used to lift cars.

Transmission of pressure in liquids

Liquids in an enclosed system are incompressible and if pressure is applied at one point to the system, it will act in all directions equally.

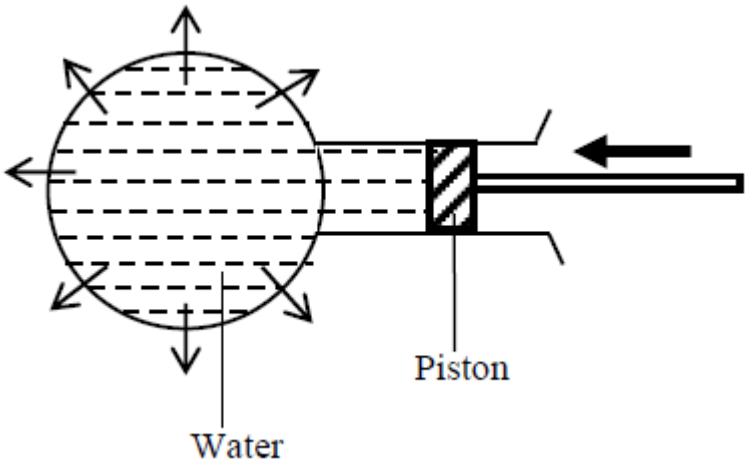
Gases transfer pressure in a similar way when confined and compressed.

Fluid pressure can also be increased through hydraulic mechanisms and changes in the velocity of the fluid.

The principle of transmission of pressure in liquids:

The principle of transmission of pressure in liquids states that pressure applied at any point of an enclosed fluid is transmitted equally throughout the whole fluid. This is sometimes referred to as **Pascal's principle.**

Considering the diagram below, when the plunger is pushed in, the liquid comes out of the holes with equal force. This shows that pressure is transmitted equally to all parts of the liquid but the holes must have the same diameter



The above principle is applied in hydraulic systems such as hydraulic press, hydraulic brakes, hydraulic jacks and hydraulic cylinders.

Assignment (Group work)

In your groups, research and make presentation about;

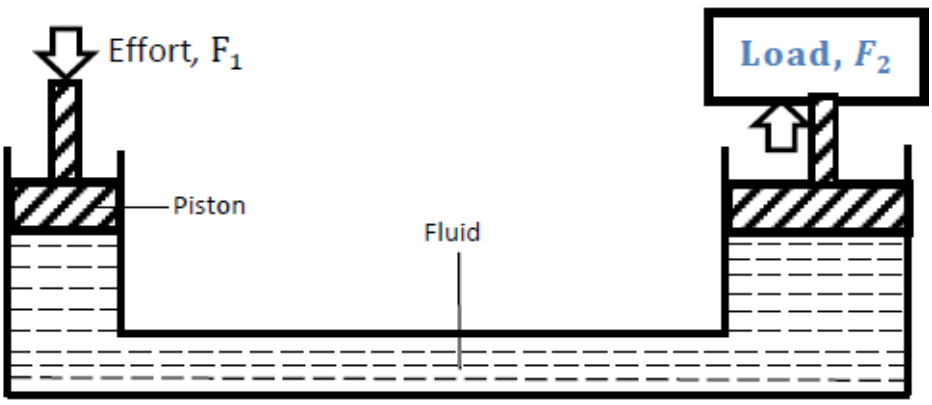
(a) How a simple hydraulic press can be constructed.

(b) How to compare densities of two liquids using Hare's apparatus.

The hydraulic press

The hydraulic press uses the principle of transmission of pressure in fluids or the Pascal's principle which states that pressure applied at any point in an enclosed fluid is transmitted equally to all parts of the fluid.

Considering the hydraulic press below.



Pressure due to the small piston is equally transmitted to large piston and to all other parts of the liquid i.e.

Pressure P_1 on small piston = Pressure P_2 on large piston

$$P_1 = P_2$$

$$\frac{F1}{A1} = \frac{F2}{A2}$$

Examples

(1) The pistons of a hydraulic press have their areas given as 3.0×10^{-2} m^2 and 2×10^{-2} m^2 respectively. If the small piston is pushed down with a force of 120N, what is the force required to push the larger piston?

Solution

For small piston, $A_1 = 3 \times 10^{-2}$ m^2

$F_1 = 120$N

For large piston, $A_2 = 2 \times 10^{-2}$ m^2

$F_2 = ?$

From $\frac{F1}{A1} = \frac{F2}{A2}$

$F_2 = \frac{F1}{A1} \times A_2$

$$F_2 = \frac{120 \times 2 \times 10^{-2}}{3 \times 10^{-2}}$$

$F_2 = 80$ N

2. A force of 40N is applied on the piston pump of area 2 cm^2 to lift a load of 1000N placed on the ram piston. Calculate the;

(a) Pressure transmitted to the ram piston

(b) Area of the ram piston in square centimetres

Solution

(a) For the pump piston

$F_1 = 40$N, $A = 2$cm^2 $= 2 \times 10^{-4}$m^2

Pressure transmitted to the ram piston

$$P_1 = \frac{F1}{A1} = \frac{40}{2 \times 10^{-4}} = 200{,}000 \text{ Nm}^{-2}$$

(b). Pressure due to the pump piston (P_1) is equal to the pressure on the ram piston (P_2)

$$P_1 = P_2$$

$$200{,}000 = \frac{F2}{A2}$$

$$200{,}000A_2 = F_2$$

$$A_2 = \frac{F2}{200{,}000}$$

$A_2 = 0.005$m^2

$A_2 = (0.005 \times 10^4)$ cm^2

$A_2 = 50$cm^2

The area of the ram piston is 50cm^2

Assignment

1. In a hydraulic press, a force of 300N is applied to the master piston of area 35cm^2 if the hydraulic press is designed to produce a force of 5000N, determine;

(a) The area of the slave piston.

(b) The radius of the slave piston.

2. A hydraulic press machine is used to raise a load W placed on a piston of cross-sectional area of 100cm^2 by using an effort of 20N at a piston of cross-sectional area of 2cm^2 calculate the;

(a)Pressure transmitted throughout the liquid.

(b) The load W.

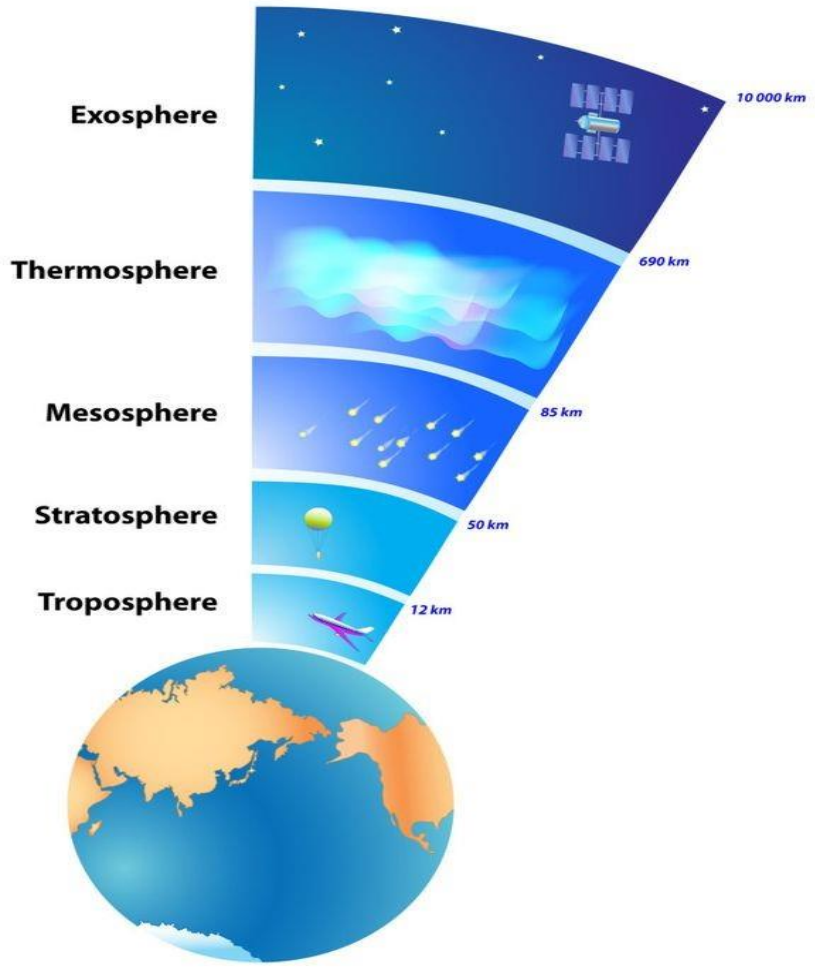
3. Describe how a hydraulic car brake system works.(draw an illustration)

4. State the factors of pressure and explain how they affect pressure.

THE ATMOSPHERE

The earth is surrounded by an envelope of gases known as the atmosphere. It is made up of five layers with different characteristics. These layers are;

1. **Troposphere.** This is the layer closest to the earth's surface where all weather conditions occur. The temperature of air close to the earth's surface is higher and decreases as you move upwards.
2. Stratosphere. This is the second layer from the earth's surface. It contains ozone gas which protects us from absorbing dangerous radiations (ultra-violet radiations) from the sun.
3. Mesosphere. This is the coldest part of the earth's atmosphere at an average temperature of about -90^{o}C.
4. Thermosphere. This is the hottest layer reaching temperatures above 1500^{o}C the density of the thermosphere is too low.
5. Exosphere. This is the top most layer of the atmosphere. It is extremely thin and is where the atmosphere combines with the outer space. It is composed of widely dispersed particles of hydrogen and helium.



Effects of human activities on the atmosphere

The ozone gas found in the stratosphere is of great importance to humans as this protects us by absorbing harmful sun radiations. However, human activities destroy it.

Research assignment

In groups, research and write about the human activities that affect the atmosphere suggest possible solutions.

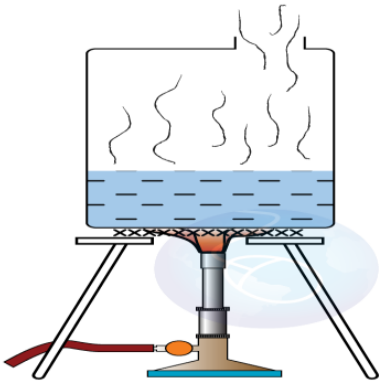
ATMOSPHERIC PRESSURE

The earth is surrounded by a sea of air called atmosphere. Air has weight therefore it exerts pressure at the surface of the earth. The pressure this air exerts on the earth's surface is called atmospheric pressure.

Atmospheric pressure is the pressure exerted by the weight of air on all objects on earth's surface.

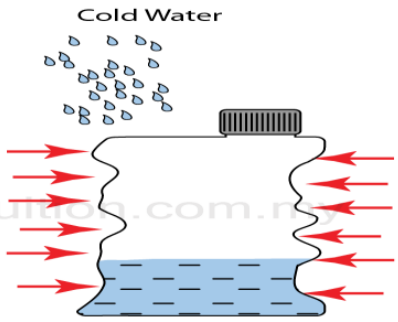
The higher you go the less dense the atmosphere and therefore atmospheric pressure decreases at high altitude and increases at low altitude. The value of atmospheric pressure is about 101325 Nm^{-2}.

Demonstrating the existence of atmospheric pressure by the crushing can experiment or collapsing can experiment



(a)

Water in a can is heated



(b)

The can is closed and is cooled down rapidly by pouring cold water on it, it crushes instantly, due to the high atmospheric pressure from the surrounding.

A metal can with its tight stopper removed, is heated until the small quantity of water in boils.

When the steam has driven out all the air, the cork is tightly replaced and the heat removed at the same time.

Cold water is poured over the can. This causes the steam inside to condense reducing air pressure inside the can

The can collapses inwards. This is because the excess atmospheric pressure outweighs the reduced pressure inside the can.

Assignment

Describe how to demonstrate the existence of atmospheric pressure using a glass, water and a cardboard.

Atmospheric pressure varies across the earth, it is highest at sea level and decreases with altitude. In the upper layers of the atmosphere, there is little air and thus little oxygen for breathing. This is the reason why mountain climbers use oxygen cylinders and areoplanes have pressurized cabins in which air pressure is increased sufficiently to enable people to breathe comfortably.

Measurement of atmospheric pressure

The atmospheric pressure is measured using a liquid-in-glass barometer or aneroid barometer.

Types of barometers	**Units of pressure**
1. Simple barometer	Nm-2
2. Fortin barometer	Pa
3. Aneroid barometer	atmospheres

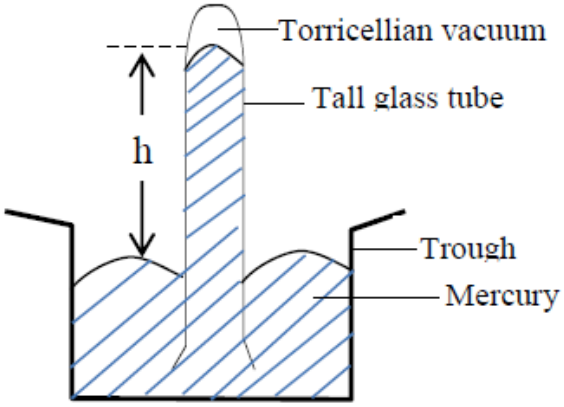
Simple barometer

A barometer is a manometer which measures atmospheric pressure.

Describing how a simple mercury barometer is made in the laboratory.

1. A 1 m long thick walled tube is filled with mercury.
2. The filled tube is inverted several time with finger over the open end. This is done in order for the large air bubble to run up and down collecting any air small air bubble in mercury.
3. After inverting several times, the tube is refilled with mercury.
4. With a finger on the open end, the filled tube is inverted into a bowl of mercury.

When the finger is removed, the mercury column falls until it is equal to atmospheric pressure.



Note;

- Mercury is harmful, therefore the activity should be carried out with guidance of a teacher.
- When mercury is used, the height of the mercury column is 760mm. therefore the atmospheric pressure is measured as 760mmHg (760mm of mercury)
- If water is used, the corresponding column would be 10m or 10,000mm. Thus may not be appropriate for use in a simple barometer.
- When a mercury barometer is taken from sea level to the top of a mountain i.e. low altitude to high altitude, the mercury column falls. This is because the atmospheric pressure decreases at the top of the mountain. The decrease in atmospheric pressure is due to density of air decreasing because air is less compressed above.
- Deep-sea divers must return slowly to the surface because the sudden decrease in pressure when they return fast from deep water is very painful.

- Pilots operating at great heights must have protective headgear to prevent nose bleeding because atmospheric pressure at great height is much smaller than blood pressure.

Calculating the height of the reading of the mercury barometer at high altitude:

This is calculated from;

Pressure change for air = Pressure change for mercury

$$h_a\rho_a g = (H_{atm} - h_m)\rho_m g$$

Where: h_a is the height of altitude, ρ_a is the density of air, h_m is the mercury column barometer at that altitude and H_{atm} is atmospheric pressure before rising.

Examples:

1. A mercury barometer reads a pressure of 75cmHg at the bottom of a mountain and 73.5cmHg at the top. If the density of mercury is 13600kgm^{-3} and that of air is 1.25kgm^{-3}. Calculate the height of the mountain.

Solution:

Change in pressure,

P = 75.0 – 73.5

= 1.5cmHg

But P = hρg

$$P = \frac{13600X1.5\,X10}{100}$$

P = 2040Nm^{-2}

$2040 = h_{air}\rho_{air}g$

2040 = H x 1.25 x 10

Height, H = 163.2m

Research Assignment

In groups, research and prepare a class presentation about the following.

(1) The structure and features of aneroid barometer and the fortin's barometer.

(2) The advantages of an aneroid barometer over a mercury barometer.

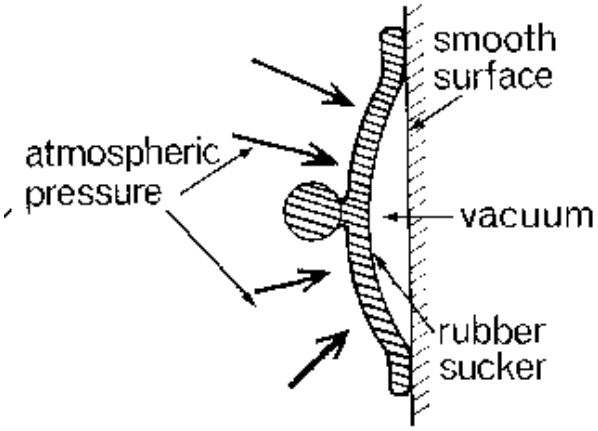
NB: Aneroid barometer can also work as an altimeter, which is a device that is used in aircrafts to measure altitude. Atmospheric pressure decreases as altitude increases.

Applications of atmospheric pressure

The presence of atmospheric pressure has enabled humans to design machines and devices that simply work such as rubber suckers, bicycle pump, lift pump, force pump, siphon, water supply system and drinking straw among others.

Rubber Sucker

This is circular hollow rubber cap before it is put to use it is moisturized to get a good air seal and firmly pressed against a small flat surface so that air inside in pushed out then atmospheric pressure will hold it firmly against surface as shown below



Uses of rubber sucker;

- Fitting sheets against walls
- It is used printing machines for lifting papers to be fed into the printer

Drinking straw:

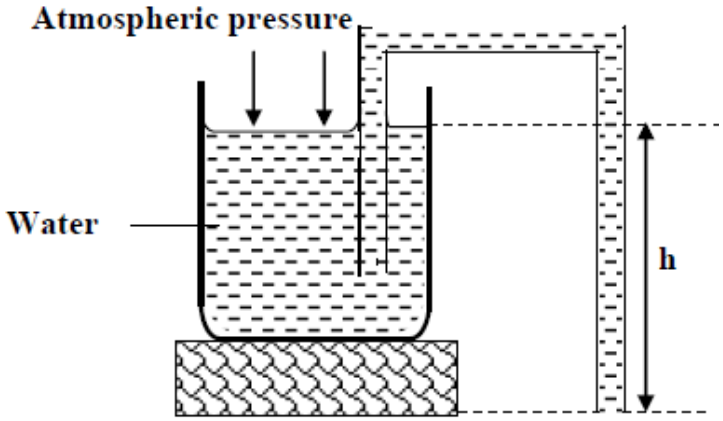
When drinking using a straw some of the air in the straw goes into the lungs once sucked. This leaves space in the straw partially evacuated and atmospheric pressure pushing down the liquid becomes greater than the pressure of the air in the straw.

Syringe:

When the piston is pulled up from the lowest part of the barrel, a vacuum is created below it. Atmospheric pressure then forces the liquid into the barrel.

The siphon:

A tube can be used to empty tanks or draw petrol from petrol tanks in cars referred to as a siphon



The pressure at the surface of the water is atmospheric pressure. One end of the tube is at a height, h below the surface of the water and therefore pressure at this end is greater than pressure at the surface (atmospheric pressure). The tube is then filled with water and water will continue running out so long as its end is below the water surface. Pressure at this end of the tube is equal to atmospheric pressure and pressure due to height h. $P = H + h\rho g$ where H is the atmospheric pressure. Therefore water flows out the tube at this end due to excess pressure $h\rho g$.

Conditions for a siphon to operate:

- The end of the tube must be below the surface of the liquid to be emptied.
- The tube is first filled with the liquid without any bubble in it.
- One end of the tube is inside the liquid to be emptied.
- The tube does not rise above the barometric height of the liquid from the surface of the liquid to be emptied.

Note; A siphon is a tube which transfers a liquid from a higher level to lower level. The flow is maintained by gravity and atmospheric pressure. For a siphon to work the tube must be filled with water at all times.

Applications of siphon principle

Automatic flushing tank: This uses siphon principle. Water drips slowly from a tap into the tank. The water therefore rises up the tube until it reaches and fills the bend. In the pipe, the siphon action starts and the tank empties (the water level falls to the end of the tube).The action is then repeated again and again.

Flushing tank of water closet: This also uses the siphon principle. When the chain or handle is pulled, water is raised to fill the bend in the tube.
The siphon action at once starts and the tank empties.

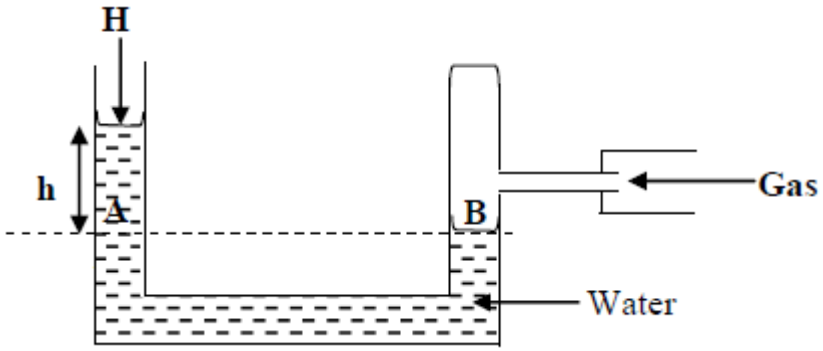
Lift pump or Common pump;

Pumps are used to raise water from walls. They consist of cylindrical metal barrel with side tubes near the top to act as spouts

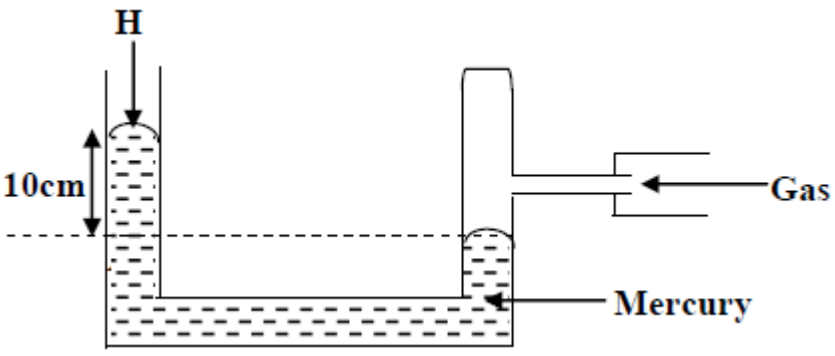
Measurement of pressure:

1. Manometer:

This is an instrument used to measure fluid pressure. It consists of a U-tube filled with either water if the pressure to be measured is low or mercury if the pressure to be measured is high.



When one limb of the manometer is connected to the gas supply, the water level in the other limb rises due to the gas pressure.
The difference in water levels is the difference between gas pressure and atmospheric pressure.
Pressure at A is equal to pressure at b since they are at the same horizontal level and pressure at B is the pressure of the gas.
Pressure at A = H + h. Where H is the atmospheric pressure.
If the atmospheric pressure is known and taking the density of water to be $1000kgm^{-3}$. Then pressure of the gas can be calculated as P = H + hρg
P = 103360 + 0.2 x 1000 x 10
P = $105,360Nm^{-2}$
The diagram below shows a mercury manometer



Find the pressure of the gas in Nm^{-2} in cmHg and Nm^{-2}

Solution:

i) P = H + h

P = 76 + 10

P = 86cmHg

ii) P = hρg

P = 0.86 x 13600 x 10

P = 116,960Nm^{-2}

Note: If the enclosed end is opened the gas trapped escapes and the liquid level in both arms will be the same.

BERNOULLI'S EFFECT

Thus, Bernoulli's effect is the decrease in pressure of a fluid as its velocity increases. It states that when the speed of the fluid increases, the pressure in the fluid decreases and vice versa.

Activity: Demonstrating Bernoulli's effect

Key Question: Explain how you can demonstrate Bernoulli's effect?

Required materials

Two pieces of paper

What to do

(1) Arrange two sheets of paper as showed below and blow air between them.

(2) Write down what you observed.

_____

_____

(3) Explain the impact of blowing air between the papers and that outside the papers

_____

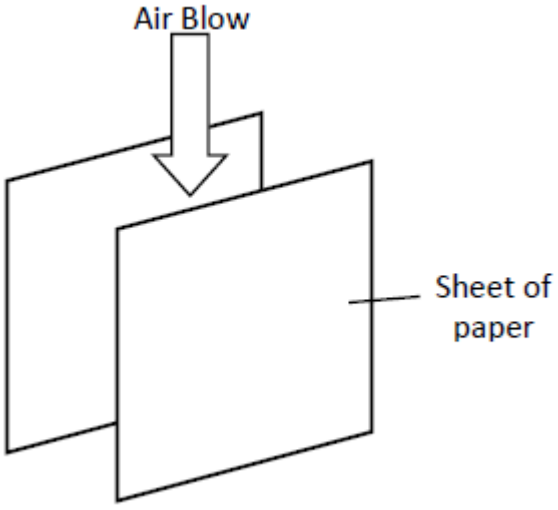
_____

_____

(4) Share with other groups and discuss the reasons for the observation.

(5) Make research on the internet and find out the machines that operate upon this principal.

Bernoulli Effect in an air stream can be shown by blowing air between two sheets.



Application of Bernoulli's principle

- When the fluid comes out of a jet, the speed increases as the pressure decreases.
- At the jet the gas comes out at high speed so the pressure is low at the jet. This results in air to be drawn in.
- A spinning ball takes a curved path because the ball drag air around causing air to pass more rapidly over one side than the other. This results in pressure difference that causes a resultant force on the ball.
- An aeroplane wing called aero foil is shaped so that air has to travel farther and so faster on the top than underneath. This results in a pressure difference that causes a resultant up ward force on the wing, thus it lifts.
- When two large vehicles pass each other, a force of attraction is experienced. This is because:
  The speeding vehicles drag layers of air along with them. As these layers of air pass each other at high speed, they cause a pressure decrease.
  This results in the vehicles being pushed towards each other.

Research assignment

In groups, research and make a presentation about the following.

(1) State the Bernoulli's effect and explain how it is applied also in Bunsen burner jets.
(2) Why do you think it feels very comfortable when airplanes fly in regions where air flows in streamlines?
(3) Explain why cars feel light when moving at high speeds?
(4) Share your findings with the whole class.

Reasons why it is necessary to measure the rate of flow

(1) In various industrial processes, it is crucial to measure the rate of fluid flow accurately within a system as a whole or in part. This applies equally to gases and liquids which are an integral part of the process, or to compressed air, water or steam, which are essential to plant operation.
(2) Flow describes a wide range of fluid movement, such as blowing through the air, flowing through pipes, or running along a surface. The flow of the fluid is classified in a variety of different ways based on the various properties of the flow.
(3) A flow meter is used to measure the rate of fluid or energy flow to allow the process to be controlled and also ensure that the product is of the appropriate quality.

SINKING AND FLOATING (UPTHRUST)

When an object is dropped in water, it may stay on the water surface or fall to the bottom of the water. Those objects that stay on the surface of water without drowning are said to be floating objects while that fall to the bottom of water are said to be sinking objects.

In addition, it is easier to carry an object in water than in air. This is due to up thrust.

Activity one: Sorting out items that can float or sink

Key Question: what items float on water?

Required materials

- Bucket filled with water
- Various items such as oranges, apples, stone, piece of wood, sharpener, pen, pencil, piece of chalk and rubber.

What to do:

(1) Fill a bowl with water.

(2) Name the items you think will float or sink.

Floating objects	Sinking objects

(3) One at a time, place each object in water. As you place them in water, observe what happens and record your results.

_____

_____

_____

(4) Name the forces that make the items to sink or float.

_____

_____

_____

Activity two: Experimenting forces that act on floating objects

Required materials

- A basin filled with water
- Small piece of wood

What to do:

(1) Put a piece of wood on top of water. What do you observe?

_____

(2) Explain your observation in (1) above

_____

_____

(3) Also, explain what would happen if the mass of the wood is increased.

_____

_____

(4) Basing on your observations, explain why objects weigh less in water than in air and relate your findings to the density of the body.

_____

_____

_____

Note;

- Floating or sinking objects in a fluid (liquid or gas) experience some forces
- If the upward force is equal to the downward force, the object floats in the fluid
- If the upward force is greater than the downward force , the object rises
- If the downward force is greater than the upward force, the object sinks.

UPTHRUST AND WEIGHT OF FLUID DISPLACED

Bodies submerged in fluids experience an upward force due to the fluid, known as up thrust (buoyancy force) the up thrust is due to the pressure a fluid exerts on the surface of the body. **Up thrust** is an upward force due to the fluid resisting being compressed. When any object is immersed or submerged into fluid its weight appears to have been reduced because it experiences an up thrust from the fluid. Up thrust is expressed as;

Up thrust, F = weight in air – water in fluid

Up thrust, F = weight of displaced fluid (w)

$$F = mg = \rho vg \quad \text{since } m = \rho v$$

Where ***m*** is the mass, ***ρ*** is the density and **v** is the volume of the displaced fluid. This relationship was discovered by a Greek physicist called Archimedes, who later came up with the Archimedes principle.

Archimedes principle states that when a body is partially or totally immersed in a fluid, it experiences an upthrust (upward force) that is equal to the weight of the fluid displaced.

Assignment: Research and prepare a presentation about;

(a) The relationship between apparent loss, up thrust, and weight of a displaced fluid.
(b) The relationship between the weight of a body in air and weight of liquid displaced by a floating body.
(c) How can you make a simple hydrometer?

Responses:

Practical assignment
In groups, demonstrate sinking and floating using two oranges (one peeled), a transparent glass and clear water. Explain your observations.

_____

_____

_____

_____

ARCHIMEDE'S PRINCIPLE AND LAW OF FLOATATION

A giant ship made from iron easily floats on water yet a nail from the same material sinks. An object submerged in a fluid will either sink or float depending on the weight of the fluid it displaces compared to its own weight.

Floatation can be defined as the tendency of an object to rise to the upper levels of the fluid or to stay on the surface of the fluid.

The opposite of floatation is sinking and this can be defined as the tendency of an object to fall on the lower levels of the fluid.

The **law of floatation** states that a floating body displaces its own weight of fluid in which it floats. This means that a log of 400kg (4000N), floating in water displaces 400kg (4000N) of water.

Conditions for objects to float

(1) The average density of the object should be less than the density of the fluid in which the object has to float. For example, a ship is very heavy but floats because it's hollow inside containing air which causes its average density to be less than that of the water.
(2) The up thrust force of the fluid on the object must be equal to the weight of the object. For example, a coin will sink to the bottom when placed on the water surface. This is because the up thrust of water on the coin is less than its weight.
(3) The volume of the object submerged must be large so as to displace a large amount of fluid.

Activity: Determining the weight of a fluid displaced by a floating body

What is needed

- Spring balance
- Water in a jerry can
- thread
- wooden block
- beaker
- weighing scale
- displacement can (overflow can)

What to do

(1) Use a spring balance, measure and record the weight of the block in air.
(2) Pour water in an over flow can until it starts flowing out of the spout. When the water stops flowing out, place a measuring cylinder below the spout.
(3) Place the wooden block in the over flow can. State and explain what you observe.

_____

_____

_____

(4) Measure the mass of the displaced water and calculate its weight.

_____

_____

(5) Compare the weight of the wooden block and that of the displaced water.

_____

(6) Draw your conclusion and discuss your findings with other groups.

_____

Application of the law of floatation

(i) A hydrometer

The relative density of any liquid may be found using *a* **hydrometer.**

-It is used to test the purity of milk.

-It is used to test R.D of a car battery acid.

This consists of a float with along stem. A heavy weight is placed beneath the float to keep the hygrometer up right. The higher the hydrometer float the higher the relative density of the liquid.

Applications of a hydrometer:

- To determine the degree of purity of milk
- To determine the level of charge of batteries
- To determine the level of sugar in some drinks
- To determine the alcoholic content of drinks

(ii) Submarines

The average density of submarines is varied by means of ballast tanks. For the submarines to float, the ballast tanks are filled with air. To sink the submarines, the tanks are filled with water causing average density to rise higher than that of water.

(iii) Ships (Why ships float)

Ships float on water, although they are made from iron and steel which are denser than water. This is because a steel or iron ship is made hollow and contains air. So the average density of the ship is less than that of water.

The loading lines called plimso-line marks on the sides show the level to which it can be safely loaded under different conditions.

Weight of displaced water (Ww) = weight of the ship (Ws) + weight of the cargo (Wc).

Ww=Ws+Wc

(iv) Balloons

These are airships used in meteorological measurements.

A balloon filled with hydrogen weighs less than the weight of air it displaces.

The upthrust being greater than its weight, a resultant upward force on the balloon causes it to rise.

The balloon continues to rise up until the upthrust acting on it is equal to the weight of the balloon plus its content and then it floats.

The lifting power of the balloon is calculated from the formula:

$$U = W_{balloon} + W_{hydrogen} + W_{load}$$

$$U = m_b g + V_h \rho_h g + m_l g$$

ARCHIMEDE'S PRINCIPLE

Archimedes' principle states that when a body is partially or totally immersed in a fluid, it experiences an upthrust (upward force) that is equal to the weight of the fluid displaced.

Application of Archimedes' principle

1. Submarine: A submarine has a large ballast tank, which is used to control its position and depth from the surface of the sea. A submarine submerges by letting water into the ballast tank so that its weight becomes greater than the upthrust on it. Otherwise, it floats by reducing water in the ballast tank. Thus its weight is less than the upthrust.

2. Hot Air balloon: The atmosphere is filled with air that exerts up-thrust force on any object. A balloon rises and floats when the up-thrust force is greater than its weight. It descends when the balloon's weight is higher than the up-thrust force. It becomes stationary when the weight equals the up-thrust force.

3. Hydrometer: A hydrometer is an instrument to measure the relative density of liquids. It consists of a tube with a bulb at one end. Lead shots are placed in the bulb to weigh it down and enable the hydrometer to float vertically in the liquid. In a liquid of less density, a greater volume of liquid must be displaced for the up-thrust force to be equal to the weight of the hydrometer so it sinks lower. Hydrometer floats higher in a liquid of higher density.

4. Ship: A ship floats on the surface of the sea because the volume of water displaced by the ship is enough to have a weight equal to the weight of the ship. A ship is constructed in a way so that the shape is hollow, to make the overall density of the ship less than the density of water. Therefore, the up-thrust force acting on the ship is large enough to support its weight.

The **plimso-line** marked on the body of the ship acts as a guideline to ensure that the ship is loaded within the safety limit.

A ship submerges lower in fresh water as fresh water is less dense than sea water (salty water). Ships will float higher in cold water as cold water has a relatively higher density than warm water.

5. Fishes:

Certain group of fishes uses Archimedes" principles to go up and down the water. To go up to the surface, the fishes will fill its swim bladder (air sacs) with gases. The gases diffuse from its own body to the bladder and thus making its body lighter. This enables the fishes to go up. To go down, the fishes will empty their bladder, this increases its density and therefore the fish will sink.

Uses of Archimedes' principle

1. Measurement of relative density of solids
2. Measurement of relative density of a liquid

Measurement of relative density of a solid

1. Weigh the object in air and note it to be W_a
2. Weigh the object in water and note it to be W_w
3. Determine the upthrust $U = W_a - W_w$
4. Relative density of solid = $\frac{Wa}{Wa - Ww}$

Determination of RD of a liquid

Weigh the object to find its weight in air W_a using a spring balance
Weigh the object in the liquid whose RD is to be determined, label it W_1
Weigh the object in water, call it W_w
Find the upthrust in liquid = $W_a - W_1$
Find the upthrust in water = $W_a - W_w$
Obtain R.D of a liquid from $R.D = \frac{Wa - W1}{Wa - Ww}$

Examples

A metal block of volume $0.2m^3$ is hanging in a water tank by the help of a string. What is the tension in the string? (Density of the metal is 8×10^3 kgm^{-3} and that of water is $1x10^3$ kgm^{-3})

Solution

Let the tension in the string be T, weight of the metal block be W, and up thrust be F.

At equilibrium, T + F = W
T = W – F
T = $\boldsymbol{\rho}_1$ V g – $\boldsymbol{\rho}_2$ V g
Where $\boldsymbol{\rho}_1$ is the density of the metal and $\boldsymbol{\rho}_2$ is the density of water.
T = (8000 x 0.2 x 10) – (1000 x 0.2 x 10)
T = 14,000N

The tension in the string is 14,00N.

Assignment

(1) A wooden sphere of density $0.9gm^{-3}$ and mass 180g, is anchored by a string to a lead weight at the bottom of a vessel containing water. If the wooden sphere is completely immersed in water, find the tension in the string.

(2) A steel cable holds a 12kg shark tank 3m below the surface of salt water. If the volume of the water displaced by the shark tank is $0.1m^3$, what is the tension in the cable? Assume the density of the salt water is $1025kgm^{-3}$

Activity of integration

Your geography teacher intends to take S.3 and S.4 students to one of the two tourist locations; mountain Rwenzori and the shores of Lake Albert in western Uganda. Suppose you are their tour guide, write the guidelines based on the knowledge of pressure that students should follow to ensure safety while on the tour.

REVISION SCENARIO ITEMS

1. ***a)*** Juliet and Remah failed to agree in a discussion that was organized towards the end of term one last year. The discussion was whether energy exists informs or not. Juliet said there cannot be forms of energy whereas Remah said they exist about seven of them.

Task

As a S.2 student, write a report guiding them clearly out their arguments and include the applications of content in daily life.

b) During the holidays of term three, the father asked his son to go and join a certain construction site. As he was to wok, an engineer lifted a heavy stone of 2,200 kg from a deep hole through a vertical height of 7m from the bottom of the hole using crane within 2 minutes.

Task

As a physicist, help him to get how much work was done by the crane and its power. (Use g = 10 ms^{-1})

2. One of the most important components of our solar system is the sun. Another important component of our solar systems are the big masses called planets.

(a) Name all the planets found in our solar system.

(b) (i) Identify the planet that sustains life in our solar system.

(ii) How are the times and seasons of the year explained on the planet mentioned in (ii) above?

(c) Explain the statement "the sun has a life cycle".

3. While in your literature lesson, your teacher asks your friend to stand up and read for the class a book of Oliver Twist, however your friend always tells your literature teacher that she is unable to see the letters in the books and even when she sits near the board, she's unable to see but your teacher and other fellow literature students think she's bewitched. On the S.4 leavers' party, a boy of height 120cm stands in front of a lens camera with a lens of focal length 40cm at a distance 160cm from camera.

Task

As a learner of physics,

a) By scale drawing find the; nature size and position of the image of the boy on the camera.

b) Explain to your fellow students and the literature teacher the cause of the problem and the would-be possible solution to the above problem.

4. Zacharias is puzzled because his metallic doors are always very hard to close during day time when it is shining too much, and he says that the same doors are very easy to close in the evenings when the temperatures have lowered by considerable amounts.

Task:

As a Physics learner who understands better, the effect of temperature change on matter:

(a) Explain the cause and applications of Zacharias' puzzle in our daily life
(b) Basing on the kinetic theory, explain why liquids expand much more than solids for the same temperature change?
(c). Explain the Biological importance of the anomalous expansion of water in preserving aquatic life in countries like Switzerland where temperatures go below 0o C, relating to the diagram shown below.

5. In your trading Centre, empty mineral water bottles are scattered everywhere, thus causing blockage of trenches. A business man came to your trading Centre to buy empty mineral water bottles and pays according to the mass of each bottle. The businessman only buys bottles whose mass exceeds 30g. Your brother wants to sell his mineral water bottle but wants to know its mass before selling to the businessman and has no access to any instrument measuring mass.

Task:

You are given a metre rule, a knife edge, a 100g mass and two pieces of thread. As a student of physics describe how you will assist your brother to determine the mass of the bottle so that he is able to sell it. In your investigation you find that when a mass of 100g is placed 15.0cm from the knife edge placed at the Centre of gravity of the metre rule, the bottle should be placed 37.5cm for the metre rule to balance. Assist your brother to find out whether the bottle can be sold to the businessman.

6. A jackfruit of mass 2500g is plucked off fruit the jackfruit tree from a height 4m above the ground and falls freely. The jackfruit accelerated to the ground and hit the ground.

Task.

As a learner of physics;

a) State and calculate the form of mechanical energy stored in the jackfruit before falling.
b) Determine the kinetic energy of the fruit as it hits the ground stating clearly the assumption and hence calculate the velocity with which it hits the ground.
c) Explain why the jackfruit comes to rest after hitting the ground and does not bounce back to the original height hence state the law shown by the behaviour of the fruit.
d) Determine the kinetic energy possessed by the fruit as it passes a point 1.5m above the ground.

7. For man to earn a living, he has to do some work. A certain business man has to climb 20 stairs each of height 20cm to reach out his business store on the first floor of their business Arcade in Kampala city.

Task:

As a physics scholar;

a) Help a lay man to understand the meaning of the term “work” and state its appropriate S.I units.
b) If the businessman has a mass of 73.5kg and is holding a bag of mass 1.5kg, determine the work done by the man when climbing the stairs and the power dissipated in 5minutes.
c) Explain why it is easier for the man to move down stairs than climbing them.

8. At a certain construction site in a given town casual labourers were required to raise construction materials to the 3rd level which was 2400m from the ground,

they requested for a crane consisting of a pulley system of velocity ratio 7. The operator raised a total load of 40,000N using an effort of 8,000N.

Task:

As a learner of physics;

a) Draw a diagram to illustrate the pulley system contained in the crane.

b) Determine the efficiency of the pulley system.

c) (i) Explain why the efficiency of the machines is always less than 100% and state how it can be improved.

(ii)State the applications of pulleys in our daily life.

9. A heap of weed of mass 3 tonnes is moving towards the turbines at the Jinja power station. A group of engineers needs to use a machine operating at 20 kW for five minutes, to remove the weed from the river and place it at the bank, which is 15 m above the river.

Task

As a learner of physics;

a) Determine the efficiency of the machine and explain its value.

b) Explain how the machine is capable of floating in the water yet it is denser than water.

10. A uniform metallic rod of length 4.0m is pivoted at its centre that is used at a certain children's play resort.

Task:

As a physics scholar;

a) Given that a boy of mass 48kg sits 1.5m from end A. Help the guide at play resort to determine if another boy of mass 40kg will restore equilibrium in the beam if he sits at a distance of 0.6m from the centre.

b) Identify two other instances in which the knowledge in this scenario would be applicable in real life.

c) With the boys off the rod, explain what would happen to the beam if the end B was heated by a considered hot flame.

11. Mugumya logistics is a new company that specializes in transportation of heavy cargo. The company wishes to recruit workers who are powerful enough to load cargo on to large trucks. In order to ensure that only powerful candidates are recruited, the manager uses two criteria to interview the applicants. First, he estimates the power of the applicants. Any applicant who has a power exceeding $\mathbf{4}\boldsymbol{W}$ passes the first interview and goes to second interview where the applicant is expected to lift load of $\mathbf{450}\boldsymbol{N}$ using a machine **75**% efficient and known to have a velocity ratio **4**. The manager was advised to determine the power of the applicant using a stair case of **10 stairs** each of height $\mathbf{12}\boldsymbol{cm}$.One applicant of mass $\mathbf{50}\boldsymbol{kg}$ takes **2 minutes** to run up the stair case.

Task

As a learner of Physics;

(a) Advise the learner on whether to allow the applicant to proceed to the next interview.

(b) Determine the minimum effort that would be required by the applicant to lift the load.

12. In a certain country, a Television reporter was reporting live near the ocean about the high tides during night time. Viewers in another country were watching the live broadcast of the news bulletin during day time. There were views of different shapes of the moon in a documentary on the same television that opened up the viewers' minds since they could also testify that they have always been seeing different shapes of the moon desiring for a clear explanation about the incidence, there were also videos about planets of the solar system: claiming that there are gaseous planets in space! A number of viewers did not believe this can be true! And still wondered how it could be day in one country and night in another at the same time.

Task

As physics learner, how would to help the viewers to understand;

a) The reason for it being day in one place and night in another.

b) The occurrence of High Ocean tides.

c) The existence of gaseous planets. Which they are and what keeps them in space

d) The cycle of the moon and the different stages of the moon

13. Ocheng was moving on a rainy day and his umbrella was blown away by a strong wind. On picking it up, he realized that its spring had gone missing and its plastic handle had also flown off. He so much liked his umbrella that he didn't want to buy a new one but to repair it. On picking it, he touched its metallic flame and he felt much coldness than before the wind had blown the umbrella.

On taking it to a specialist, he was told to buy a spring of force constant **$50Nm^{-1}$** from the neighboring shop. He was given a spring but was doubtful whether it was the required spring or not.

He decided to measure the length and diameter of the spring and found them to be **10cm** and **4cm** respectively. He then applied a force of **2N** onto the spring and it was stretched to **15cm.**

Task:

As a physics student help Ocheng,

a) Know the tensile strain and stress caused in the spring?

b) Did Ocheng buy the required spring for the umbrella? (support your answer with the necessary calculations)

c) Explain to Ocheng why there was a difference in the coldness felt before the plastic handle of the umbrella had flown off and after when the hand is missing.

d) Explain to him what made his umbrella be blown by wind.

14. A rider who has been using a simple bicycle has purchased a new and improved one. The total mass of the rider and this new improved bicycle is **80kg**. The rider uses this bicycle to go up a hill of height **5m** in **20 seconds** and he is **75%** efficient. On the other hand, the simple bicycle has two toothed wheels are connected by a chain, with **48 teeth** in the big toothed wheel and **16 teeth** in the smaller toothed wheel. The rider is looking for more explanations to convince his brother that he is not just wasting money by buying the improved bicycle

Task

Using your Physics knowledge, help the brother to:

a) (i) Determine the velocity ratio of the simple bicycle.

(ii) Explain the advantages and disadvantages of having a high velocity ratio in the connected toothed wheels.

b) Determine the power used by rider to move up the hill using the improved bicycle.

c) Understand why the rider preferred to use the improved bicycle for riding up a hill.
d) Explain why it is important for the rider to sweat.

15. A newly recruited dentist was supposed to examine the tooth of the patient. The dentist wants to use a curved mirror of focal length 10cm but he is not so sure of the position of the patient's from the mirror. The possible positions of the tooth from the mirror are A, B, C, D and E.
Support material;

Position	A	B	C	D	E
Distance from the mirror.	10cm	5cm	15cm	20cm	25cm

Task:
(a) Which type of the curved mirror is the dentist supposed to use?
(b) As a physics learner, explain how you would help the dentist to select the best position of the patient's tooth and give a reason why you have not selected the other positions.
(c) Draw a ray diagram to illustrate the image of the tooth in the mirror when the tooth is at a position you have selected in (b) above and give atleast two features of image formed.

16. A certain company is packing sugar in packets for sell equal to m kg each packet, which is to be transported to the wholesalers using a bus. At the transportation point, peter observed that the bus was being loaded in the boot and not at the roof rack. John a wholesaler man has received complaints from the customers that he is selling to them sugar that is not equal to the branded amount which has caused him to lose more customers every day.
John in his shop has a mass of 2kg, a knife edge, a strong metre rule of mass 0.3kg, and a strong thread.
Task:
(a) Help john and prepare for him a massage on how he can use the available materials in his shop to verify the amount of packed sugar which the company sells to him.
(b) Given that john pivoted a metre rule at 60cm which balanced horizontally when a 2kg mass is at 30cm and a packet of sugar at 90cm mark. The branded (marked) value of sugar is 4kg. Verify if the customers' complaint was true or false. What should john do with the sugar?
(c) Explain peter's observation.

17. During the midday heat of an extremely hot day, district engineers made a visit to a construction site situated near a primary school. However, one of the engineers expressed concern about a foul odor coming from the primary school latrines. This prompted him to approach the school administrators, who admitted their lack of knowledge regarding the cause of the odor spread, attributing it to hot weather conditions beyond their control. A week later the engineers presented their findings:
- Some construction materials lacked sufficient mechanical properties.
- Carrying concrete on their heads posed a risk to the builder's safety. They urged them to continue using concrete however recommended reinforcing concrete for increased strength.

- A small material of the same type as the iron bars used at the site measuring $14cm$ in length, exhibited an extension of $0.3cm$ when subjected to a load of $20kg$.

This information caused confusion among the builders.

Hint: the diameter of the iron sample material (having the same properties as the iron bars used at the site) was $7\times10^{-2}mm$ **,**the recommended iron bars should have a Young's modulus of at least $4.0\times10^{9}Nm^{-1}$, acceleration due to gravity, g = $10ms^{-2}$

Task;

Having acquired some physics knowledge, help

a) The builders understand;

i) The emphasized mechanical properties highlighted in the report.

ii) Why they urged them to continue using concrete, what it means by reinforcing concrete and suggest alternative methods for transporting concrete to higher floors.

b) The builders evaluate whether the iron bars used were suitable for construction of such structures.

c) The school administrators understand why the odor could spread much during hot days and provide strategies to minimize the odor spread.

18. One day Mukasa a primary six boys from Nawangoma village was crossing a small river that separates nawangoma from Kivubuka. On reaching the river, he was surprised on seeing insects and some birds walking on water something he didn't believe. He picked a stone of about 10g to hit the birds, he hit off target and the stone sunk in water something that surprised him more. Not only that, he picked on a dry stick to wipe the insects off from water and after he threw it in water and this time round the stick remained in the water surface and Mukasa couldn't really believe what he was experiencing. On reaching where he was going, he was forced to take a shower and dried himself using a towel.

Hint;

Acceleration due to gravity, g =$10ms^{-2}$

Task;

a) As a physics student help Mukasa to clear his surprises by telling him why the insects and the birds behaved that way when he first saw them.

b) State two ways of reducing the effect that made Mukasa surprised as given in (a) above.

c) Educate Mukasa on why the stone and the stick behaved differently when he dropped them in water.

d) Calculate the weight of the stone that Mukasa used to hit the bird.

e) i) State the phenomenon under which Mukasa's body got dried,

ii) State any other two applications of the above phenomenon in e(i) above.

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