SENIOR

2

LEARNER'S BOOK

PHYSICS

Sphere Supplies Ltd

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TABLE OF CONTENT

CHAPTER 1
WORK, ENERGY AND POWER

Key words

- Work done
- Power
- Energy
- Potential energy
- Kinetic energy

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

(*a*) Know that the sun is our major source of energy and the different forms of energy.

(b) Know that energy can be changed from one form to another and understand the law of conservation of energy.

(c) Understand the positive and negative effects of solar energy.

(d) Understand the difference between renewable and non-renewable energy resources with respect to Uganda.

(e) Know and use the relationship between work done, force and distance moved, and time taken.

(f) Understand that an object may have energy due to its motion or its position and change between kinetic energy and potential energy.

(g) Know the mathematical relationship between positional potential energy and kinetic energy and use it in calculations.

(h) Understand the meaning of machines and explain how simple machines simplify work .

(i) Understand the principles behind the operation of simple machines.

1.1. Introduction

In everyday life, we do work as we walk, run, do house chores, etc. In order to make work easier, we use machines, such as hammers, pegs, bottle openers. This machines are simple and are used in industries. The amount of work we do or a machine does depends on the energy required.

In this chapter, you will study the relationship between energy, work and power.

1.2. Source of Energy

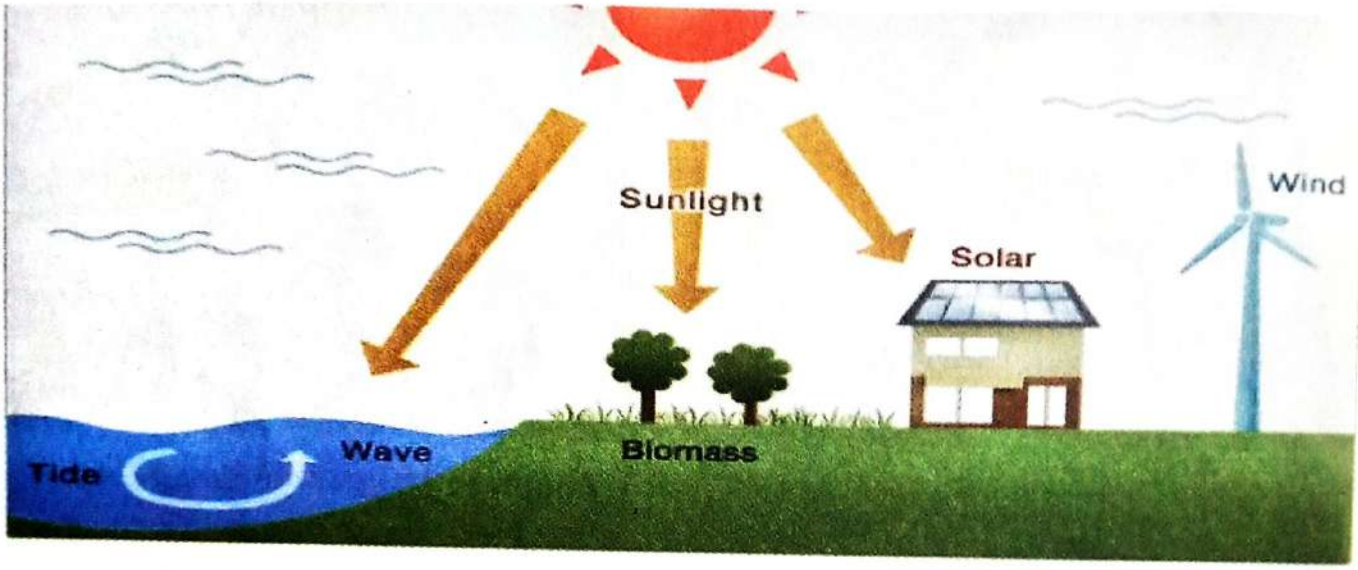


Figure 1.1: The sun as the source of energy

Energy is obtained from many sources. They include the sun (solar energy), wind (wind energy), water (geothermal energy), etc. In this section you will study and discuss the sun as a major source of energy.

Activity 1.1. Debating about the energy provided by the sun

Key Question: Why do living things on earth need sun energy?

What you need

- Pen
- Physics notebook
- Motion of debate: "No life without the sun"

What to do

1. Select speakers, 2 proposers and 2 opposers and a time keeper.
2. Debate the motion as a class.
3. Agree on the major points and write them on a chart. Hung the chart in the science corner of your classroom.
4. Transfer the points to your book

FOR YOUR KNOWLEDGE

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 make their own food. We are able to get food because plants got energy from the sun.

In the section above, you discussed the sun as one of the sources of energy. You will now discuss other sources of energy.

Activity 1.2 Sources of energy

Key Question: What forms of the energy can be produced by wind and water falls?

What you need

Figure 1.2 (a): Wind Turbines

Figure 1.2 (b): Water Falls

Activity 1.2: Sources of energy

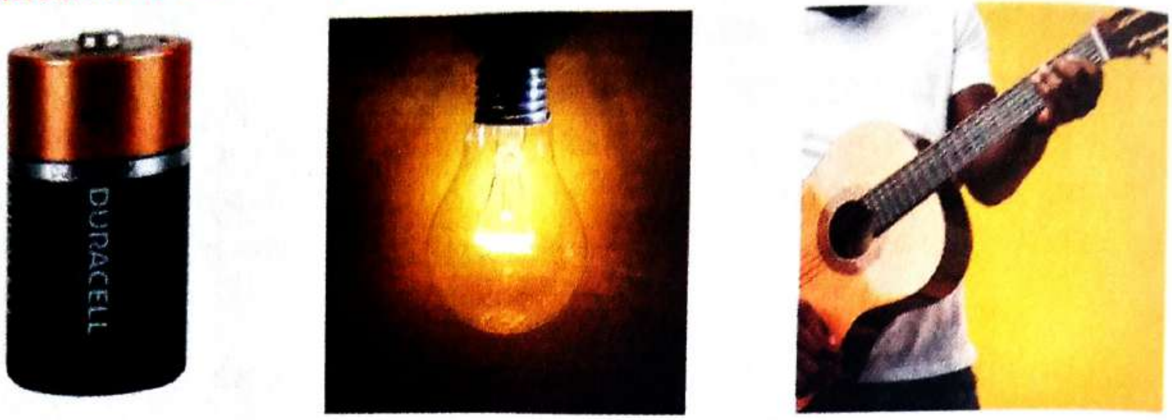
In groups, discuss and make short notes on how a wind mill and water falls generate energy.

1.3. Forms Of Energy

Energy is difficult to visualize. You cannot pick it up or touch because it has no mass; neither does it occupy space. Instead of defining energy in terms of what it is, energy is defined in terms of what it does or can do. It is the ability to do work.

Activity 1.3: Forms of energy

Key Question: What are different forms of Energy used in real life?



(a) Dry Cell (b) Electric Bulb (c) Guitarist

Figure 1.3: Forms of energy

What to do

1. List the forms of energy shown in Figure 1.3 (a) – (c).
2. List other forms of energy that you use in your day-to-day life.
3. Record your points and share with the rest of the class

1.4. Energy Transformations

One of the most important features of energy is that one type of energy can be changed into another. All the energy in the universe comes originally from the sun. The energy from the sun is huge. Using both natural and man-made systems like solar panel, it can be transformed into many different forms of energy. Green plants change sun energy into chemical energy (food we eat) and solar panels transform sun energy into electricity and light we use in our homes.

Activity 1.4: Energy transformations

What you need

- A bulb
- Loud speaker

What to do

1. Discuss the energy changes that take place in the bulb and Loud speaker
2. State the energy transformations in the following devices/events:
   a). A torch using dry cells
   b). A man running

1.5. Conservation of Energy

One of the most important features of energy is that energy can be changed from one form to one or more forms of energy. For example, in electric bulb electric energy is transformed into light energy (useful need) and heat energy (wasted energy) in the connecting wires.

Activity 1.5: Conservation of energy

Key Question: How can you state the law of conservation of Energy?

- When you burn fire wood, we get heat and light energy.
- Discuss a cycle showing the origin of this energy.
- Draw a cycle showing the origin of this Energy

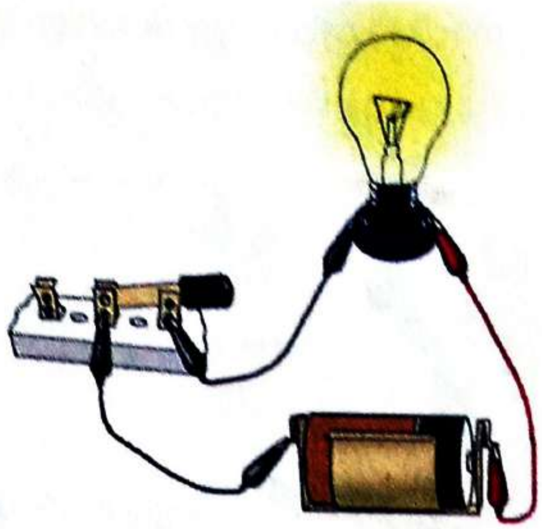


Figure 1.4. Lighting a bulb

DID YOU KNOW?
The law of conservation of energy states that energy can neither be created nor destroyed. but can only be changed / converted from one form to another.

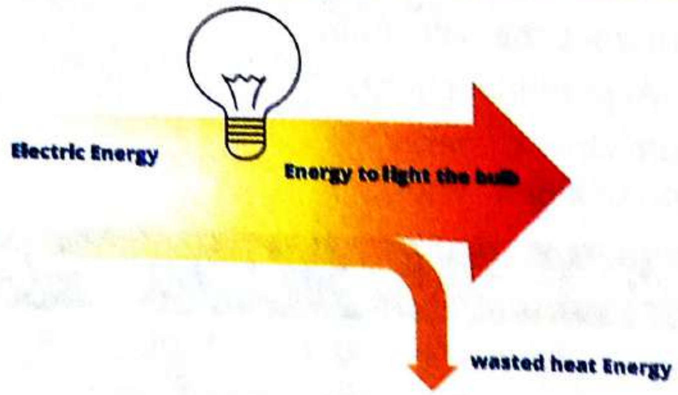


Figure 1.5. Conservation of electric energy

Energy input = total energy output
= useful energy output + wasted energy output

It is also important to note that no energy transformation is 100% efficient. For example when electrical energy is transferred to light energy in a light bulb, not all energy is converted into light. Some of the energy is transformed into heat. The heat spreads out into the surroundings as wasted energy.

Conservation of Mechanical Energy

Recall: Mechanical energy is energy possessed by a body due to its position or state of motion.

There are two types of mechanical energy. The potential energy (P.E) and kinetic energy (K.E). Potential energy is the energy possessed by an object by virtue to its position. While kinetic energy is the energy a moving body possesses by virtue of its motion.

Activity 1.6: Interchanging mechanical energy between kinetic and potential energy

Key Question: How do you state the law of mechanical conservation of energy ?

What you need

Figure 1.6: Ball

What to do

1. Hold a ball in your hand above the ground and release it to fall freely.
2. What energy transformation will take place?
3. Draw the diagram to show how mechanical energy is transformed during the motion of the ball
4. At which point does the ball attain
   i). maximum potential energy
   ii). maximum kinetic energy
   iii). a fraction of kinetic energy

FOR YOUR KNOWLEDGE

As the pendulum bob swings to and fro, its height above the tabletop is constantly changing. As the height decreases, potential energy is being lost; and simultaneously, the kinetic energy is being gained. Yet at all times, the sum of the potential and kinetic energies of the bob remains constant at a point. There is no loss or gain of mechanical energy, only transformation from kinetic energy to potential energy as in the Figure 1.7.

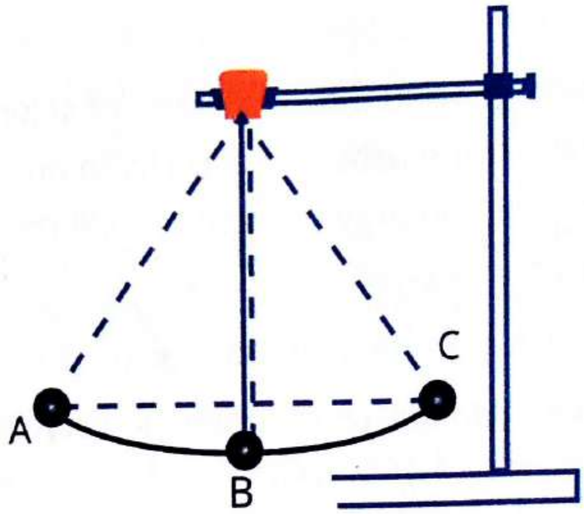


Figure 1.7: swinging pendulum bob

ercise 1.1

ıdy Figure 1.7

which point does the bob attain:

a). maximum potential energy and
b). maximum kinetic energy
c). momentarily stop moving
d). the highest speed

sitive And Negative Effects Of Solar Energy

e sun is a powerful energy source. It supplies the universe with its energy all the ıe. The solar energy has many advantages and disadvantages for creatures living earth.

tivity 1.7: Discussing the effects of solar energy

y Question: What are the advantages and Disadvantages of solar Energy?

ıat you need

Figure 1.8: Advantages and Disadvantages of solar Energy

What to do

1. Discuss the advantages and disadvantages of solar energy
2. In your note book, list the uses of electricity in our homes.
3. If you begin using solar energy for lighting, will the bill remain the same?
4. Give reasons for your answer.

1.6. Renewable And Non- Renewable Energy

Renewable energy sources can be used again or recycled while non-renewable energy sources cannot be reused or recycled.

Activity 1.9: Renewable and non-renewable energy sources

Exercise 1.2

1. Use the table1.1 to list renewable energy and non-renewable energy sources.

Table 1.1: Renewable and non-renewable energy resources

Renewable energy	Non-renewable energy

2. Why do you think we mostly use non-renewable energy sources?

The sun is a powerful energy source, and if we were able to collect most of this energy, it would make a significant difference to the planet. Solar energy has advantages and disadvantages.

Relationship between work, energy and power

Work

When we walk, run, ride a bicycle, dig, cook, pushing a loaded wheel barrow etc., we say we have done work. For example, to push a wheel barrow loaded with bags of cement is hard work. Therefore, in our everyday life, work describes any activity that a person does.

You will now investigate the scientific meaning of work.

Activity1.10: Pushing moving and non-moving objects

Key Question: What is Work?

Figure 1.9 (a) pushing a desk that is against a wall.

Figure 1.9 (b) pushing the same desk (but not against a wall-in free space).

What to do

Study the two Pictures above and answer the following questions

1. In which case is work being done? Give your reasons for answer
2. In which case is energy not being transferred?

FOR YOUR KNOWLEDGE

- Energy is the ability to do work.
- Work is defined as the product of force and the distance moved in the direction of the force. The **S.I** unit for work is Joules **(J)**

Figure 1.10: Object of 1N through 1m

If the object below is moved through a distance of 1m by a force of 1N, then from Work done (W) = force (F) x distance (x) the SI unit of work is: 1 N x m = 1 J (joule)

Therefore 1joule = 1 Nm

The joule is defined as the work done when a force of 1 newton (N) moves the point of application through a distance of 1m.

Exercise 1.3

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

Figure: 1.13: A lady pushing a trolley

2. Abu pushes a concrete wall in his dormitory with a force of 25 N. How much work does he do?

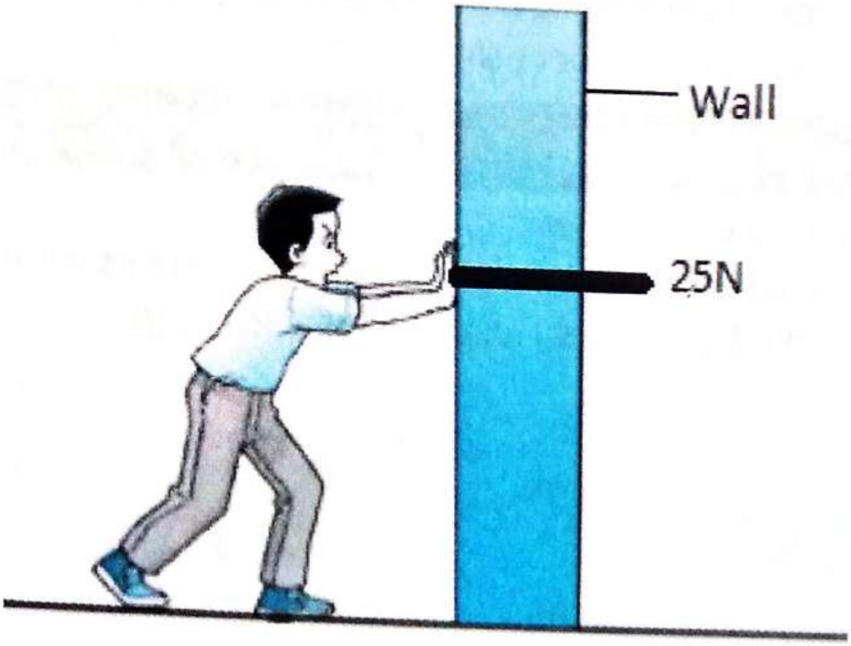


Figure 1.12: pushing a wall

POWER

FOR YOUR KNOWLEDGE

The rate at which work is done is called power. The SI unit of power is the Watt (W)

$$\text{Power, } P = \frac{\text{Work done}}{\text{Time taken.}}$$

Exercise 1.4

Jane and her son visited a supermarket and bought goods on two trolleys, each weighing 150N. They pushed their trolleys through a horizontal distance of 10m each. Jane reached the cashier in 10 minutes while her son reached the cashier in 15 minutes.

a). How much work did each of them do?

b). Who did more work faster? Explain how you arrived at your answer.

Exercise 1.5

A student who is practicing gymnastics has a mass of 45 kg and takes 6 s to climb a flight of stairs of 36 steps. If each step is 16 cm high, how much power is generated by the student? [Take g = 10 m s-2]

Work Done By Mechanical Energy

Mechanical energy is energy possessed by a body due to its position and state of motion. It is divided into two types; Potential energy **(PE)** and Kinetic energy **(KE)**

1.7. Potential Energy

It is defined as the energy possessed by objects or bodies due to their position. It is the stored energy in an object due to its position with respect to some reference point in a potential field. There are different types of potential energy, some of which include: gravitational potential energy, elastic potential energy and chemical potential energy.

1. Gravitational potential energy

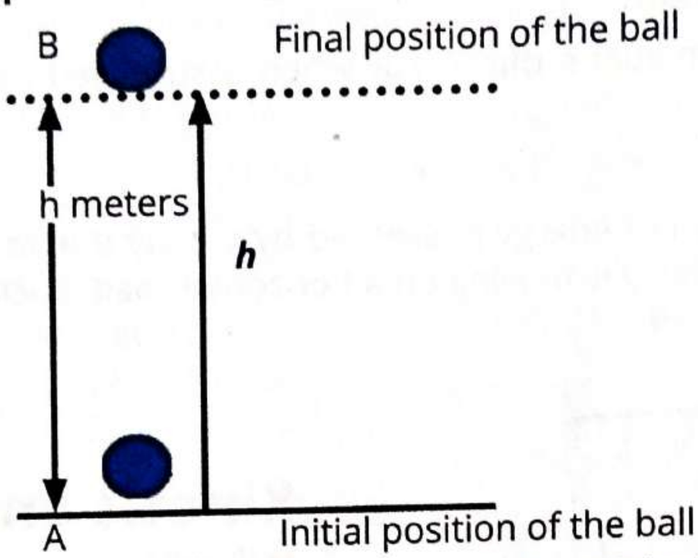


Figure 1.13: Potential energy of a raising body

At position B, the ball possesses gravitational potential energy = mgh; where m = mass of the ball, h = height through which the ball is raised and g = acceleration due to gravity

P.E = m X g X h

Elastic potential energy

Activity 1. 8 Making a catapult

Key Question: How can you make catapult

What you need

- An old Car tyre tube
- Y- shaped sticks
- Razor blade
- A small stone or paper ball
- Pebble

Try the instructions out to see if you can reach the final product

Making a catapult

What to do

1. Cut strips of rubber from a car tyre tube or a bicycle tube.
2. Tie the two ends of the rubber strips at the same point on a piece of wood so as to make a loop.

3. Resting in a horizontal position, put a pebble in the loop and pull away the strips stretch to a reasonable distance and release.
4. Repeat the procedure for different stretched lengths and each time the distance travelled by the stone.
5. What kind of energy does the stretched rubber band possess?
6. What type of energy does the flying stone possess?

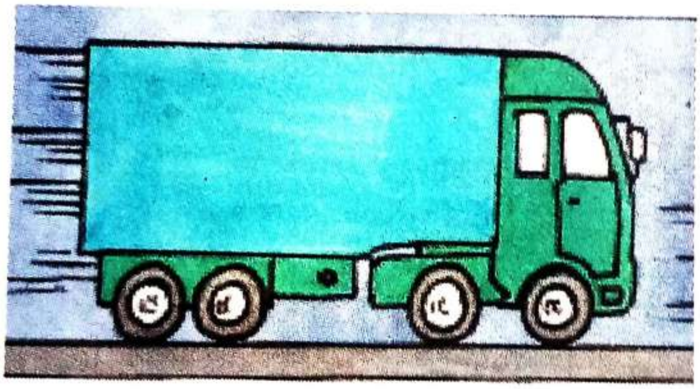
Caution: Be very careful that nobody will be hit by the stone or paper ball!

Conclusion and application

List the energy transformations that occur when a stretched catapult is used project a stone.

Kinetic energy

Kinetic energy is the form of energy possessed by a body due to its motion in Figure below where the lorry is moving on a horizontal road. Such bodies have ability to do work.



Kinetic energy

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

Fig 1.14: Kinetic energy of a moving object

Exercise 1.6

Identify the type of mechanical energy possessed by the following;

1. A flying bird
2. A moving mass of air.
3. A stationary block
4. Moving cars
5. Stationary cyclists
6. Falling rocks
7. Erupting volcanoes

Transformation between kinetic energy and potential energy.

1. Study the picture. It shows a paw paw fruit of mass, m kg falling from a height of h metres to the ground.
2. Before falling, of the paw paw tree possesses gravitational potential energy, **PE** = *mgh*. Since the paw paw is at rest, its kinetic energy, **KE** is zero.
3. As the pawpaw falls to the ground, the gravitational potential energy, **PE** decreases while the kinetic energy, **KE** increases due to its increasing velocity.
4. However, the sum of kinetic and potential energy remains constant as the paw paw falls.
5. When the pawpaw is just about to reach the ground reaches the ground, all its initial potential energy has been changed into kinetic energy.
6. This is a typical example of the conservation of energy.

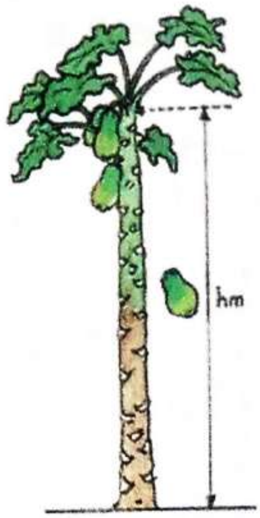


Figure 1.15 an example of conservation of energy

FOR YOUR KNOWLEDGE

Potential energy (P.E) is calculated by:
P.E=mass ×acceleration due to gravity(g)×height(h)
Kinetic energy (K.E) is calculated by:
K.E=1/2×mass(m)×velocity(v)xvelocity(v)

Work done by mechanical energy

Exercise 1.7

Figure 1.16: climbing steps

The top of climbing steps is 20 m above the ground. A man releases a brick of mass 5 kg from the top to fall towards the bottom.

Exercise 1.8

Determine maximum potential energy stored in the brick

Suppose it passes a certain point with a speed of 20 m/s, how much kinetic energy does it possess at that point?

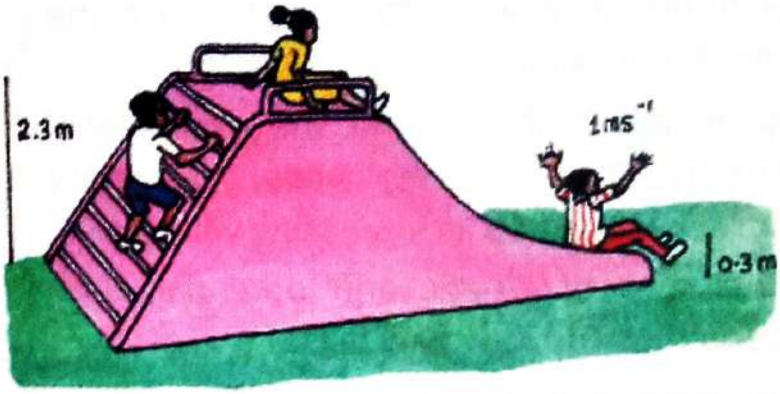


Figure 1.17: concrete slide

At a playground, Musa of 25 kg mass climbs up a concrete slide of 2.3 m height and slides down the slope. At the end of the slope, which is 0.3 m above the ground, his velocity is 1 m s–1.

a). What is his change in potential energy?

b). What is his kinetic energy at the end of the slope?

(Take g = 10 m s-2)

A mango falls from a height of 6 m. What is the velocity of the mango just before it hits the ground? [Take g = 10 m s–2]

A ball is thrown up at a velocity of 8 m s–1. How high will it go?

[Take g = 10 m s–2]

Simple machines

A simple machine is a device that is used to change motion and force in order to perform work.

Examples of simple machines include the inclined plane, lever, wedge, wheel and axle, pulley and screw.

Activity 1.9: Identifying and classifying simple machines

Key Question: What are the different classes of machines?

What you need

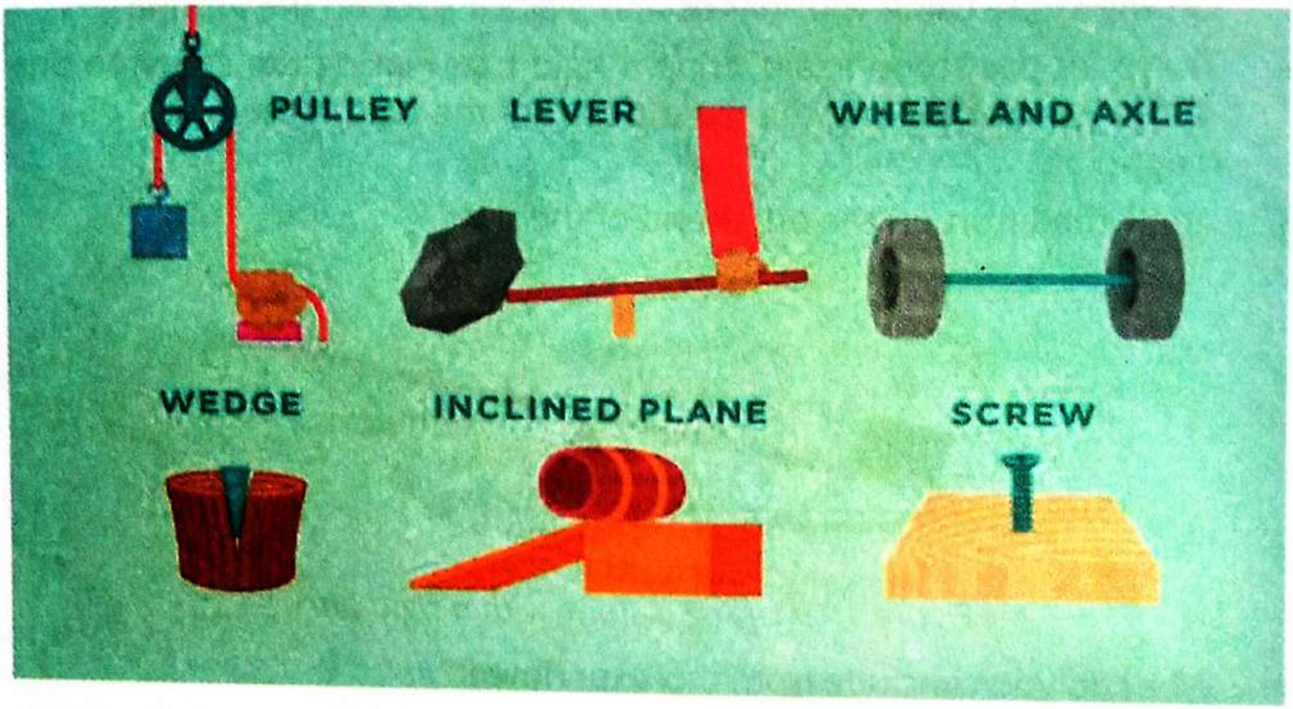


Figure1.18: Different types of simple machines

What to do

1. Write the name and use of each of the simple machines in Figure 1.8
2. Summarize your findings in the table1.2

Table 1.2: Names and uses of simple machines

Letter	Name of simple machine	Uses
A	Inclined plane	

LEVERS

A lever is a simple machine. It consists of a rigid bar which is free to turn about a fixed point called fulcrum. The weight to be lifted is the load and force applied to the bar is called effort. The distance of the load from the fulcrum is called the load arm and the distance of effort from the fulcrum is called the effort arm.

Activity 1.10: Demonstrating a lever as a simple machine

What you need

- Rigid bar
- Heavy stone
- Two bricks

THEME: Mechanics and Properties of Matter

What to do

1. Lift the stone using your hands and place it back on the ground
2. Try to lift the stone again using a rigid bar. Placing the stone on one end of the bar and placing the middle part of the bar on the bricks of a certain height.
3. Apply the effort on the other end of the bar

Figure 1.19 Lifting a stone with a rigid bar

4. What do you conclude from this experiment?

DID YOU KNOW?

There are three types of levers. They include: first class lever, second class lever and third class lever.

They are classified depending upon the position of the load, effort, and fulcrum.

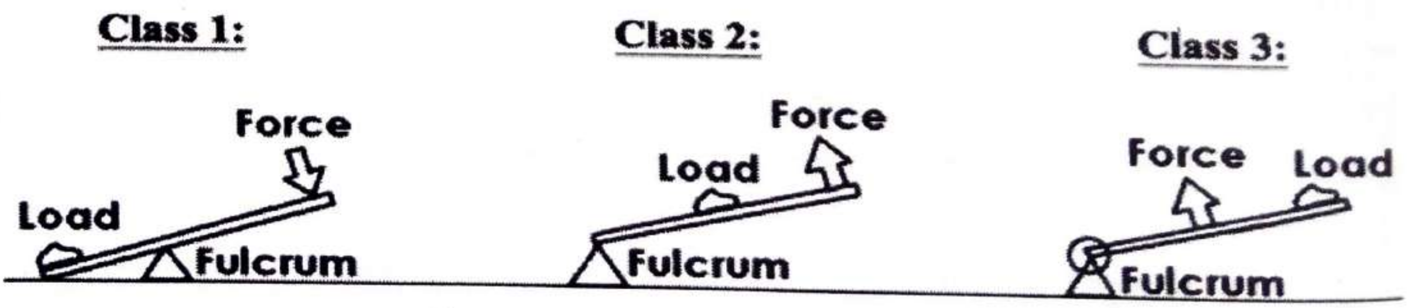


Figure1.20: Three Classes of Lever

Activity1.11: Classifying levers

Key Question: Identify the class of lever for each of the machines in figure 1.21

What you need

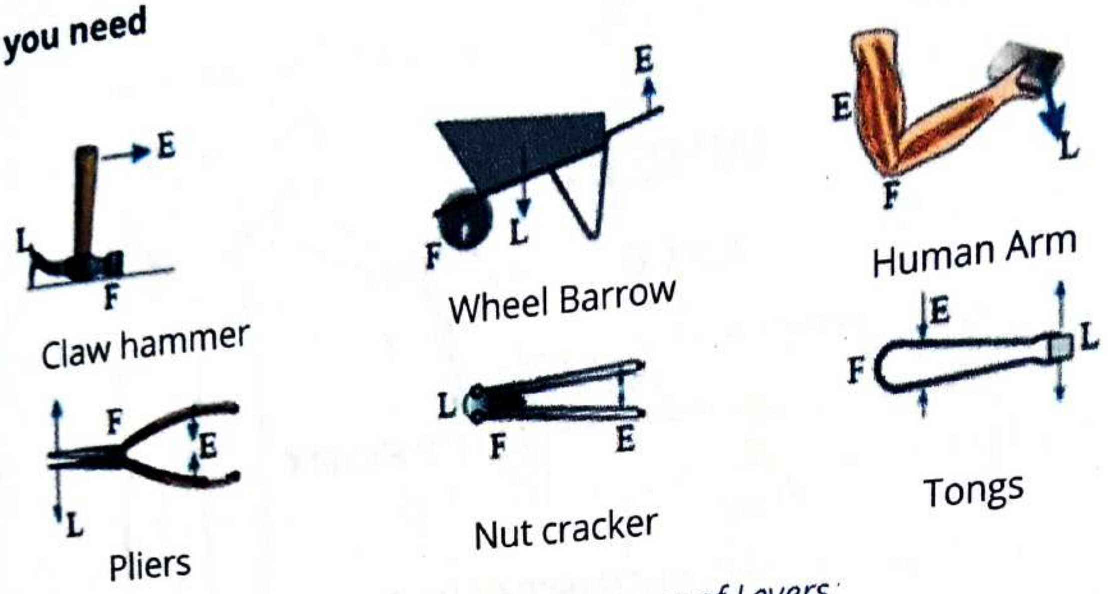


Figure1.21: Different types of Levers

What to do

1. Identify the fulcrum, load and effort on each of the simple machines in Figure 1.21
2. Suggest the class of lever where each one belongs.
3. Design a table to summarize your finding

PULLEYS

A pulley is a simple machine consisting grooved circular disc and rope. The rope passes over the groove in the circular disc. A load is attached to one end of the rope while the effort is applied at the another end of the same rope.

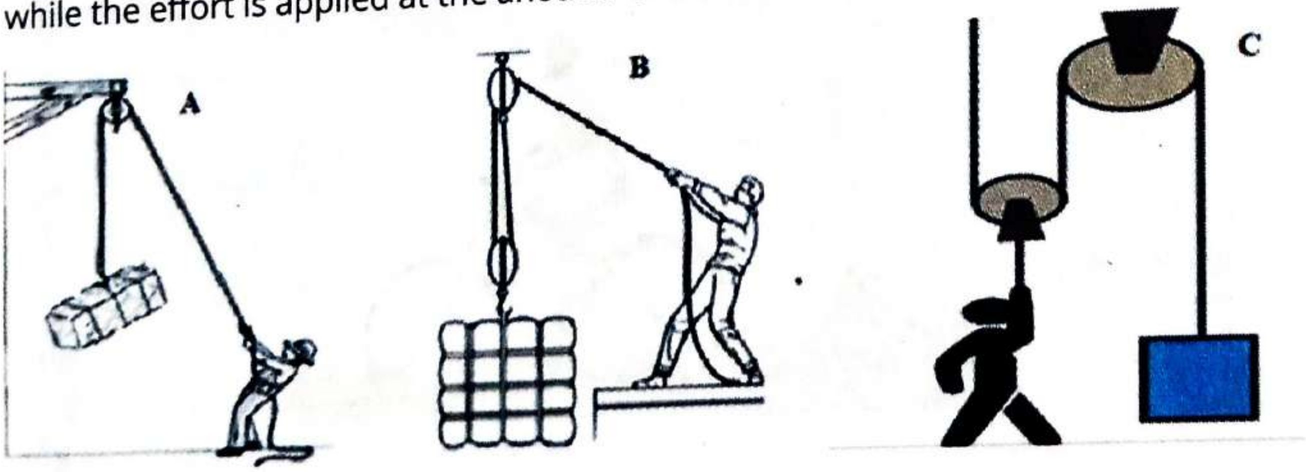


Figure 1.22: Pulleys

Wheel and axle

Wheel and axle consists of two cylinders having different radii. The cylinder with a small radius is the axle while the cylinder with a large radius is a wheel. The load is attached to the axle and the effort is applied on the wheel to lift the load.

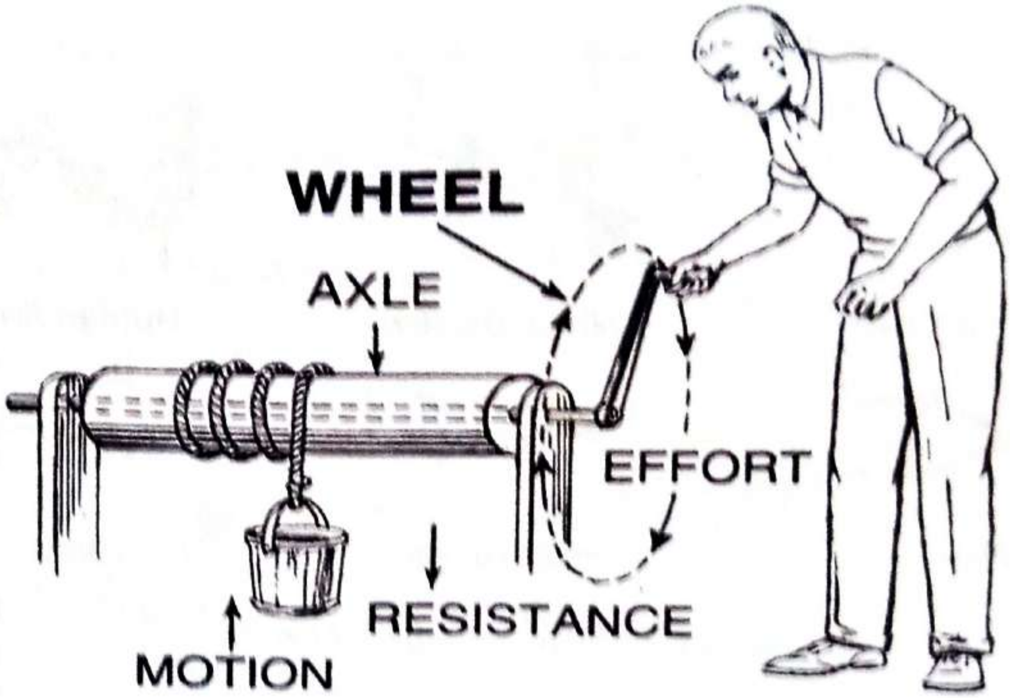


Figure1.23: Wheel and Axle

There are many applications of wheel and axle including: paddle of bicycles, d used by carpenters, steering wheel and door lock designs

Activity 1.12: Explaining the operation of wheel and axle in bicycles

Key Question: Explain the operation of the wheel and axle in bicycles

What you need

- A bicycle

Figure1.24: Bicycle as application of wheel and axle machine

What to do

1. Turn the paddle of a bicycle.
2. As the paddle turns, observe the paddle and wheels.
3. Which of them turns faster?
4. Explain your answer.

Inclined plane

Activity 1.13: The inclined plane

Key Question: How can an inclined plane be used to make work easier?

What you need

- Plank of wood
- Load
- High table

What to do

1. Suggest how you can use the plank of wood to deliver the load on top of the table.
2. Give examples where the inclined plane is used in everyday life.

SCREWS

Figure1. 25: Screws

Activity 1.14: Driving a screw into wood

What you need

- Screw
- Piece of Wood
- Screw driver
- Hammer

What to do

1. Place a screw with its pointed end on the wood. Try to hammer its head to drive the screw into the wood.
2. Place another screw with its pointed end on the wood and drive it into the wood by rotating its head with a screw driver
3. Which method is easier? Explain your answer

Mechanical Advantage (MA) and Velocity Ratio (VR)

Mechanical advantage is defined as the ratio of resistance force to be overcome (load), to the effort applied. The simple machine requires force to work. The resistive force to be overcome is called load. The force applied to overcome the load is called effort.

Velocity Ratio of simple machine is the ratio of distance travelled by the effor the distance travelled by the load in the machine.

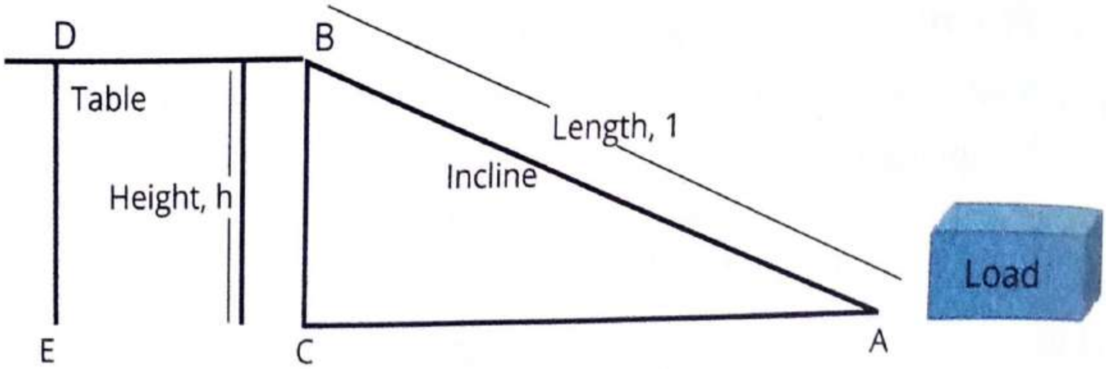


Figure1.26: Inclined plane

The load moves a vertical height h from the ground to the top of the table. Howev the effort moves a distance l (length of the incline) in pushing the load from t ground to the top of the table.

$$\text{Velocity ratio for the inclined plane} = \frac{\text{length of the incline, l}}{\text{Height of the incline, h}}$$

$$\text{Velocity ratio for the wheel and axle} = \frac{\text{Radius of wheel}}{\text{Radius of axle}}$$

DID YOU KNOW?

Mechanical Advantage or Velocity Ratio does not have unit.

Mechanical Advantage(MA)

$$\text{Mechanical Advantage(M.A)} = \frac{\text{Load(L)}}{\text{effort applied(E)}}$$

- The Mechanical advantage describes how many times is load in terms of the effort.
- It depends on friction

Velocity Ratio (VR)

$$\text{Velocity Ratio} = \frac{\text{Distance moved by Effort(DE)}}{\text{Distance Moved by Load(DL)}}$$

- The effort distance is always further than the load distance
- The velocity ratio does not depend on friction

Efficiency (Eff)

Efficiency is the ratio of mechanical advantage to the velocity ratio as a percentage

$$\text{Efficeincy} = \left(\frac{MA}{VR} \times 100\right)\%$$

Efficiency is always less than 100% because of friction which causes energy loss

Exercise 1.9

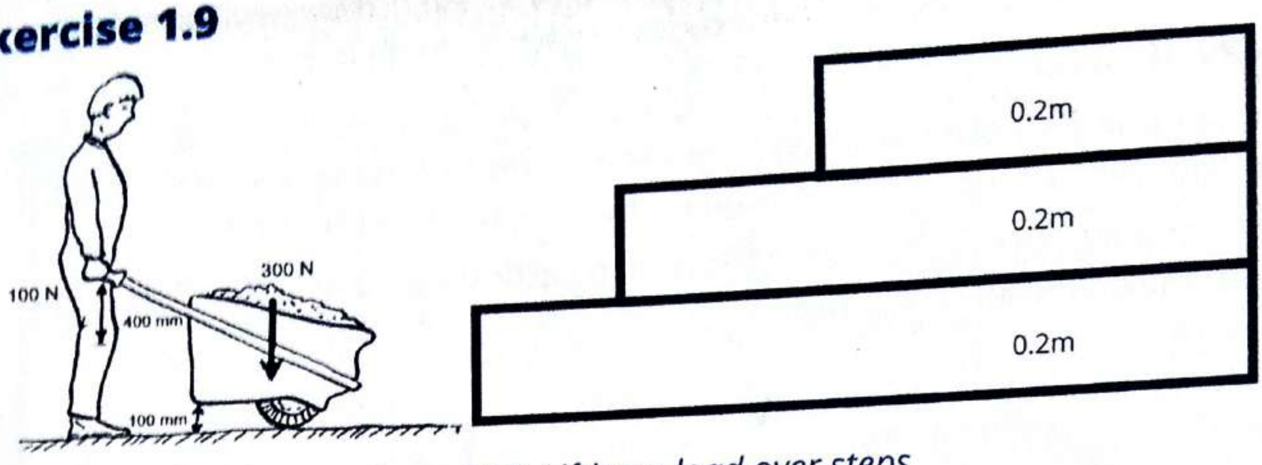


Figure1.27: Lifting a load over steps

A man lifts a load of 300N on wheel barrow through a load distance of 100mm with force 100N through effort distance of 400mm.

Determine

1. work input into the wheel barrow
2. work output
3. mechanical advantage
4. velocity ratio
5. efficiency of the machine

If the man took 5 minutes to push the wheel barrow with 80 N through a horizontal distance 10 m. Determine his power.

If the man is required to move the load on the room three steps each 0.2m above, which strategy should apply to accomplish the task. Explain your answer.

Chapter Summary

- No life without the sun.
- Mechanical energy is energy possessed by a body due to its position or state of motion.
- The law of conservation of energy states that energy can neither be created nor destroyed.
- Renewable energy sources can be used again or recycled while non-renewable energy sources cannot be used again or recycled.
- Energy is the ability to do.
- Work is defined as the product of force and the distance moved in the direction of the force. The S.I unit for work is Joules(J)
- Simple machine is a device that is used to change motion and force in order to perform work.
- The rate at which work is done is called power.
- There are three types of levers which include: first class lever, second class lever and third class lever.
- Mechanical advantage is defined as the ratio of resistance overcomes to the effort applied.

4

- Velocity Ratio of simple machine is the ration of distance travelled by the effort to the distance travelled by the load in the machine.

Activity of integration

Jaden can pull a load of mass 120 kg along a 3 m inclined wooden plane onto a lo 0.9 m high with a rope whose tension is 600 N as shown in Figure 1.28(a).

Instead of pulling, Jaden can also lift the load vertically up a height of 0.9 m onto t lorry as shown in Figure 1.28(b).

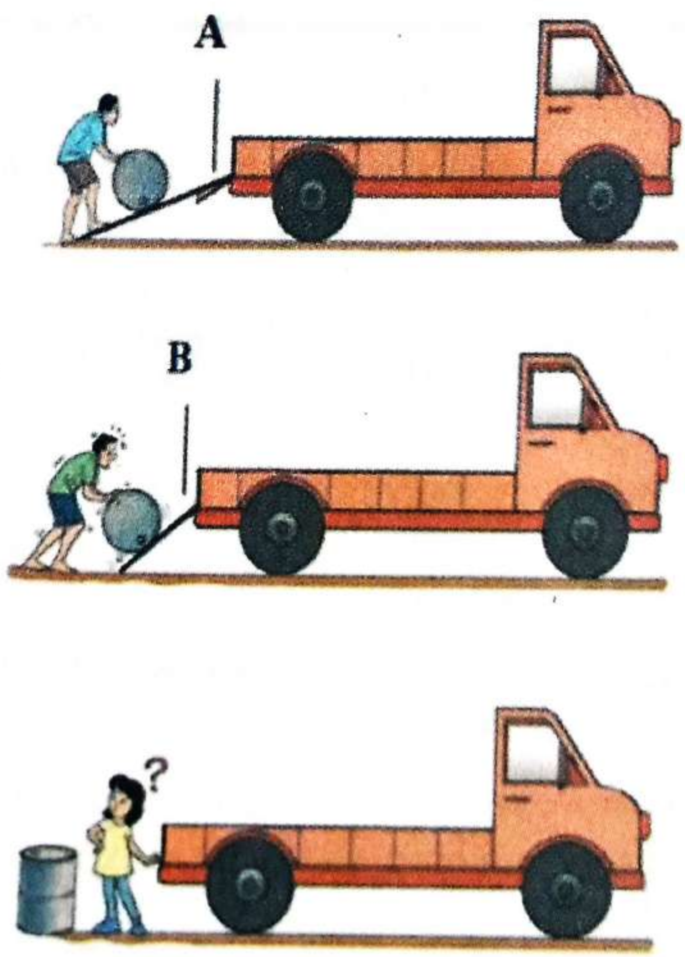
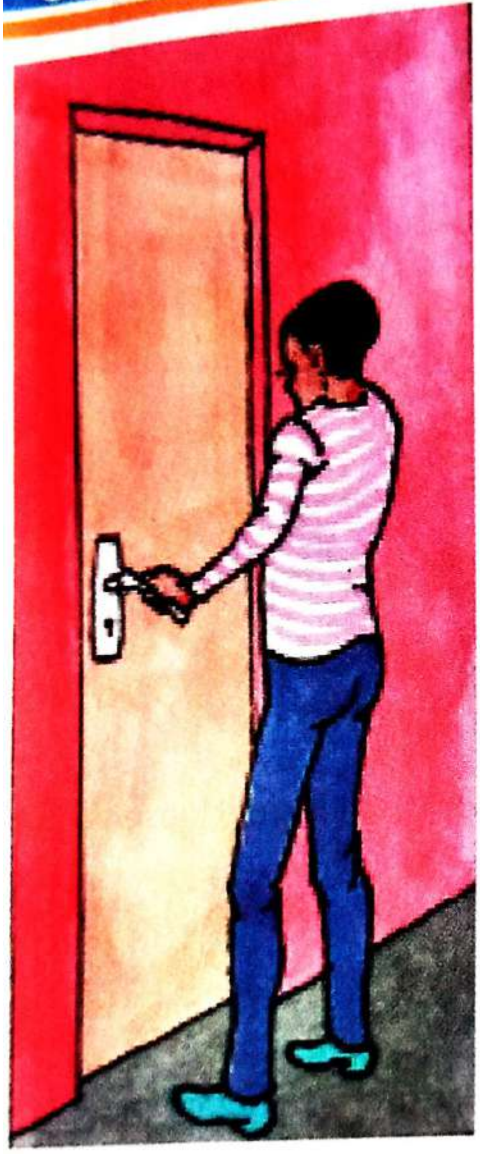
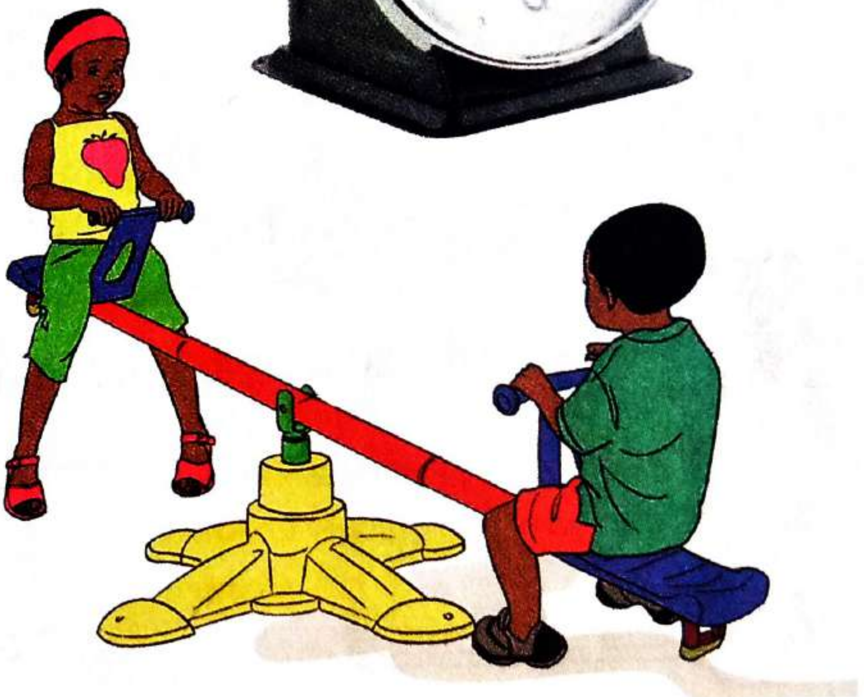


Figure1.28: Lifting a load over an incline plane

Advise Jaden, with reasons, which method would be easier to use to raise the hea load onto the back of the lorry.

CHAPTER 2
TURNING EFFECT OF FORCES, CENTRE OF GRAVITY AND STABILITY





Key words

- Pivot
- Moment
- Clockwise moment
- Anticlockwise moment
- Equilibrium
- Centre of gravity
- Stability
- Stable equilibrium
- Unstable equilibrium
- Neutral equilibrium

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

a) Understand the turning effect of forces and its applications.

b) Understand and apply the concept of centre of gravity.

THEME: Mechanics and Properties of Matter

2.1. Introduction

When a body is hinged or pivoted at a point and a force is applied to it, it can about the point. Every time we open a door by turning the handle, turn on a tap, a steering wheel of a car or even tighten up a nut with a spanner, we exert a tur force. Can you find out other examples where a turning force is applied in our life? The turning effect of force also plays a big role in stability of all things aroun In this chapter, you will understand how the turning effect of forces affects stal of bodies.

Factors on which the turning effect of a force depends

Activity 2.1. Investigating the turning effect of a force

Key Question: Which spanner would tighten and untighten the nut

What you need

- Long spanner
- Short spanner
- Nut and bolt
- Piece of wood with a fixed bolt

What to do

1. Use spanners in Figure. 2.1 (a) and 2.1(b) below to tighten and loosen a from a bolt.
2. Select the spanner easier to use.
3. Explain why it is easier?

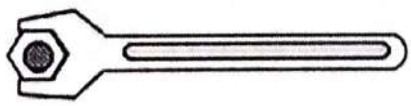


Figure. 2.1 (a) Short spanner

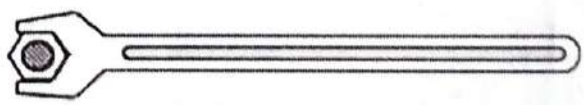


Figure. 2.1 (b) Long spanner

4. State what would happen if you used the longer spanner in Figure. 2.1 above to undo the tight nut.
5. Another Instruction point along its length you would hold in order to produ a biggest turning effect? Explain your answer.
6. Describe other everyday examples of turning forces.

DID YOU KNOW?

The turning effect of a force depends on both the size of the force and distance from the point about which a body turns. This point is called pivot or fulcrum and the turning effect of a force is its moment.

2.2. Principle of moments

Activity 2.2: Verifying the principle of moments

Key Question: How do you state the principle of moments?

What you need

- A knife edge
- One metre rule
- Two pieces of thread (each about 20 cm long)
- Six 20g masses (preferably slotted)

What to do

1. Balance the metre rule provided horizontally on the knife edge and note the position of the point of balance.
2. Use a piece of thread to suspend a 20 g mass (M_1), 10 cm from one end of the metre rule and another mass of 40 g (M_2) on the other side of the knife edge.
3. Adjust the position of the 40g mass until the metre rule balances horizontally.
4. Measure and record the distances y^1 and y^2 of the 20 g and 40 g masses respectively from the knife edge. See Figure 2.2 below.

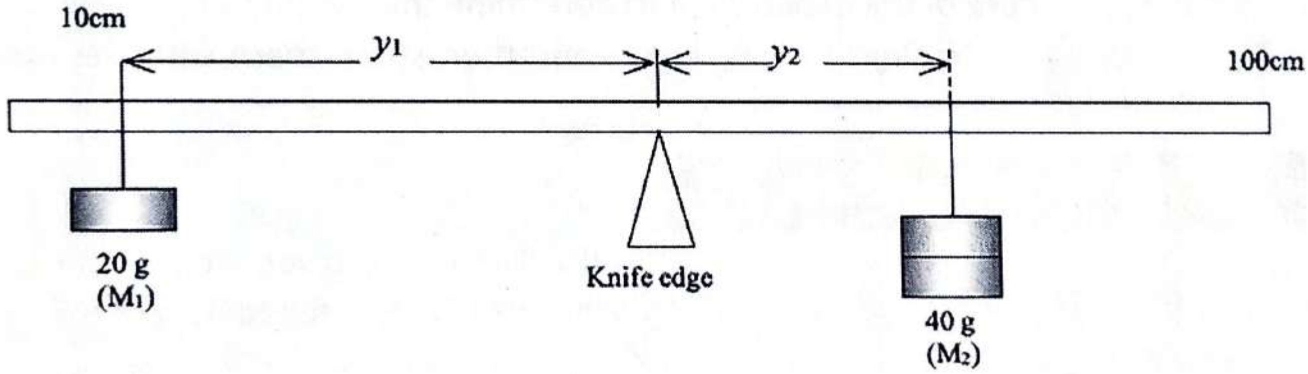


Figure. 2.2 Principle of moments

5. Repeat the experiment by hanging different pairs of masses at different points on either side of the knife edge.
6. Record your results in the table below and include values of the products of the weights (W_1 and W_2 respectively) of the masses (in N) and distances measured (in m).

Table 2.1

M_1(g)	W_1(N)	y_1(cm)	y_1(m)	M_2(g)	W_2(N)	y_2(cm)	y_2(m)	$W_1 x y_1$ (Nm)	$W_2 x y_2$ (Nm)
20	0.2			40	0.4				

7. What is your comment about the columns for the products of the weights and their distances from the knife edge?
8. Give everyday life examples where the principle of moments is applied.

9. Discuss your findings in your group and prepare present atom them to the rest of the learners in your class.

Weighing by using the principle of moments

The principle of moments can be used to find the weight of an object by using a known weight.

Activity 2.3: Determining weight of an object

Key Question: How do you determine weight using the principle of moments?

What you need

- A metre rule
- Knife edge
- Two pieces of thread (each about 20 cm long).
- Unknown amount of salt between 100 g and 200 g.
- Known mass (50 g).

What to do

1. Estimate the unknown amount of salt
2. Suggest an experimental setup of the apparatus you are provided with, and the procedure of the experiment to determine the weight of the object.
3. Discuss your findings in your group and then share them with the other groups in your class.

FOR YOUR KNOWLEDGE

Where there is more than one force on the side of the pivot, we find the sum of the moments and still apply the principle of moments to handle the calculations.

Exercise 2.1

1. A uniform metre rule of negligible weight is balanced horizontally on a knife edge at its middle when masses of 0.2 kg and 0.5 kg are hung from the 20 cm and 90 cm marks as shown in Figure. 2.3.

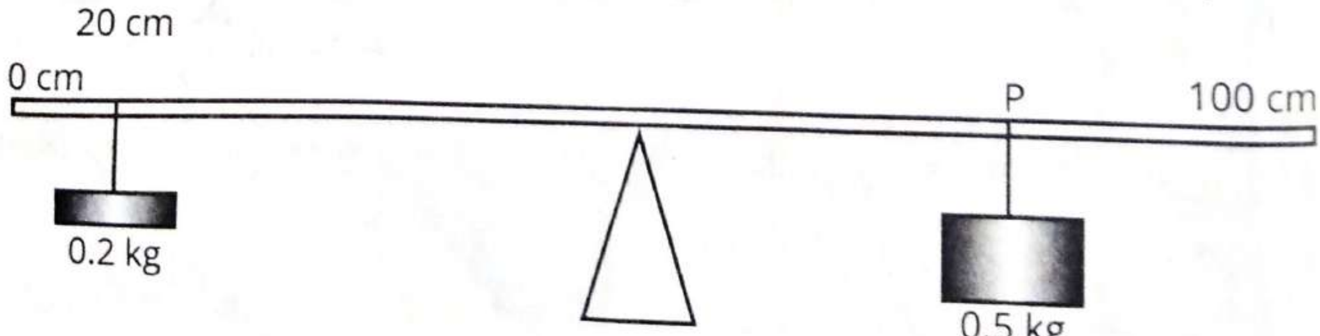


Figure. 2.3: Weights on a metre rule balancing on a pivot

a). What is meant by the term uniform metre rule?
b). At what point is the metre rule pivoted?
c). Calculate the distances of the 0.2 g mass and 0.5 g mass from the pivot.
d). Calculate the moments due to the 0.2 g and 0.5 g masses about the pivot.
e). Use the principle of moments, find the position x at which the 0.5 g mass is suspended on the metre rule.

Exercise 2.2

A wooden beam of negligible weight is balanced horizontally at its centre as shown in Figure. 2.4 below. Using the principle of moments, find the weight P.

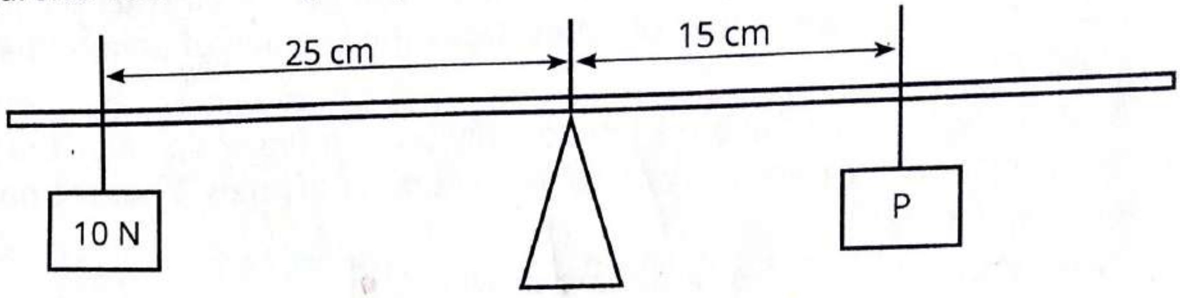


Figure. 2.4: Weights on a wooden beam

Exercise 2.3

1. In Figure. 2.5 below, the uniform rod of negligible weight balances when weights of 3 N, 4 N and W are suspended at points A, B and C respectively. Find W.

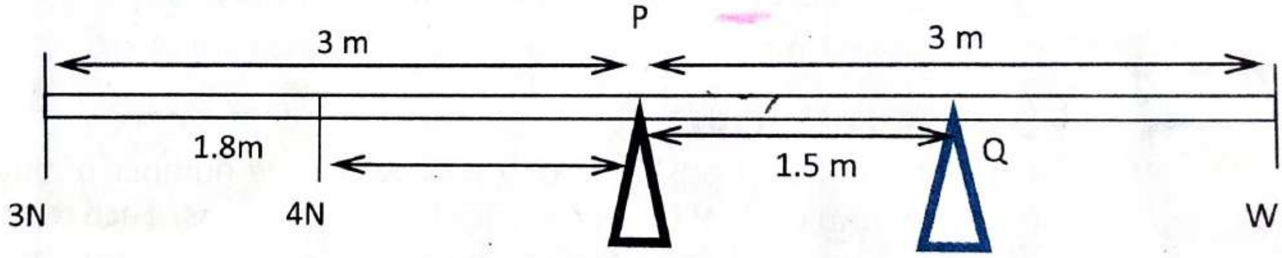


Figure. 2.5: Weights on a metre rule balancing on a two pivots

Group Assignment

What to do

1. Use the internet or other sources to:
   a). Find the meaning of the following terms:
      i). Parallel forces.
      ii). Like and unlike forces.
      iii). Couple.
   b). State the conditions for a body to be in equilibrium.
2. Present your findings to the rest of the learners in class.

2.3. Centre of gravity

Have you ever balanced a book or a metre rule on your finger-tip? Try it.

Activity 2.4: Locating point of balance on a metre ruler

Key Question: How do you estimate the center of gravity of different objects?

What you need

- Metre rule
- A book (preferably with hard cover like a counter book)
- A rectangular cardboard (20 cm by 15 cm).

What to do

1. Balance the metre rule horizontally at your finger-tip. At what point does it balance? Do it a number of times. Does the position of point of balance change?
2. Now try to balance the book horizontally on your finger-tip. Mark the point of balance with a pencil. Try to do this a number of times. Does the point of balance change?
3. Repeat step 2 using the cardboard provided.
4. Draw diagonals on the book and also on the cardboard. Mark the point where the diagonals meet. What do you notice about the position of the point of balance and the point of intersection of the diagonals drawn?
5. Name the term given to the point at which these objects balance?
6. Share your findings with the other learners in class.

DID YOU KNOW?

A body like your book is made up of very large number of tiny particles, and each of these particles have equal mass. Each mass is equal in weight because of gravity of the earth. The earth's pull on the body thus consists of a very large number of equal parallel forces, which will have a resultant force equal to the total force of gravity on the body, known as weight of the body.

How then can you define the centre of gravity?

From **Activity 2.4**, you will notice that a body can only balance at only one point. It is this point through which the total weight of a body acts. Also, **Activity 2.4** helps to describe how the centre of gravity of a regular object can be located. For instance, the centre of gravity of a uniform metre rule is at the 50 cm-mark, for a regular (or a square) cardboard, it is at the point of intersection of the diagonals.

For a circular cardboard, where is the centre of gravity?

Activity 2.5: Locating centre of gravity of an irregular lamina

Key Question: How do you locate the center of gravity of an irregular?

What you need

- An irregular cardboard.
- A straight edge (or a metre rule)
- A plumbline (or a pendulum bob tied to a piece of thread).
- A nail or optical pin.
- A retort stand with a clamp.

What to do

Method 1: Balancing method

1. Make a metre rule lie on its edge on the table and balance the irregular cardboard on it.
2. Mark on the cardboard the line AB along which it balances on the metre rule.
3. Change the position of the cardboard and balance it again on the metre rule and mark the new line CD along which it balances.
4. Mark the position of the point of intersection of the two lines.
5. Mark the third line **EF** of balance on the cardboard. What do you notice?
6. Try to balance the cardboard on your finger-tip.
7. Write the conclusion you can draw from your findings?
8. Discuss your findings and present them to the rest of the learners in your class.

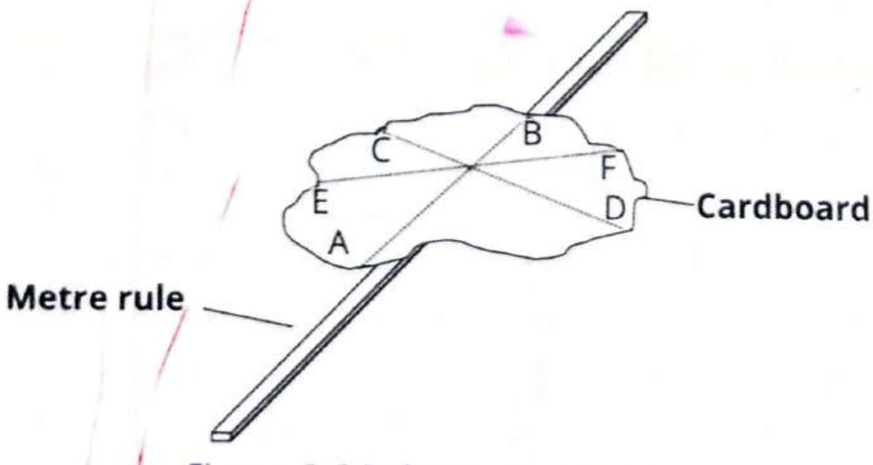


Figure. 2.6 Balancing a cardboard

Method 2: Plumbline method

1. Make three small well-spaced holes a, b and c, near the edge of the irregular cardboard. (The holes should be large enough to allow the cardboard turn freely when supported through an optical pin or nail clamped horizontally).
2. Suspend the cardboard at hole a by using a nail or optical pin clamped horizontally and leave it to swing freely in a vertical plane.

3. Suspend the plumbline from the point of support as shown in Fig. below.

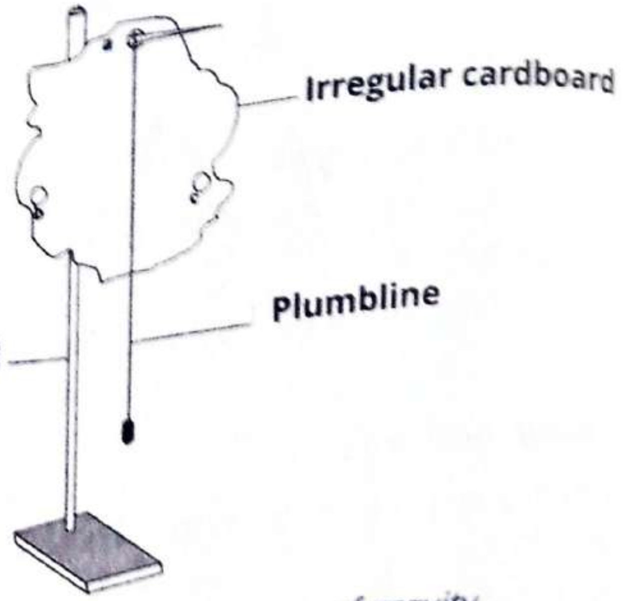


Figure.. 2.7 Locating centre of gravity

4. When both the cardboard and the plumbline have stopped swinging, two marks on the cardboard along the plumbline and join them using drawn using the metre rule through hole a.
5. Repeat the steps by suspending the cardboard from holes b and
6. Record your observation?
7. Try balancing the cardboard at the point of intersection of the drawn. Name conclusion you can draw from this experiment?

For a uniform metre rule, its centre of gravity is at the 50 cm-mark and so acts through that point.

Activity 2.6 Determining weight of a metre rule

Key Question: How can you find the weight of metre rule ?

What you need

- Metre rule
- Two pieces of thread (each about 50 cm long)
- Retort stand with clamp
- 100g mass

What to do

1. Suspend the metre rule in a loop of thread hung from a clamp of a stand and adjust its position until it balances horizontally. Mark the point of balance on the metre rule as G. What is this point called?
2. Suspend the 100 g mass at the 5 cm-mark and adjust the position of the in the loop of thread until it again balances horizontally as shown in Fig 2.8 below.

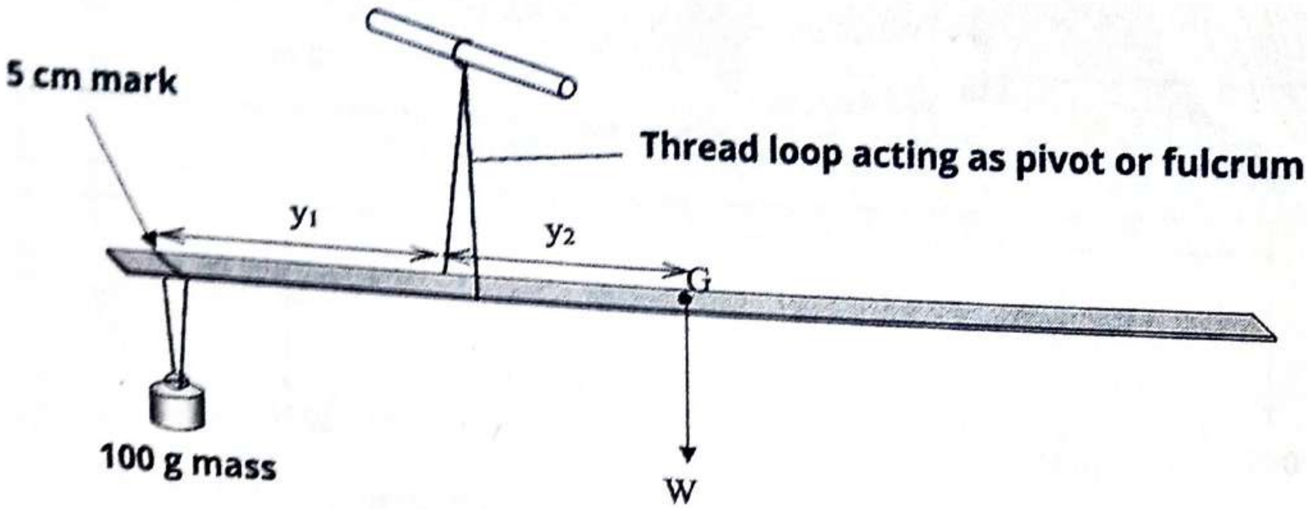


Figure.. 2.8 Determining weight of metre rule

3. The metre rule is said to be in equilibrium under the action of two moments. Can you identify the moments?
4. Determine the distances y^1 and y^2 respectively of the 100 g mass and G from the loop of thread used to suspend the metre rule.
5. Using the principle of moments, write a formula that can be used to determine the weight W of the metre rule. What is the calculated value of W?
6. Repeat the steps when the 100 g mass is suspended at the 10 cm-mark.
7. Determine the new weight W_1 of the metre rule.
8. Compare the values of W and W_1.
9. Share the results of this activity with the rest of the learners in your class.

Exercise 2.4

1. A uniform metre rule AB is pivoted 30 cm from end A. It balances horizontally when a weight of 5 N is hung at A. Calculate the weight of the metre rule.
2. A uniform bar weighing 40 N and measuring 2 m is hinged at one end so that the unhinged end can move up and down. If it is held horizontally by a spring balance at 0.3 m from the free end, determine the reading of the spring balance.
3. A uniform metre rule balances on a knife edge at the 60 cm-mark when a weight of 20 N is suspended at one end. Calculate the weight of the metre rule.
4. A uniform beam AB 4 m long is pivoted at its geometrical centre and is held in equilibrium by a number of weights suspended as shown in Figure. 2.9 below. Determine the value of distance x.

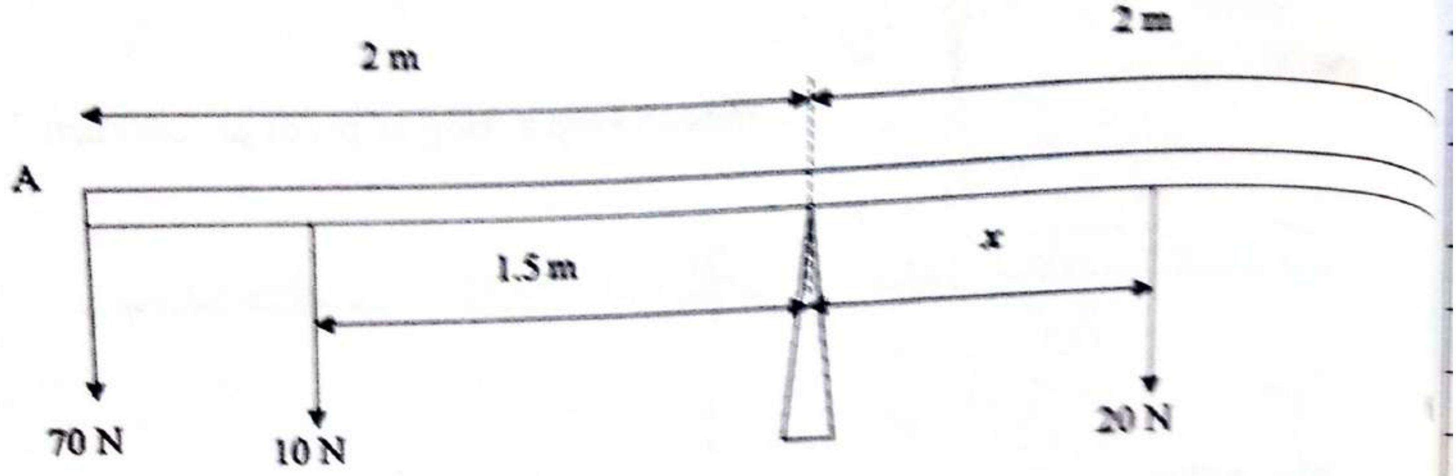


Figure.. 2.9 Uniform beam AB on pivot

Stability and states of equilibrium

Stability is a term used to describe how easy or difficult it is for an object to t over when a force is applied to it. Some bodies are more stable than others. Have you ever tried to make a pencil balance on its tip? How easy was this? about balancing it on its flat end? How about balancing a plastic thistle funne tip and base? Which is easier?

Assignment 2.3: Recording the states of equilibrium

What to do

1. Conduct a research from the internet or any relevant textbook o meaning of stability of a body and the states of equilibrium.
2. Describe each of the states of equilibrium.
3. Compare and discuss your findings with other groups in your class.

Activity 2.7: Identifying stable and unstable positions of items

Key Question: What is meant by stability of an object?

What you need

- A ball
- A pencils
- Filtering funnel
- Mineral water bottle

What to do

1. In which position would an object remain unchanged if you slightly tilt Discuss with one of your classmate
2. Record your results in the table 2.1

Table 2.1

Items	Positions		
	Remains unchanged	**Changes to a new position**	**May change or not to the position**
Pencil			
Filter funnel			
Ball			
Mineral water bottle			

3. Describe each of the states of equilibrium.
4. Compare and discuss your findings with other groups in your class.

DID YOU KNOW?
Stability is a term used to describe how easy or difficult it is for an object to topple over when a force is applied to it. The positions of some bodies are more stable than others.

Activity 2.8 Investigating the relationship between the position of center of gravity and stability of an object (work in pairs)

Key Question: What is the relationship between stability and center of gravity?

What you need

- Plastic filter funnel

What to do

1. Place the filter funnel with its wider mouth resting on the bench or table.
2. Displace the funnel slightly in the direction shown in Figure. 2.10 below and then released. What do you observe?

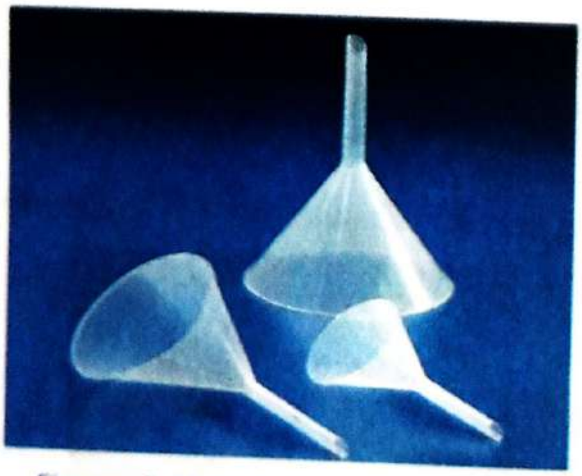


Figure. 2.10 Stability of filter funnel

Table 2.1

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	Remains unchanged	Changes to a new position	May change or not to the position
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Filter funnel			
Ball			
Mineral water bottle			

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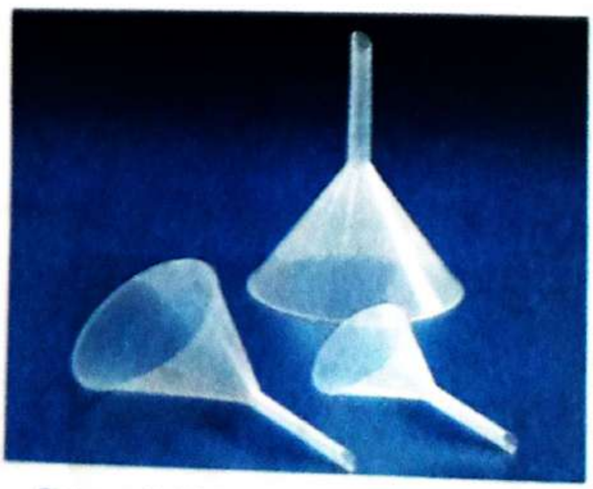


Figure. 2.10 Stability of filter funnel

3. Explain the behaviour of the funnel in terms of the changes in position of center of gravity. What state of equilibrium is the funnel in?
4. Discuss your findings and share them with the rest of the learners in class.

Activity 2.9 Demonstrating unstable equilibrium (work in pairs)

Key Question: How do you demonstrate unstable equilibrium?

What you need

- Plastic filter funnel

What to do

1. Place the filter funnel upright with the narrower mouth resting on the or bench as shown in Figure. 2.11 below.

Figure. 2.11 Instability of filter funnel

2. Displace the funnel slightly with your finger and release it.
3. Explain Your observation in terms of the change in position of its cen gravity in this activity.
4. Place the funnel to rest horizontally on its side as shown in Figure. 2.1
5. Displace the funnel slightly by giving it a slight push.

Activity 2.10 Demonstrating neutral equilibrium

Key Question: How do you demonstrate neutral equilibrium?

What you need

- Plastic filter funnel

What to do

1. Place the funnel to rest horizontally on its side as shown in Figure. 2.1

Figure 2.12 Neutral filt...

2. Displace the funnel slightly by giving it a slight push.
3. Explain the behaviour of the funnel in terms of the change in position of its centre of gravity when slightly displaced.
4. Discuss your findings and make a presentation to the class.

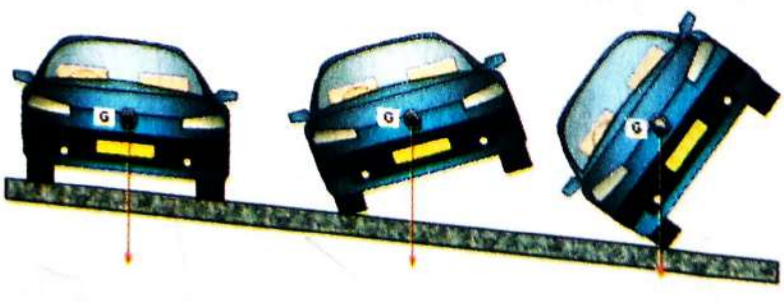
Some applications of the position of centre of gravity

Assignment 2.2

1. Conduct a research on the applications of the position of centre of gravity.
   a). Why is the bus chassis made heavier than the other parts? Heavier chassis are placed in the low part of the bus because this lowers the centre of gravity so that it can acquire stable equilibrium
   b). Why does the luggage compartment in a bus designed below the passengers' seats instead of roof rack?
   c). Why are racing cars low and have wide wheel base?
   d). Why do people who are taller than the average height tend to fall more easily as opposed those who are shorter?
   e). Why does someone have to lean in the opposite direction when carrying a load.
   f). Why does someone has to lean in the opposite direction when carrying a load.
   g). Why it is not advisable for people in a small boat on water to neither stand or lean over its sides.
2. Compile your findings and discuss with other groups and then prepare a presentation to the whole class.

Racing car made as low as possible, and wheel axle is wide

(a) Racing car



(b) Tilting cars

(c) Testing the stability of a bus (d) Double-decker bus

Figure. 2.13 Stability of racing cars and buses

Chapter Summary

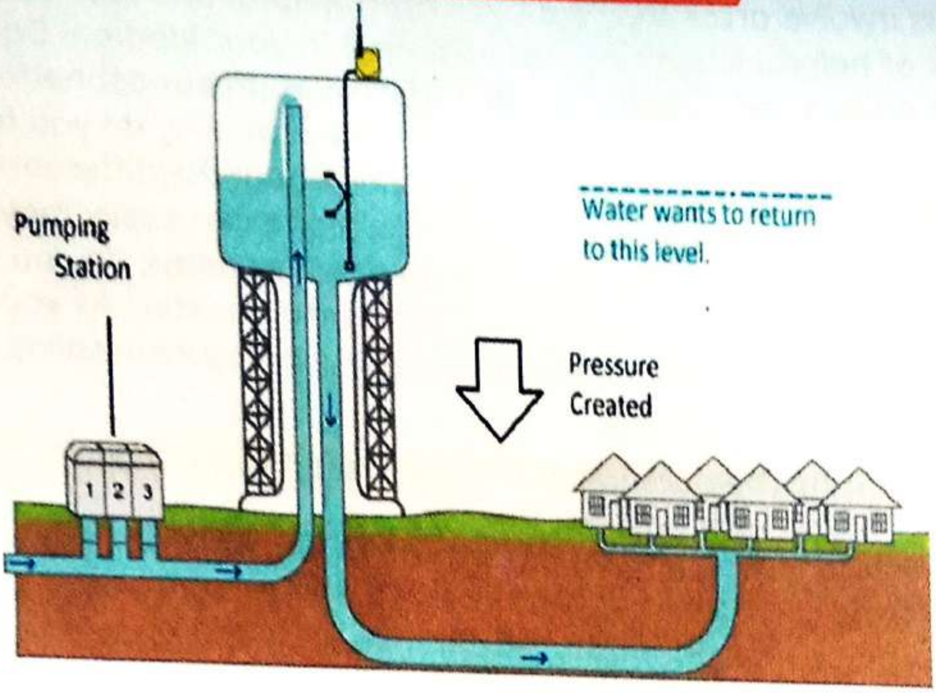
In this chapter, you learnt about:

- turning effect of a force, which is moment of a force.
- the factors affecting the turning effect of a force.
- the principle of moments.
- conditions for a body to be in equilibrium.
- everyday examples where principle of moments is applied.
- calculations involving principle of moments.
- parallel forces, like and unlike forces and couples.
- centre of gravity and how it can be located for regular and irregular lami
- stability of a body and the three states of equilibrium, i.e. stable, unstab and neutral equilibrium.
- applications of the position of centre of gravity especially in the manufac of motor vehicles and other areas of our everyday life.

Activity of integration

Truck drivers in your community load their trucks beyond what is required by tra rules. They are always arrested and charged for over loading by the traffic po department. Present a sensitization message to truck owners and the police in yo community using the scene of turning effect of forces and stability.

CHAPTER 3
PRESSURE IN SOLIDS AND FLUIDS



Key words
- Fluid
- Liquid
- Gases
- Atmospheric pressure
- Bernoulli's principle
- Atmosphere
- Mesosphere
- Troposphere
- Stratosphere
- Exosphere

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

a) Understand that pressure is the result of a force applied over an area.

b) Understand the effect of depth on the pressure in a fluid and the implications of this.

c) Understand the nature of the atmosphere and how atmospheric pressure is measured.

d) Know the structure of the atmosphere and the significance of the different layers.

e) Understand the use of the Bernoulli effect in devices like aero foils and Bunsen burner jets.

f) Understand the concept of sinking and floatation in term of forces acting on body submerged in a fluid.

g) Understand and apply the Archimedes principles in different structures.

3.1. Introduction

In our world, we experience and apply pressure in solids and fluids (liquids an
For instance, do you ever ask yourself why you wear shoes? Why closed w
leak after using it for some time? Or why the tyres of parked flatten after so
All these situations involve pressure. We have both helpful and harmful s
of pressure. Think of helpful situations you observed in your lifetime. Do y
that you could not drink a soda using a straw if there was no atmospheric p
What about harmful experiences of pressure? For example, why do you fee
pain if a sharp object penetrates into your body. Think about the difference i
the design of a tractor and a small saloon car. Which one can easily move
water logged ground and why? In the construction of water dams, do you kn
the base is wider than the top. What do you think is the reason? As you re
chapter, will learn about pressure and be able to explain pressure in solids an
and identify examples in everyday life.

Activity 3.1: Experiencing the bursting of inflated balloon with a pin

Key Question: Which side of the pin can burst an inflated balloon easily?

What you need

- 2 Balloons
- 1 thumb pin

(a). An inflated balloon (b). Thumb pins

Figure 3.1 Bursting of the ballon

What to do

1. Inflate a balloon and close so that air does not escape
2. Name the end of the thumb pin can easily burst the balloon?

3.2. Pressure in Solids

Activity 3.2: Investigating the relationship between weight and area of contact
ground

Key Question: What is the relationship between pressure, weight and contact
area?

What you need

- Spring balance
- Metre rule

Figure 3.2. A pile of five bricks

What to do

1. Make a vertical pile of 5 bricks by adding one by one on top of the other as in Figure 3.2.
2. Discuss how you can find mass, weight and contact area of the pile.
3. Measure mass and length of the sides of the brick.
4. Explain How you can find mass, weight and contact area between two bricks in a pile?
5. Record your results of mass, weight and contact area of pile as you add bricks.
6. Plot a graph of weight of a pile of 1-5 bricks against their contact areas.
7. Name the quantities that change as you add bricks to make taller pile?

FOR YOUR KNOWLEDGE

Pressure is force acting normally per unit area. The SI unit for pressure is Pascal(Pa) or newton per square metre (N/m2).

Mathematically, we can calculate pressure using:

$$Pressure(P) = \frac{\text{Force(F)}}{\text{Contact area(A)}}$$

F in Newton (**N**)

A in m^2

P in **Pa**

One Pascal is defined as a force of **1 N** acting normally on a contact area of **1 m²**

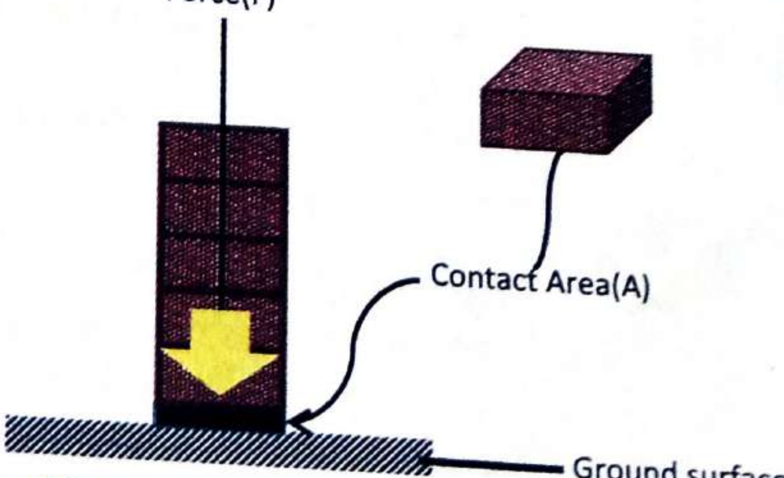


Figure 3.3. Normal force on contact area

DID YOU KNOW?
Pressure is scalar quantity. It is a derived quantity that has only magnitude and no direction.

Factors Affecting Pressure in Solids

Activity 3.3: Investigating factors affecting pressure exerted by solids on surfaces

Key Question: What factors determine the amount of pressure exerted by a body?

What you need

- A (6 cm x 4 cm x 3 cm) brick
- A bar of plasticine (molding clay)
- 1 Kg or 2 Kg weighing stone
- Ruler

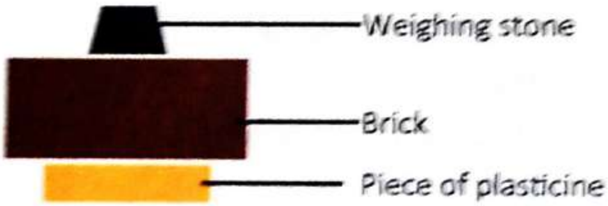


Figure 3.4 (a) brick resting on plasticine

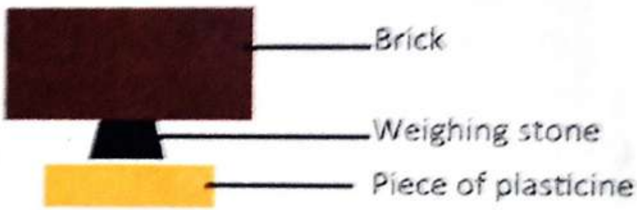


Figure 3.4 (b) Stone resting on plasticine

What to do

1. Cut two pieces of plasticine equal size from the molding clay like a piece soap from a bar of soap. Measure the sides of each piece of plasticine.
2. Place a brick on the plasticine and then a weighing stone on the brick a Figure 3.4 (a). Observe the changes on the plasticine.
3. Repeat by reversing a weighing stone and a brick as in Figure 3.4 (b). Do you notice any difference on plasticine? Explain.
4. Discuss how you determine the contact areas in Figure 3.4 (a) and Figure (b)
5. Determine pressure exerted on the plasticine in the two cases: Figure 3.4(a) and Figure 3.4 (b).
6. Discuss the factors that affect pressure in solids

DID YOU KNOW?
The two main factors affecting pressure exerted on a body are:
i). magnitude of force, and
ii). size of contact area between a force and the body

Exercise 3.1.

1. A brick of mass 3.0kg and dimensions 5.0 cm x 3.0 cm x 2.0 cm rests on different sides on the laboratory table. Calculate the possible amount of pressure exerted on the table.
2. Akello and Nakato are two women with the same mass 50 kg, but wear different types of shoes. Nakato wears a high heeled pair of shoes with area of contact 202 cm^2 while Akello wears flat pair of shoes with area of contact of 400 cm^2. Which woman exerts the highest pressure on the ground? With reason, which shoe can you recommend for wearing on the soft ground?
3. Why do farm tractors have large hind tyres?

Figure 3.5. Farm tractor

4. Why does an elephant walk easily in mud than an antelope?

Figure 3.6. (a) Elephants Feet

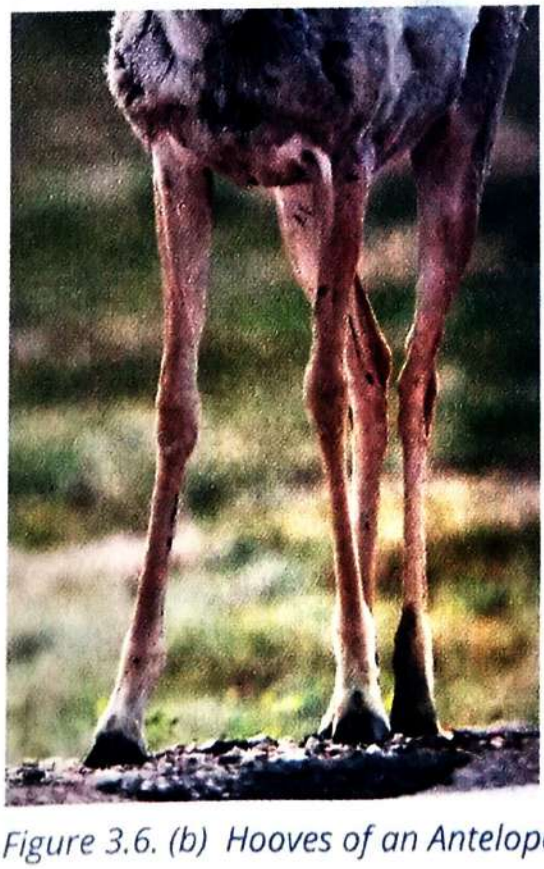


Figure 3.6. (b) Hooves of an Antelope

3.3. Pressure In Fluids

FOR YOUR KNOWLEDGE

A fluid may be a liquid or a gas? Like solids, fluids have mass and volume solid, fluids are not rigid and have no definite shapes. In fluids particles a further apart than in solids. Gases can be change the shape if compress liquids cannot be compressible. Both solids and liquids exert pressure.

Pressure in fluids (Liquids and Gases)

We have liquids like cooking oil and water around us. Which one exerts large pressure than the other? In urban areas, supply of water to houses fr rivers is possible because of pressure in liquids. In modern water-supply water is collected from a dam or a reservoir, stored in tank, treated, supplied to houses. Do you have water reservoir in your school? If yes, h water flow from the reservoir?

Figure 3.7. Water tap connected to water tank.

Activity 3.4: Researching a water storage and supply system in your comm

Key Question: How do you explain the flow of water from water dam reservoir to a house?

What you need

In modern water-supply systems, water is collected from a dam or reservoi in tank, treated, and then supplied to houses.

Figure 3.8 Water reservoir station for urban centre

What to do

1. Describe the flow of water from the reservoir to the storage tank.
2. Illustrate how water flow from the storage tank to a house?
3. Suggest why storage water tanks are always placed about the house?
4. Write a field report.

Conclusion and application

Naturally, water usually flows from upland sources such as crater lakes in the mountain to sources in low land due to differences in pressure. To lift water from lower level to a storage tank at upper levels, you need extra power using a water pump.

Activity 3.5: Investigating factors of pressure in liquid

Key Question: What are factors on which pressure depends?

What you need

- Sand on tray or in the basin
- Tall container (improvise with 1-liter empty mineral bottle water)

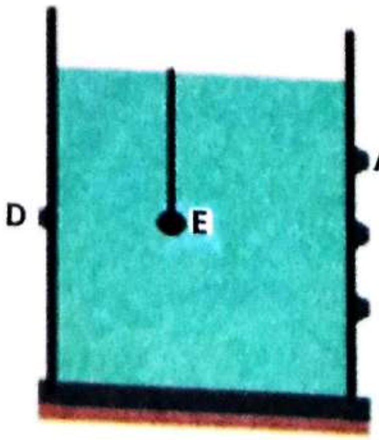


Figure 3.9: Tall container with holes A, B and C

What to do

1. Design a tall container (about 30 cm) with three holes: A, B, and C, equally space along the vertical line as in Figure 3.9
2. Close the holes with moldering clay and fill the container to the beam
3. Fill the container with water and open the holes almost at once. You can maintain the level of water as you observe the patterns of flow.
4. Mark points where water flowing from A, B, and C strike the sand
5. Describe the characteristics of water flowing from A, B and C
6. Measure the horizontal distance from the bottom of the line along the holes to the points where water struck the sand.
7. Suppose you replaced water with oil, what is the difference in the characteristics of the oil flow patterns?
8. State how far from the bottom of the can does water from each hole travel?
9. Draw the diagrams to compare the patterns of water and oil flow.
10. Suggest factors on which pressure in liquids depends.

DID YOU KNOW?
If you put a liquid in a container, it exerts pressure on the sides of the container because of the continuous motion of particles. Pressure in liquids increases on depth and density of a liquid.

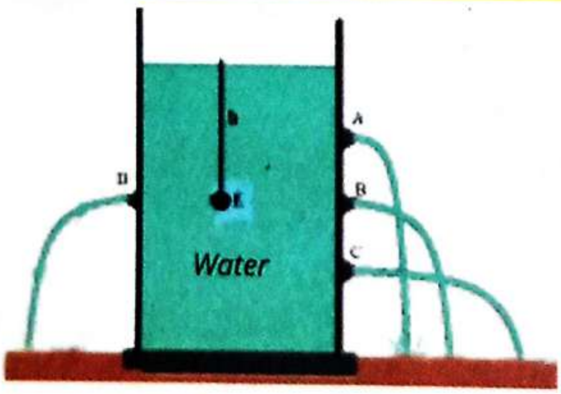


Figure 3.10. Pressure in a liquid

Note: Pressure at depth h of liquid of density ρ is equal to height (h) x density (ρ) x acceleration due to gravity(g) , $P=h\rho g$

Activity 3.6: Demonstrating that pressure in liquid is the same at a given level

Key Question: How do you demonstrate that pressure in liquid at a point is transmitted equally?

What you need

- 1.5 liter empty mineral water bottle
- Cello tape
- Water
- Sharp pin
- Basin

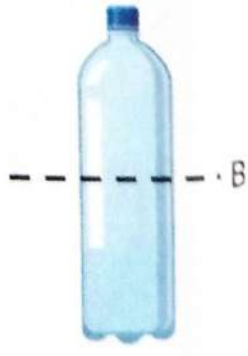


Figure 3.11: empty bottle

What to do

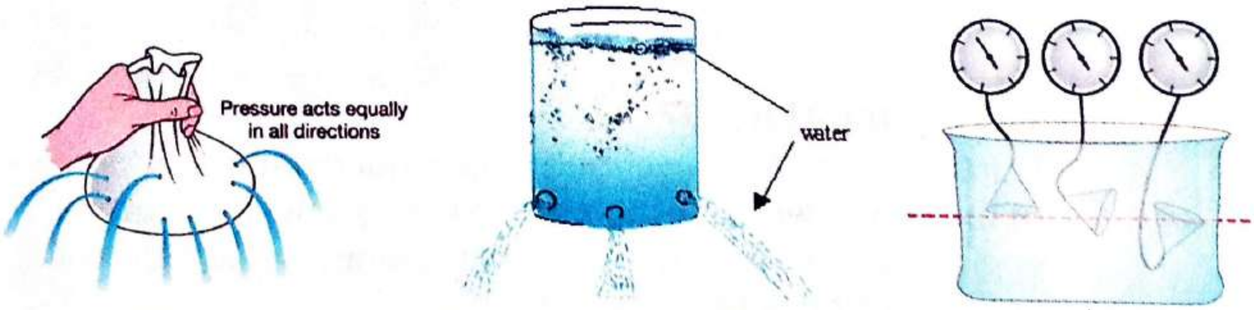
1. Design the empty mineral water bottle by making small holes D, E, F equally spaced, along the same horizontal level at B.
2. Close the holes using plasticine and cello tape and fill the bottle with water
3. Record what do you observe if you open the holes covered with cello tape?
4. Name the kind of pattern of water-jet you observe from bottle through the holes D, E and F?
5. State the principle of transmission of pressure.

FOR YOUR KNOWLEDGE

- At a given depth, a liquid splashes equally in all direction because pressure acts equally in all directions
- At any point in (incompressible fluid) pressure is transmitted equally in all directions.

Assignment

Write brief notes to describe how the diagrams in Figure 3.12 (a), (b) and (c) illustrate the principle of transmission of pressure in liquids



(a) Water in a clear bag (b) Water in a container (c) Pressure gauge

Figure 3.12: Pressure at a given level of depth

Activity 3.7: Demonstrating relationship between pressure in liquids, size of container and its shape

Key Question: How does a liquid behave in a container connecting bottles of different size and shapes?

What you need

- Empty plastic bottles of different shapes and sizes
- Flexible connecting rubber tube
- Simple drilling machine (improvise with a device that can drill a small hole on a bottle)

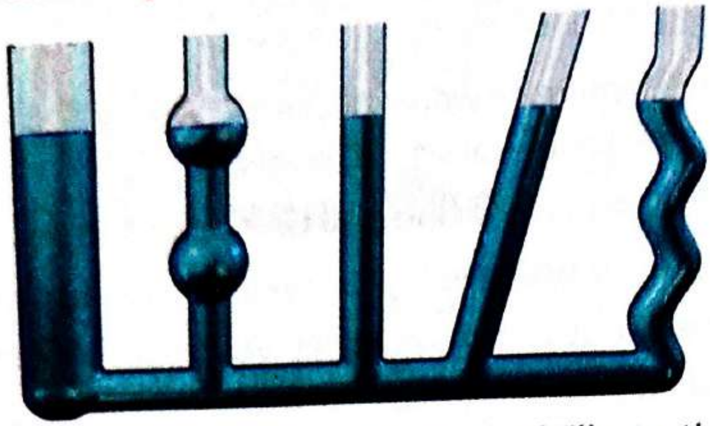


Figure 3.13: Liquid finds its own level (illustration)

What to do

1. Design a system connecting bottles of different sizes and shapes simila one shown in Figure 3.13. You should ensure that the connection does leak out water.
2. Pour water into one of the bottles until it is about halfway the height of smallest bottle.
3. Record what you observe in each bottle. Draw a diagram to illustrate w you observed.
4. Suggest relationship pressure in liquid, size and shape
5. Present your findings to the rest of the class.

DID YOU KNOW?
Liquid finds its own level, and it does not depend on the shape of the container. For example, in building and construction, engineers use this method to locate same level at different points on a building.

Exercise 3.3:

1. The density of milk is 800 kg/m^3 was poured into the rectangular metal c of height 0.5 m and square bottom of 0.2 m. How much pressure does t milk exert on the bottom surface of the can?
2. Why is the base of reservoir dam built wider than the top?

Figure 3.14: A water reservoir dam

3. Which fish experiences the highest pressure in Figure 3.15?

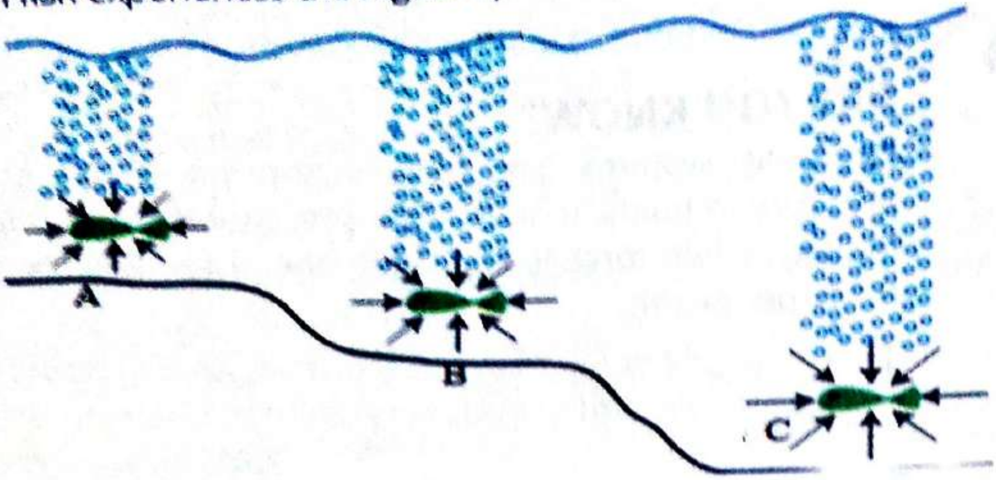


Figure3.15: Pressure on the fish on sea beds

4. Explain the differences in pressure at each point A, B, C, D, and E 2 in Figure 3.16: connecting tubes?

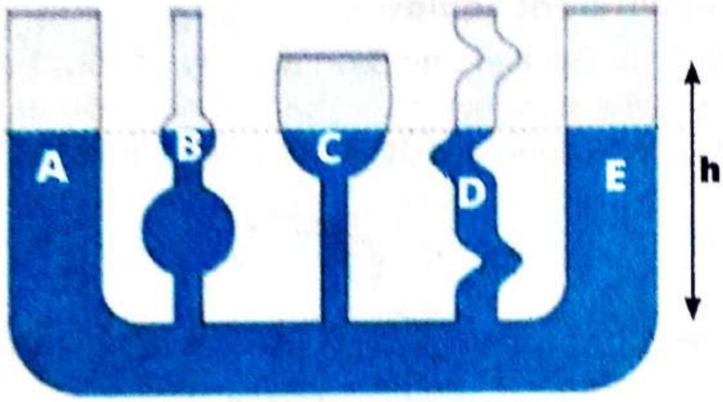


Figure 3.16: Communicating Tubes

Hydraulic system

Have you ever wondered why a little push on car brake pedal stops a vehicle with tons of load? The braking system is one of the forms of hydraulic systems. In industries, hydraulic system which is known as hydraulic press are often used to lift heavy loads. During road construction caterpillars and excavators use hydraulic system to lift construction materials.

Exercise 3.4

1. Identify devices or systems that apply Pascal's law of transmission of pressure in liquids
2. With the aid of a diagram, discuss how (a) the hydraulic brake and (b) hydraulic press work
3. The master cylinder piston in a car braking system has a diameter of 2.0 cm. The effective area of the brake pads on each of the four wheels is 30 cm2. The driver exerts a force of 500N on the brake pedal. Calculate:
4. The pressure in the master cylinder.

5. The total braking force in the car.

DID YOU KNOW?

Hydraulic systems use Pascal's principle of transmission pressure in fluids. It states that pressure is transmitted equ in fluids when force is applied in one piston and transmitted the other piston.

Thus, $P = \frac{F_2}{A_2} = \frac{F_1}{A_1}$

Exercise 3.5

1. The area of the smaller piston of a hydraulic press is 0.01 m2 and that bigger piston is 0.5m2. If the force applied to the smaller piston is 20N force is transmitted to the larger piston?
2. Suggest examples, where hydraulic press is applicable

Compare densities of different liquids

You learnt that pressure in fluids depend on density of liquid and depth(h), acceleration due to gravity is constant. The Hare's apparatus relates pr exerted by liquid columns to compare densities of two liquids.

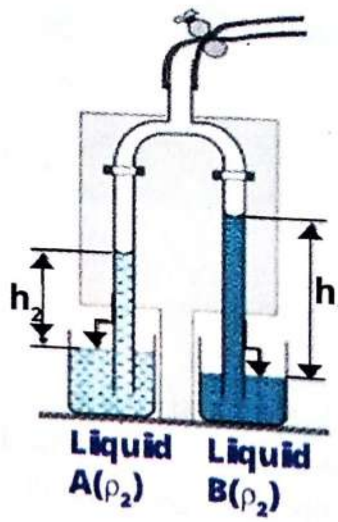


Figure 3.17: Hare's apparatus

Activity 3.8: Designing Hare's apparatus with improvised materials

Key Question: How can you design your own model of Hare's apparatus?

What you need

- Cooking oil
- Two glass tubes
- Flexible rubber
- Retort stands
- Hare's apparatus

What to do

1. Look at Figure 3.18, discuss and list down material used to set up the Hare's apparatus.
2. Use the materials provided to design a Hare's apparatus as in Figure 3.18
3. Use the apparatus to measure heights h_1 and h_2, water and oil.
4. Record down your observations
5. Explain the differences in pressure at the base of water-salt solution and of oil.
6. What would you do to raise the heights h_1 and h_2?
7. What can be done to minimize errors in this method?

FOR YOUR KNOWLEDGE

- Hare's apparatus consists of two long vertical wide-bore glass tubes connected at the top by a glass T-piece.
- These tubes are placed into beakers containing two liquids of different densities, ρ_1 and ρ_2
- Some air can be sucked out of the tubes through the center limb of the T-piece and the clip closed.
- The decrease of air causes pressure inside reduce, and then the atmospheric pressure pushes the liquids up the tubes.
- The liquids rise until the pressures exerted at the base of each column are each equal to atmospheric pressure A

Activity 3.9: Comparing the densities of salt-solution and cooking oil

Key Question: How do you compare density of two liquids using Hare's apparatus?

What you need

- Salt-water solution
- Cooking oil
- Food colors (blue and brownish) – other different colors can work
- Cooking oil
- Syringe
- Meter rule

What to do

1. Add salt into water in a beaker and stir until all the salt is dissolved.
2. Turn the color of the solution blue by adding a quarter spoonful of food color.
3. Turn the color of cooking oil by adding a different food color to it.
4. Connect a syringe to the T-tube and slowly suck out air from the tubes.
5. Measure and record height h_1 and h_2
6. Repeat sucking, measuring and recording more three sets of reading of h_1 and h_2?

7. Determine the average readings of h_1 and h_2?
8. Name the density ratio of salt solution to cooking oil.

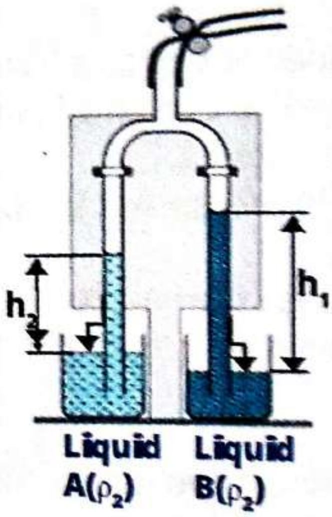


Figure 3.18: Hare's apparatus

FOR YOUR KNOWLEDGE

Pressure at the base of salt-water solution is equal to pressure at the base
$P + h_1\rho_1 g = P + h_2\rho_2 g$.

Ratio of density is given as $\frac{\rho_2}{\rho_1} = \frac{h_1}{h_2}$

3.4. Earth's Atmosphere

The planet earth is surrounded by a layer of air – a mixture of gases that s life. This air surrounding the earth is called atmosphere. The main gases atmosphere include: nitrogen, oxygen, carbon dioxide and other inert gas heavier gases such as nitrogen and oxygen are pulled closer to the earth sur gravitational force of the earth. This atmosphere has weight and it exerts p on the earth's surface, which is called atmospheric pressure.

Activity 3.10: Demonstrating effect of atmospheric pressure

Key Question: How do you demonstrate the effect of atmospheric pressure liquid in a cup?

What you need

- A rigid cup
- Light paper card
- Water

What to do

1. Fill the glass with water just to its brim.
2. Gently cover the water in the glass so that there is no air between th and water.
3. Hold the card paper with your palm while the other hand holds the
4. Fast but carefully turn the glass upside down and release your pa from the card.

5. Record what you observe?

DID YOU KNOW?
Water can be held in cup turned upside down without pouring

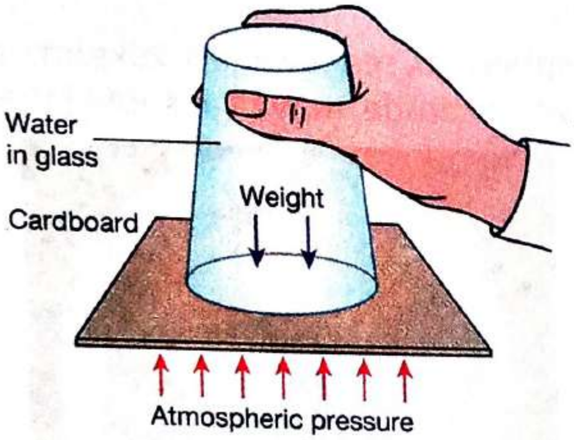


Figure 3. 19: Water held in a cup by atmospheric pressure

Activity 3.11: Experiment to demonstrate existence of atmospheric pressure

Key Question: How can you demonstrate the existence of atmospheric pressure?

What you need

- Empty plastic bottle
- Cold water in bowl

What to do

1. Pour small amount of hot (boiled) water into an empty bottle
2. Shake bottle until all the cold air in the bottle is expelled
3. Close the bottle tightly and quickly place it into cold water.
4. Record your observation?
5. Draw the diagram to show the state of the can before and after crushing. Explain your observation

FOR YOUR KNOWLEDGE

When you pour cold water on the can, vapour inside the can condenses. This action makes the pressure in the can to lower, and then the large atmospheric squashes the can. This explains why a person may experience nose-breeding when he/she moves to a region of low atmospheric pressure such mountain peak. In another case, a person experiences headache if he/she goes from region of high atmospheric pressure to low atmospheric pressure.

DID YOU KNOW?

The standard atmosphere(atm) is a unit of pressure. 1 a
101,325 Pa , therefore, 1 atm = $atm = H\rho_a g$
Where H is atmospheric height and ρ_a is average density of a

Exercise 3.6

The density of the atmosphere at sea level is 1.29kg/m^{-3} and g = 9.8m/s^2. As
that both do not change with altitude, how high should the atmosphere?

Figure 3.20: Atmosphere round the earth

DID YOU KNOW?

The height of the earth's atmosphere is too big to be measu
using metre rule. This is because the density of air is too sm
To measure atmospheric pressure, a mercury barometer is us
because it is liquid metal with the highest density.

Exercise 3.7

If a barometer is placed at a location exerted by 1 atm(101325Pa), what i
barometric height of mercury?

Activity 3.12. Designing your own simple barometer

Key Question: How can you design simple barometer using locally avail
materials?

What you need

- Capillary tube
- Stopper/cork
- Rigid glass bottle
- Water
- Food color

What to do

1. Design a simple barometer using materials indicated on Figure 3.21.
2. Explain how your barometer can be used to measure atmospheric pressure.
3. Explain the disadvantage of a water – barometer over mercury barometer.

Type of barometers

A barometer is an instrument for measuring atmospheric pressure. There are three main types of barometers include: (1) simple barometer (2) Fortin's barometer and (3) Aneroid barometer.

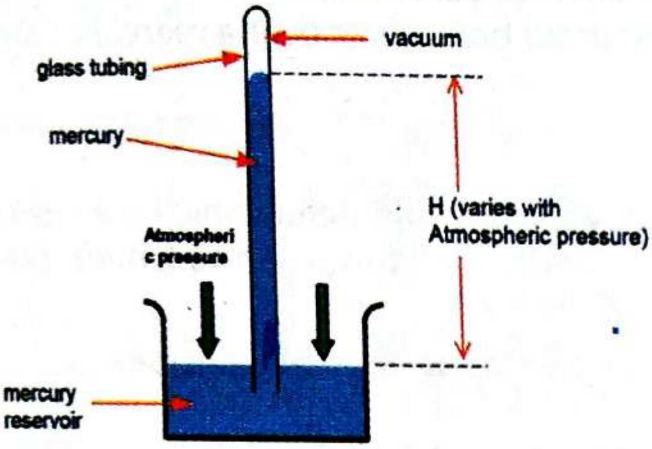


Figure 3.21: Simple barometer

DID YOU KNOW?
Density of mercury is 13593 kilograms per cubic meter (~ 13.6 grams per cubic cm)

Activity 3.13: Describing the structure and operation of Fortin's barometer

Key Question: What is the main difference between Fortis's barometer and simple barometer?

What you need

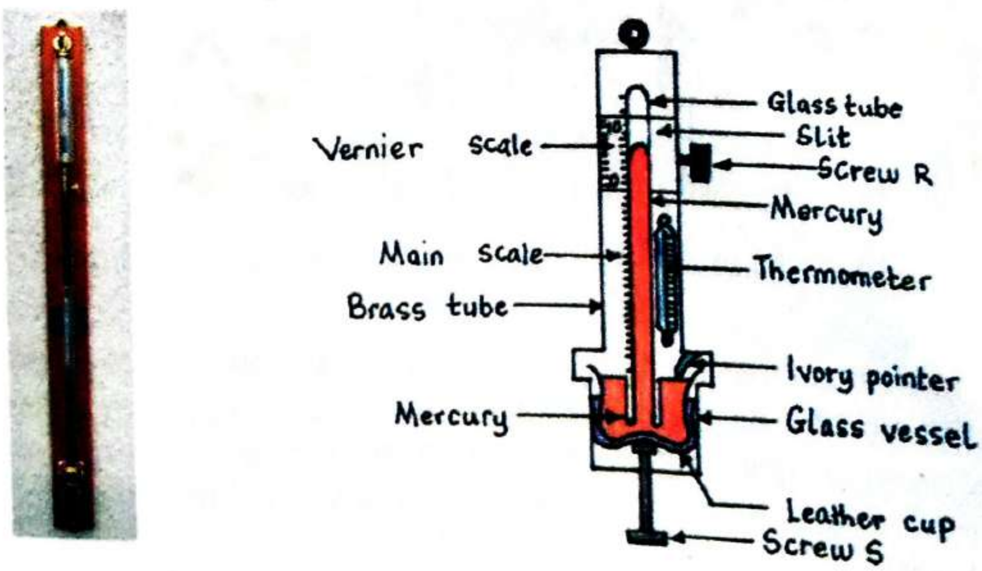


Figure 3.22: Fortin's barom

What to do

1. Compare the features of Fortin's barometer and simple barom state what features makes the two types of barometers different?
2. Explain the advantages of using mercury over water as a baromet
3. List down the defects of a simple barometer.
4. Describe how a Fortin's barometer measures atmospheric pressur

Assignment 3.1

1. Draw and label the features of aneroid barometer.
2. What are the main uses of an aneroid barometer?
3. Discuss the advantage of an aneroid barometer over a mercury bar

DID YOU KNOW?

Aneroid barometer can work as an altimeter, which is a devic is used in aircrafts to measure altitude. Atmospheric pre decreases as altitude increase.

Atmospheric pressure decreases as altitude increase.

Activity 3.14: Discussing systems that apply atmospheric pressure

Key Question: What is operation of each of the devices in relation to atmosphere pressure?

What you need

Some examples of systems that apply atmospheric pressure include;

- Drinking using a straw
- Emptying water from an overhead tank using a horse pipe
- Sucking medicine using a syringe

Figure 3.23. Example of applications of atmospheric pressure

What to do

1. List and Discuss the key features in each of the examples in Activity 3.1
2. With the aid of a diagram, explain how pressure changes make each of following work: drinking straw, syringe, siphon and water pumps work
3. How do changes to the volume of our chest lead to pressure changes breathing?
4. Why space is left when bottling liquids and why soda bottles do not h flat bottoms?

DID YOU KNOW?

Without atmospheric pressure, drinking using a straw, emptying a tank and using a pump of water would not work. Above all, breathing in animals would be difficult.

Atmospheric pressure decreases as altitude increase.

Activity 3.15: Describing the layers of atmosphere around the earth

Key Question: How do you describe the layers in the structure of atmosphere?

What you need

Figure 3.24. Structure of the earth's atmosphere

What to do

Study the Figure 3.24,

1. Identify different features and events that occur in each layer
2. Identify the ranges of height in which each of the five layers are located
3. Describe how temperature changes with altitude of the atmosphere.

DID YOU KNOW?

- Tropopause, Stratopause, Mesopause separates layers of the structure of earth's atmosphere.
- Tropopause separates Troposphere and Stratosphere
- Stratopause separates stratosphere and mesosphere
- Mesopause separates mesosphere and Thermosphere
- Atmospheric pressure decreases as altitude increase.

Weather and climate

Weather is day to day changes in the state of the atmosphere while climate ... average weather conditions of a place over a longer period of time.

Exercise 3.8

a). Which layer is closest layer to the earth?

b). Which layer is farthest layer from the earth?

c). In which layers does temperature increase with altitude?

d). In which layers does temperature decrease with altitude?

e). Where do you find Ozone layer, Ionosphere layer and Exosphere ...

f). Draw a model and arrange the layers of atmosphere in order of al...

g). Of what significance or importance is each layer?

h). What is the difference between weather and climate?

Activity 3.16: Demonstrating effect of Bernoulli principle

Key Question: Why do two objects come together when faster air pass... between them?

What to do (in groups)

1. Hold one a piece of paper in your hands
2. Blow air over the top of the paper?
3. What do you observe?
4. What can you conclude about your observations?

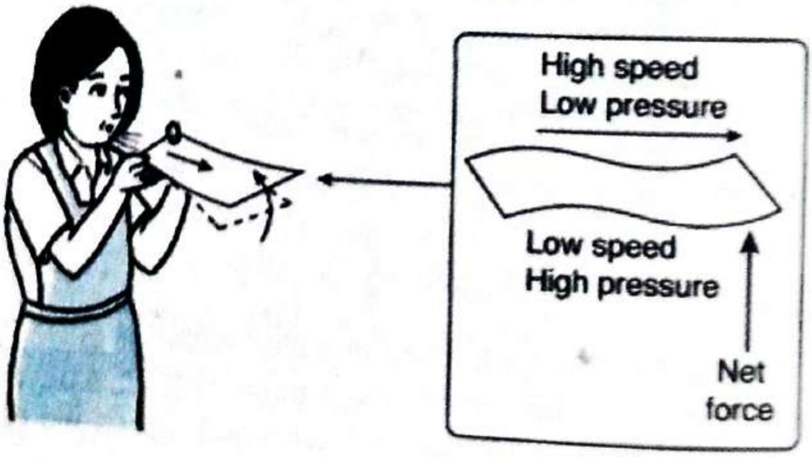


Figure 3.25. Child blowing air above the paper

DID YOU KNOW?

When you blow between above the paper, the paper lift upwa... This is Bernoulli's principle. Less pressure is exerted on the pa... by the moving fluid than the pressure than the stationary air.

Example of Bernoulli's principle: The roof top of a building can be easily blown-off by speedy winds because the speedy wind makes pressure on top of the building less than that of the inside. This causes large lift force upward hence destroying the building.

Exercise 3.9

Explain what would happen to a building with a triangular shaped roof when a fast moving wind passes above the roof.

Floating and sinking

When you drop a substance in water, it may stay in the surface of the water or down to the bottom of water. Those things that stay on the surface of water without drowning are said to be floating while those that fall to the bottom of water are said to be sinking. In book one, under density, we

Learnt that those things that float on water are less dense than water while those that sink are denser than water. By the end of this section, you will be able to explain sinking and floating.

Activity 3.17: Sorting out items that float or sink

Key Question: What items float on water?

What you need

- Deep bowl or container filled with water
- Various items (oranges, apples, avocados, lemons, potatoes, mangoes and bananas

What to do

1. Fill a bowl with water
2. Name the items you think will float or sink? Write your results in the prediction column.
3. One at a time, place each fruit in the water. As you place them in water observe what happens. Record your results on the activity sheet.
4. Name the forces that make items to sink or float? Explain

Table 3.1

Items	Prediction (What you thought?)	Observation (What you saw happening)	Give reason for what happened?

Engineer built the base of the dam reservoir wider than the top **because it has to** cope with the higher pressure.

DID YOU KNOW?

- Floating or sinking objects in a fluid (liquid or air) experience some forces.
- If the upward force is equal to 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.

Up-thrust and weight of fluid displaced

Activity 3.18: Investigating the relationship between apparent loss in w (upthrust) and weight of fluid displaced

Key Question: What is the relationship between apparent loss, upthrust and weight of displaced fluid?

What you need

- Water
- A measuring cylinder
- Spring / weighing balance
- Thread
- A stone or any other sinking object
- Displacement can

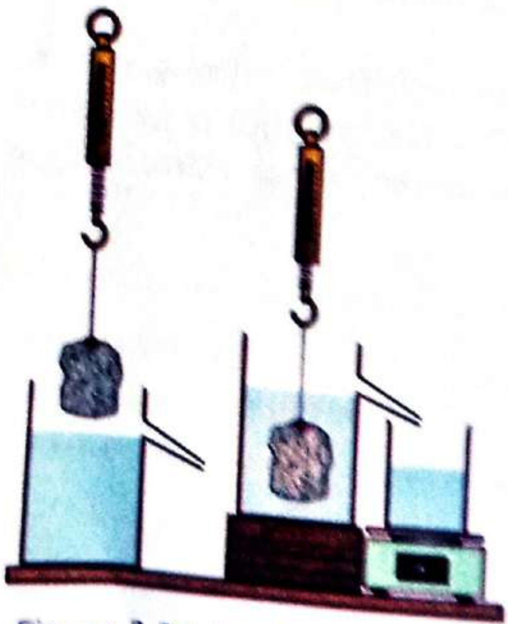


Figure 3.26.Displacement Can

What to do

1. What is the weight of the stone in air?
2. What is the weight of the stone whil

3. How much volume of water did the stone displace when completely immersed in water?
4. How much weight of water did the stone displace when completely immersed in water?
5. What relationship do you notice about weight of water displaced, weight of stone in air and weight of stone in water?
6. What is your conclusion?

Activity 3.19: Investigating the relationship between weight of a body in air and weight of liquid displaced when it is floating.

Key Question: How do you state law of floatation?

What you need

- Weighing balance
- Any object which floats on water
- Plate
- Bowl

What to do

1. State the weight of the floating body in air.
2. Name how much volume of water was displaced.
3. State the weight of water displaced.
4. Name your conclusion.

DID YOU KNOW?

Law of floatation states that a floating body displaces its own weight of the fluid in which it floats.

Activity 3.20: Making a buoy

Key Question: How can you make a falling object float in air?

What you need

- A balloon
- Metal piece or stone
- Nylon threads
- Pump
- Water source e.g. large basin or pond
- Weighing scale

Figure 3.27. Floating Balloon with extra weight

What to do (Group work)

1. Blow air into a balloon and tighten the mouth of balloon using a nylon thread so that air does not escape. Does it float on water?
2. Weigh and compare its weight in air when filled with air and when it is not?
3. Tie a stone using a thread onto the balloon and place the stone in water. Why doesn't the stone not pull the balloon to sink in water?
4. Suggest Where buoys are useful in life.

Activity 3. 21. Making a hydrometer

Key Question: How can you make a simple hydrometer?

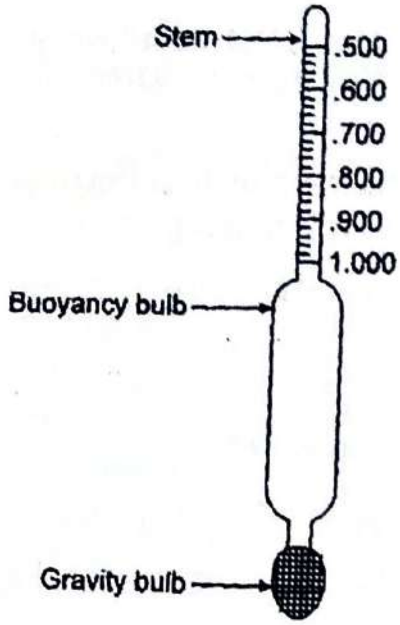


Figure 3.28. Hydrometer

What you need

- Sand
- Drinking straw
- Cellotape
- Different liquids e.g. water, paraffin, milk and motor oil
- Graph paper

What to do

1. Use cellotape to seal one end of the straw.
2. Put a little sand into the straw.
3. Float the straw on water.
4. Continue dropping more grits of sand into the straw until it floats uprig the water.
5. Mark on the straw the point where the water level stops.

Exercise 3.9

1. What does it mean if a hydrometer floats in liquid X with level of liqu above the mark on the hydrometer?

Chapter Summary

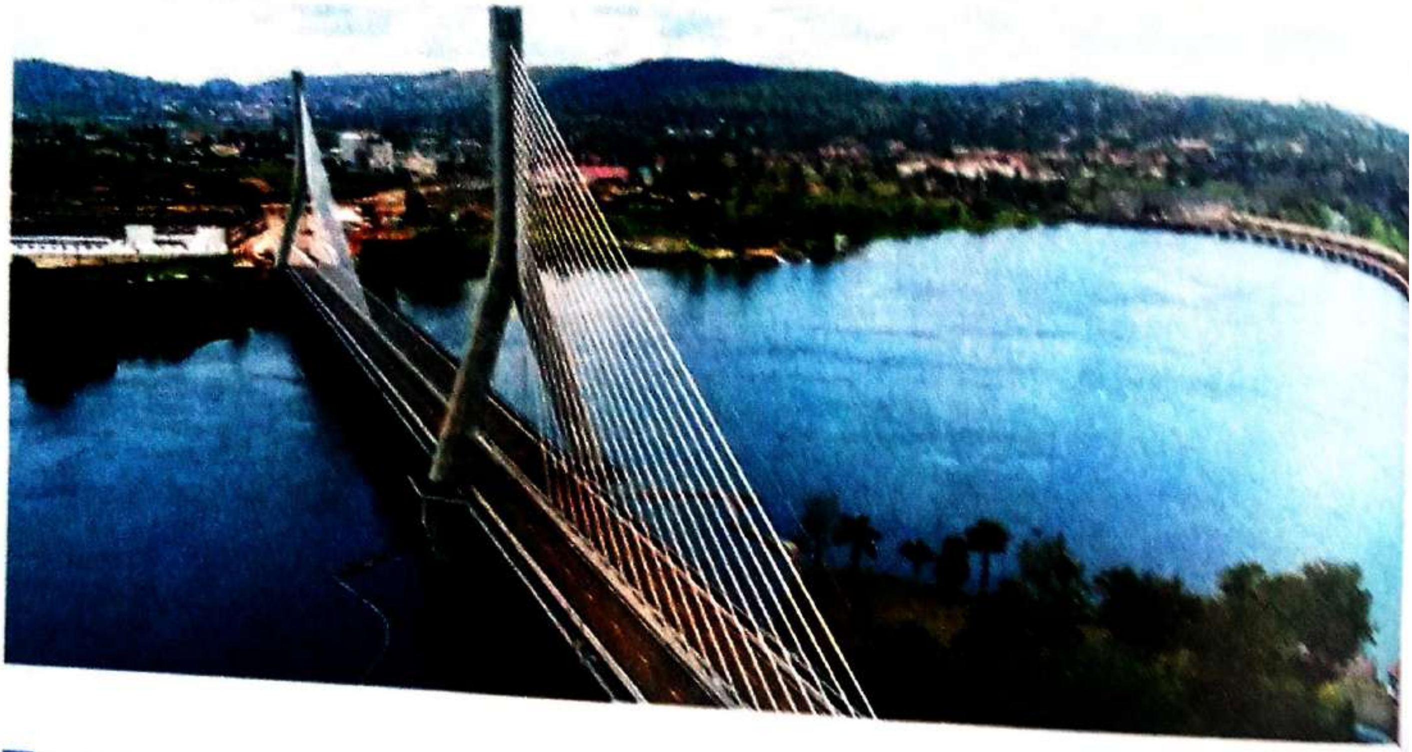
- Pressure is force acting normally per unit area of contact
- SI unit for pressure is Pascal, which or Pascal (Pa)
- We can calculate Pressure using an expression
- Pressure is scalar quantity
- Pressure increases with an increase in force when the contact area is constant.

- Fluids (liquids and gases) have no definite shape and can flow. They can flow freely.
- Pressure depends on density and depth of fluid
- At a given depth, a liquid splashes equally in all directions because pressure acts equally in all directions.
- At any point in liquid (incompressible fluid), pressure is transmitted equally in all directions. This is the principle of transmission of incompressible fluid (Pascal's law)
- Engineers build the base of the dam wall wider than the top because it has to cope with the higher pressure at the base.
- Pressure at a given level does not depend on shape but depth of the fluid. The deeper you go, the higher the pressure.
- Pressure due to column of air on the earth's surface is called atmospheric pressure
- A barometer is an instrument for measuring atmospheric pressure.
- The common types of barometers include: (1) simple barometer (2) Fortin's barometer and (3) Aneroid barometer
- One atmosphere is equal to 760 mm of Hg at temperature 0°C, which equal to 10^5pa(Nm^{-2}) of atmospheric pressure. Atmospheric pressure decreases as altitude increases.
- In the structure of atmosphere, there are 5 layers including: troposphere, thermosphere, mesosphere, exosphere and stratosphere
- The pressure exerted by a moving fluid is less than the pressure of the surrounding fluid. The faster the fluid the less pressure it exerts. This is called the Bernoulli's principle.
- Upthrust is an upward force on an object by the fluid
- Archimedes principle states that when a body is wholly or partially immersed in a fluid, it experiences an upward force which is equal to the weight of the fluid displaced
- Law of floatation states that a floating body displaces its own weight.

Activity of integration

Students from a secondary school intend to visit one of the two tourist locations: the peak of mount Rwenzori, and the shores of Lake Albert in western Uganda. As a tour guide, write down the guidelines based on knowledge of pressure that students should follow to ensure safety while on tour.

CHAPTER 4
MECHANICAL PROPERTIES OF MATERIALS: HOOKE'S LAW



Key words

- Compression
- Tension
- Shear
- Torsion
- Bending
- Strut
- Tie

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

a) Understand how the mechanical prope of common materials can be utilized in physical structures.

b) Understand that the tensile strength of materials is determined by the propertie of the substances they are composed of

c) Understand that heating changes the structure and properties of some mater

4.1. Introduction

In most of our homes, our houses have brick walls and the roof structures are made of timber. Have you realized that in modern societies, the walls of some houses are made of glass while the roof structures are constructed using metal bars? Look at the chairs in your homes, some have their frames made of timber while others have their frames made of metal. What are the advantages and disadvantages of each type of frame? In order to choose a material for any construction purposes, you need to know about its mechanical properties. In this chapter, you will investigate and understand how the mechanical properties of different materials relate to their uses (applications).

4.2. Mechanical Properties of materials.

Different materials are selected for use in construction works or for home use depending on the behavior of the materials when acted upon by a force. The way in which a material behaves when a force is applied to it is called its Mechanical Property. Some materials break easily when a force is applied to them while others do not. A measure of how large a force a material can resist before breaking is known as the strength of the material. A force can be applied to a material in any of the forms shown in Figure 4.1.

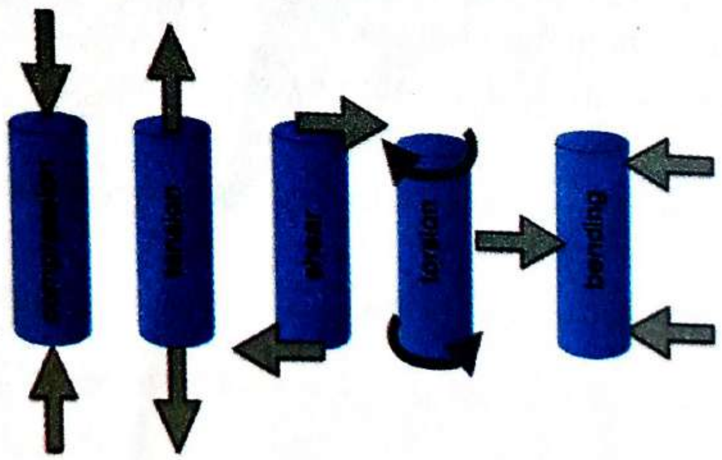


Figure 4.1: Forces acting on materials

Activity 4.1: Action of forces on materials (Group activity)

Key Question: How are forces applied to different objects?

1: Types of forces

What you need:

- Manila paper
- Markers
- Library and
- Internet.

What to do:

The arrows in Figure 4.1 show the direction in which force is applied to the material. Study these directions and use them to explain what you understand by;

- Compressive strength.
- Tensile strength.
- Shear strength.
- Torsional strength.
- Bending strength.

With reference to textbooks or internet, identify two (2) materials with high

- Compressive strength.
- Tensile strength.
- Shear strength.
- Torsional strength.
- Bending strength.

Write your findings on a manila paper and present them to the rest of the
Thereafter pin your work on the walls of the class.

DID YOU KNOW?

Did you know that the strength of a material depends on:

Nre
- The size of material used.
- The nature of the material used.

We shall now compare the effects of tensile force and compression for
materials. This is shown in table 4.1.

Table 4.1: Effects of tensile and compressive forces on materials.

Tensile force	Compressive force
Molecules of material are pulled apart	Molecules of material are pushed c
Length of material increases	Length of material decreases
Thickness of material reduces	Thickness of material increases

Activity 4.2: Understanding mechanical properties of materials

Key Question: What are the different mechanical properties of materials?

What you need:

- Access to a library.
- Internet

What to do:

Search in textbooks or internet for the meaning of the following mechanical properties of materials;

- Ductility.
- Brittleness.
- Hardness.
- Malleability.
- Elasticity.
- Plasticity.

Qn1 List down two (2) examples of materials that show each of the mechanical properties mentioned above.

2 Identify where each of the mechanical properties mentioned above are best used in everyday life.

- Compare your answers with the other groups.

Note that materials made out of clay are brittle. When a force is applied to them, they can easily break like the toy in Figure 4.2 (a). When a force is applied to a material made of metal, the material can be bent, rolled or stretched into different shapes without breaking. Therefore, metal is said to be ductile. Look around your class or home, can you identify things made of brittle materials? How different are their usage compared to those made of ductile materials?

(a) brittle (b) ductile materials

Figure 4.2: Comparison between (a) brittle and (b) ductile materials

FOR YOUR KNOWLEDGE

- Mechanical properties are properties of a material which determine its behavior under the influence of a force applied to the material.
- Mechanical properties relate to the elastic and plastic behavior of materials.
- A sound knowledge of mechanical properties of materials provides an understanding of the behavior of the materials when different loads are applied to them.

THEME: Mechanics and Properties of Matter

4.3. Hooke's law

Activity 4.3: Verifying Hooke's law (Group activity)

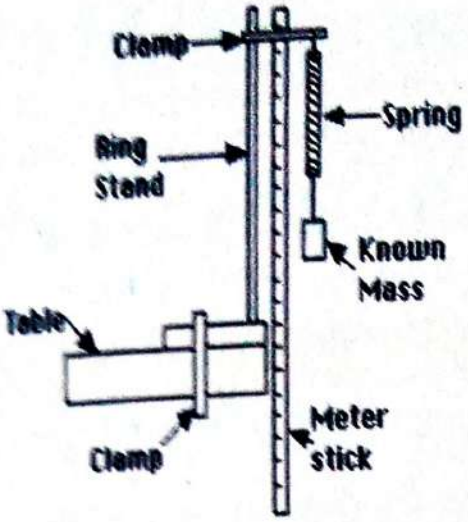
Key Question. What is the relationship between the load and the extension of a spring?

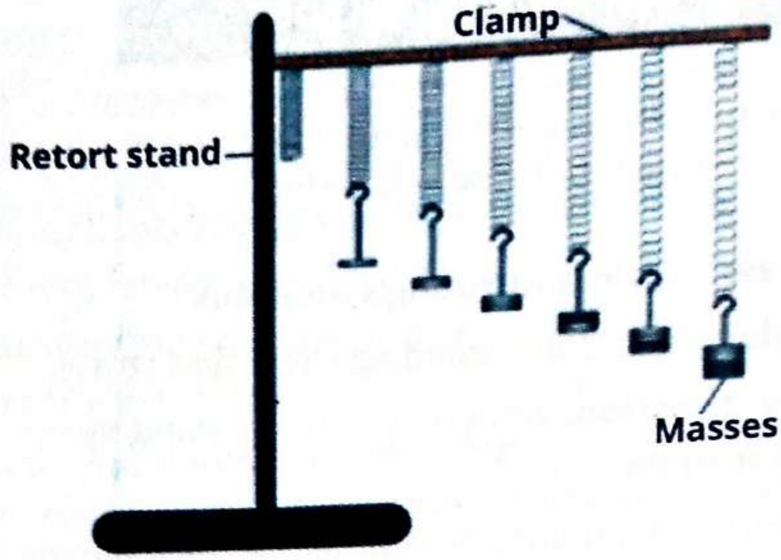
What you need:

- Retort stand with a clamp
- Helical spring
- 6 100 g slotted masses
- 1 100 g mass hanger
- A pointer.
- A meter rule
- A graph paper
- Piece of cellotape.

What to do:

1. Form groups of five students. Select a chairperson and a secretary for your group.
2. Fix the spring to the free end of the clamp on a retort stand and attach a point to the free end of the spring.
3. Place the meter rule/stick vertically next to the pointer. Read and record the initial position of the pointer, P_o, on the meter rule.
4. Suspend the mass hanger from the free end of the spring. Read and record the new pointer position, P_1 on the meter rule.
5. Calculate the extension, x_1 of the spring.
6. Add a 100g mass on the mass hanger. Read and record the new pointer position, P_1 on the meter rule. Find the extension, x_1 of the spring.
7. Repeat the above procedure until all the masses have been suspended.
8. Calculate the weights of the masses hung on the spring.
9. Plot a graph of weight of masses against extension of the spring.
10. Comment on the shape of the graph.
11. What relationship exists between the weights of the masses added to the spring and the extension of the spring.





Figures 4.3: Verifying Hooke's law

Figure 4.4: Verifying Ohm's

Note: When the load on the spring is small, the spring stretches and once the load is removed, the spring returns to its original size and shape. However, as the load is increased, there reaches a time when the spring can not return to its original size and shape. The spring is then said to have by passed its elastic limit. It then becomes plastic. Therefore, a graph of force (Weight) against extension would appear as shown in Figure 4.3 and Hooke's law applies only to the elastic region OA.

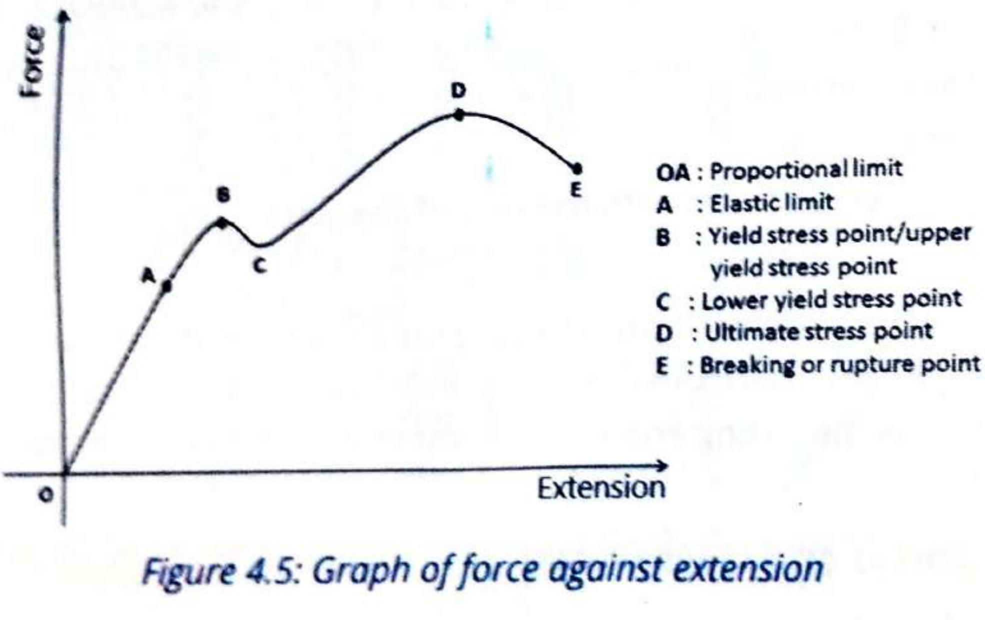


Figure 4.5: Graph of force against extension

Assignment 4.1:

With reference to Figure 4.5,

1. Make short notes about the regions AB, BC, CD and DE.
2. State the significance of the points B, C, D and E.

FOR YOUR KNOWLEDGE

Hooke's law states that the extension produced in an elastic material is directly proportional to stretching force applied provided the elastic limit of the material is not exceeded.

Stress, strain and Young's modulus

Activity 4.4: Understanding stress and strain

Key Question: What do you understand by the Young's Modulus of a material?

What to do:

Search in textbooks or internet for the meaning of the following terms as applied to materials;

1. Tensile stress.
2. Tensile strain.
3. Young's modulus.
4. Write down the mathematical expression for each of the terms above and state the SI unit of each, where applicable.
5. A wire of length 2m has a cross section area of 2.4 x 10-3 cm2. When a tensile force of 600N is applied to the wire, the extension produced is 1.8mm. Determine;
6. The tensile stress.
7. The tensile strain.
8. Compare your results with the rest of the class.

Beams

A beam is a structural element used to support a load. Beams are used in buildings, bridges and machines. The most important characteristics of a beam used is that it must be strong enough to resist tensile and compressive forces when loaded.

Activity 4.5: Forces on a loaded beam

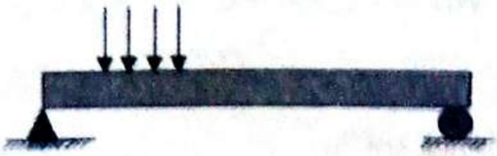
Key Question: How do beams behave when subjected to a force?

What you need:

- A visit to a bridge
- A beam
- Two knife edges
- Four 100 g masses

What to do:

1. Study the picture in Figure 4.3 and answer the questions that follow.



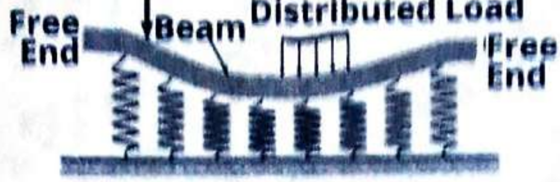


Figure 4.6: Unloaded and loaded beam in a bridge

2. What is the significance of the neutral line in the beam?
3. What is the use of the ball bearing in the construction of a bridge?
4. Name the type of forces on side A and side B of the bridge?
5. Why is it necessary for engineers to state the maximum load a bridge can carry?
6. Write your answers on a manila paper and present them to the rest of the class.

Types of beams

Solid beams are disadvantageous in their use because of their weight. To reduce on the weight of a beam, the solid material around the neutral region can be removed since this region experiences neither compression nor tension. The resulting beam is called a hollow beam.

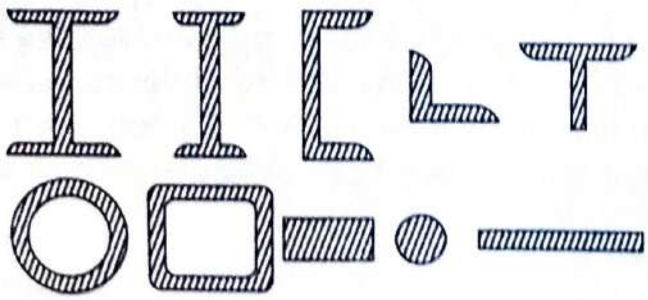


Figure 4.7 shows the cross section of some of the types of beams sold in the Ugandan markets.

Project 4.1

Visit a nearby hardware shop and;

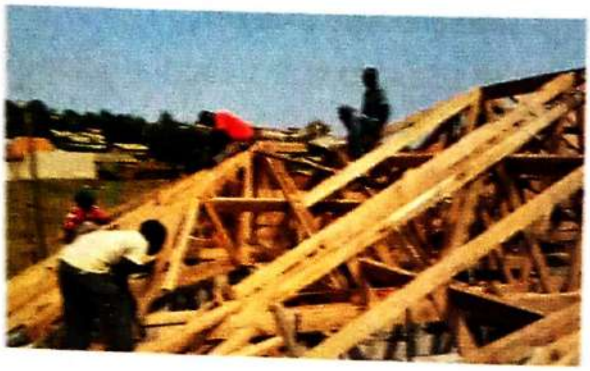
1. Identify each type of beam shown in Figure 4.7.
2. Ask and record where each type of beam is applied and why it is preferred.
3. Discuss the advantages of using hollow beams instead of solid beams in construction works.
4. Prepare a presentation of your finding to the class.

Structures

Structures are made by combining beams to form a framework for supporting different loads. Examples of structures include bridges, water tank stands, roofing structures, cranes etc. The structures are made rigid and strong by adding diagonal pieces. Some examples of structures are shown in Figure 4.8.

(a) Construction site

(b) A bridge



(c) A roofing structure

(d) Water tank stands

Figure 4.8: Different structures constructed using various types of beams

Struts and ties

A strut is a beam which is being acted upon by compressive forces i.e. it is a beam placed to resist compression. A strut cannot be replaced by a string, wire or a rope. A tie on the other hand is a beam which is being acted upon by tensile forces i.e. it is a beam placed to resist tension. A tie can be replaced by a string, wire or a rope.

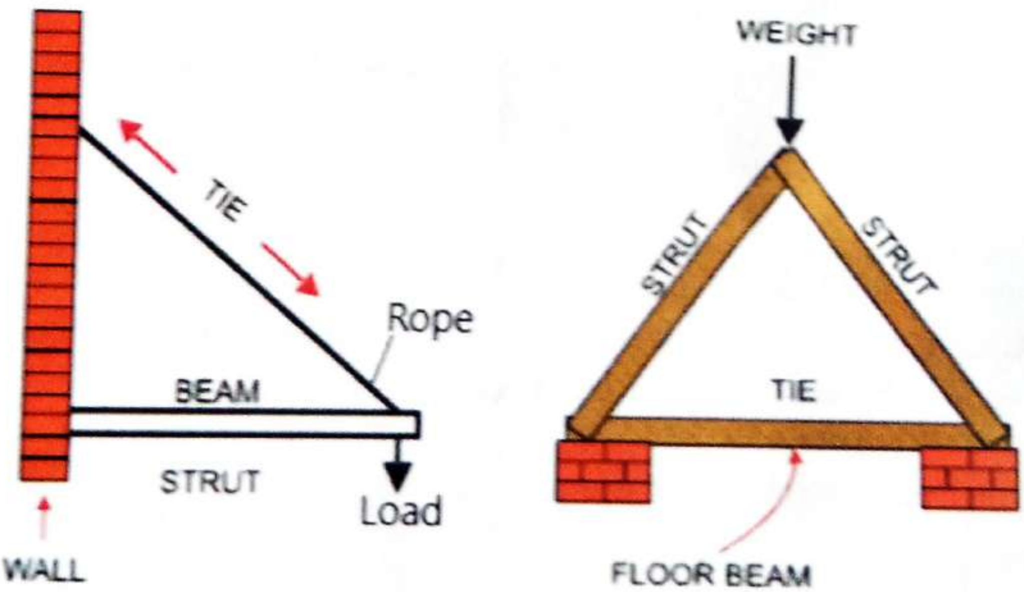


Figure 4.9: Structures showing struts and ties

Project work 4.2:

1. Study the structures (a), (b), (c) and (d) in Figure 4.7. Identify the ties and struts, and explain the significance of each beam.
2. Construct a model bridge structure using straws and mark on it beams which are ties and those which are struts.

Building materials

Project work 4.3:

1. Study the buildings at school and in your community,
   - List the most commonly used materials for construction.
   - List the rarest materials used for construction.
2. Find out why some of the materials are most commonly used while others are rarely used in constructions.
3. If you are to become an engineer, what things would you look for when selecting materials for construction?
4. Glass is increasingly gaining popularity for use in walling of building. Discuss the advantages and disadvantages of the suitability of glass for this purpose.

DID YOU KNOW?

- That reinforced concrete withstands more tensile and compressive forces that metal bars?
- That concrete can resist fires and other environmental hazards unlike metal bars?

Chapter summary

In this chapter you have learnt that:

1. Mechanical properties refer to the way in which a material behaves when subjected to a force.
2. Tensile strength is the maximum stretching force which a material can withstand without breaking.
3. Compression strength is the maximum squeezing force which a material can withstand without crashing.
4. Beams are structural elements used to support a load.
5. Ties and struts make structures more rigid and stronger.

Activity of integration

The construction of a four (4) storeyed building at a certain school collapsed and scores of people died. The LC 1 accused the headteacher of sacrificing the deceased to appease his spiritual ancestors in order to get riches. This created a lot of and the residents want to gang up to destroy the studied material science, prepare

CHAPTER 5
REFLECTION OF LIGHT BY CURVED SURFACES

Key words

- Pole
- Centre of curvature
- Radius of curvature
- Principal axis
- Principal focus
- Focal length
- Aperture
- Real and virtual images
- Linear or lateral magnification

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

a) Understand reflection of light and the formation of images by curved mirrors.

b) Use ray diagrams to show how images are formed by curved mirrors and the nature of the images.

c) Determine the focal length of a concave mirror using a variety of methods.

5.1. Introduction

Have you ever wondered why some reflectors are curved and others are not? Reflection of light is very useful to us. We can see better using these mirrors when reflection takes place in them. For some, the reflecting surface bulges outwards while for others, their reflecting surface is curved inwards. In this chapter, you will understand how images are formed in these mirrors and describe the uses of the mirrors in everyday life.

5.2. Mirrors

Types of curved mirrors

Activity 5.1: Identifying the types of curved mirrors

Key Question: Can you identify the different types of curved mirrors?

What you need:

- Concave mirror
- Convex mirror
- Stainless spoon

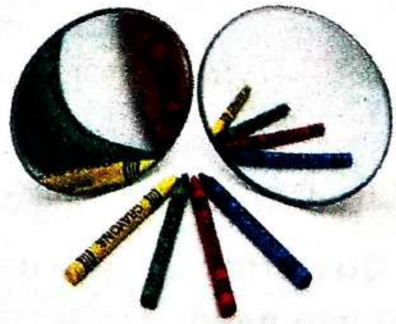


Figure 5:1 Reflection in curved mirrors

Caution: *Handle the mirrors with care to avoid breakages.*

What to do

1. Hold the mirrors and the polished stainless steel spoon provided one at a time and observe the shape of each reflecting or silvered surface.
2. Describe the shape of each reflecting or silvered surface.
3. Now, hold one mirror close to your eye and look into it. Describe what you observe when the mirror is moved slowly away from your eye.
4. Repeat step 3 above using the other mirror.
5. Discuss your observations in your group and share your findings with other groups in your class.

Did you notice that the mirrors provided above have spherical shapes? They are obtained from a hollow spherical glass. Such mirrors are called spherical mirrors. Therefore, depending on the side coated with silvery paint, front or back, the two types of spherical mirrors are called concave and convex mirrors.A concave mirror is coated silvery on the outside of a hollow glass sphere and curves inwards like a "cave" while a convex mirror is coated on the inside of the sphere and curves outwards.

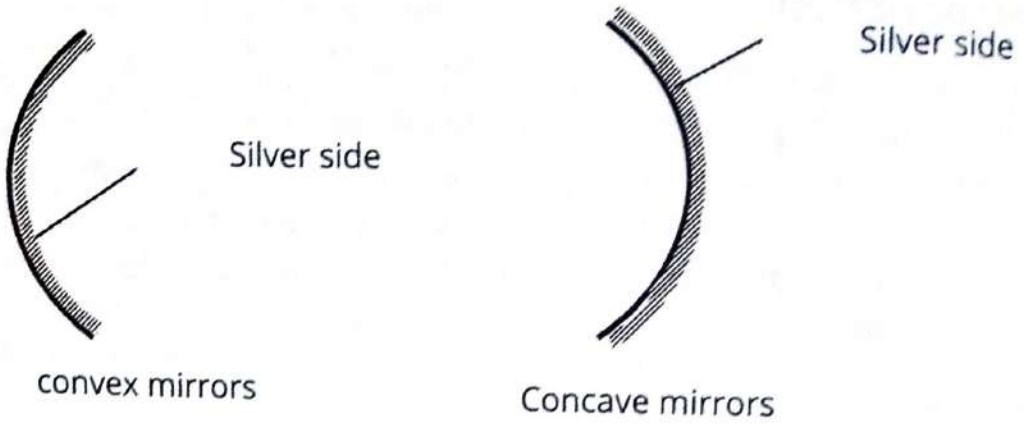


Figure. 5.2 Spherical mirrors

DID YOU KNOW?
Concave mirrors are called converging mirrors while convex mirrors are called diverging mirrors. Why are they called so?

Activity 5.2: Researching on the definitions of terms used in spherical mirrors

Key Question: Can you define the different terms used in spherical mirrors?

What you need:

- Computer or smart phone with internet connectivity
- Relevant textbooks

What to do

1. Carry out research on the following terms as applied to spherical mirrors (concave and convex) and write out their meaning or definitions:
   a). Pole.
   b). Centre of curvature.
   c). Radius of curvature.
   d). Principal axis.
   e). Principal focus.
   f). Focal length.
   g). Aperture.
2. Draw a diagram for each of the mirrors mentioned in question 1. above, showing the parts from (a) to (g).
3. What is the relationship between parts (c) and (f) for each mirror?
4. Discuss your findings and present them to the rest of the learners in your class.

Drawing ray diagrams

It is important to note the following:

- The laws of reflection apply to any ray incident on a spherical mirror. A beam of parallel rays will not be parallel after reflection. Why is this so?

- A point on an image can be located by the point of intersection of two reflected rays. In all drawings, an object is presented by a vertical arrow that stands on the principal axis, and a ray from the object incident on the mirror comes from its top.
- By geometry, the normal to a curved surface at any point becomes the line that passes through the centre of curvature of the surface.
- Two of the following three rays can be used to construct ray diagrams to show how images are formed in both concave and convex mirrors:
  - i). A ray passing through the centre of curvature is reflected back along the same or its own path. See Figure. 5.3 (i) and (ii) below.
  - ii). A ray parallel to the principal axis is reflected through the principal focus. See Figure. 5.3 (iii) and (iv) below.
  - iii). A ray through the principal focus is reflected parallel to the principal axis. See Figure. 5.3 (v) and (vi) below, for concave mirrors and convex mirrors respectively.

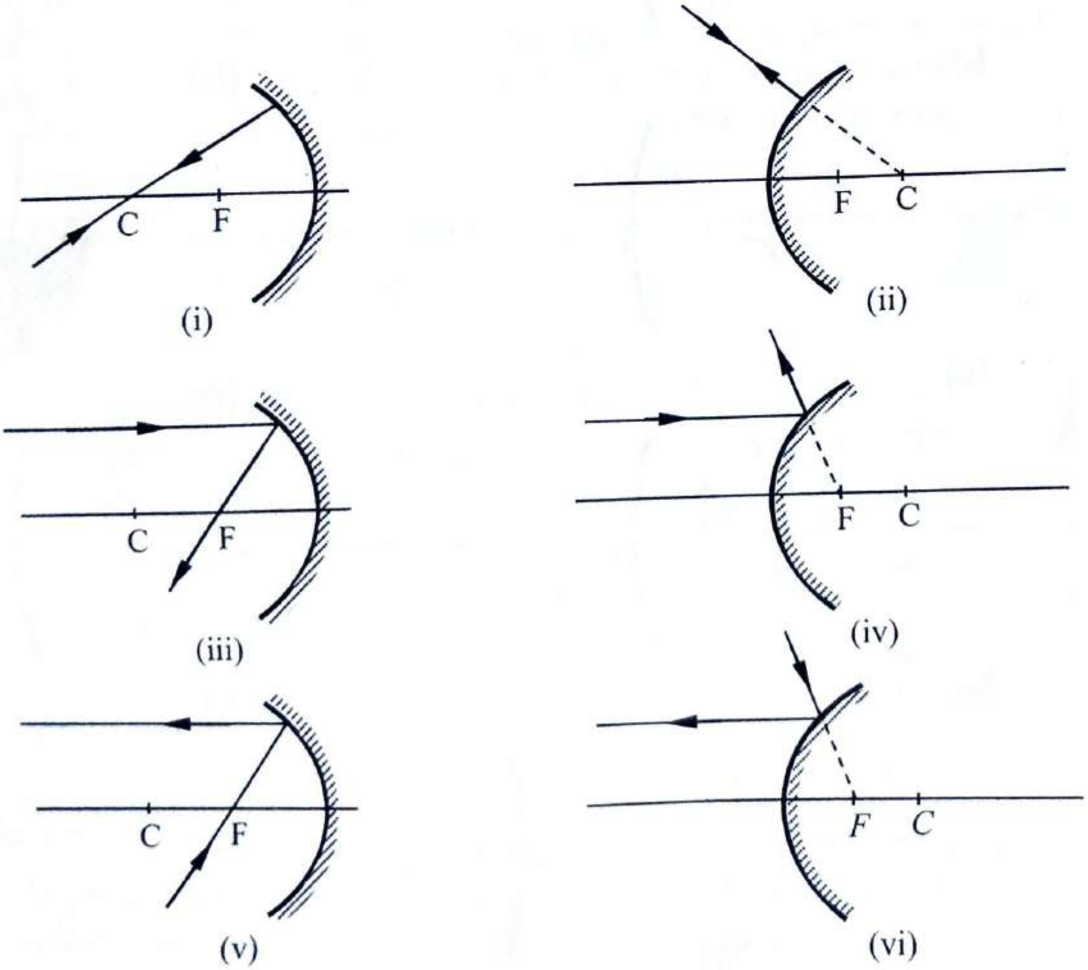


Figure. 5.3 Reflection in spherical mirrors

Real and virtual images

When reflected rays from a mirror converge to a point, an image is formed at that point. This image can be formed on a screen. It is called **a real image**. However, if the reflected rays diverge instead, they can never meet or intersect. So when their directions are produced backwards, they appear to come from a point usually behind the mirror. They form a **virtual image**. Such an image cannot be formed on the screen. Also, an image can be smaller (diminished in size) or larger (magnified) than the object, erect (same way up as the object) or inverted (upside down). Real rays and real images are represented by using full lines while virtual rays and images are represented by drawing dotted lines.

Activity 5.3 Drawing ray diagrams

Key Question: Can you construct ray diagrams in spherical mirrors?

What you need:

- Pencil
- Foot ruler

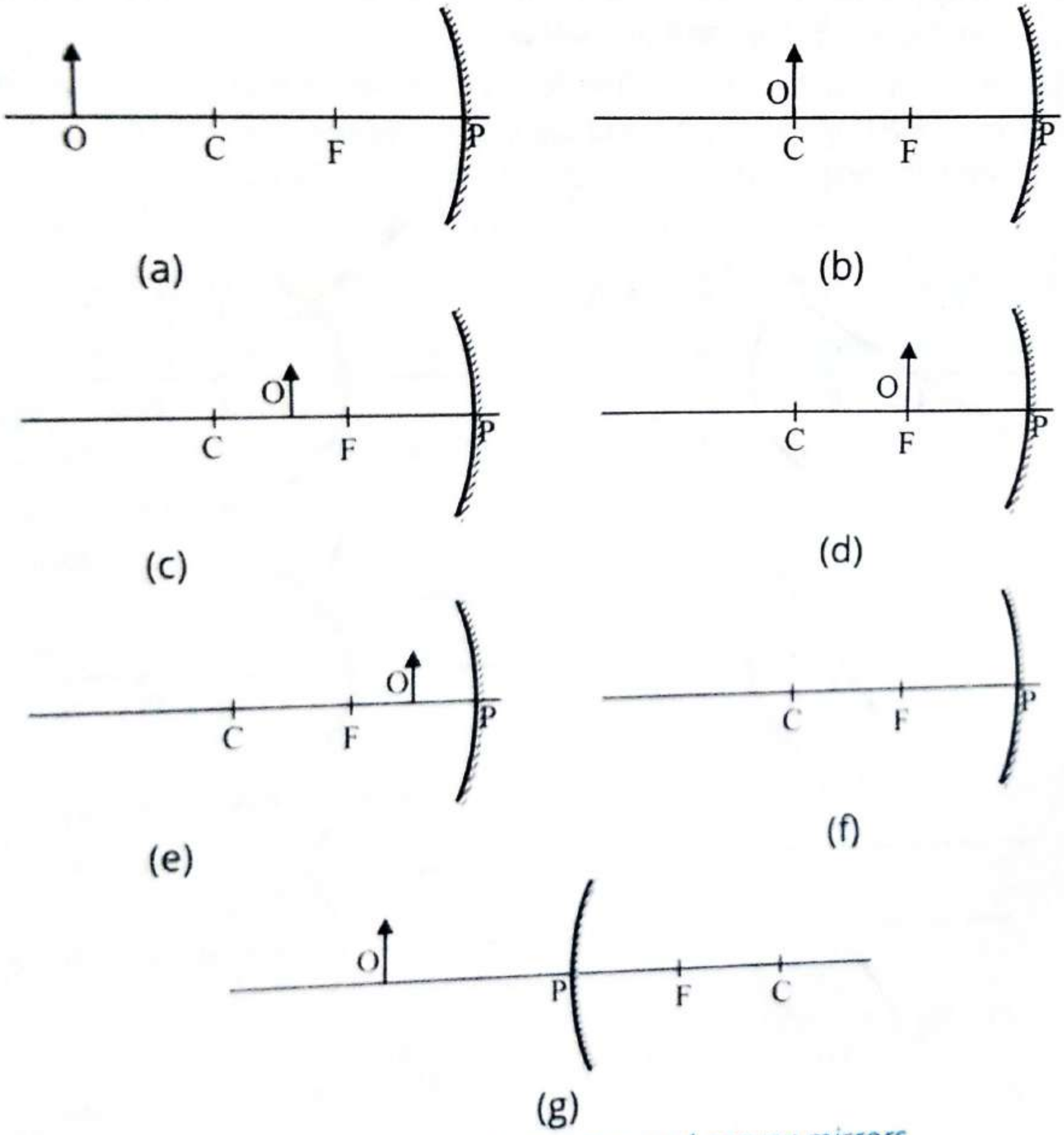


Figure 5.4: Images in concave and convex mirrors

What to do

1. Working in pairs, copy and complete the ray diagrams in Figure. 5.4 below to show how an image can be formed in concave and convex mirrors when an object O is placed:
   a). beyond centre of curvature C.

b). at C.

c). between C and principal focus F.

d). at F.

e). between F and the pole P.

f). at infinity (very far from the mirror).

g). in front of a convex mirror.

2. Describe the characteristics (nature and position) of the images formed in diagrams (a) to (g).
3. Where do we find practical applications of the arrangement in diagrams (b), (d), (e), (f), and (g).
4. Discuss and present your findings to the rest of the learners in your class.

Accurate construction of ray diagrams

The position, size and nature of the image of an object can be accurately determined by using a graph paper. A suitable scale is chosen, say 1 cm on the graph to represent 5 cm. The spherical mirror is represented by drawing a straight line (perpendicular to the principal axis) instead of a curved one. The distance between the centre of curvature and the principal focus must be equal to the distance between the principal focus and the pole of the mirror. Recall that ***r* = *2f*.**

Activity 5.4 Determining the position, size and nature of an image formed by a concave mirror by scale drawing

Problem

Suppose an object of height 5 cm is placed 45 cm in front of a concave mirror of focal length 20 cm. Using graphical construction method, determine the position, size and nature of the image formed.

What you need:

- A graph paper (of A4 size)
- Foot ruler
- Pencil

What to do

1. Draw a straight line on one of the main grid lines in the middle of the graph paper and on it mark the positions of the centre of curvature, principal focus and pole using symbols C, F and P respectively, using a scale of 1 cm on the graph to represent 5 cm.
2. Draw a perpendicular line to the principal axis to represent the position of the mirror.
3. Draw a line (with an arrow at the top) of height 1 cm to represent the object at a distance of 9 cm (why?) from the mirror line.
4. Use any two of the three rays mentioned under Drawing of ray diagrams,

determine the following:

a). the position of the image; i.e. the distance of the image from the mirror.

b). the size of the image; i.e. the height of the image.

c). the nature of the image; i.e. whether it is real or virtual.

5. Record your results in Table 5.1 below.
6. Using a similar approach, determine the position, size and nature of the image of the object placed at various distances from the concave mirror and record your results in Table 5.1.

Table 5.1: Graphical construction

Object distance (cm)	Object height (cm)	Radius of curvature (cm)	Focal length (cm)	Image distance / position (cm)	Image size/ height (cm)	Nature of image (Real of virtual)	Inverted or erect
45	5	40	20				
40	5	40	20				
30	5	40	20				
20	5	40	20				
10	5	40	20				

7. For what position of the object does a concave mirror form an image which is:
   - real,
   - virtual?
8. Discuss your results and then compare them with those of other learners in your class.

Activity 5.5: Determining the position, size and nature of an image formed by a convex mirror by scale drawing (Work in pairs)

Key Question: Suppose an object of height 10 cm is placed 30 cm in front of a convex mirror of focal length 25 cm. Using graphical construction method, determine the position, size and nature of the image formed.

What you need:

- A graph paper (of A4 size)
- Foot ruler
- Pencil

What to do

1. Draw a straight line on one of the main grid lines in the middle of the graph paper.
2. Draw a perpendicular line to the principal axis to represent the position of the mirror.

3. On the principal axis mark the positions of the pole, principal focus and centre of curvature using symbols P, F and C respectively, using a scale of 1 cm on the graph to represent 5 cm. Note that for the convex mirror, F and C are behind the mirror.
4. Draw a line (with an arrow at the top) of height 2 cm to represent the object at a distance of 6 cm (why?) from the mirror line.
5. Using any two of the three rays mentioned under Drawing of ray diagrams, determine the following:
   a). the position of the image; i.e. the distance of the image from the mirror.
   b). the size of the image; i.e. the height of the image.
   c). the nature of the image; i.e. whether it is real or virtual.
6. Record your results in Table 5.2 below.
7. Using a similar approach, determine the position, size and nature of the image of the object placed at various distances from the convex mirror and record your results in Table 5.2

Table 5.2 Graphical construction

Object distance (cm)	Object height (cm)	Radius of curvature (cm)	Focal length (cm)	Image distance / position (cm)	Image size/ height (cm)	Nature of image (Real of virtual)	Inverted or erect
30	10	50	25				
20	10	50	25				
10	10	50	25				

8. What conclusion can you draw about the nature of images formed by the convex mirror?
9. Discuss your results and then compare them with those of other learners in your class.

Exercise 5.1

1. An object of height 5 cm is placed (a) 30 cm, (b) 10 cm, in front of a concave mirror of focal length 15 cm. Using graphical construction method, determine the position, size and nature of the image formed in each case.
2. An object 10 cm tall is placed 25 cm in front of a convex mirror of focal length 20 cm. Determine, using accurate construction method, the position, size and nature of the image formed.

Lateral magnification formula

From Activities 5.4 and 5.5, you notice that the size of the image formed by the spherical mirrors is either larger (magnified) or smaller (diminished) than the object. In some cases, it has the same size as the object.

The ratio of the height of image to the height of object is referred to as linear magnification. It is also known as linear magnification.

i.e. Linear magnification, $m = \frac{\textbf{(height of image)}}{\textbf{(height of object)}}$

You can now determine the magnifications produced in all the above cases in Activities 5.4 and 5.5, including the cases in Exercise 5.1

Let the learners know that magnification, $m = \frac{\textbf{(image distance)}}{\textbf{(object distance)}}$

Measurement of focal length of a concave mirror

Activity 5.6 Measuring focal length of a concave mirror (Group work)

Key Question: How do you measure the focal length of a concave mirror

What you need

- Concave mirror in its holder
- Small white screen
- Metre rule
- Table or a horizontal surface
- A well-illuminated window

What to do

1. Place the concave mirror on the table to face the illuminated window.
2. With the small white screen placed slightly close to the mirror and between the window and the mirror, move the mirror to and from the screen until a clear and sharp image of the window is seen on the screen.
3. Describe the appearance of the image of the window on the screen.
4. Measure and record the distance between the mirror and the screen.
5. Repeat the experiment two more times and find the average of the distances recorded. Why did you have to get the average value of the distances measured? What name is given to this distance and why?
6. Discuss your findings in your group and present to the rest of the class.

Activity 5.7: Measuring focal length of a concave mirror

Key Question: How do you measure the focal length of aconcave mirror(method 2)

What you need

- Concave mirror in its holder
- Optical pin fixed into a rubber bung or cork
- Metre rule
- Table or a horizontal surface

What to do

1. Using the experimental set up of the apparatus in Figure. 5.5 below, suggest the procedure you can use to determine the focal length of the concave mirror provided.

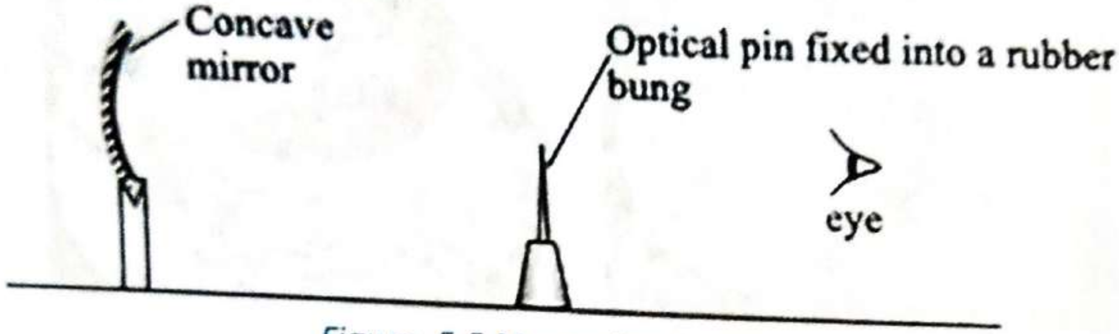


Figure. 5.5 Measuring focal length

2. Discuss your findings in your group and present them to the rest of the learners in your class.

Activity 5.8: Measuring focal length of a concave mirror

Method (3)

What you need

- Concave mirror in its holder
- Small white screen with a wire gauze across a hole in its centre
- Metre rule
- Table or a horizontal surface
- A torch bulb connected to two dry cells in a cell holder

What to do

1. Place the small white screen provided in front of the concave mirror.
2. Position the lit torch bulb behind the wire gauze so that light can fall on the mirror.
3. Move the mirror to and from the screen until a sharp image of the gauze is formed on the screen adjacent to the gauze.
4. Measure and record the distance between the mirror and the screen. What distance is this called and why?
5. Repeat the above procedure for two other measurements and find the average value.
6. How is the focal length of the mirror obtained from the average value?
7. Discuss your results and compare them with the ones from other groups in your class.

5.3. Parabolic mirrors

Only rays of light parallel and close to the principal axis of a concave mirror pass through the principal focus. When a wide beam of light is incident on a concave mirror, the rays far from the principal axis are reflected to points nearer to the mirror than the principal focus. A curved image called caustic is instead formed. A parabolic mirror is used to bring a wide beam of light to a single focus. Caustics can be seen in cups with shiny inner surfaces as shown in Figure. 5.6 below.

(a)

(b)

Figure. 5.6 Caustics in cups

Activity 5.9: Application of curved and parabolic mirrors / surfaces

Key Question: Where are curved and parabolic mirrors used?

What you need:

- Access to internet and a library

What to do

1. Investigate;
   a). Why convex mirrors are preferred as driving mirrors to plane mirrors.
   b). Why concave mirrors cannot be used as driving mirrors.
   c). Why most people prefer to use concave mirrors as shaving mirrors.
   d). Why most car head lights and torches have parabolic surfaces.
2. Explain why satellite dishes are made parabolic in shape.

Assignment 5.1

Give two reasons why convex mirrors are preferred to plane mirrors when used as driving mirrors. Use a diagram to illustrate your explanation.

Chapter Summary

In this chapter, you have learnt that:

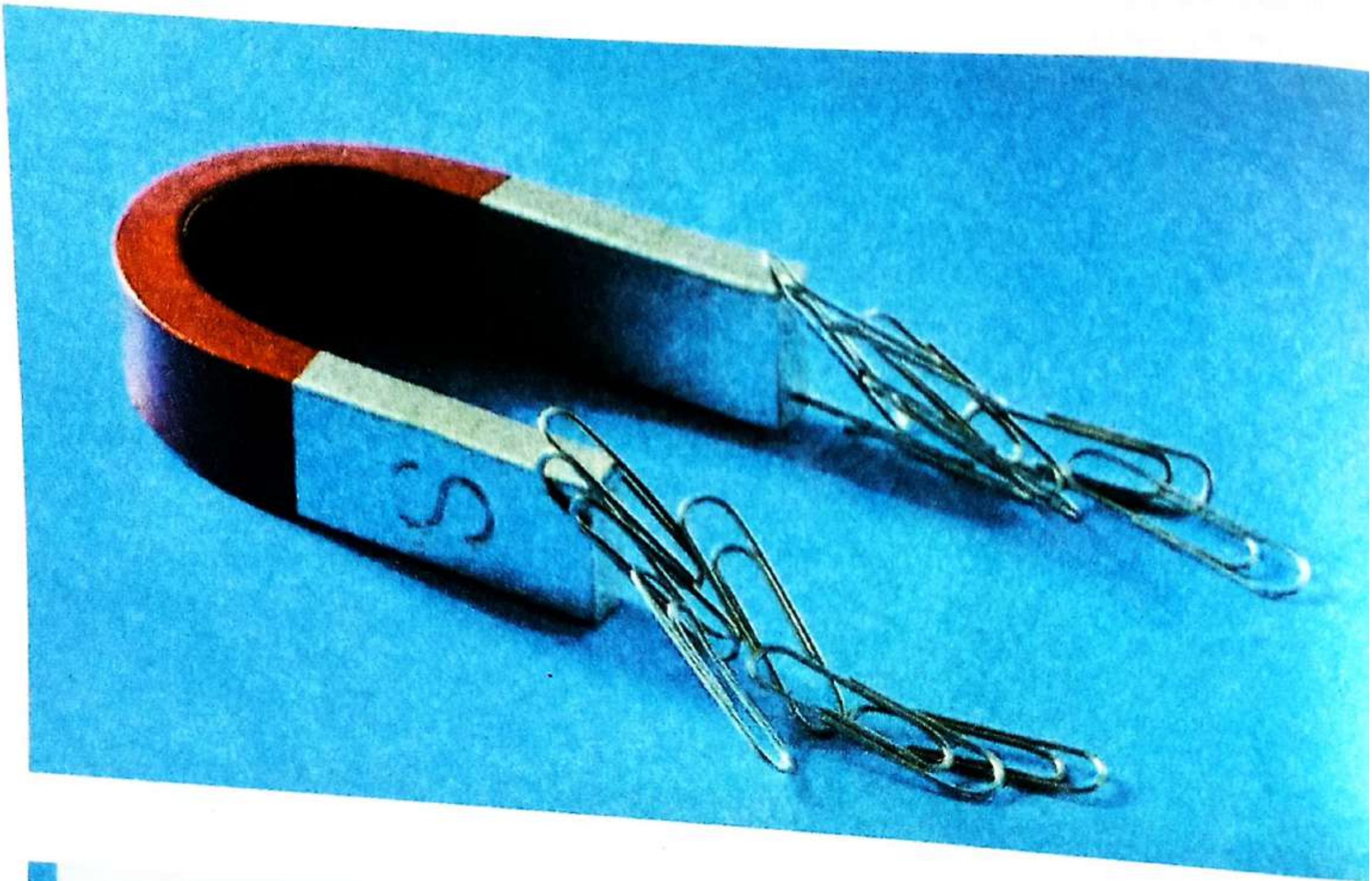
- Curved mirrors can be spherical; either concave or convex and parabolic.
- A concave mirror curves inwards like a 'cave' while a convex mirror curves outwards.
- Concave mirrors are also called converging mirrors whereas convex mirrors are called diverging mirrors.
- The main parts of curved mirrors are: the pole, principal axis, principal focus, centre of curvature, radius of curvature, focal length and aperture.
- Concave mirrors can form real or virtual images whereas convex mirrors form only virtual images. The images can also be described as magnified or diminished.
- Images in a spherical mirror can be obtained using ray diagrams and their positions accurately determined by using scale drawings of ray diagrams.

- Curved mirrors have various applications.
- Focal lengths of spherical mirrors can be determined experimentally.

Activity of integration

You have been selected amongst science students to go on a field trip. You have been tasked to design and make a solar concentrator that will be used for cooking while on the field tour. Using the knowledge of reflection of light, what materials are you likely to use and what design would you prefer to make it work?

CHAPTER 6
MAGNETS AND MAGNETIC FIELD



Key words

- Magnets
- Magnetism
- Magnetic and non-magnetic materials
- Earth as a magnet
- Pole

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

a) Know that a small number of materials are magnetic, but most are not.

b) Know how magnets can be made and destroyed.

c) Understand the behavior of magnets and magnetic fields.

d) Know that the earth is a magnet and how a compass is used to determine direction.

6.1. Introduction

In your childhood, you probably played with magnets. They can be used to attract metals, generate electricity. Small magnets embedded in a computer store the software and files. The earth itself is a giant magnet with north and south poles and because of this compasses with magnets can show geographical direction. In this chapter, you will investigate the behavior of magnets and how the earth behaves as a magnet.

Magnetic and non-magnetic materials

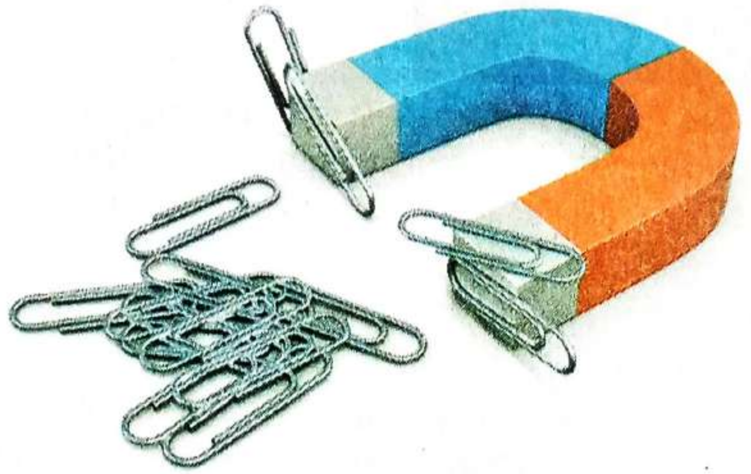


Figure 6.1: A bar magnet

A magnet has the ability to attract or repel other materials. A magnetic field is an area around a magnet where the magnet's force can be felt. Once in this field, a magnetic material will be attracted or repelled by the magnet while a non-magnetic material will not be attracted or repelled.

Activity 6.1: Identifying magnetic and non magnetic materials

Key Question: How do you identify magnetic and non-magnetic materials?

What you need

- Iron and steel nails
- Copper
- Wood
- Bar magnet
- Cobalt
- Zinc
- Chalk
- Glass rods
- Paper

What to do

1. Place some iron nails on the table. Bring a bar magnet close to the iron nails and observe what happens. Explain your observations.
2. Repeat the activity with other materials such as copper, cobalt, steel, sulphur, brass, wood, cork, nickel, plastic, pens, wax, zinc, glass rods, carbon, aluminum, paper, chalk etc.

3. Record your observations in a tabular form as shown below;

Substances attracted by a bar magnet	Substances not attracted by a bar magnet

4. Discuss your observation in step 3 in your group and suggest the name given to substances that are attracted by a magnet and those that are not.

FOR YOUR KNOWLEDGE

The materials which are attracted by a magnet are called magnetic materials while those which are not attracted are called non-magnetic materials. The magnetic materials that are strongly attracted by a magnet are called ferromagnetic materials.

These include nickel, iron, cobalt and steel. Materials that are not attracted by a magnet at all are called non-magnetic materials. Examples of non-magnetic materials include copper, brass, aluminium, wood, cork, plastic etc.

When metals are mixed together, they form alloys. Some alloys are ferromagnetic materials. An example is Al-ni-Co which is composed of aluminium (Al), nickel (Ni), and cobalt.

6.2. Making magnets (Magnetization)

Activity 6.2: Making temporary magnets

Key Question: a. What is a temporary magnet?

b. How can you make a temporary magnet?

What you need

- A magnet
- Iron nails or paper clips

What to do

1. Bring the magnet close to one of the nails.
2. State your observation.
3. Hold the magnet with the first nail close to another nail.
4. State your observe.
5. Repeat this for as many nails as you can.
6. Draw your conclusion.
7. Carefully separate the magnet from the nails.
8. State What happens.

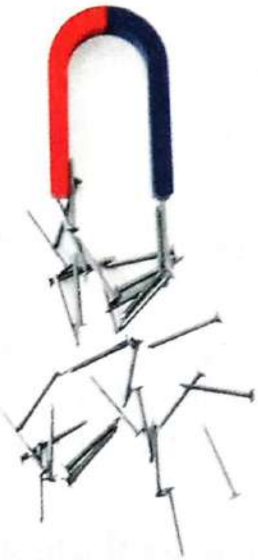


Figure 6.2: Making temporary magnets

When a magnet touches a nail, the nail itself becomes a magnet and it can pick up other nails. But when the magnet and the nail are separated, the nail loses its magnetism. The nail became a magnet, but temporarily. Temporary magnets are made of 'soft' magnetic materials, such as iron. These materials gain and lose magnetism easily.

Activity 6.3: Magnetisation using electricity

Key Question:

a. What is an electromagnet?
b. How do you make an electromagnet?

What you need

- An insulated connecting wire
- Cells and a cell holder
- Switch
- Nail
- Iron fillings.

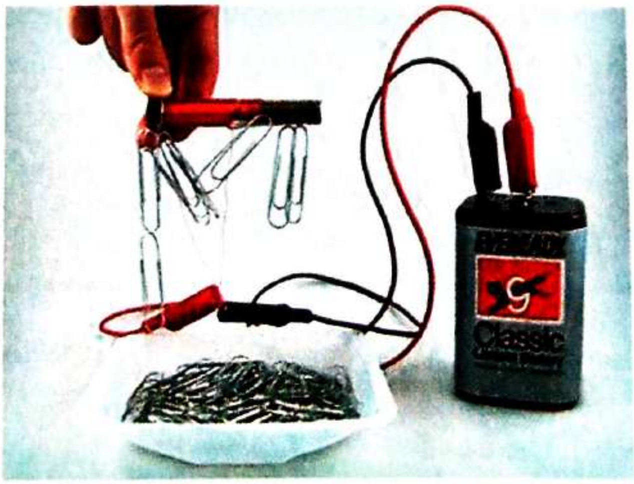


Figure 6.3: Magnetization using electricity

What to do

1. Assemble the circuit as shown in Figure 6.3.
2. Switch on for about 3 minutes and then switch off.
3. Use your magnet to attract a small piece of iron.

Question: You have now made a magnet. Does soft iron attract iron filings when you disconnect the circuit?

From activity 6.3, you will notice that the soft iron nail attracts the iron filings only when the circuit is complete. This shows that the iron nail has become a magnet. This kind of magnet which is made by passing current through a coil is called an electromagnet.

Activity 6.4: Making magnets using the single stroke method

Key Question: How do you make a magnet using the single stroke method?

What you need

- Bicycle spoke
- Bar magnet

What to do

1. Lay the bicycle spoke on the table and hold down one end firmly.
2. Using one pole of the bar magnet to stroke the bicycle about 30 times in one direction.
3. Use your previous knowledge to confirm that it has been magnetized.
4. Establish the poles on the bicycle spoke.
5. Do a library research and find out how you can make a magnet with north poles at both ends, and south poles near the middle (or the other way round)

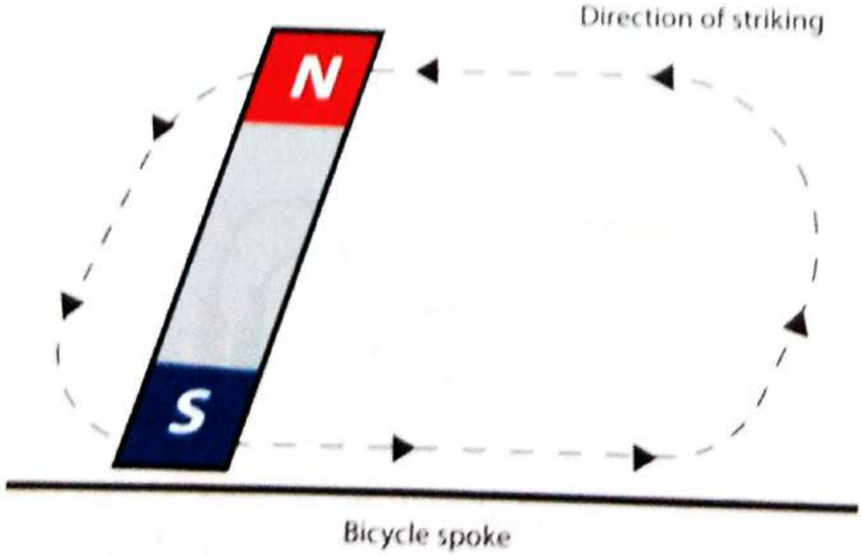


Figure 6.4: Single stroke method

FOR YOUR KNOWLEDGE

As the spoke is stroked with the one end of the magnet in one direction, the domains are being aligned to face in the same direction. Therefore the spoke becomes magnetized.

Assignment 6.1

Do a library research and state where:

a). Electromagnets are used.
b). Permanent magnets are used.

Give reasons for each.

Types Of Magnets

Activity 6.5: Comparing magnetism retention of different magnets

Key Question: How do you compare the strength of different types of magnets

What you need

- Dry cell
- Iron and steel nails
- Cello tape,
- 1m thin coated copper wire

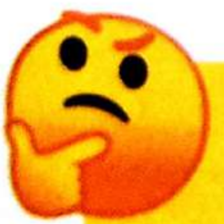
What to do

1. Carry out the experiment in 6.4 using a steel nail and iron nailer rod each at a time. Explain your observations.

FOR YOUR KNOWLEDGE

Permanent magnets can be made into any shape to fit usage. They can be made into round bars, rectangles, horse-shoe, donuts, rings, disks and other custom shapes.

Permanent magnets are used to lift heavy loads in industries. They pick loads with extreme ease. This makes them efficient because they always operate from the top without compressing or deforming the load.



DID YOU KNOW?

Permanent magnets are those magnets that retain magnetic properties for a long time. They are made from hard magnetic materials e.g. Steel.

What to do

1. Place a cardboard on top of a bar magnet
2. Sprinkle iron filings on the cardboard and tap the cardboard gently several times.
3. What pattern do you observe being formed by the iron filings?
4. Draw a sketch diagram of the pattern formed.

Caution: *Do not inhale the iron filings. Avoid touching them because you may end up in your food or you may rub them into your eyes*

You may have noted that;

i). Most iron filings remained clustered around the ends of the magnet.

ii). The iron filings are aligned along lines.

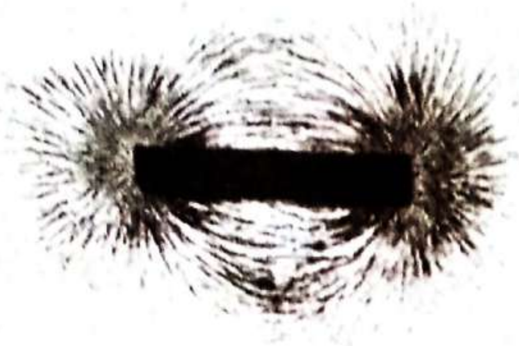
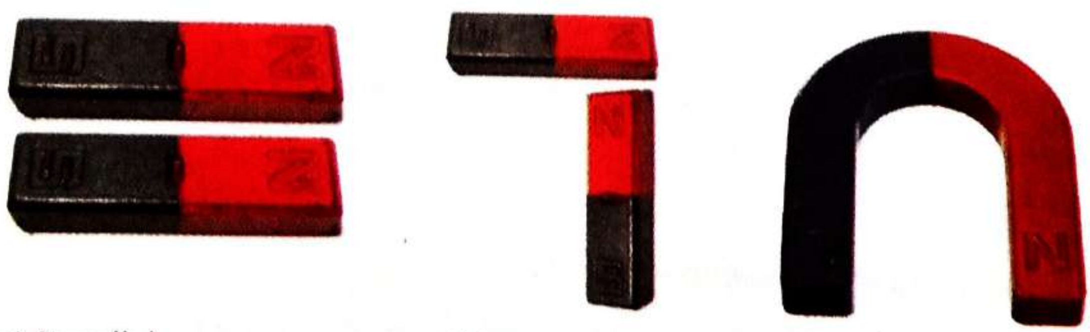


Figure 6.6: Magnetic field pattern

The ends of a magnet where the attraction is strongest are known as the magnetic poles. Magnetic poles are the places in a magnet where the total attractive force seems to be concentrated.

The lines along which the filings are aligned are called magnetic field lines or lines of magnetic force.

5. Arrange bar magnets in different positions and repeat the procedures above.



(a) Parallel *(b) At right angle* *(c) U-shaped*

Figure 6.7: Different positions of magnets

6. Observe the patterns that will be formed by the iron filings.
7. Draw the diagram showing patterns magnetic field line in each case of Figure 6.7 ?

Activity 6.9: Observe the directional property of a magnet

Key Question: In which direction will a free suspended magnet settle?

What to do

1. Suspend a bar magnet freely at its center by a length of a cotton thread from a support as shown below. Make sure there are no steel or iron objects near the magnet.

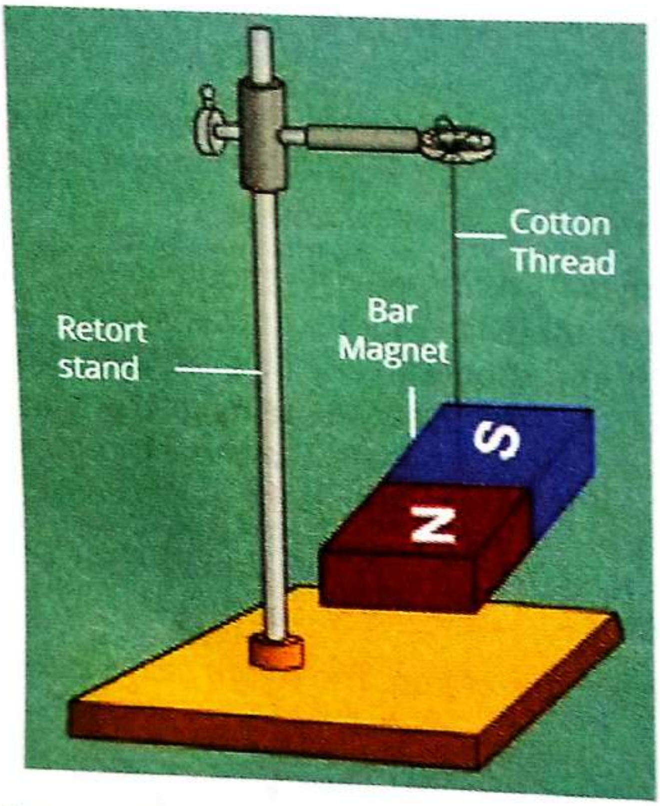


Figure 6.8: Directional properties of a magnet

2. Displace the magnet slightly so that it swings in a horizontal plane.
3. Note the direction in which the magnet finally comes to rest. Suggest a reason why it rests in that direction.
4. Repeat the activity at different places and note the resting direction of the magnet. What do you observe? Explain.

You may have observed that the bar magnet swings to and from and finally rests in a north-south (N-S) direction of the earth. In order to identify the poles easily, the ends should always be painted in different colours. For example the N-pole is painted red and the S-pole is painted blue or white.

FOR YOUR KNOWLEDGE

The pole that points towards the north pole of the earth is called the north seeking pole or simply the north pole (N).The other pole is called the south seeking pole or south pole (S).

Activity 6.10: Test the polarity of magnets using the basic law of magnetism.

What you need:

- A nail,
- Two bar magnets,
- Cotton thread

What to do

1. Freely suspend a bar magnet.
2. Bring the pole of the magnet close to a nail placed on a table. What do you observe?
3. Repeat with the other pole close to the nail and record your observations.
4. Repeat steps 2 and 3 using a second bar magnet instead of the nail. What do you observe? Discuss your observations.

You observed that there is attraction when the south or north pole of the suspended magnet is brought near the nail. You also observed that when the second bar magnet is used, there is attraction with one pole and repulsion with the other pole. Therefore, there is always attraction between a magnet and a magnetic material and also between the unlike poles of magnets. But there is repulsion only between two like poles of magnets. Therefore repulsion is the only sure way of testing for polarity of a magnet.

The earth as a magnet

The center of the earth is made of iron. The Figure below is a simple illustration of this.

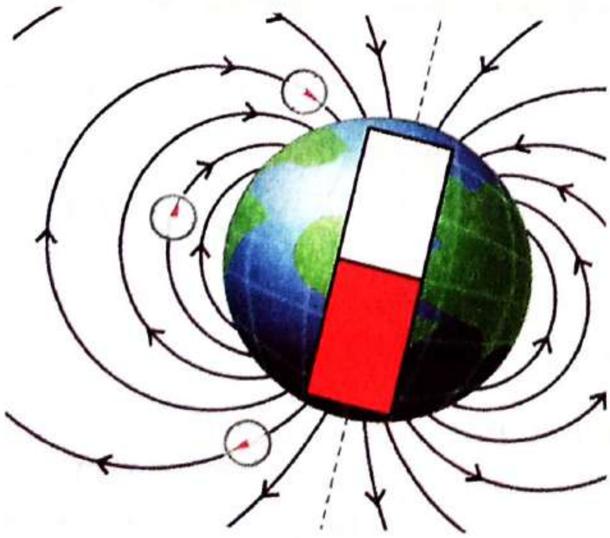


Figure 6.9: The earth as a magnet

This causes the earth to behave like a huge or giant magnet with a magnetic field all around the earth, and for some distance into space as illustrated in the Figure below. behaves like a magnet with North and South poles. Magnetic field lines of the earth run from the South Pole to the North Pole.

Research work

Read and make short notes on

i). Animal use the earth's magnetic field.

ii). How they use the earth's magnetic field to guide them on their journey

Some people claim that the study and use of magnets has contributed a lot to science and development. However, some scientists say this is not true. Prepare a document to explain what you believe about this claim.

Chapter Summary

In this chapter, you have learnt about;

- Magnetic and non magnetic materials.
- Magnetisation and demagnetisation.
- Application of magnetic and non-magnetic materials.
- Uses of the earth's magnetic fields.

Activity of integration

The public is complaining that beans supplied by a certain trader contain magnetic metals. This claim has raised serious concerns on the health of consumers. The Uganda National Bureau of Standards (UNBS) is investigating this concern. As technical officer, design a system to screen the bean and prove or disprove the claim that there metal impurities in beans. Write a report resolve this claim.

CHAPTER 7
ELECTROSTATICS

Key words

- Static electricity
- Protons
- Electrons
- Electric charge
- Glass rod
- Polythene rod
- Ebonite rod
- Silk cloth
- Animal skin fur
- Charging by induction
- Gold leaf electroscope
- Lightening spark
- Lightening arrestor Electric force

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

a) Understand everybody effects of static electricity and explain them in terms of the build-up and transfer of electrical charge.

b) apply knowledge of electrostatic charge to explain the operation of devices like lightening conductors.

7.1. Introduction

Sometimes your body hair stands when a rubbed polythene is brought near you. In the dark, you can see a flash of light if you slide your hand on a dry ironed nylon cloth. And during the storm, you see a flash of light in the sky and shortly thunder follows. Do you ever wonder why such occurrence exist? All these happen because of the effects of electrostatics. In this chapter, you will explore different events of electrostatics that naturally occur and use the knowledge of electrostatics to explain the occurrence of lightening and other phenomena.

7.2. Static Electricity

Effect of static electricity

In our world, every day, we use, see, experience or generate the occurrence of electricity. What do you see if you rub your plastic rule or pen against a piece of cloth and bring it near to small pieces of paper? What you notice is a form of energy called static electricity.

Activity 7.1: Generating static electricity by rubbing

Key Question: How do you generate opposite charges?

What you need

- Plastic straws
- Silk cloth/animal skin fur
- Plastic rule

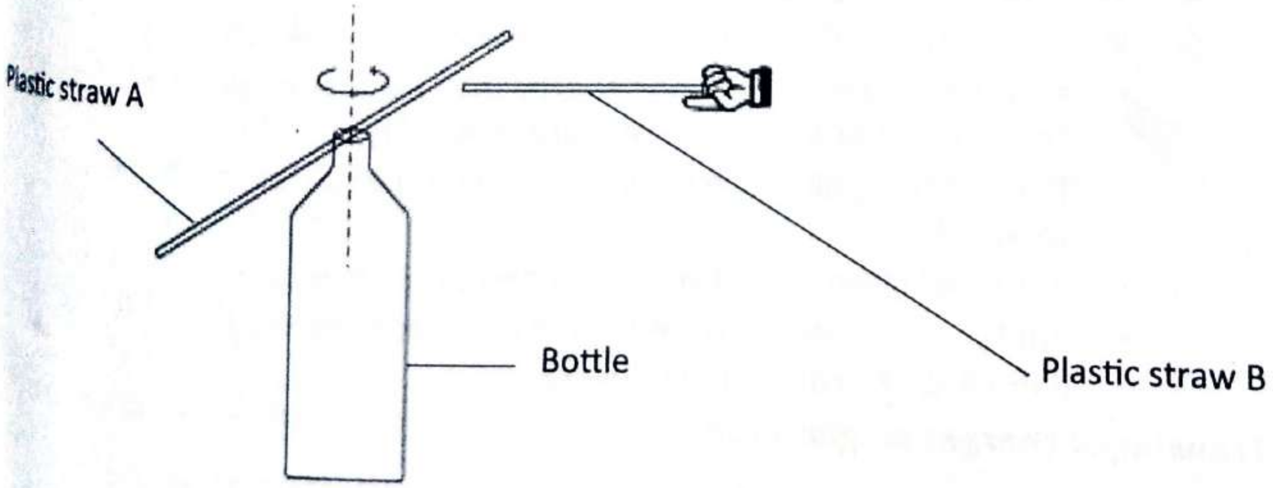


Figure 7.1(a). Plastic straw on a bottle

What to do(pair)

Part A: (Electric charges on plastic materials)

1. What do see if you rub your plastic rule or pen against a piece of cloth and bring near to small pieces of paper?
2. Rub the one side of the hanging straw with a cloth
3. Set the plastic straw to balance horizontally on a bottle as in Figure 7.1
4. Open half way of one side of the second plastic straw B and rub it with cloth.
5. Bring the straw near one end of straw A on the bottle

6. What do you observe?

Part B:(Electric charges on glass materials)

What you need

- Glass rod
- Silk cloth/animal skin fur

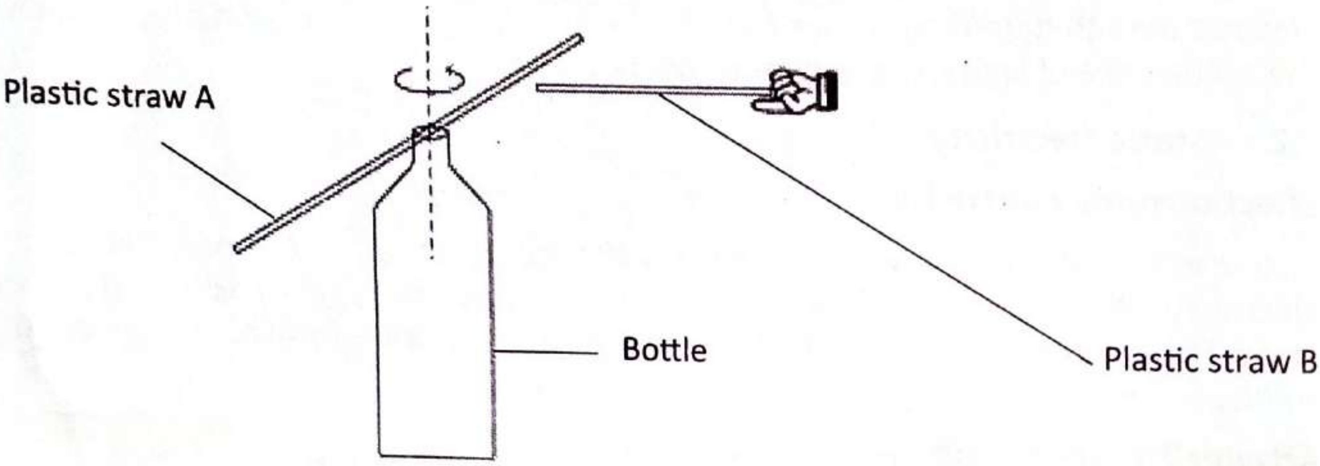
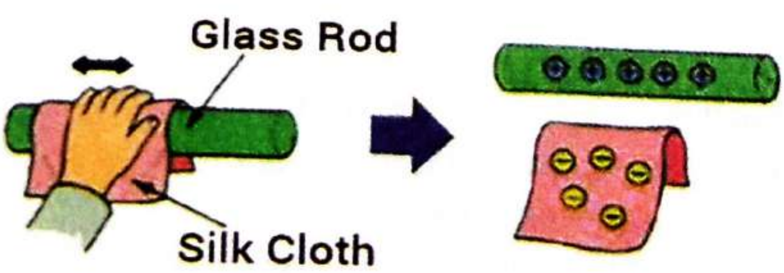


Figure 7.1(b). Plastic straw on a bottle

What to do

1. Rub the one side of the hanging straw with a cloth
2. Set the plastic straw A to balance horizontally on a bottle as in Figure 7.1(b)
3. Rub a glass rod with a silk cloth, and then bring it near plastic straw A?
4. What do you observe?
5. Write the report of your finding and present it to the rest of class.
   - A rubbed material contains energy that attracts small pieces of paper. This form of energy is called static electricity.
   - Two rubbed polythene rods repel each other as two rubbed plastic straws do
   - A rubbed glass rod attracts a rubbed polythene rod
   - Rubbing is a method of removing or adding negative particles(electrons) on a material

Transfer of charges on glass rod



Ebonite rod

In some school laboratories, there is special rubber rod called ebonite rod. When you rub ebonite with animal fur it is charged with a negative charge as a positive charge remain on fur. It behaves in the same way as polythene rod.

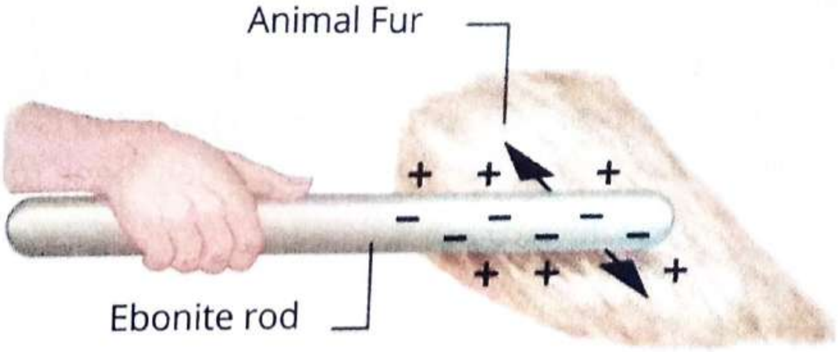


Figure 7.3. ebonite rod rubbing on fur

Exercise 7.1.
What do you think would happen if you brought two rubbed glass rods near another freely suspended rubbed glass rod?

For your knowledge

Basic characteristics of static electricity

- The effect of static electricity can be explained by what we call electric charges.
- There are two types of charges, one is called positive and the other is negative.
- One way to generate charges is by friction(rubbing)
- When you rub a glass rod with silk, you generate a positive charge on the glass rod and a negative charge on silk.
- When you rub a polythene rod with cloth, you generate a negative charge on the polythene rod and a positive charge on silk.

Where do these charges come from?

In chapter three of book 1, you learnt that matter is made up of atoms. In this chapter, we will learn that an atom contains two smaller components called protons and electrons.

How are charges generated?

- When you rub two materials together electrons move from one material to another.
- The material that loses electrons becomes positively charged.
- The material that gains electrons becomes negatively charged.
- If a material neither gains nor loses electrons, it is referred to as uncharged material, such materials are called neutral materials.

Exercise 7.2.

1. What is meant by the following terms
   (a) Proton
   (b) Electrons
   (c) Neutron
2. (a) Describe how charges can be generated?
   (b) Explain the transfer of electrons when a glass rod is rubbed with silk?
   (c) Explain the transfer of electrons when a polythene rod is rubbed with woolen cloth?

For your knowledge

Laws of electric charges

- Like charges repel, whereas unlike charges attract

7.3. Charging by induction

What method of charging did you learn earlier on? You can check and find about it. Induction is another method to charging materials.

Activity 7.2: Charging metal sphere by induction

Key Question: How do you generate charges on the spheres by induction?

Figure 7.6

What you need

- A metal sphere standing on insulators
- Ebonite rod
- A hairy animal skin (fur)

What to do

1. Charge the ebonite rod by rubbing it with fur.
2. Name what type of charge ebonite acquire.
3. Bring charged ebonite (without contact or touching) near a metal sphere standing on an insulate (piece of wood).
4. As you still hold the ebonite rod close to the touch a point on the side of spheres farthest the rod
5. Remove your finger while still holding the rod and then take away the ebonite rod.
6. Name what charge the metal sphere acquire.
7. Discuss and explain how the charge was acquired on the sphere?

Charging by Induction

To induce a charge in a neutral object by moving a charged object close to it without contact is referred to as charging by induction. Induction creates a temporary and opposite charge near the inducing charge. This is considered temporary because when the inducing charge is withdrawn, the object restates its neutral state. How then do we retain this charge on the object?

Positive charge by induction

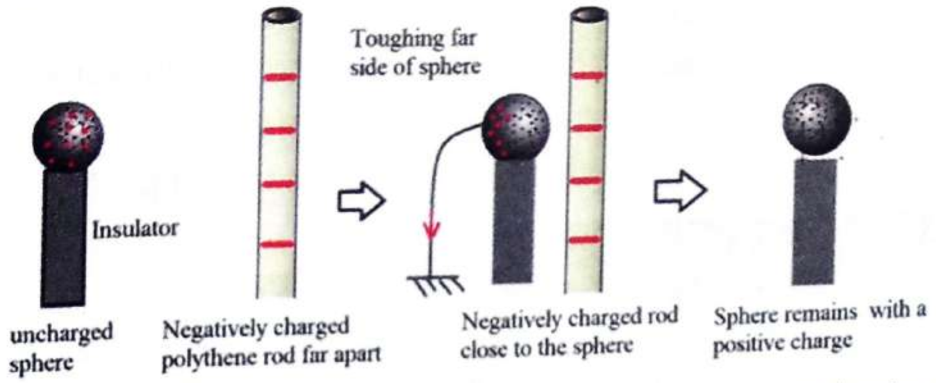


Figure 7.4. charging a sphere with positive charge by induction

Exercise 7.3

a). What charge does the glass rod acquire when you rub it with animal skin fur?

b). Explain the charge acquired by induction when you bring a charged glass rod near the metal sphere?

c). Do research and write steps of charging two spheres at the same time using a single charged rod

Detection of charges

One way to predict the presence of charge on a light material is when one material repels or attracts another. For heavy materials like two charged metal spherical bobs, the two may not repel or attract. This does not mean, there is no charge, but electric force between them is too small to move the bodies.

DID YOU KNOW?

Gold leaf electroscope is an instrument for detecting and testing small electric charges on bodies

Activity 7.3. Discussing function of features of gold leaf electroscope

Key Question: What are features of an electrostatics?

What you need

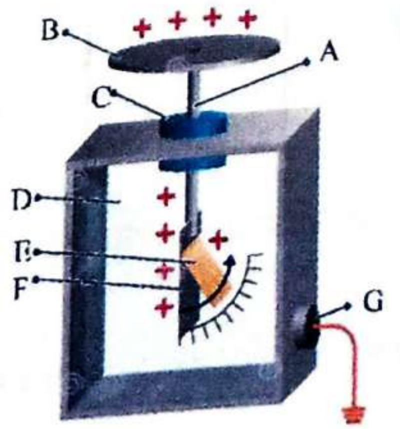


Figure: 7.5 : Gold leaf Electroscope

What to do

1. Name and discuss the features (A-G) of gold-leaf electroscope.
2. Describe how you would charge and discharge a gold leaf electroscope.
3. Explain how you would detect a charge using gold leaf electroscope.
4. Explain how you use a gold leaf electroscope to compare sizes of charge.

FOR YOUR KNOWLEDGE

We can predict the presence of charge on a material using repulsion method. But, we cannot be sure using attraction method. Another way for detecting and measuring electrostatic charge is by use of an instrument called Gold leaf electroscope.

DID YOU KNOW?

- A gold leaf electroscope can be charged using contact and induction method
- When a charge similar to that on the gold leaf electroscope is brought near the cap, the gold leaf rises away from the plate - the bigger the charge the more the leaf rises.
- Where the charge opposite to that of the gold leaf electroscope is brought near the brass cap, the leaf falls towards the plate.

Figure 7.6 and 7.7 shows steps of charging an electroscope negatively and positively by contact and positively by induction respectively.

1. Write brief note to describe the process of charging an electroscope positively by contact.
2. Explain how you can charge an electroscope negatively by induction.

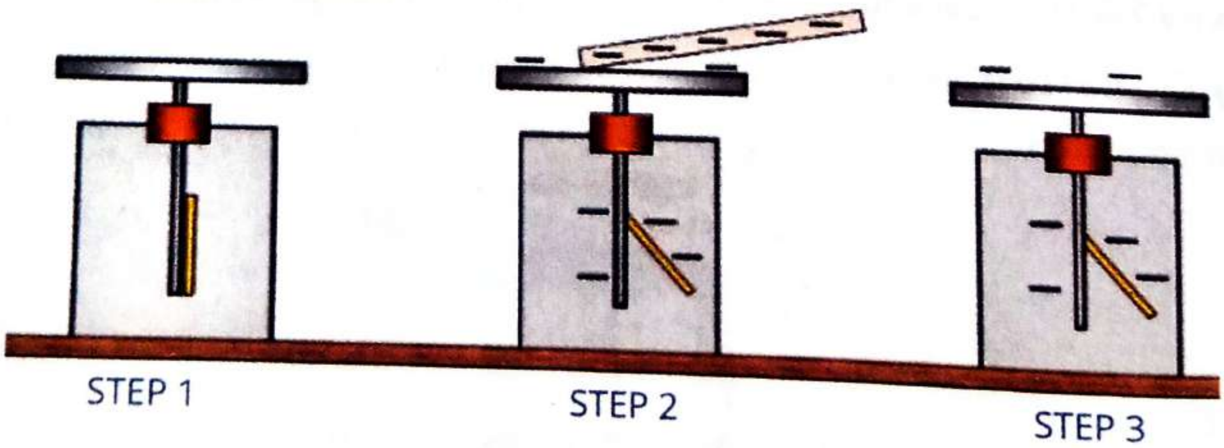


Figure 7.6: charging a gold leaf electroscope negatively by contact

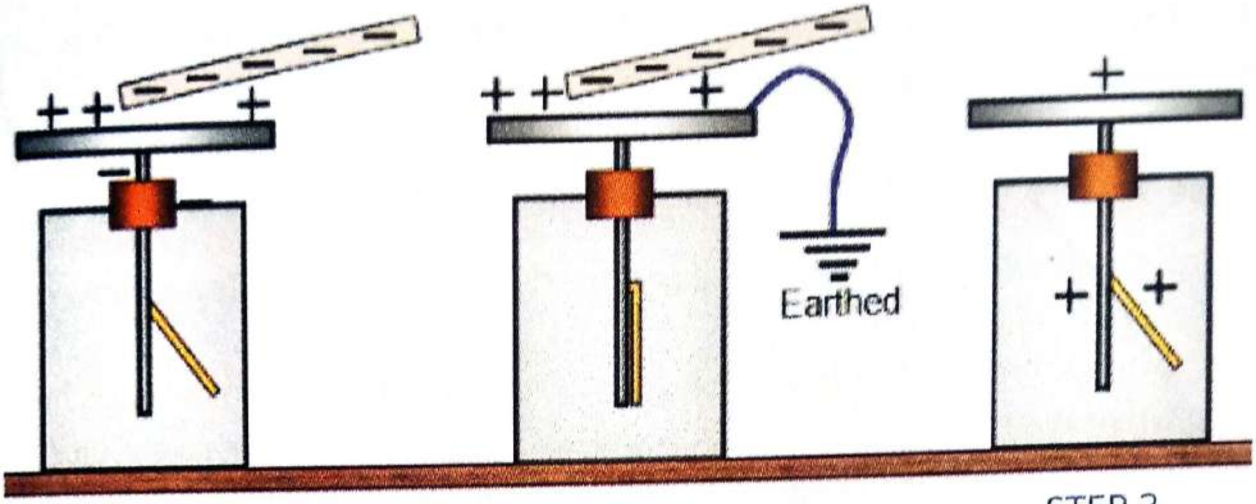


Figure 7.7: charging a gold leaf electroscope positively by induction

7.4. Lightening and thunderstorm

Lightening is a huge spark that discharges in the sky or between the sky and the ground. It can destroy aircrafts, buildings and animals if they not protected. You need to take care where you stand or what you hold when you suspect a lightening strike. Engineers design buildings with lightening arrestors(conductors) in order to protect.

Activity 7.4: Investigating lightening

Key Question: What are the common dangers of lightening strike and how can you avoid them?

What you need

Past reports on lightening strike in Uganda

(a) (b)

Figure 7.8: (a) Lightening and thunder and (b) lightening conductor

What to do

1. Do research in past news papers reporting on three lightening disasters in Uganda. Describe each type of disaster.
2. Explain how lightening and thunder happen?

3. Explain what can be done to avoid danger of lightening strike.
4. Explain how a lightening conductor works?

Exercise 7.4

1. Explain why there is a cracking sound when you take off a pullover over a nylon shirt?
2. Explain why a charged comb picks dry small pieces paper but it does not when wetted?
3. How do we protect our buildings from danger of lightening strike?
4. Why do we need lightening arrestor on pylons that carry electricity?

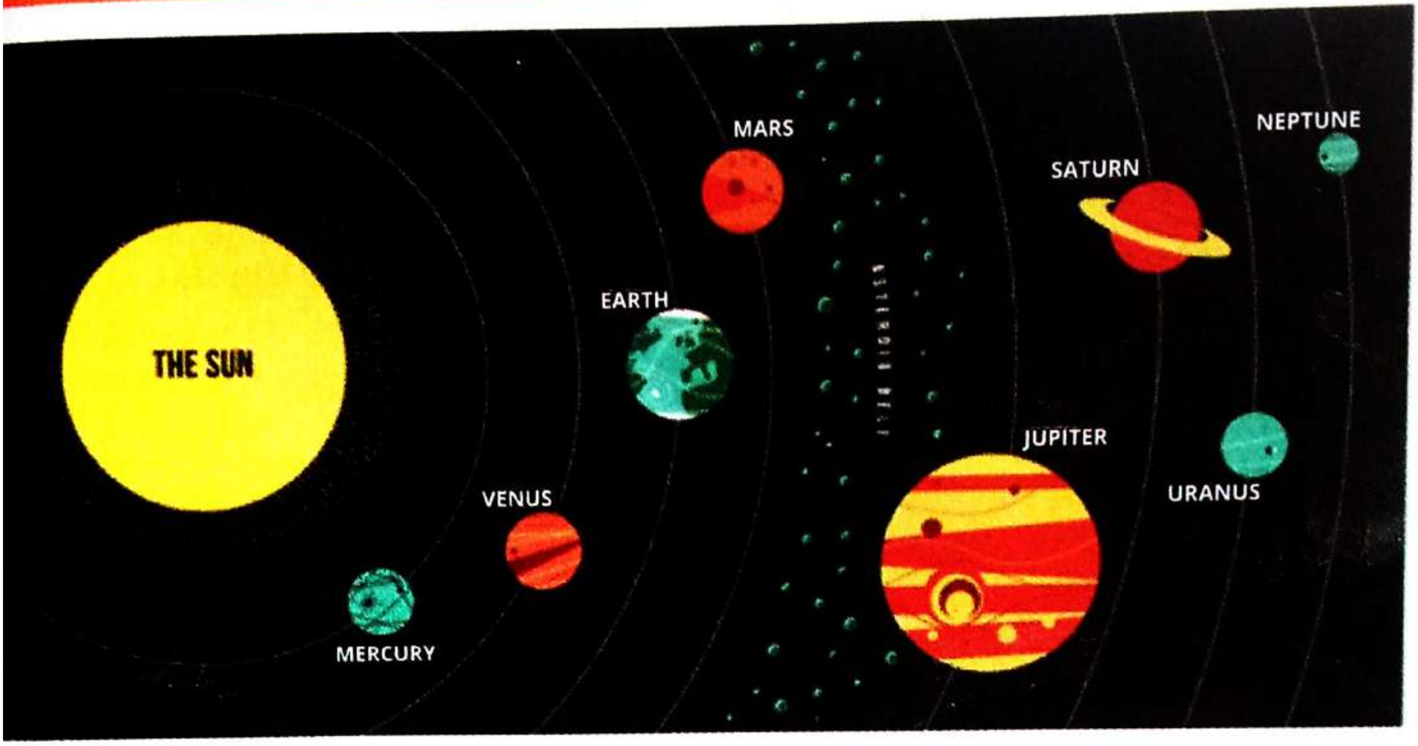
Chapter Summary

- The effect of static electricity can be explained by what we call electric charges.
- There are two types of charge. The positive and the negative charge.
- We can charge by rubbing (friction) or induction.
- In an atom, we have protons, electrons and neutrons.
- Protons carry positive charge while electrons carry negative charge.
- The neutrons carry no charge.
- Electrons can be moved from one material to another.
- Like charges repel, whereas unlike charges attract.
- Lightening is formed because of a buildup of electric charge in a cloud.
- The huge electric force overcomes the insulation of air and a huge lightening spark occurs.

Activity of integration

A certain primary school is located in a village which is prone to lightening strike. You are invited to talk to pupils and teachers in the primary school about the causes and dangers of lightening and thunder, and how to protect oneself against lightening strike. Prepare a speech of your talk.

CHAPTER 8
THE SOLAR SYSTEM



Key words

- Static electricity
- Phases of the moon
- Ocean tides
- Planet
- Solar system
- Universe

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

a) Know the relative sizes, positions and motions of the earth, moon and the sun.

b) Understand how day and night occur and demonstrate the phases of the moon.

c) Understand the roles of the sun, earth and the moon in explaining time, seasons, eclipses and ocean tides.

d) Know the components of the solar system and their positions.

e) Know the main characteristics of the inner and outer planets of the solar system.

f) Understand various views about the origin and structure of the universe.

8.1. Introduction

Everyday you wake up in the morning, you see the sun rising from the East and in the evening setting in the West. You might be asking yourself whether it is the same sun that rises up and sets down or two different suns; one rising up in the morning and the other setting down.

You have also observed that in some nights, there is no moon while others the moon appears in different sizes - as crescent or full moon. How do these scenarios happen? In this chapter, you will understand the relative movement of the earth and the moon in relation to the sun and explain the consequences of these movements

Relative sizes, positions and motions of the earth, moon and the sun.

Life on earth is greatly influenced by two bodies in the universe, namely the moon and the Sun. These two bodies are actually very big, but you see them appearing small because they are very far from the earth.

(a) (b)

Figure 8.1: Appearance of the moon and the Sun in the sky

Facts for you

The Moon, the Earth and the Sun are all spherical with the following diameter;

- The diameter of the Moon is approximately 3,500 km.
- The diameter of the Earth is approximately 12,800 km.
- The diameter of the Sun is approximately 1,400,000 km.

Activity 8.1: Comparing the sizes of the Moon, Earth and Sun **Page 97 from the Learners Guide**

Key Question: How do the sizes of the Moon, Earth and Sun compare?

What you need:

Information about the diameter of the Moon, Earth and Sun.

What to do:

1. Calculate the volume, in km3, of;
   - The Moon.
   - The Earth.
   - The Sun.

2. How many moons can fit in the Earth?
3. How many Earths can fit in the Sun?

When we look at the full Moon or the Sun (in the morning or in the evening), they appear circular in shape.

Activity 8.2: Scale modeling of the sizes of the Moon, the Earth and the Sun.

Key Question: How can you model the sizes of the Moon, Earth and the Sun?

What you need:

- Manilla paper,
- String, Measuring tape,
- A Notebook,
- Pencil,
- Pair of Scissors,
- A complete mathematical set,
- Pieces of cellotape.

What to do:

1. Copy and complete the following table.

Table 8.1

Object	Actual diameter (km)	Scale diameter (cm)	Scale area (cm2)
Moon	3,500		
Earth	12,800	1.0	
Sun	1,400,000		

2. Use a pair of compass and a pencil to draw a circle on a manilla paper whose diameter is the scale diameter of the Moon. Cut out the circle using the pair of scissors and label it 'Moon'.
3. Use a pair of compass and a pencil to draw a circle on a manilla paper whose diameter is the scale diameter of the Earth. Cut out the circle using the pair of scissors and label it 'Earth'.
4. Tie the pencil using the string and draw a circle on the manilla paper whose diameter is the scale diameter of the Sun. Cut out the circle use the pair of scissors and label it 'Sun'.
5. Using pieces of cellotape to stick the three circles on a vertical wall and compare the sizes of the Moon, the Earth and the Sun.
6. Compare your observations to what you actually see in the sky and explain the variation.

Facts for you

1. The distance between the Earth and the Moon is approximately 400,000 km.

Activity 8.3: Investigating the relative distances between the Moon, the Earth and the Sun.

Key Question: What is the relative distance between the moon and the sun from the earth

What to do:

1. Divide the average distance of the Sun from the Earth with the average distance of the Moon from the Earth.
2. Divide the diameter of the Sun with the diameter of the Moon.
3. Compare the results and explain why the Moon and the Sun appear almost the same size in the sky.

Activity 8.4: Making a scale model of the relative distances between the Earth, the Moon and the Sun.

Key Question: How can you make a model of the relative distances between the Earth, the Moon and the Sun?

What you need:

- A long piece of string,
- Three pieces of paper labelled Moon, Earth and Sun,
- A marker,
- A tape measure,
- A calculator.

What to do:

1. Using a scale of 1 cm to 400,000 km, determine the scale distance between the Earth and the Sun.
2. Mark one end of the long string and using a piece of cellotape, tie the piece of paper labelled Earth at this mark.
3. Measure the scale distance between the Earth and the Moon and mark the position of the Moon on the string. Using a piece of cellotape, tie the piece of paper labelled Moon at this mark.
4. Measure the scale distance between the Earth and the Sun and mark the position of the Sun on the string. Using a piece of cellotape, tie the piece of paper labelled Sun at this mark.
5. Ask two friends to hold the string and the position of the Earth and the other at the position of the Sun. Let them stretch the string.
6. What observation do you make and what conclusion can you draw?

8.2. The Earth's rotation

The Earth is not stationary. It is constantly rotating/spinning in an anticlockwise direction about an axis which passes from the North-pole to the South-pole.

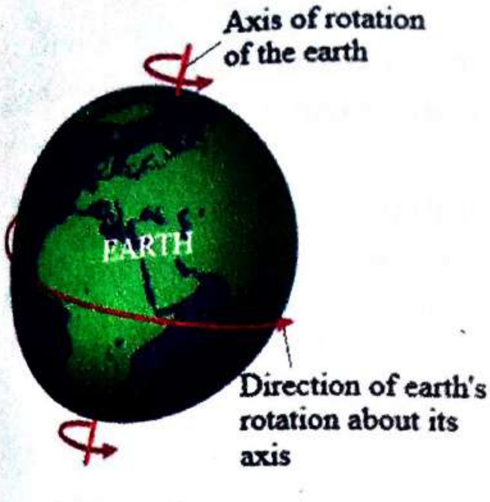


Figure 8.2: (a) Rotation of the Earth about its axis (b) Occurrence of Day and Night on the Earth's surface

Facts for you

The Earth takes 1 day (24 hours) to make one complete rotation about its axis.

Activity 8.5: Investigating the speed of rotation of the Earth about its axis.

Key Question: At what speed does the Earth rotate about its axis?

What you need:

- Prior knowledge on calculating circumference and speed.

What to do:

1. Given that the diameter of the Earth is 12,800km, calculate the circumference of the Earth.
2. Find the speed at which the Earth rotates about its axis in km/h.
3. Compare the average speed of rotation of the Earth about its axis with the average speed of a car moving at 100km/h.

As the Earth rotates about its axis, some part of the Earth receives light from the Sun while the other part does not receive Sun light. The part of the Earth which receives Sunlight is called Day while the other part which does not receive Sunlight is called Night. This explains why the day is always bright while the night is always dark, indicating the absence of light.

Activity 8.6: Investigating the occurrence of day and night.

Key Question: How do "day" and "night" occur?

What you need:

- A globe/orange,
- A stick,
- A marker and
- A torch.

What to do:

1. Place the globe at suitable distance from you or pierce the orange with the stick and then ask a friend to hold up the orange using the stick at suitable distance from you.
2. Use a torch, flash light on to the globe or orange.
3. Identify the side of the globe or orange lit by the torch (call this day time) and the other side not lit by the torch (call this night time).
4. Mark a spot on the globe or orange using a marker.
5. Spin/rotate the globe or orange slowly so that the mark goes from day to night and again back to day and night.
6. Compare this spinning of the globe to the rotation of the Earth about its axis. Is the spot always lit by the same torch flash as it comes to the day side of the globe/orange? What conclusion can you draw about the rising Sun. Hence, explain occurrence of day and night.

8.3. Revolution of the Earth around the Sun

As the Earth spins about its axis of rotation, it revolves around the Sun in a circular path called an orbit, see Figure 8.3. The Earth takes 365.25 days to revolve in its orbit around the Sun. Thus, during ordinary years, it is assumed that the Earth takes 365 days to revolve around the Sun. However, after 4 years the fractional days (0.25 x 4 = 1day) add one more day to the revolution of the Earth. Such years are called leap years. Hence in a leap year the Earth takes 366 days to revolve around the Sun.

Figure 8.3: Revolution of the Earth around the Sun.

Research work:

1. How do the spinning of the Earth about its axis and its revolution about the Sun give rise to the different seasons on Earth?
2. Discuss the economic importance of the spinning and revolution of the Earth to the survival of life on the Earth.

8.4. Rotation of the Moon around the Earth

Just as the Earth rotates around the Sun, the moon also rotates around the Earth. The time the Moon takes to make one complete revolution around the Earth is approximately 27 days and 7 hours. During this rotation, we can only see the part of the moon which receives and reflects Sun light to us on Earth. This explains why we see different shapes of the Moon every day. The different shapes are called the phases of the moon, which are shown in Figure 8.4. The phases repeat themselves after every 29 days and 12 hours.

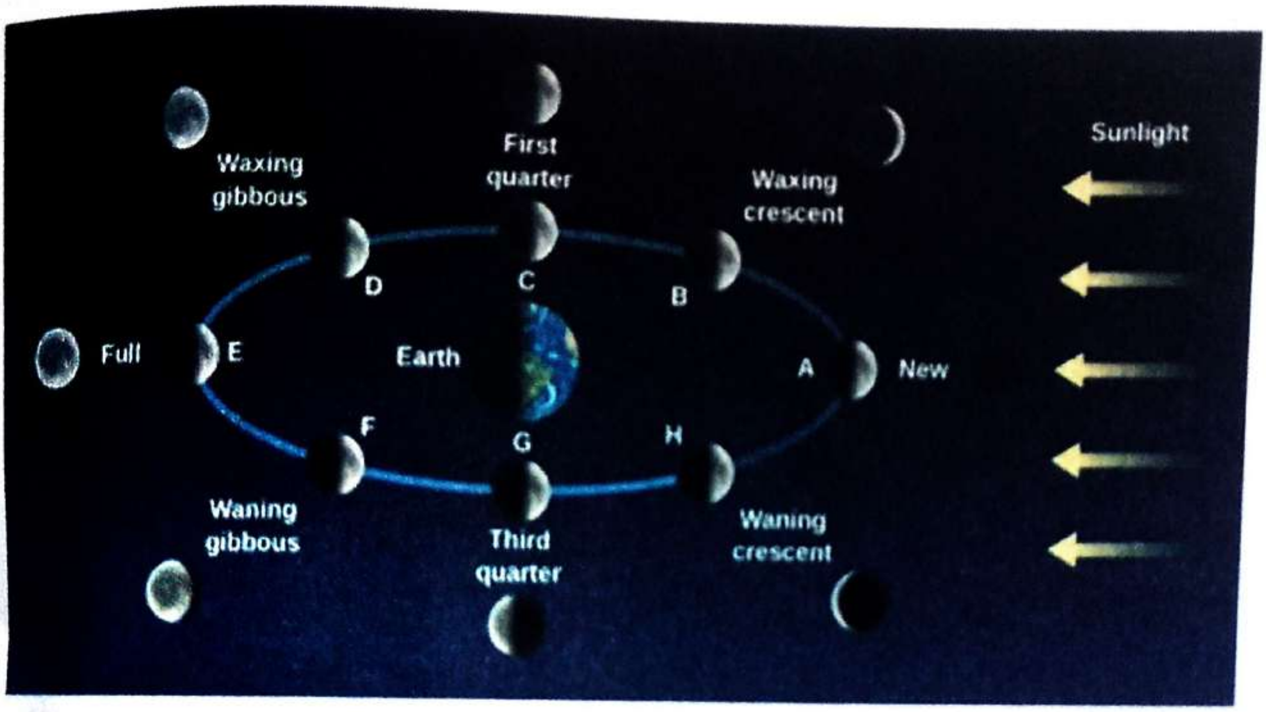


Figure 8.4: Phase of the moon

Facts for you

Waxing means growing. It is used to describe the moon as it grows from new moon to full moon.

Waning means shrinking. It is used to describe the moon as it gets smaller from full moon to new moon.

The first quarter of the moon is when it has completed 1/4 of its orbit around the Earth. This occurs when the moon appears to us as a half moon.

The third quarter of the moon is when it has completed 3/4 of its rotation around the Earth. During the third quarter, the moon also appears as a half moon.

From Figure 8.4 new moon (at position A) occurs when the moon is on the same side of the Earth as the Sun and full moon occurs when the moon is on the opposite side of the Earth relative to the Sun.

Exercise 8.1

1. Explain why you cannot see the new moon?
2. Why are the waxing or waning crescents less bright compared to the full moon?
3. Why don't the eclipses you learnt about in Learner's book 1, chapter 8, occur every month?

Activity 8.7: Investigating the phases of the Moon

Key Question: What leads to the occurrence of the phases of the Moon?

What you need:

- A screen,
- A simulation video,
- Access to Internet and
- Manilla paper

What to do:

1. Search on the internet for a video which shows the phases of the Moon.
2. Watch it carefully and draw on manilla paper a diagram showing the phases of the Moon.
3. Discuss how the different phases of the Moon occur.
4. Write down the names of the different phases of the Moon.

8.5. Occurrence of ocean tides

Tides are periodic rise and fall in the level of large bodies of water, like oceans and seas. Tides are caused by the attraction between the masses of the Earth and the Moon. This attraction is commonly known as gravitational attraction. The gravitational attraction of between the Moon and the Earth causes the oceans to bulge (rise) out from the surface of the Earth in the direction of the Moon. Another bulge occurs on the opposite side, since the Earth is also being pulled toward the Moon (and away from the water on the far side). Since the earth is rotating while this is happening, two tides occur each day.

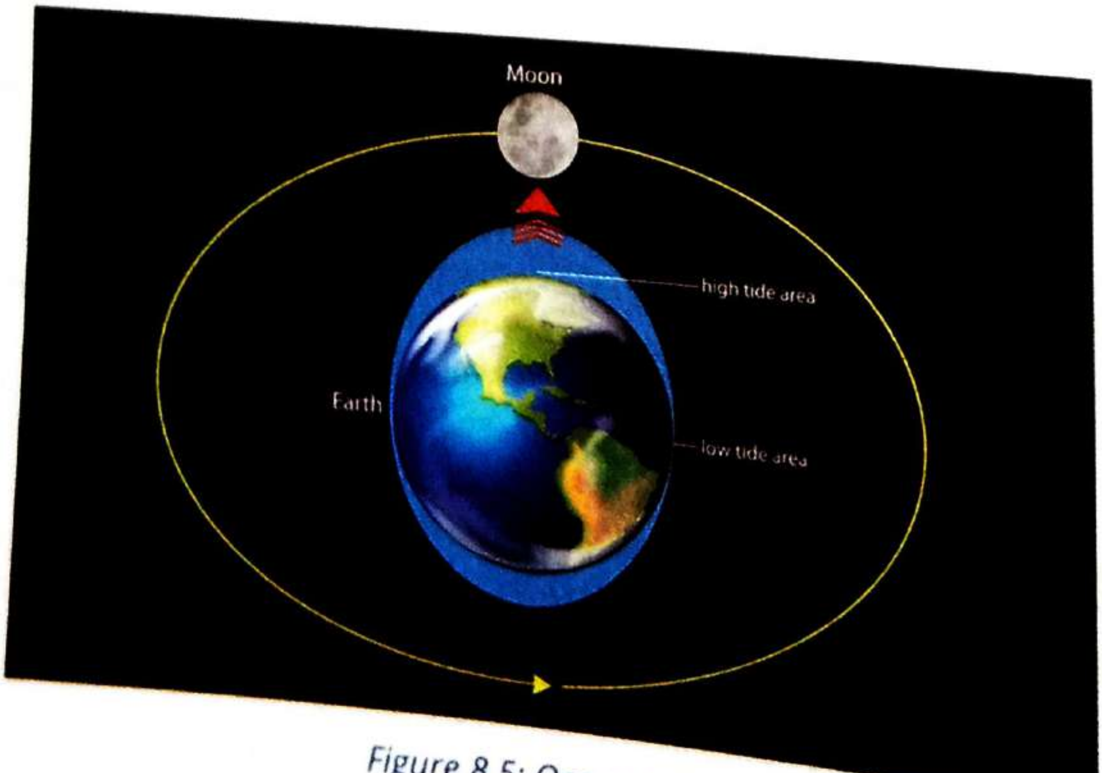


Figure 8.5: Ocean tides

Exercise 8.2

1. Describe the occurrences of tides.
2. What are the economic importance of ocean tides to people living along coastal lines?
3. Search on internet about the dangerous impacts of ocean tides.

8.6. Components of the Solar System

The Solar System is a system of objects that orbit the Sun, either directly or indirectly, under the influence of the Sun's gravitational pull. Of the objects that orbit the Sun directly, the largest are the eight planets, with the remainder being smaller objects (comets), the dwarf planets (Asteroids) and dust particles. All these objects are shown in Figure 8.6. Can you identify the planets, the comets and the asteroids?

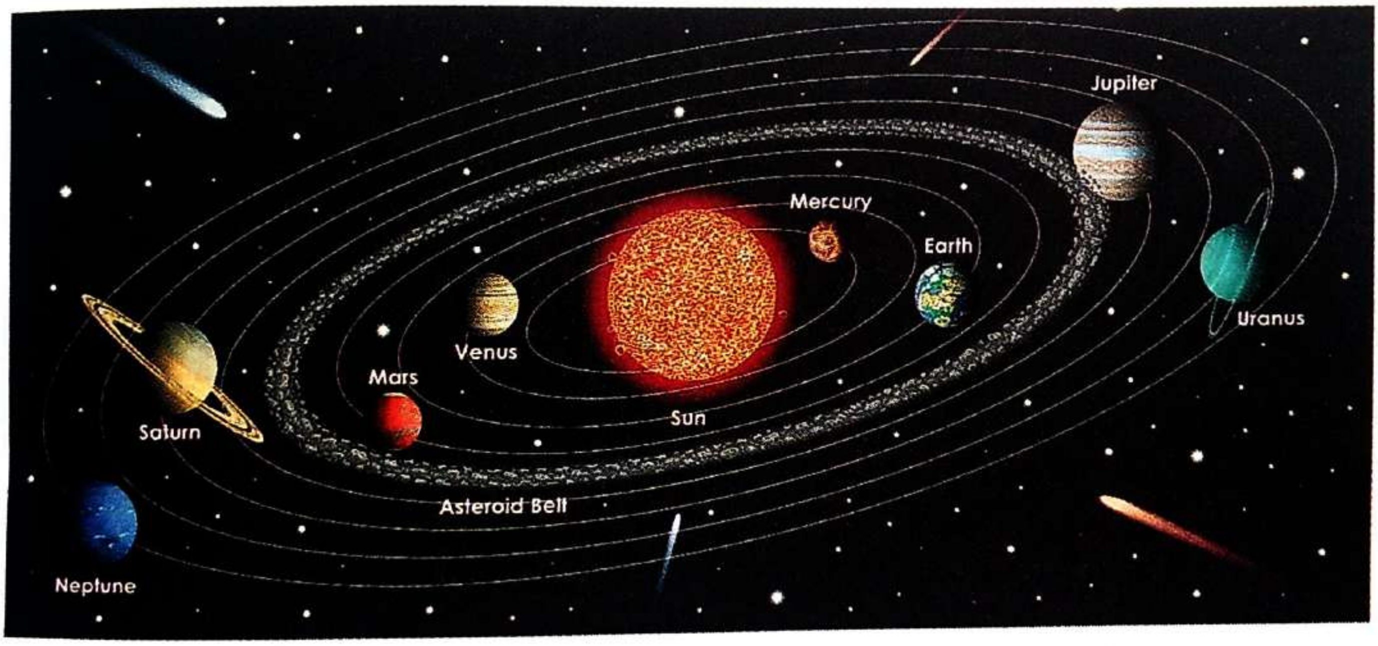


Figure 8.6: Our solar system

Right from primary school you were told that the planets revolve around the Sun. But have you ever asked yourself how far these planets are from the Sun and what distances exists between them?

The people who study the universe, including our solar system are called Astronomers. They have discovered that our solar system is extremely large in size. As a result, they have introduced a new unit to measure the distances between planets and from the Sun. This unit is called Astronomical Unit (AU), where;

1 AU = 150,000,000 km or 1.5 x 108km (the distance between the Sun and the Earth). This unit provides an easier way to compute the distances between planets and from the Sun.

Exercise 8.3:

Table 8.2

Planet	Distance from the Sun (AU)	Distance from the Sun (km)	Colour
Sun	0.0		Yellow
Mercury	0.4		Solid red
Venus	0.7		Cream
Earth	1.0		Clear blue
Mars	1.5		Clear red
Asteroid belt	2.8		Black
Jupiter	5.2		Orange
Saturn	9.6		Clear gold
Uranus	19.2		Dark blue
Neptune	30.0		Light blue
Pluto	39.5		Brown

Activity 8.8: Investigating the relative sizes and distances of the planets in our solar system.

Key Question: What are the relative sizes and distances of the planets in our solar system?

What you need:

- Internet,
- Text books,
- A long string,
- A marker,
- Pieces of paper each having the name of a planet,
- Manilla papers and
- A pair of scissors.

What to do:

1. Research on internet about the relative sizes of the planets in our solar system and then complete the table below.

Table 8.2

Planet	Diameter (km)	Scale diameter (cm)	Volume (cm3)
Mercury			
Venus			
Earth	12,800	1	4.2

Planet	Diameter (km)	Scale diameter (cm)	Volume (cm3)
Mars			
Jupiter			
Saturn			
Uranus			
Neptune			
Pluto			

2. Determine how many Earths' can fit in each of the planets.
3. Make a scale model showing the relative sizes of planets in our solar system and display the models on a vertical wall.
4. With reference to exercise 8.3 and taking 1 cm to represent 1 AU, mark the distances of the planets from the Sun on a long string. At each mark, place the piece of paper containing the name of the planet at that point.
5. Ask two friends to stretch the string so that you can compare the relative distances of the planets from the sun.
6. Investigate on the period of revolution of each of the planets in the solar system and calculate the speed of revolution of each planet.

Activity 8.9: Investigating the inner and outer planets.

Key Question: What do you understand by inner and outer planets?

What you need:

- Internet and text books.

What to do:

1. Search on the internet or text books for the meaning of inner planets and outer planets.
2. Name the inner and outer planets in our solar system.
3. Write down the characteristics of each of the eight planets in the solar system.
4. Why is it that it's only the Earth that supports life among all the planets?

8.7. The origin and structure of the universe

Have you ever asked yourself how and when the universe began? What existed before the universe? Such questions have often puzzled many people and have provoked scientists to carryout deep researchers. Since none of us was around when the universe began, the best that scientists can do is work out the most practicable proofs backed up by theory and observations of the universe.

Activity 8.10: Comparing different theories about the origin universe.

Key Question: What do different theories say about the origin of the universe?

THEME: Earth and Space Physics

What you need:

- Access to the Internet,
- Text books,
- Tales.

What to do:

1. Research on the internet, text books or through tales on information about the theories that describe the beginning of the Universe.
2. Compare the evidence that supports each of the theories that you have discovered.
3. Which of these theories is more convincing to you about the origin of the universe and why?

Facts for you

A number of theories namely Steady State, Big Bang, Quasi-Steady State, Cosmic Inflation, Religious Cosmology and Metaphysical Cosmology have been advanced, each trying to answer these questions the question on the origin of the universe in a different way.

Chapter Summary

In this chapter, you have learnt that;

1. The moon and the Sun influence life on Earth.
2. There are eight major planets in our solar system that revolve around our Sun.
3. Our solar system is part of a greater universe.

Activity of integration.

The world population is growing so fast that different governments have expressed concern that in the near future the available land on Earth may not be sufficient for the economic activities required to sustain the growing population. There is need to explore the planets in our solar system with the view of identifying another planet that can sustain life. Imagine that you are a scientist or an engineer designing a new space probe to explore our solar system for this purpose. Watch a video on "space probes". Make a plan and create your own design of a space probe that can enable you to review the weather conditions on the different planet of our solar system.

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