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Preface

In preparing this book as an integrated science book, several new concepts have been introduced without neglecting the basic aspects.

The following are the main features of this book.

- Every chapter begins with an introduction which high lights its importance by relating the contents with day-to-day life situations so as to motivate the students to learn its contents.
- The content material of each chapter is presented in small sections and sub sections. Each chapter is followed by five types of questions namely objective type, fill in the blanks, match the following, short and long answers for reflection of what the learners have studied in the particular chapter.
- Emphasis on developing concepts rather than merely providing information, through simple activities, explanations and simplified illustrations are given.
- The number of activities suggested are not prescriptive. These may modified or even replaced depending upon resources available in schools.
- 'Do you know' gives related information and updates the children's knowledge.

While preparing for the examination, students should not restrict themselves, only to the questions/problems given in the self evaluation. They must be prepared to answer the questions and problems from the text/syllabus.

It is a pleasure to express my thanks and gratitude to all those who have been associated at all stages with the development of this book. I thank all the authors and reviewers for their valuable contribution and relentless efforts in giving the present shape to this book.

Dr. D. Karunakaran
Chair person

CONTENTS

1. The Universe

1.1 The night sky

During the day, the sun is the only object visible in the sky. After sunset, the sky becomes dark and appears dotted with thousands of bright twinkling stars. Star light comes to us through moving layers of air that surrounds the earth. This causes twinkling of stars. On a clear night, we can see about 6000 stars with naked eye. Further, many more stars can be seen with the help of a telescope.

At night, moon is another object visible to us. Also, we can see some objects which do not appear to twinkle. These objects are called planets, like our earth which revolve around the sun. We may sometimes happen to see a bright line of light that appears for a short duration in the background of stars at night. It is likely that we have observed a shooting star, called meteor. Hence, the star, the sun, the moon, planets and shooting stars are some of the celestial bodies that are a part of the Universe.

1.1.1 Stars

A star is a huge ball of glowing gas held together by gravity. It continuously emits light and heat. The sun is the nearest star to the earth. So, sun appears large compared to other stars. Actually, many of the stars are much larger than the sun. But these stars appear like a point because of large distance from us. All stars shine day and night. But we can see the stars only when the sky is dark and clear. During the day, the stars are not visible because of the glare of bright sun light.

All stars including the sun move around some celestial body or a group of bodies with high speed. In spite of their great speed, the distance between any two stars does not seem to change when viewed from the earth. This is because the stars are very far away from us. If any change in distance occurs between them they do become perceptible in a few years or even during one's life time.

Everyday the sun and all other stars seem to move across the sky rising in the east and setting in the west. The rising and setting comes from the rotation of the earth from west to east about an imaginary axis that passes through its centre. However, there is one star, which appears stationary to us. This star is known as pole star or Polaris.

A star is made up of mainly hydrogen and helium gases. The great mass of a star makes the temperature at its centre high enough for a nuclear reaction to produce energy. This energy released by the reaction keeps stars shining.

1.1.2 Astronomical distance

Light from the distant stars takes millions of years to reach the earth. So, the distances of stars are measured in terms of light year. One light year is the distance travelled by light in one year at a speed of light which is about 3×10^8 metre per second. So, light year is the unit of astronomical distance.

Relation between light year and kilometre

Distance = Speed x time

$1 \text{ light year} = 3 \times 10^8 \times 365 \times 24 \times 60 \times 60$

$= 9.46 \times 10^{15} m$

$= 9.46 \times 10^{12} \times 10^3 m$

$1 \text{ light year} = 9.46 \times 10^{12} km$

Astronomical distance is also expressed in terms of millions of kilometre.

1 million of kilometre = 10^6 km

The distance of the earth from the sun is 1.496×10^8 km and is called astronomical unit (AU).

Therefore 1 AU = 1.496×10^8 km

The sun is about 150 million kilometre from the earth (150 million kilometre = 150000000 km). It means that light takes about 8 minutes 20 seconds (8.3 min) to reach the earth from the sun. In other words the distance of sun from the earth is nearly 8.3 light minutes. The star nearest to the earth after the sun is alpha centauri which is at a distance of about 4.3 light years.

1.1.3 Constellations

A group of stars, as seen from the earth appears to form some kind of pattern. Our ancestors imagined some known shapes formed by many group of stars and gave them specific names. Such a group of stars is known as constellation. The modern astronomers have divided the whole sky into 88 constellations. Some of them are Ashvini, Bharani, Chitra, Mriga, Aries, Gemini, Cancer, Leo, Virgo, Libra and Pisces.

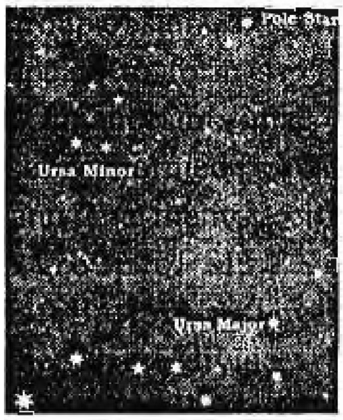


Fig. 1.1 a Stars in Ursa Major and Ursa Minor

You can easily see some constellations with naked eyes. Ursa major (saptarishi), Ursa minor (laghu saptarishi) and Orion (Mriga) are some easily identifiable constellations. The relative position of stars in Ursa major and Ursa minor is as shown in figure 1.1a.

Ursa major has seven chief stars making up a pattern known as Plough (Fig.1.1a). It is also known as Big Dipper, the Great Bear or Saptarishi. A straight line drawn through the pointer stars of the Plough will meet the pole star or Polaris.

Ursa minor constellation is similar to Ursa major constellation except that the stars are less bright and much closer together. The last star in the handle of the Little Dipper (Ursa minor) is the pole star itself.

Both Ursa major and Ursa minor constellations are visible in summer.

Orion is one of the brightest constellations that are seen in the north in winter and in the south in summer. This constellation appears like a hunter. The three stars in the middle represent the belt of the hunter. Hanging from Orion's belt is his sword containing three stars (Fig. 1.1b).

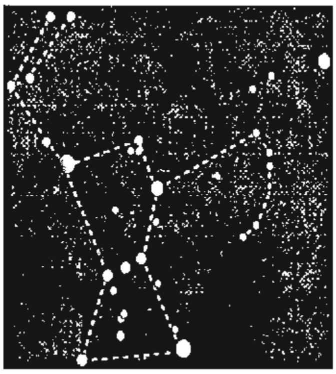


Fig. 1.1b Stars in Orion

1.1.4 Galaxies

A galaxy is a system of stars, dust and gas physically bound together by gravity. The galaxies are the building blocks of the Universe. The universe includes everything from the smallest sub-atomic particle to the largest galaxies and groups of galaxies.

The milkyway is a galaxy consisting of about hundred billion (10^{11}) stars. It includes the sun, the earth and rest of our solar system. It is thick in the middle and thin at the edges as shown in figure 1.2. In the Milkway the sun is situated at a distance of 27,000 light years away from the centre.

Astronomers estimate as many galaxies as are stars in the Milkyway. They classify the galaxies according to their appearance and shape. There are three main types: spiral galaxies, elliptical galaxies and irregular galaxies. Milkyway is a spiral type galaxy.

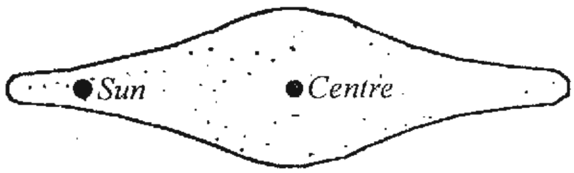


Fig. 1.2 Milkyway

Only three galaxies outside the Milkyway can be seen from the earth without a telescope. Andromeda is the nearest major galaxy to the earth. Andromeda galaxy is 2×10^6 light years away from our galaxy. People in the northern hemisphere can see Andromeda galaxy.

People in the southern hemisphere can also see two galaxies, the large and small Magnellanic clouds, which are about 160000 and 180000 light years away. The three visible galaxies can be seen most easily on clear and dark nights.

Activity 1

Explain the size and shape of galaxies, stellar constellations with charts. Also, locate the solar system in the Milkyway galaxy.

1.2 Solar system

A part of the Milkyway in which sun occupies a central position of the system holding together all planets, satellites and other heavenly bodies that revolve around it is called solar system.

1.2.1 Planets and satellites

The solar system consists of nine planets. They are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto. Between Mars and Jupiter there is a belt of minor planets called Asteroids. They revolve in elliptical orbits around the sun. Figure 1.3 shows a schematic view of the solar system.

The motion of planets in their orbits is due to the force of gravitation of the sun on them. The planet Mercury is nearest to the sun and Pluto is farthest from the sun. Jupiter is the largest of all the planets and Saturn is the second largest. Mercury and Venus are called inferior planets, as their orbits are smaller than that of the earth. The other planets are called superior planets whose orbits are larger than that of the earth.

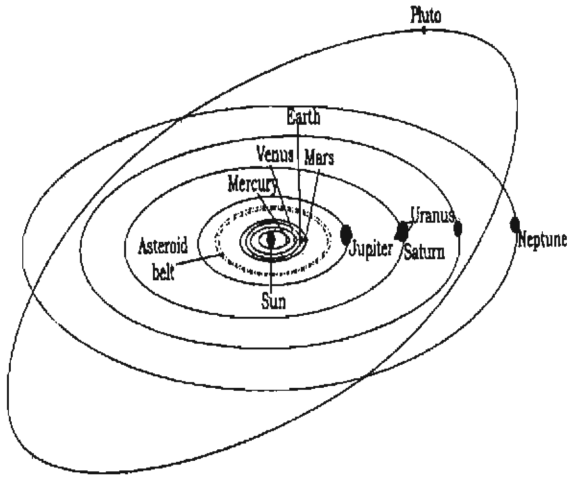


Fig. 1.3 Solar system

In the solar system, only the sun emits its own light. The planets appear bright by reflecting the light falling on them from the sun. The planets have heavenly bodies called satellites revolving around them.

The Kepler's laws of planetary motion and Newton's law of gravitation along with radiation laws help us to determine various physical properties such as distance, size, period of revolution, mass, surface temperature and atmosphere of planets in solar system.

The size of the solar system is

equal to the radius of the orbit of pluto which is about 5.6 x 10^9 km.

In addition to the sun, nine planets and their satellites, and asteriods, the solar system contains many bodies called comets and meteors. These are other types of celestial bodies whose motion is also due to the gravitational force of the sun.

It is believed that the sun has a total life of about 10 billion years. Out of which, nearly 5 billion years is already over.

The sun is made up of extremely hot gases giving out huge flames. Also, sun is the only source of heat and light energy to all the heavenly bodies that revolve around it. The interior of the sun is called photosphere. The temperature of the core is of the order of 14 million kelvin. The outer region of the sun is called the chromosphere and its temperature is of the order of 6000 kelvin.

Activity 2

Examine the physical conditions of planets of the solar system.

1.2.1 Observations of planets and satellites

Planets:

1) Mercury

The planet nearest to the sun is called Mercury. The surface of Mercury is full of craters of different sizes similar to that of the moon. There is no atmosphere surrounding mercury. The temperature variation between day and night is very large.

Mercury is hidden in the sun's glare most of the time. So, it is occasionally visible just before the sunrise or just after the sunset. It has no known satellites.

2) Venus

Venus is similar to the earth in respect of radius, mass and density. So, it has been rightly called the earth's twin. Venus is a brilliantly shining planet as it reflects as much as 85% of the sunlight falling upon it. Surface temperature of the Venus is 700K. Venus appears as an evening star just above the western horizon and it also appears in the eastern sky as morning star. However, it is not visible throughout the year due to being closer to the sun than to the earth. Venus does not have a moon.

3) The earth

Earth has only one natural satellite, the moon. The earth is the only planet known to have life on it. Its radius is 6400 Km. The earth rotates once in 24 hours about an imaginary axis that passes through its north and south poles. The day and night on the earth occur due to this rotation. The earth completes its journey around the sun in 365.25 days. The axis of rotation of the earth with respect to its orbital plane is tilted by an angle of 23.5^0. This tilt causes change in seasons on the earth.

4) Mars

Even for naked eyes Mars appears reddish. It is also called red planet. The Mars is visible from the earth for most part of the year. However, it is best situated for observation when it is opposite to the sun's position in the sky with respect to the earth. On these days, it is closer to the earth as well. Mars has two tiny satellites. It has no atmosphere. A view of the Mars from the earth is as shown in figure 1.4.

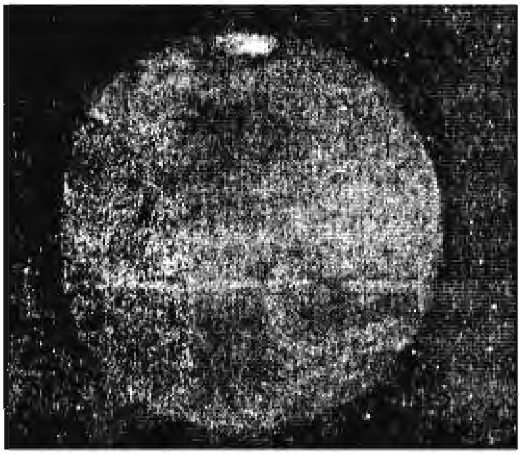


Fig. 1.4 View of the Mars

5) Jupiter

Jupiter is the largest planet of our solar system. It is covered by clouds and an enormous red spot can be seen in the clouds. Jupiter has 28 known satellites.

6) Saturn

Galileo first observed it with a telescope in 1610. It is seen with naked eyes as a bright yellow planet. Saturn has several beautiful rings around it. It has 18 named satellites and 12 recently discovered satellites. The division between the main and the outer rings is called Cassini's division (Fig.1.5).

7) Uranus

It is a large planet and appears green when seen through a telescope. It has 21 satellites.

8) Neptune

It is very far off and can be seen only through telescopes. It has rings too. Neptune has 8 satellites.

9) Pluto

It is the outermost and coldest planet of the solar system. It has one satellite.

Satellites

Heavenly bodies revolving around a planet are called natural satellites or moons. Some planets do not have any satellites whereas some have many.

The moon is the only satellite of the earth. The moon does not emit light like the sun and other stars. The moon appears to be the brightest due to the reflection of sun's light falling on it.

Therefore, we see only that part of the moon, which is lighted by the sun and is towards us. So, it is not possible to see the other side of the moon.

The surface of the moon is rough. There are number of craters on the moon which are similar to volcanic craters on the earth. The surface of the moon is very hot during the day and very cold during night. The moon has no atmosphere. One can see its surface features clearly with powerful telescope.

The moon revolves round the earth in 27.32 days. The time period of the moon about its own axis is also equal to 27.32 days. So, the same face of the moon is always directed towards earth. The distance of Moon from the Earth is about 384,400Km. The gravitational pull on the Moon is 1/6th of that on the Earth.

Fig. 1.5 View of the Saturn

1.2.2 Comets

Comets are very small-sized celestial bodies. They revolve around the sun in highly elliptical orbits. They become visible from the earth only when they come close to the sun. A comet has a distinct head and a glowing tail away from the sun as shown in figure 1.6. Many comets break up into smaller pieces while approaching the sun.

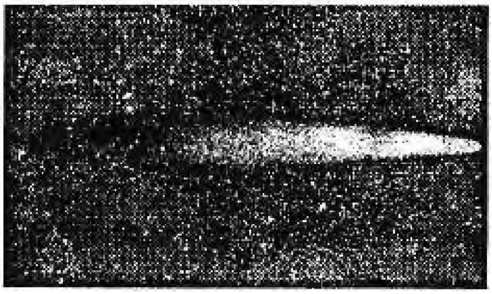


Fig. 1.6 A Comet

1.2.3 Important comets and their features

Many comets are known to appear again and again after a definite period of time. Enck's comet has the shortest known period about 3.3 years. The period of Hale-Bopp is about 4000 years and the period of Khoutek's is about 785,000 years. Halley's comet and comet 1884 I (Pons - Brooks) are quite bright. Halley's comet appears after nearly 76 years. Halley's comet was last seen in 1986. It may reappear in 2062.

Astronomers found out on july 8th 1992 Shoemaker - Levy, at 43,000 km from Jupiter, close enough for the immense tidal forces created by gravity to pull the comet and break it into 21 fragments which finally plunged into Jupiter.

Activity 3

Collect the pictures and information about comets.

1.2.4 Meteors and meteorites

Meteors are known as shooting stars. We can see a meteor on clear moonless light. Meteors are not stars. Meteors are very small pieces of rocks or metals. Meteors are formed due to breakage of comets, when they pass very close to the sun. When a meteor enters the atmosphere of the earth, it gets heated due to friction of air. Due to the high heat, the meteor begins to glow and evaporates within a short time. Therefore, the path of the meteors appear as a streak of light in the night sky as shown in figure 1.7.

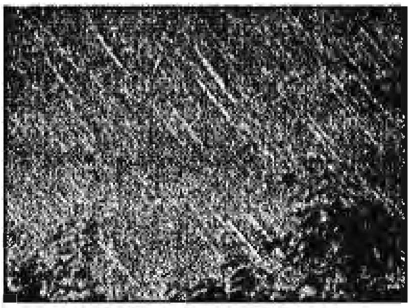


Fig. 1.7 The Meteors

Part of large meteors reaches the surface of earth before they get evaporated completely. These are known as meteorites. Meteorites help the scientists to study the nature of the material of celestial bodies which are part of the solar system.

Activity 4

Collect the pictures and information about meteors and meteorites.

1.3 Artificial satellites

The celestial bodies revolving around a planet are called satellites. For example, the moon is a natural satellite of the earth. An artificial satellite is a man-made object. When it is made to revolve round the earth, it becomes an artificial satellite of the earth. However, artificial satellites are much closer to the earth than the moon.

They have the same time period as the earth and so they stay at the same point as seen from the earth. Artificial satellites are called geostationary or geosynchronous satellites.

Artificial satellites stay in space for few years. The lifetime of each artificial satellite depends on its size and its distance from the earth. Artificial satellites must maintain a certain speed to stay in orbit. If an artificial satellite slows below this speed, it comes into the atmosphere and burns up because of friction with the air.

Most of the artificial satellites carry the radio transmitter and receiver. Transmitter sends signals to find the exact position of the satellites in space. Also, it sends the scientific information to the earth. A satellite's receiving equipment is turned on and off by means of signals beamed from the earth.

Scientists have developed very powerful launch vehicles or rockets capable of carrying the satellites into the space and launch them as an artificial satellite of the earth. The movement of a rocket is based on the principle of the law of conservation of momentum and Newton's third law of motion. At present, only six countries in the world have the technology for developing artificial satellites and launching them to orbit the earth. India is one of these six countries.

1.3.1 Uses of artificial satellites

Some important practical applications of artificial satellites are given below :

Artificial satellites are used for

i) long distance communication through telephones and internet.

ii) transmission of television and radio programmes.

iii) locating mineral and water resources.

iv) weather forecasting.

v) gathering more information about outer space.

vi) remote sensing.

Remote sensing means collecting information from a distance. This techonology is used to collect information about weather, agriculture, land and ocean features including movement of fishes in oceans.

Activity 5

Prepare an album on Indian satellites. Also, list out the uses of artificial satellites on everyday life.

1.3.2 Space exploration

Space exploration is man's quest for knowing the unknown in space. In that effort, manned and unmanned space probes have even crossed the borders of the solar system to collect information about the earth's neighbours, etc.,

The era of space exploration started in 1957, when Russian (erstwhile USSR) scientists succeeded in launching an artificial satellite in outer space. Within a few months, the United States of America (USA) also succeeded in launching its own satellite. Afterwards, USA created an independent agency for space exploration. The agency was called National Aeronautic and Space Administration (NASA). NASA has played a very important role in space exploration.

1.3.3 Space programme in India

The Indian space programme

began in 1962 with the creation of the Indian National Committee for Space Research (INCOSPAR). The Indian Space Research Organisation (ISRO) at Bangalore was setup in 1969. In the history of Indian space programme, the era of experimentation was during the 1970s, when experimental satellite programmes like Aryabhata, Bhaskara, Rohini and Apple were conducted. The success of those programmes led to the era of operationalisation in 1980s, when operational satellite programmes like INSAT (Indian National Satellite) and IRS (Indian Remote Sensing Satellite) came into being. Today, INSAT and IRS are the major programmes of ISRO.

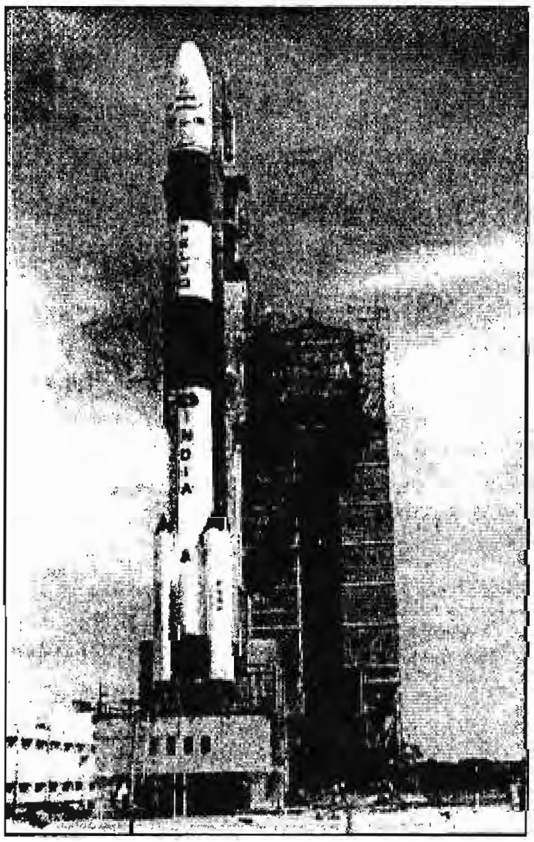


Fig. 1.8 Polar satellite launch vehicle

The significant milestone of the Indian space programme during the year 2002 - 03 is the seventh launch of polar satellite launch vehicle (PSLV) from Satish Dhawan space Centre, SHAR - Sriharikota (Andhra Pradesh) on september 12, 2002 which successfully placed 1,060 kg METSAT (Meteorological Satellite) in a geosynchronous transfer orbit. Later METSAT was renamed as KALPANA-I Figure 1.8 shows polar satellite launch vehicle (PSLV) developed by ISRO.

Activity 6

Collect materials on life and scientific contributions of Dr. A.P.J. Abdul kalam.

Some ISRO Programmes

Indian National Satellite (INSAT) System series :

INSAT - 1, INSAT - 2 , INSAT - 3

Indian Remote Sensing Satellite (IRS) System series :

IRS - 1, IRS - P

IRS data is marketed commercially. METSAT is used for weather monitoring. Rohini satellite system Series is for astronomical observations.

Polar satellite launch vehicle (PSLV) was developed and tested successfully. It is now available for launching 1000-2000 kg class of remote sensing satellites.

Geosynchronous satellite launch vehicle (GSLV) has already been tested successfully.

SELF EVALUATION

I. Choose the correct answer

1. The star nearest to earth is

   a) alpha centauri b) chitra c) sun d) dhruva

2. A group of stars that appears to form a familiar pattern is known as

   a) supernova b) neutron stars c) constellations d) milky way

3. In solar system, the planet farthest from the sun is

   a) mercury b) earth c) pluto d) uranus

4. Shooting star is

   a) an asteroid b) a planet c) a meteor d) a satellite

5. The movement of a rocket is based on the principle of

   a) Newton's third law b) Coulomb's law

   c) Boyle's law d) none of the above

II. Fill in the blanks

6. A vast collection of atoms held together by mutual gravity is called ________.
7. Light from the sun reaches us in ________ seconds.
8. Next to the sun, the star nearest to earth is ________.
9. The planet saturn is surrounded by ________ concentric rings.
10. ________ satellites are used for long distance communication.

III. Match the following

11. Light year	–	The galaxy closest to the earth
12. ISRO	–	Moon
13. Earth's twin	–	Bangalore
14. Satellite of earth	–	Unit of distance
15. Andromeda	–	Venus

IV. Give short answer

16. What are stars?
17. Define light year.
18. What is Milkyway?
19. Name the star, which appears to be stationery from the earth.
20. Name the planets of the solar system.
21. Name any two artificial satellites.

V. Give detailed answer

22. What are the differences between a star and a planet?
23. What are the differences between a satellite and a planet?
24. Write short notes on Moon.
25. Write an essay on constellation.
26. Mention the uses of artificial satellites.
27. What are the differences between meteors and meteorites?

2. Hydrostatics

Introduction

Hydrostatics deals with the equilibrium of fluids. Liquids and gases can flow freely and for this reason, they are called fluids. Fluids do not have a fixed shape like solids.

In this chapter, we shall study about the atmospheric pressure, measurement of atmospheric pressure using Aneroid and Fortin barometers, Archimedes' principle and its applications, laws of floatation, Hare's apparatus and hydrometers.

2.1 Thrust and pressure

A liquid or gas in contact with a surface is capable of exerting only a normal force on the surface.

Thrust

Thrust is defined as the total force exerted by a liquid perpendicular to the entire area (Fig. 2.1).

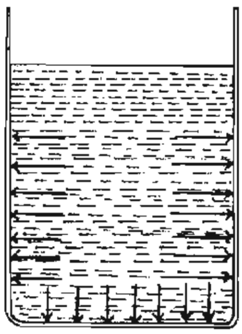


Fig. 2.1 Thrust

Thrust has both magnitude and direction. The unit of thrust is newton.

Pressure

Pressure is defined as the thrust acting normally on unit area.

The unit of pressure is N m^{-2} or pascal

The following equation gives the relation between pressure and thrust

Pressure = Thrust / area

2.1.1 Pressure at a point in a liquid

Let P be a point at a depth h below the free surface of a liquid like water of density d. Consider a very tiny area a around the point (Fig. 2.2). The thrust acting on this area is equal to the weight of the cylindrical liquid column standing over it.

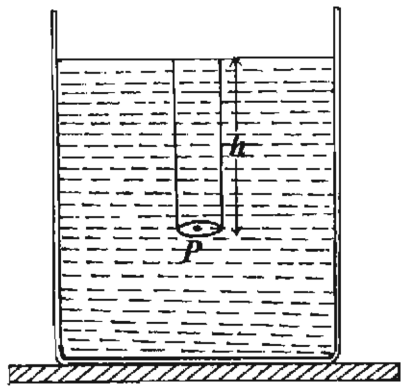


Fig. 2.2 Pressure at a point in a liquid

Volume of the liquid column on the area $a = ha$

Mass of the liquid column on this area = Volume of the liquid column × density of the liquid = had

Weight of the liquid column = *hadg*, *g* being acceleration due to gravity at that place

The thrust may be taken as uniform for this very small area.

Hence, pressure at *P* = thrust / area

$= hadg / a$

Therefore, pressure at *P* = *hdg* Nm^{-2}

At a given place, since *g* is constant, the pressure at a point in a liquid at rest depends only on ***depth*** and ***density***.

Activity 1

Variation of pressure with depth

Take a tall metal cylinder with a few holes on its side at various levels. Each hole has the same diameter. The holes are initially closed by corks. The cylinder is filled with water. When all the holes are opened, water rushes out through them but with varying forces. The water from the lowest hole falls far away from the cylinder (Fig. 2.3).

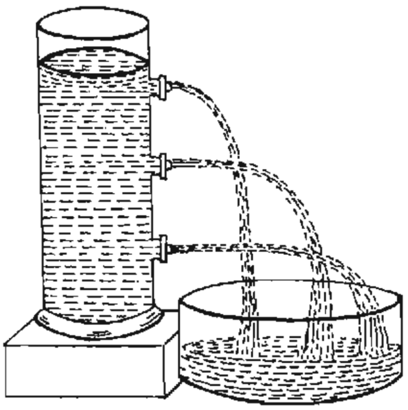


Fig. 2.3 Variation of pressure with depth

This experiment clearly shows that ***the pressure of the liquid increases with depth***.

Activity 2

Variation of pressure with density

Take two glass tubes of same height and same internal diameter. The lower ends of the tubes are closed with identical thin rubber sheets. Take water in the tube T_1 and castor oil in the tube T_2 keeping the height of the liquid columns equal in the two tubes (Fig. 2.4).

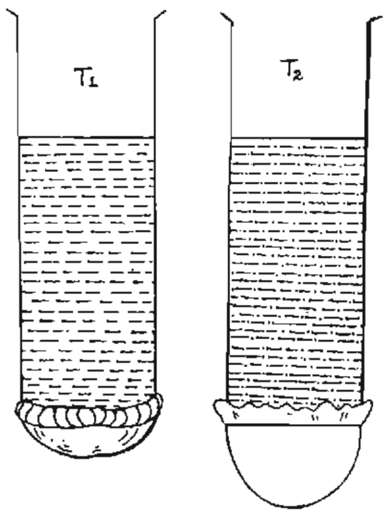


Fig. 2.4 Variation of pressure with density

The rubber sheet in the tube containing castor oil bulges out more than the rubber sheet containing water.

This experiment shows that ***the liquid having more density exerts a greater pressure.***

Problem 1

A brick measures 23 cm × 7.5 cm × 11cm and its mass is 2.75 kg. Calculate the three possible values of pressure it can exert on a surface.

Case(i) Length and breadth facing the surface

$$\text{Pressure} = \frac{\text{Thrust}}{\text{area}}$$

$$\text{Thrust} = \text{Weight (mg)}$$

$$= 2.75 \times 9.8 = 26.95 \text{ N}$$

$$\text{Pressure} = \frac{\text{Thrust}}{\text{area}}$$

$$= \frac{26.95}{23 \text{x} 7.5 \text{x} 10^{-4}}$$

$$= 1562.32 \text{ Nm}^{-2}$$

Case (ii) Breadth and height facing the surface

$$\text{Pressure} = \frac{\text{Thrust}}{\text{area}}$$

$$= \frac{26.95}{11 \text{x} 7.5 \text{x} 10^{-4}}$$

$$= 3266.67 \text{ Nm}^{-2}$$

Case (iii) Length and height facing the surface

$$\text{Pressure} = \frac{\text{Thrust}}{\text{area}}$$

$$= \frac{26.95}{23 \text{x} 11 \text{x} 10^{-4}}$$

$$= 1065.22 \text{ Nm}^{-2}$$

2.2 Fluid pressure

Take a long plastic tube and fill it partly with water. Hold the ends of the tube such that it is in the U shape. You can see that the levels of water in the two arms are the same (Fig. 2.5).

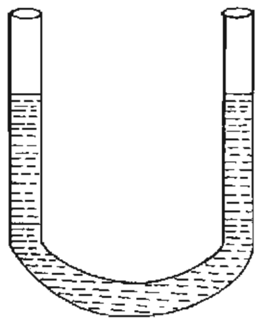


Fig. 2.5 Liquid seeks its own level

From this, it is clear that the liquid always seeks its own level.

2.2.1 Atmospheric pressure

The envelope of air surrounding the earth is called atmosphere.

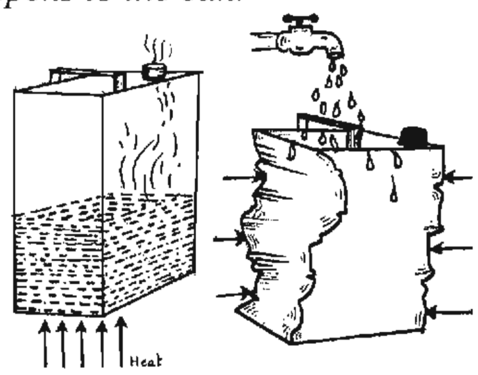
It extends up to a height of about 800 km. The density of air decreases as height increases. Air surrounds the earth because of the gravitational pull of the earth on it. The atmospheric pressure is caused by the weight of the air.

One atmospheric pressure is the weight of the air exerted over an area of one square metre.

It can be shown that one atmospheric pressure is equal to the pressure exerted by a column of 0.76 m of mercury.

Activity 3

Take a tin can. Remove the lid and pour some water into it. Heat the can for a few minutes. The water vapour displaces most of the air in the can. Close the can with the lid tightly and stop heating (Fig. 2.6a) Cool the can under the tap water and observe what happens to the can.



(a) ***(b)***

Fig. 2.6 Effect of atmospheric pressure

When cold water is poured on the can, the steam condenses into water and the pressure inside the can decreases. The atmospheric pressure outside the can is higher than the pressure inside the can and so the tin can gets crushed (Fig. 2.6b).

This experiment shows the existence of the atmospheric pressure.

2.2.2 Measurement of atmospheric pressure

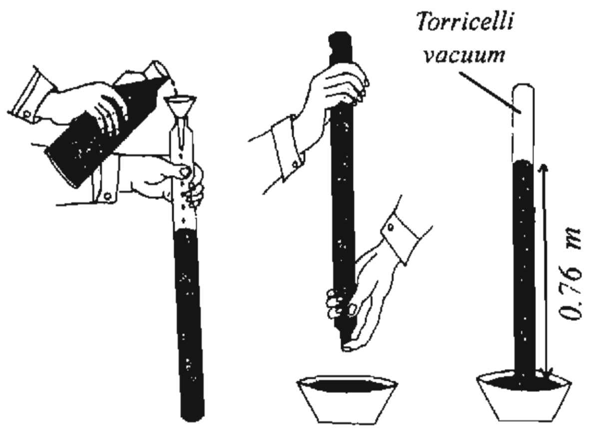
Barometers:

Barometers are used to measure the atmospheric pressure. An Italian scientist named **Torricelli** first measured the atmospheric pressure.

Take a glass tube about a metre long and closed at one end. Fill it with pure mercury (Fig. 2.7a) and plug the open end with the finger (Fig. 2.7b). Invert the tube and place it vertically in a dish containing mercury. Now remove the finger.

Measure the vertical difference in levels between the surfaces of mercury in the tube and the dish. At the sea level it is found to be 0.76 m (Fig. 2.7c). This height of 0.76 m of mercury at sea level is taken as a measure of one atmospheric pressure.

Torricelli explained that the column of mercury in the tube was supported by the atmospheric pressure acting on the surface of the mercury in the dish. The space above the mercury in the tube is called ***Torricelli vacuum.***



(a) ***(b)*** ***(c)***

Fig. 2.7 Measurement of the atmospheric pressure

2.2.3 Manometer

A manometer is an instrument used to measure the pressure of a liquid or gas contained in a vessel.

2.2.4 U tube manometer – measurement of air or gas pressure

It consists of a glass tube in the form of U and open at both the ends. The tube is partly filled with water. Initially the water level in both the arms will be the same (Fig. 2.8a).

An open end is connected to the gas tap by a rubber tube. The gas main is turned on and the difference in levels of water in the two arms is noted.

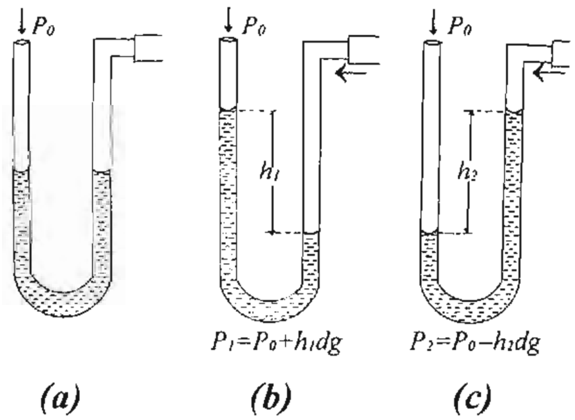


Fig. 2.8 The measurement of gas pressure

When the pressure of the gas is greater than the atmospheric pressure, the pressure of the gas is given by the equation $P_1 = P_0 + h_1dg$, where P_0 is the atmospheric pressure, h_1 is the difference in levels of water in the U tube (Fig. 2.8b) and d is the density of water.

When the pressure of the gas is less than the atmospheric pressure, the pressure of the gas is given by the equation $P_2 = P_0 - h_2dg$, where P_0 is the atmospheric pressure, h_2 is the difference in levels of water in the U tube (Fig. 2.8c) and d is the density of water.

Do you know?

Normally mercury is used as a barometric liquid due to its high density. If we use water as the barometric liquid, the height of the barometric column will be about 13.6 x 0.76 = 10.336 m, which may be highly inconvenient indeed.

2.2.5 Measurement of fluid pressure using U tube manometer

Take a U tube manometer open at both ends with mercury in it. One of the open ends is connected to the water tap as shown in the figure 2.9.

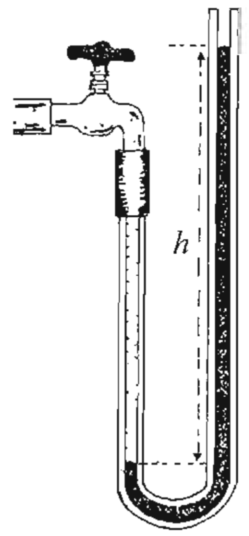


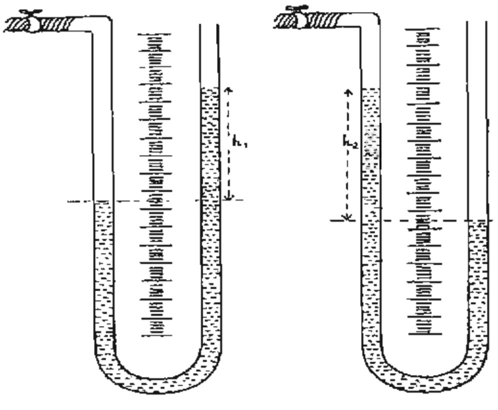
Fig. 2.9 Measurement of fluid pressure using U tube manometer

The difference in the levels of mercury in the two limbs gives the excess of pressure of the water supply over that of the atmosphere.

Activiy 4

Measurement of lung pressure

Take a plastic tube about 2m in length. The tube is bent in the U shape and fixed vertically on a wooden board. The tube is partly filled with water. Blow down one end of the tube and mark the difference h_1 in the levels of water in the two limbs (Fig. 2.10a).



(a) *(b)*

Fig. 2.10 Measurement of lung pressure

Once again the difference h_2 in the levels of water in the two limbs is noted by sucking through the tube (Fig. 2.10b).

The average of these two values h_1 and h_2 will give the lung pressure.

2.2.6 Aneroid barometer

Aneroid barometer does not use a liquid. It is an instrument used to measure the atmospheric pressure. It consists of a thin flexible metal vessel. This vessel is partially evacuated. The changes in atmospheric pressure cause the surface of the vessel to move up or down. These changes are recorded by a system of levers which make a pointer to move on a scale (Fig. 2.11).

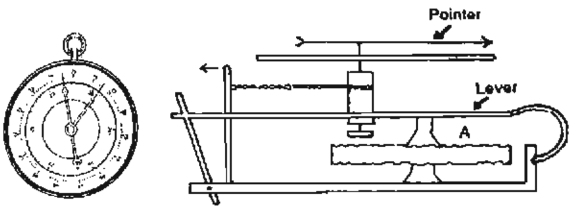


Fig. 2.11 Aneroid barometer

2.2.7 Fortin's barometer

The Fortin's barometer is the standard barometer used for the accurate measurement of the atmospheric pressure.

Construction:

One end of thick-walled glass tube is closed and the other end is open. The tube is filled with mercury and its open end is inverted inside the mercury in a cistern. The upper part of the cistern is made of glass and the lower part is made of leather which can be raised or lowered using a screw S (Fig. 2.12).

There is an ivory index I near the cistern which is fixed in such a way that the tip of it coincides with the zero of the vertical scale on the glass tube.

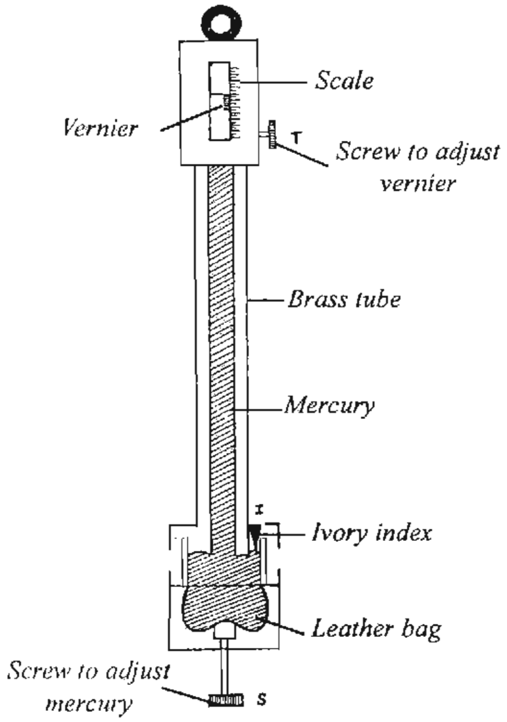


Fig. 2.12 Fortin's barometer

The barometer tube is enclosed in a brass tube, having a vertical slot at the top. The edge of the slot is graduated in centimetre. A vernier scale slides along the slot and can be fixed at any position with the help of a screw T.

Working:

The atmospheric pressure can be measured by doing the following adjustments.

1. By raising or lowering the screw S, the mercury surface in the cistern is made to touch the tip of the ivory index I.
2. The zero of the vernier scale is made to coincide with the mercury level in the tube.

The main scale reading and the vernier scale reading are noted to measure the atmospheric pressure.

2.3 Archimedes' Principle

A bucket fully immersed under water in a well appears to be very light. When this bucket is brought above the water level it weighs quite heavy. When the bucket is under the water level, the liquid displaced by the bucket exerts an upward force on it. This is known as the resultant ***up thrust (or) buoyancy***.

Archimedes' Principle states that

When a body is immersed in a liquid it suffers an apparent loss of weight equal to the weight of the liquid displaced by it.

2.3.1 Experimental verification of Archimedes' principle

A solid brass cylinder is taken and its length and diameter are determined with a vernier calipers. If l is its length and r its radius, then, its volume is $\pi r^2 l$.

The cylinder is suspended from the left hook of a balance and its weight W_1 is very accurately determined. A hydrostatic bench is introduced above the pan without touching the pan. A beaker of water is placed over the hydrostatic bench. The solid is now fully immersed in water in the beaker without touching the sides of the beaker (Fig. 2.13).

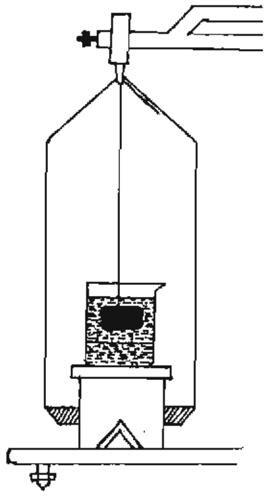


Fig. 2.13 Archimedes' principle

The weight of the cylinder in water W_2 is found accurately. It is found that W_2 is less than W_1. The apparent loss of weight of the cylinder is $(W_1 - W_2)$, which is equal to the weight of the displaced water $\pi r^2 l d$, where d is the density of the water.

Activity 5

Determination of the density of cork using Archimedes' principle

First, weigh the piece of cork in air (W_1). Suspend the cork from the hook of the left pan of the balance and a sinker from the cork. Immerse the sinker alone in water in a beaker kept on the hydrostatic bench and weigh (W_2) (Fig. 2.14a). Move the cork down the string, immerse both the cork and the sinker together in water and weigh (W_3) (Fig. 2.14b).

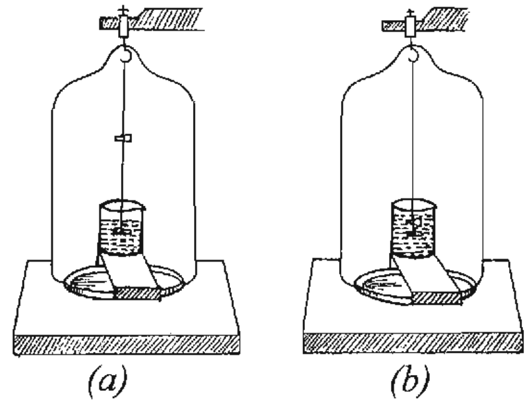


Fig. 2.14 Determination of the density of cork

The apparent loss of weight of the cork in water = ($W_2 - W_3$).
Hence, the specific gravity of the cork

$$= \frac{W_1}{W_2 - W_3}$$

But the specific gravity of the cork
= The density of the substance (cork)
÷ The density of water
Therefore, The density of the cork = Specific gravity of the cork × The density of water

---

2.3.2 Applications of Archimedes' Principle

Archimedes' principle is used to find the specific gravity of a liquids and solids.This principle is also used in the submarines.

2.3.3 Principle applied in the submarines.

According to Archimedes' principle, when a body is immersed in a liquid, it suffers an apparent loss of weight equal to the weight of the liquid displaced by it.

In the submarine boats, there is an internal water tank. When cruising, the free surface level of water is AB and a considerable portion of boat is above the water (Fig. 2.15a).

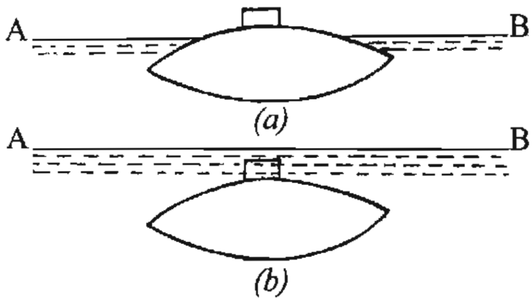


Fig. 2.15 Submarines

The boat may be sunk lower in the water by admitting water into the internal tanks. Now the free surface of water AB may be much above the boat (Fig. 2.15b). Pumps are used for emptying the water tanks, thus bringing the boat again to its original surface level.

2.4 Floatation

When a body floats freely in a liquid, two forces are acting on it.

They are

1. The weight of the body acting vertically down through its centre of gravity and
2. The resultant upthrust acting vertically up through the centre of buoyancy (the centre of gravity of the displaced liquid).

For equilibrium, these two forces must be equal and opposite.

Force of Buoyancy

Consider a small wooden block. Try to push this wooden block into a bucket of water. What do you feel? The liquid offers certain force at the bottom surface of the wooden block in the upward direction. Since the liquid pressure increases with depth the upward push is greater than the downward push. Thus the resultant force on the block will be upwards. This upward force is called the force of buoyancy.

Buoyant force depends on the following factors:

1. The size or the volume of the body immersed in a liquid.
2. The density of the liquid.

2.4.1 Laws of flotation

1. The weight of the floating body is equal to the weight of the liquid displaced.
2. The centre of gravity of the floating body and the centre of gravity of the displaced liquid (Centre of buoyancy) lie in the same vertical line.

2.4.2 Experiment to verify the first law of floatation

The first law of flotation may easily be verified experimentally.

A graduated jar is filled with

water upto three fourths of its volume. A test-tube, loaded sufficiently with lead shots is made to float vertically in the liquid (Fig. 2.16).

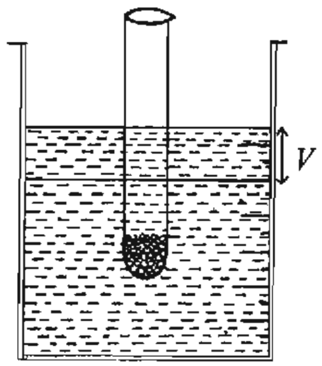


Fig. 2.16 Verification of the First law of floatation

By noting the rise in the level of water in the graduated jar, the volume of the displaced water V is determined. Hence, the weight of the displaced water is $V \times d$, where d is the density of the water.

The weight of the test-tube with the lead shots is determined.

From this, it can be noted that the weight of the floating body (test-tube with lead shots) is equal to the weight of the displaced water.

Activity 6

A displacement can is taken and water is poured until it runs from the spout. A weighted beaker is placed under the spout of the displacement can (Fig.2.17)

A rectangular wooden block is placed on the surface of water in the displacement can. As it floats on the surface of water, it displaces water through the spout. This water is collected in the beaker. When no water drips from the spout, the beaker with water is weighed. From this, the weight of displaced water is noted.

You can notice that the weight of the rectangular wooden block is equal to the weight of the displaced water. This verifies the first law of floatation.

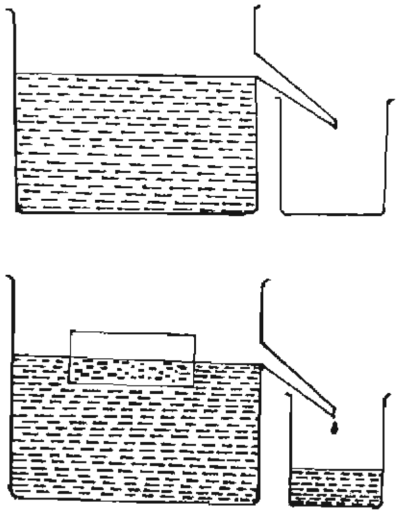


Fig. 2.17 The first law of floatation

2.4.3 Plimsoll lines

When a ship floats on the surface of the sea-water, it should not be loaded too much. Its load depends upon the density of sea water in which it travels. If the load exceeds, the ship would sink.

To indicate the depth upto which the ship can sink in seawater of different densities at different climatic conditions, several lines are marked on the sides of the ship to ensure the stability and safety of the ship. These lines are called Plimsoll lines.

(These lines are named after the historical sailor Captain Plimsoll)

2.5 Hare's Apparatus

Density:

The density of a substance is defined as its mass per unit volume.

Density = mass / volume

Specific gravity or relative density of a liquid:

The ratio of the density of liquid to the density of water is called the specific gravity of the liquid. Specific gravity has no unit.

The specific gravity of a liquid can be determined with Hare's apparatus.

2.5.1 To determine the relative density of a liquid using Hare's apparatus

Construction:

Hare's apparatus consists of an inverted U tube, whose upper bend is provided with a small opening. A rubber tube is attached to this opening. The limbs of the tube are dipped into two beakers, one containing water and the other the given liquid.

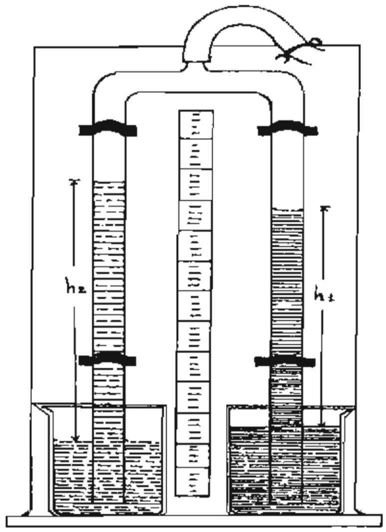


Fig. 2.18 Hare's apparatus

Working:

Some air is sucked out from the tube through the rubber tube and a pinch clamp is applied to it. Let the heights of water and the liquid columns in the limbs be h_1 and h_2 respectively (Fig. 2.18).

The experiment is repeated for different heights by pressing the pinch clamp. The readings are entered in the tabular column (Table 2.1).

Let d_1 and d_2 be the density of water and the liquid respectively. The pressure acting on the water column is equal to the pressure acting on the liquid column.

i.e., $h_1 d_1 g = h_2 d_2 g$

$$\frac{d_2}{d_1} = \frac{h_1}{h_2}$$

$\therefore$ The relative density of the liquid = height of the water column/ height of the liquid column.

Table 1 Relative density of the liquid

S. No	Height of Water column(h_1)	Height of liquid column(h_2)	Relative density $d_2/d_1 = h_1/h_2$
1			
2			
3			

Activity 7

Using Hare's apparatus determine the densities of various liquids like copper sulphate solution, sugar solution and salt solution in the laboratory and tabulate your results in table 2.2.

Table 2 Density of different liquids

S. No	Solution	Density (kg/m^3)
1	Sugar	
2	Salt (NaC*l*)	
3	Copper sulphate	

Problem 2

The heights of water and kerosene columns in Hare's apparatus are 8 cm and 10cm respectively. Calculate the density of kerosene.

Specific gravity of kerosene

$$= \frac{\text{Density of kerosene}(d_2)}{\text{Density of water}(d_1)}$$

$$= \frac{\text{Height of water column}(h_1)}{\text{Height of kerosene column}(h_2)}$$

$$\frac{d_2}{d_1} = \frac{h_1}{h_2}$$

$$\therefore\ d_2 = \frac{h_1}{h_2} \times d_1$$

Taking the density of water as 1000 kg/m^3, we have

$$d_2 = \frac{8}{10}\text{ x}1000 = 800\text{kg}/\text{m}^3$$

The density of kerosene = 800 kg m^{-3}

2.6. Hydrometers

Principle of hydrometer

When a body floats in any liquid, the weight of the floating body is equal to the weight of the liquid displaced.

A hydrometer is used to find the specific gravity of a liquidand hence its density.

Types of hydrometers:

There are two types of hydrometers.

They are:

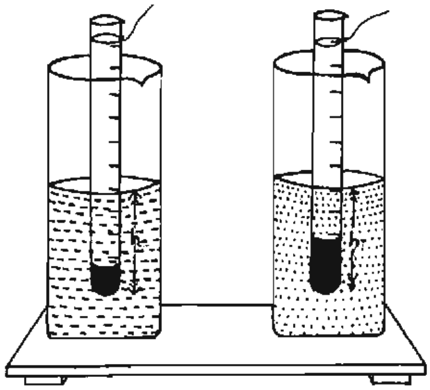
1. The constant immersion hydrometer and
2. The variable immersion hydrometer.

2.6.1 Constant immersion hydrometer

In a constant immersion hydrometer, the depth of immersion is kept constant but the weight of the hydrometer is changed to make it float to the same depth in different liquids.

Construction:

A uniform test tube can be used as a hydrometer for finding relative densities of liquids. A strip of graduated paper is pasted vertically inside the tube with the zero marking at the bottom.



(a) (b)

Fig. 2.19 Constant immersion hydrometer

Theory:

The test tube is filled with a suitable amount of lead shots or mercury and allowed to float vertically in the jar containing water. Let h be the depth of immersion (Fig. 2.19a). If the weight of the test tube float as a whole is W_1 and the area of cross section of the tube is a , then

the weight of the displaced water

$W_1 = ahd_1g$ .... (1)

where d_1 is density of water and g is acceleration due to gravity.

The test tube is next floated in the given liquid, whose specific gravity is required. Now a few lead shots are added or removed such that the tube floats vertically at the same depth h (Fig 2.19b). Let the weight of the hydrometer now be W_2.

The weight of the displaced liquid

$W_2 = ahd_2g$ .... (2)

where d_2 is the density of the given liquid.

Dividing (2) by (1), we have

$$\frac{W_2}{W_1} = \frac{ahd_2g}{ahd_1g} = \frac{d_2}{d_1}$$

The relative density of the liquid

$$= \frac{\text{Weight of the float in the liquid}}{\text{Weight of the float in water}}$$

2.6.2 Variable immersion hydrometer

In a variable immersion hydrometer, the weight of the hydrometer is kept constant but the depth of immersion varies depending on the density of the liquid.

Theory:

The test tube is first allowed to float in water and lead shots are added till it floats vertically (Fig. 2.20a). Let the depth of immersion be h_1, weight of the test tube as a whole W, area of cross section a, the density of water d_1 and the acceleration due to gravity g. Then,

$W = a\,h_1d_1g$ .... (1)

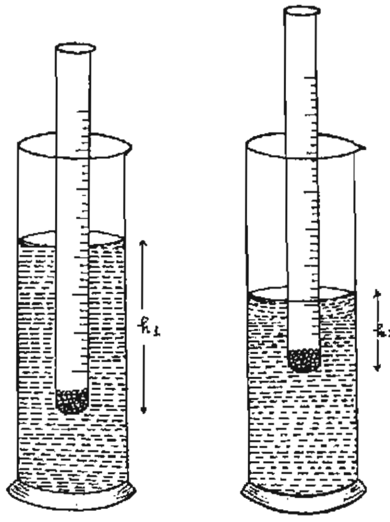


Fig 2.20 Variable immersion hydrometer

The test tube is taken out and without changing the weight of the tube, it is floated in the liquid whose specific gravity is to be determined. (Fig 2.20b). Let h_2 be the depth of immersion in the liquid and d_2 be the density of the liquid. Then,

$W = a\, h_2 d_2 g$ .... (2)

From (1) and (2), we have

$$a\, h_1 d_1 g = a\, h_2 d_2 g$$

$$\therefore \frac{d_2}{d_1} = \frac{h_1}{h_2}$$

Hence, the relative density of the liquid (d_2/d_1) = depth of immersion in water / depth of immersion in liquid.

Activity 8

Construction of variable immersion hydrometer using a straw

Take a drinking straw. Cut it off to a suitable length and seal one end of it with candle wax. Add suitable quantity of sand in the straw. Allow this straw to float vertically in water taken in a beaker. Note the depth of immersion h_1.

Take it out from water. Water droplets on the sides are dried with a clean cloth. Allow it to float vertically into the jar containing the liquid whose relative density is to be determined. Note the depth of immersion h_2.

Determine the relative density of the given liquid using the formula, the relative density = h_1 / h_2.

Do you know?

The common hydrometer is a variable immersion type. The broad and heavy base ensures stability while floating. The narrow uniform graduated stem helps to get the specific gravity of liquids readily.

SELF EVALUATION

I. Choose the correct answer

1. The unit of thrust is

   a) newton b) joule c) kg m^{-3} d) pascal

2. The expression for pressure at a point in a liquid is

   a) hadg b) hdg c) had d) ha

3. Fortin's barometer is used to measure the atmospheric

   a) temperature b) pressure c) density d) relative density

4. Plimsoll lines are marked on the sides of the

   a) buses b) aeroplanes c) trains d) ships

5. In variable immersion hydrometer,

   a) the weight of the hydrometer and the depth of immersion are kept constant.

   b) the weight of the hydrometer and the depth of immersion are not kept constant.

   c) the weight of the hydrometer is kept constant and the depth of immersion varies.

   d) the weight of the hydrometer varies and the depth of immersion is kept constant.

II. Fill in the blanks

6. The pressure of the liquid increases with ________.
7. The space above the mercury in the barometer tube is called ________.
8. Aneroid barometer is used to measure the ________.
9. In submarines, ________ principle is used.
10. The ratio of the density of the liquid to the density of water is called the ________ of the liquid.

III. Match the following

11.	Pressure	–	kg m^{-3}
12.	Density	–	no unit
13.	Specific gravity	–	N m^{-2}
14.	Manometer	–	newton
15.	Thrust	–	pressure of a liquid

IV. Give short answer

16. Define: thrust
17. Define: pressure
18. What is one atmospheric pressure?
19. What is a manometer?
20. State Archimedes' principle.
21. Give any two applications of Archimedes' principle.
22. State the laws of floatation.
23. What are Plimsoll lines?
24. State the principle of hydrometer.
25. Name the types of hydrometers.
26. State the uses of hydrometers.

V. Give detailed answer

27. Derive an equation for the pressure of a liquid at a point
28. Explain the variation of pressure with depth.
29. Explain the variation of pressure with density.
30. How will you measure the atmospheric pressure using a barometer?
31. How will you measure the air or gas pressure using the U tube manometer?
32. Explain the construction of Aneroid barometer.
33. Explain the construction and the working of Fortin's barometer.
34. Explain the experimental verification of Archimedes' principle.
35. How will you find the density of a cork using Archimedes' principle?
36. Explain how Archimedes' principle is used in submarines.
37. Explain any one experiment to verify the first law of floatation.
38. How will you determine the relative density of a liquid using Hare's apparatus?
39. Explain the method to determine the relative density of a liquid using the constant immersion hydrometer.
40. Explain the method to determine the relative density of a liquid using the variable immersion hydrometer.

3. Air

3.1 Air-Atmosphere

Earth is surrounded by a thick envelope of air called atmosphere. Air is a mixture of several gases. We are living in the atmosphere. The composition of air, and its temperature vary with height in the atmosphere. Atmosphere is divided into four major layers, namely troposphere, stratosphere, mesosphere and thermosphere (Fig. 3.1).

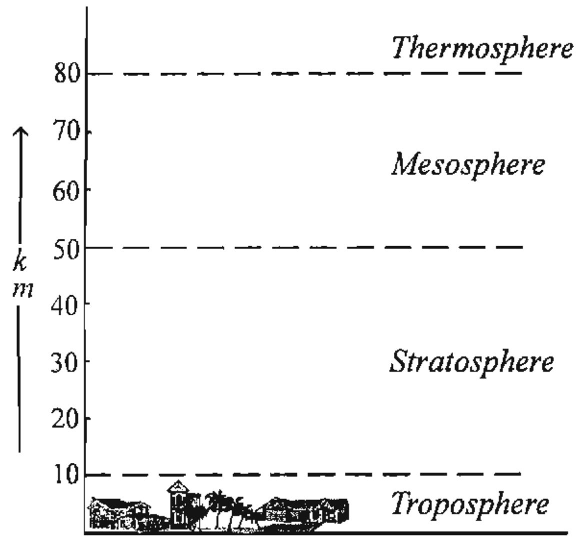


Fig. 3.1 Different layers of atmosphere

We are living in the layer, the troposphere. It may extend upto 10 km from the surface of the earth. It is the densest layer of atmosphere. The temperature in this layer decreases with height. For every one kilometer height there is a drop of temperature by 6 degrees celsius.

The stratosphere is the second layer of air which lies between 10 and 50 km above the earth's surface. The mesosphere is the third layer of air which extends from 50 to 80 km. Temperature here is less than that of other layers below it. Thermosphere is located above 80 km and it is a hot layer of air.

3.2 Importance of air - Breathing

All living beings need air. Oxygen present in air is used up for breathing. It is carried in cylinders by mountaineers, deepsea-divers and astronauts.

During respiration we take in oxygen and give out carbondioxide. Here, oxygen is used to burn food molecules for production of energy. All living things respire. Nitrogen present in air does not take part in the process of respiration.

3.3 Air as mixture

You know that air is a mixture of several gases. Nitrogen and oxygen are the major constitutents of air. Smaller amounts of argon, carbondioxide, and water vapour are also present in air. Composition of air varies slightly with place to place, depends on different activities. Composition of air is given in the table 1.

Table 1 Composition of air (Percentage by volume)

1.	Nitrogen	–	78 %
2.	Oxygen	–	21 %
3.	Argon (noble gas)	–	0.9 %
4.	Carbondioxide	–	0.03 %
5.	Water vapour	–	variable

The various gases present in atmospheric air can be seperated and they can be used for different purposes.

The presence of oxygen in air can be understood by the following activity.

Take a trough and fix a candle in the middle of it, as shown in the figure 3.2. Add water to a few centimetres height. Mark the water level. Light the candle and close it with an inverted glass jar. Burning of candle stops after few seconds. But the level of water inside the jar goes up to approximately one fifth of the height. Oxygen in the air present inside the jar is used during burning and amount of this oxygen is nearly one fifth of the volume of air.

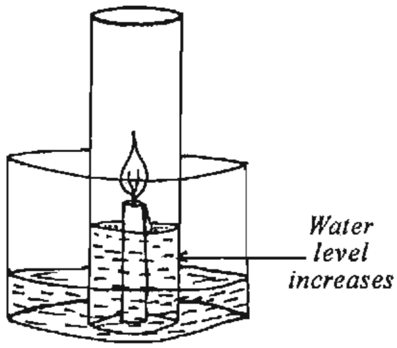


Fig. 3.2 Oxygen is used during burning

Presence of carbondioxide in the atmosphere can be proved by the following activity. Take a small amount of lime water in a boiling tube. Set the apparatus as shown in figure 3.3. One end of tube A must be dipped into lime water. Suck out air from tube B. Now air rushes in through tube A and bubbles through lime water. This turns lime water milky. This shows the presence of carbondioxide in air. (Carbondioxide turns lime water milky).

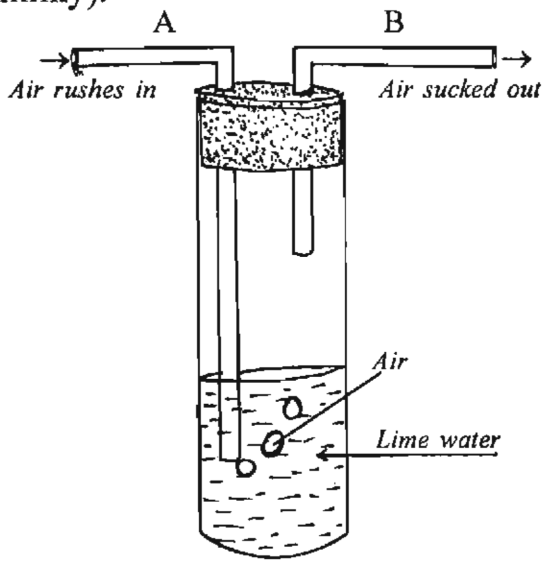


Fig. 3.3 Presence of carbondioxide in air

3.4 Separating mixture of air

Nitrogen and oxygen can be separated from air and used for different purposes. Fractional distillation is the technique used for separation of the different gases of air. First, air is liquified. Then liquid air is subjected to fractional distillation to get different fractions of air. The different gases, their boiling points and their percentage in air are given below:

Gas	Boiling point	Composition in percentage
Nitrogen	-196^0C	78.03
Oxygen	-183^0C	20.99
Argon	-186^0C	0.93
Carbondioxide (sublimes)	-32^0C	0.03

The various constituent gases boil at different temperatures and are separated in different vessels. Carbondioxide directly condenses into solid and never melts but turns into vapour directly. This is called sublimation.

Nitrogen is used for manufacturing fertilizers and oxygen is required for breathing.

3.5 Importance of nitrogen for all forms of life

You know that all of us are breathing in and breathing out nitrogen with air without any change. It provides an unreactive environment. Nitrogen protects all living things from spontaneous combustion as it is a nonsupporter of combustion. It dilutes the concentration of oxygen. Plants absorb nitrogen as soluble nitrates from soil and convert it into proteins. Plants and animals require proteins for building their bodies. Nitrogen is the building block of living things.

3.5.1 Brief note about nitrogen cycle

Nitrogen fixation:

The process of conversion of free atmospheric nitrogen into its compounds (soluble nitrates) is called nitrogen fixation. There are two types of nitrogen fixation.

Biological fixation of nitrogen:

Root nodules of leguminous plants have nitrogen fixing bacteria called rhizobium (Fig. 3.4). These bacteria directly fix atmospheric nitrogen into nitrogen compounds, which are used by plants. Blue-green algae, which are formed in paddy fields also do nitrogen fixation.

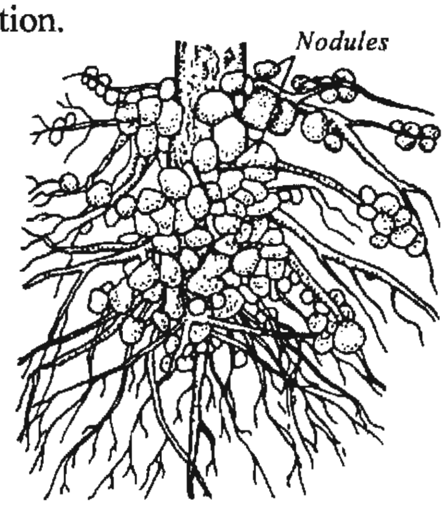


Fig. 3.4 Root nodules of a leguminous plant

Non-biological fixation of nitrogen:

The tremendous energy released during lightning in the sky, oxidises nitrogen in the atmosphere into oxides of nitrogen. These nitrogen oxides dissolve in rain water and reach the soil, where they get converted into nitrates.

Nitrogen cycle:

Nitrogen of the atmosphere is fixed in the soil by nitrogen fixation, as soluble nitrates. These nitrates are absorbed by plants and used by them in the production of proteins and other nitrogenous compounds. When animals eat the plants, these compounds are transfered to animals. But both plants and animals when die, bacteria in the soil break them and release the nitrogen back to atmosphere. Thus this cyclic process continues in the nature. This cyclic motion of nitrogen from atmosphere, through soil, plants, animals and back to atmosphere is called nitrogen cycle. Nitrogen cycle is illustrated in the figure 3.5.

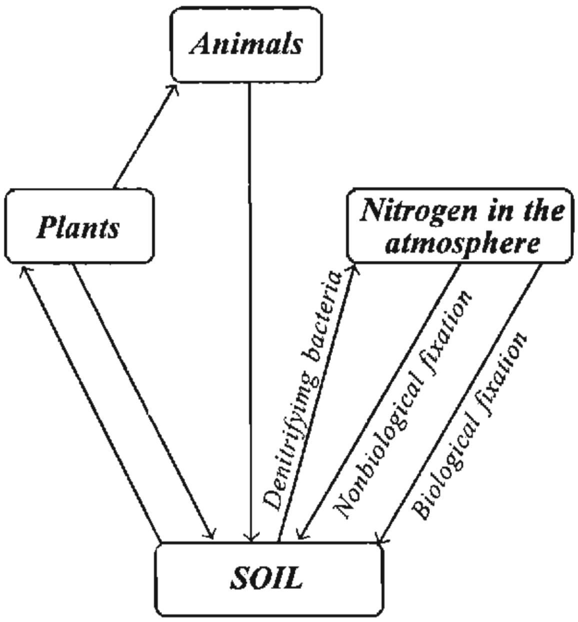


Fig. 3.5 Nitrogen cycle

3.6 Air pollution

Contamination of air with unwanted and harmful gases and smoke is called air pollution. Air pollution causes health problems and it also affects the environment.

Causes of air pollution:

a) Burning of fossil fuels

Burning of fossil fuels like coal petrol, diesel etc., produces harmful gases like oxides of carbon, sulphur and nitrogen. They pollute atmosphere.

b) Automobiles - exhaust

We use automobiles in large numbers. The gases emitted by engines of these vehicles are known as auto - exhaust. It contains harmful and acidic gases and unburnt carbon particles.

c) Industrial exhaust

Industries like, thermal power plants oil refineries, rubber industries etc., discharge harmful gases into the air. Smoke released from the industries is one of the major sources of air pollution.

d) Smoking

Smoking is a bad habit. It is injurious to health. It also causes air pollution.

Harmful effects of air pollution:

1. Polluted air is unsafe to breathe.
2. It causes a number of diseases like lung cancer, bronchitis and allergies.
3. Carbon monoxide is a poisonous gas. It affects haemoglobin of our blood and even may cause death.
4. Sulphurdioxide corrode metals and destroy marble.
5. Polluted air containing acidic oxides of nitrogen and sulphur dissolve in rain water and causes acid rain.
6. Hydrogen sulphide tarnishes silver objects.
7. Polluted air depletes ozone layer.
8. Polluted air containing excess of CO_2 causes global warming.

3.7 Prevention of air pollution

Some of the steps that can be taken to minimise air pollution are given below:

1. We can reduce the usage of fossil fuels like coal and petroleum.
2. Growing more trees help in reduction of pollution.
3. We can use non conventional sources of energy like solar energy, wind energy, tidal enegy etc.,.
4. Tall chimeys should be installed in industries.
5. Avoid smoking.
6. Burning of plastics should be avoided.
7. The automobile vehicles should be subjected to periodic air pollution checkups (emission test).

CPCB (Central Pollution Control Board) of our country check and control air pollution.

Treatment of smoke (aerosol) in industries

Industrial exhaust contain aerosols like smoke. This smoke is passed through an electrostatic precipitator containing two electrodes. High electric potential is applied between the electrodes. Charged aerosol particles get precipitated on the electrodes (Fig. 3.6).

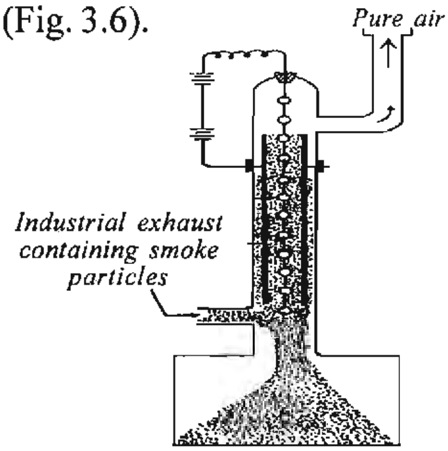


Fig. 3.6 Electrostatic precipitator

3.8 Green house effect

Burning of fossil fuels discharge a large amount of carbondioxide. Deforestation is also an another reason for the increase of level of carbondioxide in the atmosphere.

Carbondioxide present in the atmosphere absorbs infrared radiations reflected from the surface of the earth and heats up the atmosphere. This heating up of atmosphere by carbondioxide in the air is called green house effect (Fig. 3.7). Because of this green house effect the average temperature of the earth increases and this is known as global warming.

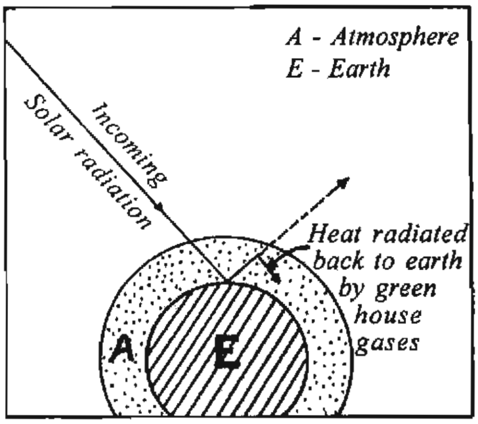


Fig. 3.7 Green house effect

3.9 Acid rain

The pollutants like oxides of sulphur and nitrogen readily dissolve in rain water and produce acids. This is called acid rain (Fig. 3.8). Acid rain can corrode buildings constructed with marble and stones. It also corrodes metals. Acid rain destroys plants and kills aquatic life.

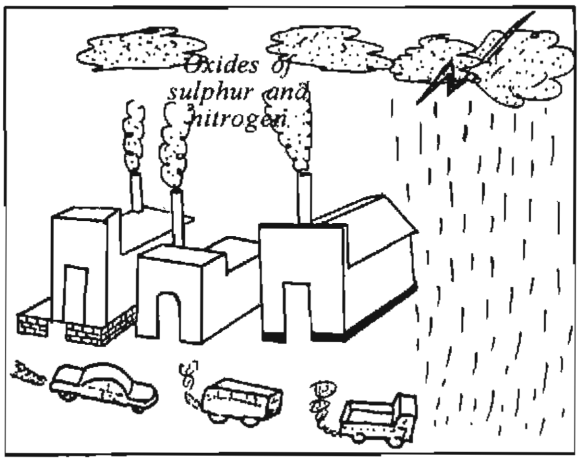


Fig. 3.8 Acid rain

SELF EVALUATION

I. choose the correct answer

1. The second layer of atmosphere is
   (a) Troposphere (b) Mesosphere
   (c) Stratosphere (d) Thermosphere

2. The gas which turns lime water milky is
   (a) Oxygen (b) Carbondioxide (c) Nitrogen (d) Argon

3. Boiling point of nitrogen
   (a) -186^0C (b) -183^0C (c) -32^0C (d) -196^0C

4. The bacteria present in root nodules of leguminous plants are
   (a) Rhizobium (b) Acetobacter (c) Bacillus (d) None

5. A poisonous gas
   (a) Carbon monoxide (b) Sulphur dioxide
   (c) Nitrogen (d) Oxygen

II. Fill in the blanks

6. Sulphur dioxide ________ metals.
7. Constituents of air can be separated by ________.
8. The noble gas present in air, in considerable amount, is ________.
9. During respiration ________ gas is given out.
10. The densest layer of atmosphere is ________.

III. Match the following

11. Carbondioxide	–	0.9%
12. Argon	–	Biological fixation
13. Rhizobium	–	Silver objects
14. Burning of fossil fuels	–	Green house effect
15. Hydrogen sulphide	–	Acid rain

IV. Give short Answer

16. Write note on stratosphere.
17. Write the composition of air.
18. What is meant by fixation of nitrogen?
19. Define nitrogen cycle.
20. Define air pollution.
21. Write two harmful effects of air pollution.
22. What is meant by green house effect?
23. What is acid rain?
24. What is the cause of green house effect?
25. Write any two uses of nitrogen.

V. Give detailed Answer

26. Briefly explain the different layers of atmosphere.
27. Explain fixation of nitrogen.
28. Explain nitrogen cycle briefly.
29. What are the causes of air pollution?
30. How can you prevent air pollution?

4. Transformation of Substances

4 Transformation of Substances

The substances which we come across in our daily life undergo changes. They do not remain forever, as they are now. Evaporation of water, weathering of rocks, rusting of iron melting of ice are some of the changes that take place around us. Some of the changes are desirable and some are undesirable. Change of milk into curd is useful but rusting of iron is harmful. We can classify the changes into two types, physical changes and chemical changes.

4.1 Physical Changes and Chemical Changes

When water is boiled, it changes into steam. Water and steam are one and the same. During this change no new substance is formed. This type of change is called physical change. Freezing, melting, distillation and sublimation are some of such changes.

Chemical changes are the changes in which new substances are formed. Burning of camphor produces different substances namely carbondioxide and water vapour. It is a chemical change. Photosynthesis, tarnishing of silver, rusting of iron and burning of fuels are some of the chemical changes. Chemical changes are otherwise called as chemical reactions.

4.2 Characteristics of chemical reactions

The substances that take part in a chemical reaction are called reactants. The substances produced in the reaction are called products. Reactants are transformed into products in a reaction. Chemical reactions are represented by chemical equations. Some of the characteristics of chemical reactions are given below.

1. change of energy
2. change of colour
3. evolution of a gas
4. formation of precipitate

For example, when a piece of magnesium ribbon is heated in a burner it catches fire, and burns with a brilliant flame. Heat and light energies are evolved. White ash produced during this process is a different substance namely magnesium oxide. Hence it is a chemical change and it can be represented as given below.

$$2Mg + O_2 \rightarrow 2MgO$$

Milk turns into curd (precipitate) by the action of enzymes. This chemical change is called fermentation.

4.3 Condition for chemical reactions

For a chemical reaction to take place a specific condition is required.

Some reactions require heat, some require light and some other may require high pressure. The chemical reaction, photosynthesis require sunlight. Ammonia is manufactured from nitrogen and hydrogen under high pressure and high temperature.

4.4 Identification of chemical reactions

A chemical change can be identified by analysing the gas evolved, change in colour, formation of precipitate etc. Here are some illustrations.

1. Take some hydrated copper sulphate in a hard glass tube. Hydrated copper sulphate is blue in colour. Heat the glass tube for some time (fig. 4.1). Note the change in colour of copper sulphate. It turns white. On heating, blue coloured hydrated copper sulphate loses its water and turns into white anhydrous copper sulphate.

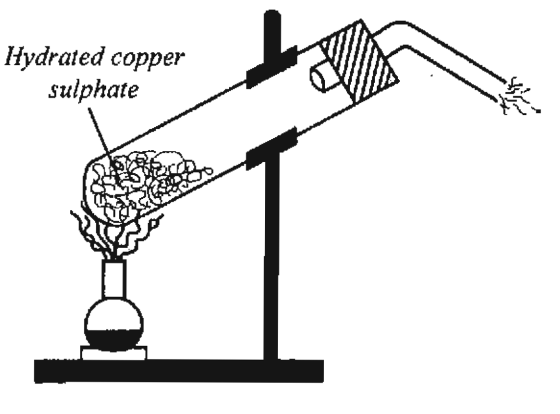


Fig. 4.1 Action of heat on copper sulphate

2. Take a candle and light it. Hold a funnel with a delivery tube as shown in figure 4.2. Pass the gas, produced during burning of wax of the candle through lime water. You will notice that lime water turns milky indicating the formation of carbon dioxide gas during the chemical change, burning.

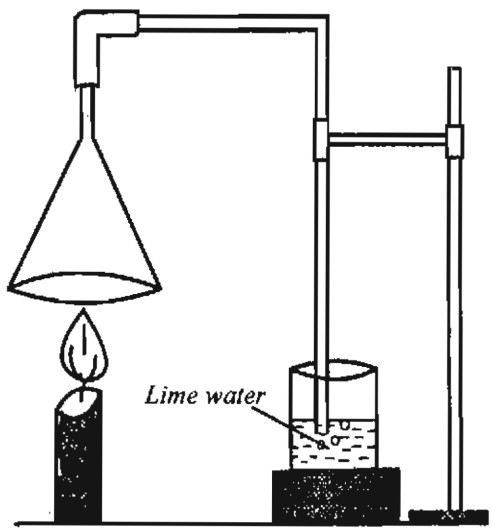


Fig. 4.2 Burning of candle produces CO_2 gas

Take some water in a beaker. Add some dry lime into it. You will feel that the water in the beaker gets heated. When dry lime is dissolved in water heat evolves. This type of change is called exothermic change. In another beaker containing water, add sodium nitrate. This time, temperature of water falls down. This type of change is called endothermic change. During endothermic change heat is absorbed by the reactants.

4.5 Purification of substances

In nature, we find most of the substances in impure forms. Impurities have to be removed before we use them. In different parts of the world sea water is purified to get drinking water and crude oil is separated into different useful fractions by fractional distillation. A metal extracted from its ore is always purified. Different purification techniques are used depending upon the nature of impurities and level of purity required. Distillation, fractional distillation, sublimation and filtration are some of the techniques used for purification.

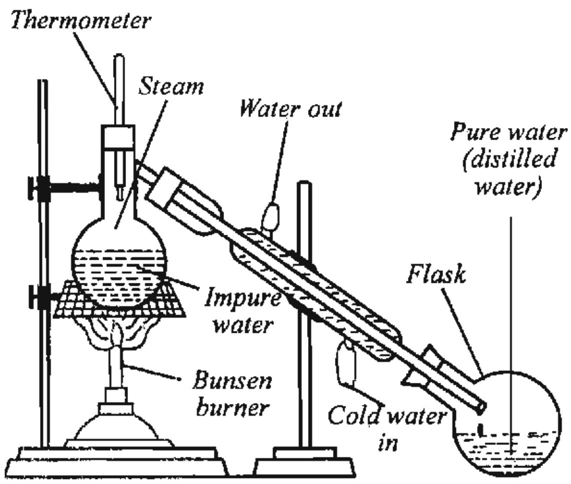


Fig. 4.3 Distillation of water

4.6 Distillation

It is a method of purification of a liquid containing non volatile impurities. It involves evaporation and condensation. Distillation is the process of converting a liquid into vapour and then condensing the vapour to get back pure liquid separately. For example, the water that we get from different sources has many dissolved and undissolved impurities. It may also contain harmful germs. To get pure water, the technique of distillation is used. Schematic diagram for the distillation of liquids is shown in figure 4.3. Impure water is first heated to get water vapour and then it is condensed. Pure water obtained in this way, is called distilled water.

Distillation can also be used for separating a mixture of miscible liquids having different boiling points.

Table 1 Melting and boiling points of some common substances

Name of the substance	Melting point	Name of the substance	Boiling point
Ice	0^0C	Water	100^0 C
Paraffin wax	54^0 C	Ethyl alcohol	78^0C
Naphthalene	80^0 C	Acetic acid	118^0C
Common salt	801^0C	Mercury	357^0C
Urea	135^0C	Sulphuric acid	337^0 C

For example, ethyl alcohol can be separated from a mixture of water and alcohol. Alcohol boils at 78°C and water boils at 100°C. Two liquids are collected in fractions in separate containers. This process of distillation is called fractional distillation.

4.7 Important physical properties

Melting and boiling points of substances are the important physical properties. Melting point is the temperature at which a solid gets converted into a liquid. Boiling point is the temperature at which a liquid starts boiling. Melting and boiling points are the characteristics of a pure substance. Melting and boiling points of some common substances are given in the table 1.

A pure substance always melts at a fixed temperature, the melting point. When the substance is impure, it usually melts at a temperature less than its actual melting point and boils at a temperature greater than its actual boiling point. The purity of a substance is ascertained by finding its melting point or boiling point.

4.7.1 Melting and boiling points

Determination of melting point of ice

Arrange the apparatus as shown in figure 4.4. Take crushed pieces of ice in a glass funnel and dip the bulb of a thermometer in it. The mercury in the thermometer falls down and stands steadily at 0°C. This is the melting Point of ice.

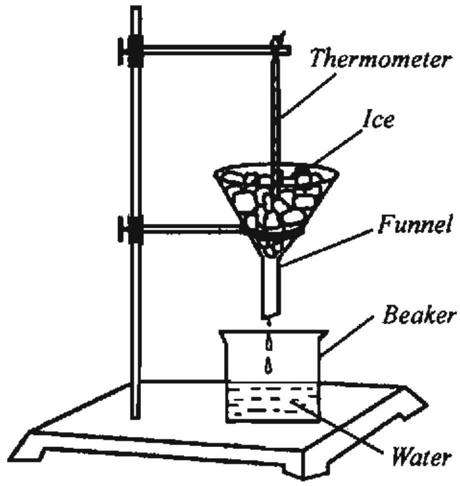


Fig. 4.4 Melting point of ice

Determination of Boiling point of water

Arrange the apparatus as shown in figure 4.5. Take some water in the boiling tube. Fix the thermometer, so that its bulb remains just above the water level in the boiling tube. The mercury in the thermometer raises and remains constant at a temperature 100°C. This constant temperature is the boiling point of water.

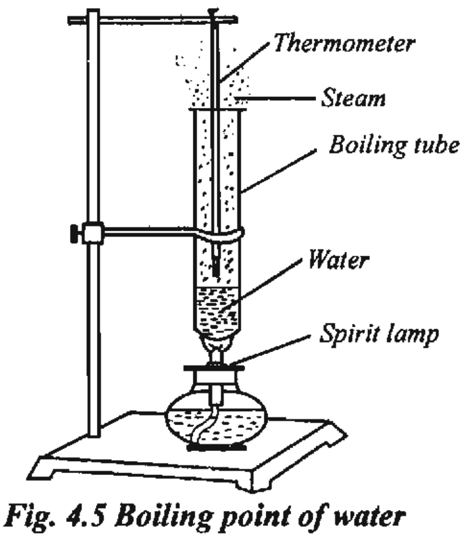


Fig. 4.5 Boiling point of water

4.8 Types of chemical reactions

On the basis of changes that take place in chemical reactions, they are classified as decomposition, displacement, neutralisation, oxidation and reduction reactions.

4.8.1 Decomposition

A chemical reaction in which a reactant decomposes into two or more products is called decomposition reaction. When calcium carbonate is heated, it decomposes to give calcium oxide and carbondioxide.

$$CaCO_3 \xrightarrow{\Delta} CaO + CO_2 \uparrow$$

4.8.2 Displacement

The reaction in which one element replace the other element in a compound, is called displacement reaction. Usually a more reactive element displaces a less reactive element from its compound. Zinc displaces copper from a solution of copper sulphate forming zinc sulphate.

$$Zn + Cu\,SO_4 \rightarrow Zn\,SO_4 + Cu$$

4.8.3 Neutralisation

The reaction between an acid and a base produces neutral compounds salt and water. Hence this reaction is called neutralisation.

$$\text{Acid} + \text{Base} \rightarrow \text{Salt} + \text{Water}$$

When hydrochloric acid reacts with sodium hydroxide, it forms sodiumchloride (common salt) and water.

$$HCl + NaOH \rightarrow NaCl + H_2O$$

Whenever we have acidity problem in our stomach, we use the principle of neutralisation in controlling acidity. Tablets containing magnesium hydroxide are used for this purpose.

4.8.4 Oxidation and reduction

A chemical reaction which involves addition of oxygen to a substance or removal of hydrogen from a substance, is called oxidation.

A chemical reaction which involves addition of hydrogen to a substance or removal of oxygen from a substance, is called reduction.

Oxidation and reduction reactions take place together. When one substance is oxidised, another is reduced. Such reactions are called redox reactions.

Rusting of iron and burning of sulphur are oxidation reactions. When copper oxide is heated in the presence of hydrogen we get copper and water.

$$CuO + H_2 \rightarrow Cu + H_2O$$

Here copper oxide is reduced to copper, while hydrogen is oxidised to water.

SELF EVALUATION

I. Choose the correct answer

1. Reaction used in controlling acidity of stomach

   (a) neutralisation (b) oxidation (c) reduction (d) dehydration

2. Boiling point of impure substance is usually

   (a) greater than that of pure subtance

   (b) less than that of pure substance

   (c) equal to that of pure substance

   (d) none of the above

3. Melting point of pure urea is

   (a) 54^0C (b) 80^0C (c) 135^0C (d) $801^0 C$

4. Rusting of iron is

   (a) displacement (b) reduction (c) oxidation (d) dehydration

5. $CuO + H_2 \rightarrow Cu + H_2O$. This reaction is

   (a) oxidation (b) reduction (c) redox reaction (d) decomposition

II. Fill in the blanks

6. The change of milk into curd is useful but rusting of iron is ________.
7. The substances which take part in a chemical reaction are known as ________.
8. The chemical reaction Photosynthesis require ________ to take place.
9. Crude oil is separated into different useful fractions by ________.
10. An impure substance has a melting point ________ than that of pure substance.

III. Match the following

11.	Burning of fuels	–	Endothermic reaction
12.	Dissolving sodium nitrate in water	–	Enzymes
13.	Magnesium hydroxide	–	Chemical reactions
14.	Formation of curd	–	Difference in boiling points
15.	Fractional distillation	–	Controlling acidity

IV. Give short answer

16. What are chemical changes?
17. Define physical change.
18. What is fermentation?
19. What is an exothermic reaction?
20. Define endothermic change.
21. What is distillation?
22. How is the purity of a substance ascertained?
23. What is a decomposition reaction?
24. Define oxidation. Give example.
25. What is a reduction reaction?

V. Give detailed answer

26. Explain displacement reaction with an example.
27. Explain neutralization reaction with an example.
28. Explain the process of distillation with a neat diagram.
29. Write chemical equations for the following reactions.

    (a) Magnesium + Oxygen → Magnesium oxide.

    (b) Calcium carbonate → Calcium oxide + Carbondioxide

    (c) Copper oxide + Hydrogen → Copper + Water.

30. How do you determine the melting point of ice?

5. Atomic Structure

5.1 Atoms as the building blocks of matter

In previous classes, you have studied that the matter is made up of tiny particles called 'Atoms'. Atoms are the fundamental building blocks of matter. The smallest particle of an element that shows the properties of that element is called an atom.

The word 'atom' has been derived from the Greek word 'atomos' which means 'indivisible'. In olden days people believed that atoms were indivisible. The concept of indivisibility of atoms was disproved by experimental evidences obtained by scientists at the end of nineteenth century.

5.2 Composition of atom

Though atoms are tiny, they have internal structure. They are made up of three subatomic particles called electron, proton and neutron.

5.2.1 Electron

Electrons are negatively charged particles and are present in the outer part of atom.

5.2.2 Proton

Protons are positively charged particles and are present in the core of the atom called nucleus.

5.2.3 Neutron

Neutrons are neutral particles and are present in the nucleus of the atom. The properties of subatomic particles are given in the table 1.

5.3 Neutral character of atoms

Atoms are very small in size. They can not be seen by naked eyes. The radius of an atom is in the order of a few angstrom ($1A^0 = 10^{-10}$m). Atoms are electrically neutral in character.

The number of electrons in the extra nuclear part is equal to the number of protons in the nucleus. Hence the atom is neutral.

Table 1 Properties of subatomic particles.

Name	Symbol	Relative charge	Mass in amu	Approximate mass in amu
Electron	e	–1	0.00054	0
Proton	p	+1	1.00727	1
Neutron	n	0	1.00867	1

Infer : The masses of protons, neutrons etc., are expressed in atomic mass unit(amu). 1 amu is taken as $\frac{1}{12}$th of the mass of one carbon (C^{12}) atom.

5.4 Structure of atom

5.4.1 Nuclear part

Nucleus is highly dense central part of the atom. It contains protons and neutrons. It is positively charged as the protons are postively charged and neutrons are neutral. It accounts for, practically entire mass of the atom as the mass of an electron present in the extra nuclear part is negligible.

5.4.2 Extra nuclear part

Electrons constitute the extra nuclear part. They revolve around the nucleus in the particular paths called orbits. The number of electrons in an atom is equal to the number of protons in it. Electrons and nucleus are held together by electrostatic force of attraction. Nuclear and extra nuclear parts of the atoms of sodium and chlorine are shown in the figure 5.1.

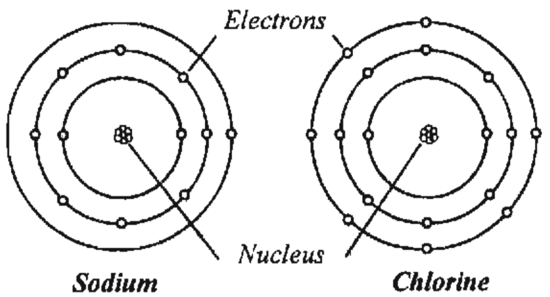


Fig. 5.1

5.5 Model of an atom

Ancient theories about model of an atom were based on abstract thinking and not on experimentation.

5.5.1 Dalton model

An English school teacher, John Dalton, in the beginning of nineteenth century propounded his theory of atoms. It was the first atomic theory based on scientific principles. The main points of Dalton's theory are given below.

1. An element is composed of extremely small indivisible particles called atoms.
2. Atoms can neither be created nor destroyed.
3. Atoms of the same elements are identical in every respect and atoms of different elements have different masses and properties.
4. Atoms of different elements combine with each other in small whole number ratio to form compounds.

Towards the end of nineteenth century, scientists disproved Dalton's concept of indivisibility of atom. Scientists discovered the presence of subatomic particles, namely, electron, proton and neutron. Different atomic models were, therefore, proposed to explain the structure of atom.

5.5.2 J.J. Thomson model

J.J. Thomson discovered electron. He proposed his atomic model in 1898. According to this model an atom consists of a uniform sphere of positive charge with electrons embedded into it. The electrons were believed to be spread through the positive sphere like raisins in a plum pudding (cake).

This model, therefore, sometimes called the 'raisin' pudding model. Figure 5.2. shows the Dalton and J. J. Thomson models of atom.

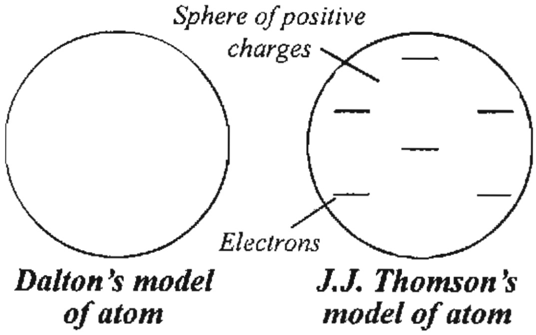


Fig. 5.2

> ***J.J. Thomson***
>
> *Thomson was born on 18th December 1856 in England. He started his career at the cavendish laboratory in Cambridge. His important contribution is the discovery of electron. He was awarded Nobel Prize for physics, in 1906. His contribution to the growth of science is significant. He died on 30th August 1940.*

5.6 Significance of atomic number, mass number and isotopes

5.6.1 Atomic Number

The number of protons or electrons in an atom is called the atomic number of that atom. It is denoted by the symbol Z. The atomic number is a characteristic property of that atom which differentiate one element from another.

For example:

Atomic number of carbon = 6

∴ Number of protons present in carbon atom = 6

∴ Number of electrons present in carbon atom = 6

5.6.2 Mass Number

We know that the mass of an electron is negligible. Hence the total mass of protons and neutrons is approximately the mass of an atom. Mass number of an atom can be defined as the sum of the number of neutrons and protons present in the nucleus of an atom. It is denoted by the symbol A.

For example:

Mass number (A) of oxygen = 16

Atomic number (Z) of oxygen = 8

∴ Number of neutrons = A–Z

= 16–8 = 8

5.6.3 Isotopes

Atoms having the same atomic number but different mass numbers are said to be isotopes of an element. All elements have isotopes. Isotopes of hydrogen are protium, deuterium and tritium. Protium has no neutron but deuterium has one neutron and tritium has two neutrons in their nuclei. Chemical properties of isotopes of an element are same but they may differ in their physical properties due to the difference in number of neutrons in them. Properties of isotopes of hydrogen are given in the table 2.

Table 2 Isotopes of hydrogen

Properties	Protium	Deuterium	Tritium
Electrons	1	1	1
Protons	1	1	1
Neutrons	0	1	2
Atomic Number(Z)	1	1	1
Mass Number(A)	1	2	3

Isotopes of many elements are used in different walks of life. They are of great help in the field of medicine, industries and agriculture. An isotope of cobalt is used to treat cancer. An isotope of uranium is used in nuclear power plants to generate electricity.

5.7 Valency of elements

Atoms combine to form molecules. An atom of each element has a definite combining capacity called its valency.

Taking the valency of hydrogen as 1, valency of other elements are found. Valency of an element is equal to the number of hydrogen atoms which combine with one atom of that element.

In hydrogen chloride (HC*l*) one hydrogen atom combines with one chlorine atom. Hence the valency of chlorine is 1.

In water (H_2O) two hydrogen atoms combine with one atom of oxygen. Hence the valency of oxygen is 2.

In ammonia (NH_3) three hydrogen atoms combine with one atom of nitrogen. Hence the valency of nitrogen is 3.

Valencies may also be determined by using valency of oxygen. In calcium oxide (CaO) one oxygen atom combines with one atom of calcium.

∴ Valency of calcium
= number of oxygen atoms x 2
= 1 x 2 = 2

Table 3 Valency of some common elements

Name	Symbol	Valency
Hydrogen	H	1
Carbon	C	4
Oxygen	O	2
Sodium	Na	1
Chlorine	Cl	1
Calcium	Ca	2
Potassium	K	1
Aluminium	Al	3
Zinc	Zn	2
Nitrogen	N	3
Magnesium	Mg	2

5.8 Composition of atoms of the first twenty elements (Table 4)

Name	Symbol	Atomic number (Z)	Mass number (A)	Number of protons	Number of electrons	Number of neutrons (A–Z)
Hydrogen	H	1	1	1	1	1–1=0
Helium	He	2	4	2	2	4–2=2
Lithium	Li	3	7	3	3	7–3=4
Beryllium	Be	4	9	4	4	9–4=5
Boron	B	5	11	5	5	11–5=6
Carbon	C	6	12	6	6	12–6=6
Nitrogen	N	7	14	7	7	14–7=7
Oxygen	O	8	16	8	8	16–8=8
Fluorine	F	9	19	9	9	19–9=10
Neon	Ne	10	20	10	10	20–10=10
Sodium	Na	11	23	11	11	23–11=12
Magnesium	Mg	12	24	12	12	24–12=12
Aluminium	Al	13	27	13	13	27–13=14
Silicon	Si	14	28	14	14	28–14=14
Phosphorous	P	15	31	15	15	31–15=16
Sulphur	S	16	32	16	16	32–16=16
Chlorine	Cl	17	35	17	17	35–17=18
Argon	Ar	18	40	18	18	40–18=22
Potassium	K	19	39	19	19	39–19=20
Calcium	Ca	20	40	20	20	40–20=20

SELF EVALUVATION

I. Choose the correct answer

1. Atom is
   - a) positively charged
   - b) negatively charged
   - c) neutral
   - d) none of the above

2. Electron is
   - a) neutral
   - b) positively charged
   - c) sub atomic particle
   - d) present in the nucleus

3. Mass of neutron is
   - a) 1.00727 amu
   - b) 0.00054 amu
   - c) 1.00867 amu
   - d) 10.0867 amu

4. Atomic number and mass number of sodium are 11 and 23 respectively. Number of neutrons in sodium is
   - a) 11
   - b) 12
   - c) 23
   - d) 34

5. Valency of carbon is
   - a) 2
   - b) 1
   - c) 4
   - d) 3

II. Fill in the blanks

6. An electron has ________ charge.
7. Nucleus of an atom is positively charged due to the presence of _____ in it.
8. An atom is electrically ________.
9. The word 'atom' has been derived from the Greek word ________.
10. There are ________ isotopes for hydrogen.

III. Match the following

11.	Indivisibility of atom	– Deuterium
12.	Discovery of electron	– Combining capacity of an element with hydrogen
13.	Valency	– Positively charged
14.	Isotope of hydrogen	– J.J. Thomson
15.	Proton	– Dalton

IV. Give short answer

16. Define atom.
17. Define atomic number.
18. What is meant by mass number?
19. What are isotopes?
20. An atom is neutral. Why?
21. Define valency of an element.
22. Mention the uses of isotopes.
23. Name the sub atomic particles present in an atom.

V. Give detailed answer

24. Write a note on Dalton's atomic theory.
25. What do you know about J.J. Thomson's model of atom?
26. Calculate number of protons, electrons and neutrons in the following atoms. Atomic and mass numbers are given in brackets.

    a) Hydrogen (Z = 1; A = 2)

    b) Helium (Z = 2 ; A = 4)

    c) Carbon (Z = 6; A =12)

    d) Nitrogen (Z = 7 ; A = 14)

    e) Sodium (Z = 11; A = 23)
27. Explain the structure of an atom.
28. Explain the composition of an atom.
29. Name the isotopes of hydrogen and write their properties.
30. Explain valency of elements.

6. Metals and Nonmetals

6 Metals and nonmetals

Elements can be broadly classified into metals and nonmetals. 92 elements occur in nature. About 70 of them are metals and about 20 of them are nonmetals. Elements like gold, silver, copper, iron and sodium are categorised as metals. Elements like carbon, sulphur, chlorine, oxygen and helium are classified as nonmetals.

6.1 Characteristics of metals and nonmetals

Metals are generally hard, malleable, ductile, possess lustre and are good conductors of heat and electricity.

Nonmetals are generally brittle, non-lustrous and are poor conductors of heat and electricity.

Most of the metals occur in nature in the form of compounds. Only a few metals like gold occur in free state. Nonmetals like nitrogen, hydrogen, carbon and sulphur are formed in elemental form as well as in the form of compounds. And most of the other nonmetals are found in the combined state.

6.1.1 Physical properties of metals and nonmetals

Let us study the important physical properties of metals and nonmetals.

Physical state

Metals generally have high melting points. Hence all the metals except mercury exist in the solid state at room temperature. Nonmetals are found in all the three states of matter. Carbon, sulphur and phosphorus are solids, bromine is a liquid state while hydrogen, oxygen and helium are gases at room temperature.

Lustre

Freshly cut surface of a metal has a shiny appearance. This property is called metallic lustre. Gold maintain its metallic lustre forever. So it is widely used in making jewels. Nonmetals generally do not have shining surface.

Hardness

Metals are generally hard and strong. However metals like sodium and potassium are so soft that they can be easily cut with a knife. Nonmetals are generally hard and strong but diamond is the hardest known substance.

Malleability

Metals can be beaten into thin sheets and this property is called malleability. Nonmetals are not malleable.

Ductility

The property due to which a metal can be drawn into wires is called ductility. This property of metals is used in making electric cables and in making filaments in the electric bulbs. Nonmetals are not ductile.

Conductivity

Metals are good conductors of heat and electricity. Gold and silver are the best conductors. Nonmetals are usually non conductors of heat and electricity. But graphite even though a nonmetal is a good conductor of electricity.

6.1.2 Chemical properties

Reactions of metals

Action of oxygen on metals

Metals combine with oxygen to form oxides. Metallic oxides are generally basic in nature.

$$2Mg + O_2 \rightarrow 2MgO$$

Action of water on metals

Sodium reacts violently even with cold water

$$2Na + 2H_2O \rightarrow 2NaOH + H_2$$

Magnesium reacts with hot water to form magnesium oxide

$$Mg + H_2O \rightarrow MgO + H_2$$

Iron and zinc react slowly with steam. But silver, copper and nickel do not react with water.

Action of acids on metals

Many metals like sodium, magnesium, zinc and iron displace hydrogen from dilute acids.

$$Mg + 2HCl \rightarrow MgCl_2 + H_2$$

$$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$$

Reactions of nonmetals

Combustion of nonmetals

Nonmetals like carbon, sulphur and phosphorus readily burn in oxygen to form their oxides.

$$C + O_2 \rightarrow CO_2$$

$$S + O_2 \rightarrow SO_2$$

$$4P + 5O_2 \rightarrow 2P_2O_5$$

Reaction of nonmetals with hydrogen

Nonmetals combine with hydrogen and form respective hydrides

$$Cl_2 + H_2 \rightarrow 2HCl$$

$$N_2 + 3H_2 \rightarrow 2NH_3$$

6.2 Uses of metals and nonmetals

Uses of metals

1. Iron and steel are used for making machinery, ships and agricultural implements and also used in pipes, automobiles, trains etc.,.

2. Copper is extensively used for making electrical appliances and is also used for making alloys like brass, and bronze.
3. Aluminium is used for making utensils, electric cables, aluminium foil and aluminium paint.
4. Widely used alloys, duralumin and magnalium contains aluminium.
5. Zinc is used to protect iron from rusting.
6. Lead is used in storage batteries.
7. Tin is used in tinning of cooking utensils.
8. Some metals are used as catalysts in chemical reactions.

Uses of nonmetals

1. Coal is one of the widely used fossil fuels.
2. Diamond and graphite have variety of applications.
3. Phosphorus is used in manufacture of fertilizers and fire works.
4. Phosphorus is one of the essential plant nutrients and also important for bones and teeth of animals.
5. Sulphur is used as fungicide. It is also used in vulcanisation of rubber.
6. Silicon, being a semiconductor, is used in transistors. It is used to prepare alloys like silicobronze which is used to make telephone wires.

6.3 Noble metals and their uses

Gold and platinum remain unaffected by air, water, acids and alkalies. Because of this inertness they are called noble metals.

Gold is largely used in making jewellery. Platinum is also used in jewellery. It is also used in electric gadgets.

6.3.1 Malleability and ductility of Noble metals

In pure form noble metals are extremely ductile and malleable. Gold can be drawn into extremely thin threads and can be beaten into sheets as thin as 0.00002 mm. A very thin silver foil is used over sweets, for decoration.

Gold is preferred for making ornaments because of the following reasons

1. It is not affected by atmosphere, water and chemicals
2. It has shining surface.
3. It is highly malleable and ductile.

Table 1 Composition and uses of some alloys

Alloy	Constituents	Uses
Steel	Iron and carbon	Railway tracks, bridges, ships, tanks, tools
Stainless steel	Iron, chromium and nickel	Utensils, cutlery, surgical instruments.
Brass	Copper and zinc	Ornamental objects, machine parts, musical instruments.
Bronze	Copper and tin	Statues, bells and medals.
Duralumin	Aluminium, copper manganese and magnesium	Aircraft parts, pressure cookers

6.4 Alloys

Addition of certain amount of other metals or non-metals improves the qualities of the metal. Such a mixture is called an alloy. An alloy is a homogeneous mixture of a metal with other metals or nonmetals. The metals are mixed in the molten state in a fixed proportion to form an alloy. List of some commercially important alloys, their constituents and their uses is given in the table 1.

6.5 Purity of gold

Pure gold is soft and hence it can not be used in jewellery. When some amount of copper or silver is mixed with gold, it becomes hard and fit for making jewellery. Carat is the unit used for measuring purity of gold in 24 parts by weight of the alloy. 24 carat gold is pure gold. 22 carat ornamental gold contains 22 parts by weight of gold and 2 parts by weight of copper. 18 carat gold has 18 parts by weight of gold and 6 parts by weight of copper, Now a days purity of ornamental gold is expressed in percentage. For example purity of 22 carat gold is expressed as 91.6% or simply 916.

6.6 Corrosion of iron and its prevention

You must have noticed that iron articles like nails, screws, railings and pipes get gradually coated with reddish brown substance called rust. The layer of rust easily get separated from the surface of iron objects. Chemically, rust is hydrated ferric oxide $Fe_2O_3 \cdot 3H_2O$.

Wasting away of metals due to formation of metal compounds on the surface is called corrosion. Corrosion of iron is called rusting. Rusting of iron is a slow oxidation process. Both oxygen (air) and water are necessary for rusting of iron. It can be shown by doing the following experiment.

Take three test tubes and label them as A, B and C. Place some anhydrous calcium chloride and some cotton over it in test tube A. And then drop 3 or 4 small fresh nails in it. Put 3 or 4 small nails in to the test tube B and fill it with boiled water. In the third test tube C take same number of nails and add some ordinary well water. Close all the test tubes with cork as shown in the figure 6.1.

After three days take out these nails and observe them. You will find that the nails in the test tube C alone have rusted and others are free from rust. Test tube A has no moisture due

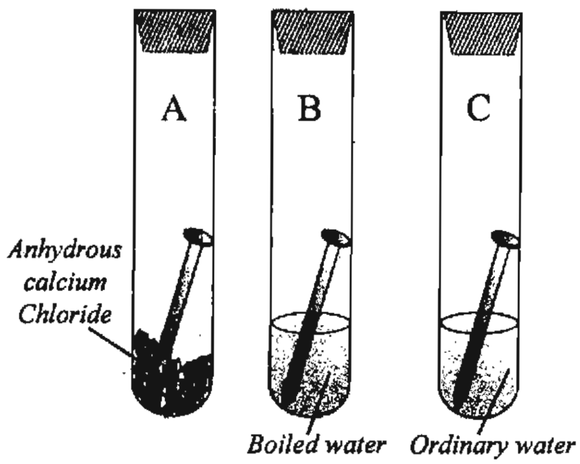


Fig. 6.1 Rusting of iron needs oxygen and moisture

to anhydrous calcium chloride, test tube B has no oxygen (because the water is boiled to expel dissolved oxygen) and water. Hence rusting of iron requires oxygen and water.

It is clear that corrosion of metals causes heavy loss to the nation's wealth. Hence it should be prevented.

Methods of preventing corrosion

1. Coating with paints

Coating of iron objects with paints prevents corrosion. For example automobiles, furniture and railway coaches are painted.

2. Galvanisation

A thin coating of zinc on iron objects prevents rusting. The process of giving a thin coating of zinc on iron to prevent rusting is called galvanisation.

3. Electroplating

Giving a thin coating of one metal on the other metal objects by using electricity is called electroplating. Handles of bicycles and many other articles are electroplated to prevent rusting.

4. Alloying

Stainless steel is an alloy of iron which does not rust easily. Hence alloying is an another way of preventing corrosion.

Table 2 Differences between metals and nonmetals

No.	Property	Metals	Nonmetals
1.	Physical State	All the metals are solids except mercury.	Nonmetals are found in all the three states of matter.
2.	Lustre	Freshly cut surface of a metal has lustre	Except diamond all of them have dull surface.
3.	Ductility and malleability	Metals are both malleable and ductile	They are brittle in nature.
4.	Hardness	Metals are generally hard except sodium potassium and calcium	They are not hard but diamond is the hardest
5.	Heat and electrical conductivity	Metals are good conductors	They are bad conductors except graphite.
6.	Oxides	Metallic oxides are generally basic in nature	Non metallic oxides are generally acidic in nature.
7.	Reaction with acids	Many metals dissolve in dilute acids and evolve hydrogen gas	No such reaction
8.	Reaction with hydrogen	Only highly reactive metals react with hydrogen to give hydrides	Most of the nonmetals form hydrides

SELF EVALUATION

I. Choose the correct answer

1. The non metal which is in liquid state at room temperature
   (a) chlorine (b) bromine (c) mercury (d) iodine

2. A soft metal that can be easily cut with a knife
   (a) sodium (b) aluminium
   (c) copper (d) gold

3. An essential plant nutrient
   (a) copper (b) calcium (c) iron (d) phosphorus

4. Used as fungicide
   (a) carbon (b) phosphorus (c) sulphur (d) chlorine

5. Rusting of iron requires
   (a) oxygen (b) water
   (c) oxygen and water (d) nitrogen

II. Fill in the blanks

6. __________ is used in vulcanisation of rubber.
7. __________ is the hardest known substance.
8. The unit used for measuring purify of gold is __________.
9. Rusting of iron is a slow __________ process.
10. The alloy that contains copper and zinc is called __________.

III. Match the following

11.	Duralumin	–	Noble metal
12.	Platinum	–	Fertilizer
13.	Lead	–	Liquid metal
14.	Phosphorus	–	Air craft
15.	Mercury	–	Storage battery

IV. Give short answer

16. What are metals?
17. What are nonmetals?
18. What is malleability?
19. Define ductility.
20. Gold is a noble metal. Why is it called so?
21. What are alloys?
22. What is corrosion?
23. What is galvanisation?

V. Give detailed answer

24. What are the physical properties of metals and nonmetals?
25. What are the chemical properties of metals and nonmetals?
26. What are the uses of metals?
27. Write the composition and uses of the following alloys.
    (a) steel (b) stainless steel (c) bronze (d) duralumin
28. Write a note on purity of gold.
29. Rusting of iron requires both air and water. Prove it by an activity.
30. Explain the methods of prevention of corrosion.

7. Carbon

Carbon is one of the most important elements. It is unique in nature. All living things whether plants or animals contain carbon. Naturally occurring substances like coal petroleum, marble and lime stone contain carbon. Carbon is a non metal represented by the symbol 'c'. The name carbon is derived from the Latin word 'carbo'. It means charcoal. Atoms of carbon can join with each other to form chains and rings of different sizes. This property of carbon is called catenation. This unique ability of carbon makes it possible to have millions of compounds of carbon. In fact there is a separate branch of chemistry known as organic chemistry, to study the compounds of carbon.

7.1 Carbon in the earth crust

Carbon constitutes only 0.03% of the earth crust. The atmosphere contains carbondioxide. Apart from coal, carbon occurs in nature in two forms namely graphite and diamond. Presence of one more form of carbon called fullerenes has been discovered. Carbon is present in the earth crust in a wide range of substances. Substances like cotton, paper, wood, sugar and food stuff contain carbon.

7.2 Atmosphere and living organism

Earth is surrounded by a thick layer of air called atmosphere. The atmosphere extends even upto 120 km above the surface of earth.

Troposphere, stratosphere, mesosphere and thermosphere are the different layers of atmosphere. The troposphere is the lowest layer of the atmosphere. Composition of air is given in the table1.

Table 1 Composition of air

Name of the constituents	Percentage by volume of air
Nitrogen	78
Oxygen	21
Carbondioxide	0.03
Inert gases	0.95
Water vapour	Variable

The percentage of carbondioxide in the atmospheric air is 0.03 only. The presence of carbondioxide in the atmosphere plays a very significant role in the biosphere.

During photosynthesis, plants absorb atmospheric carbondioxide and prepare carbohydrate, a compound of carbon. Living organisms eat these plants and get energy to live. Proteins vitamins, oils and fats are some of the other compounds of carbon which are important for the survival of living organisms.

7.3 Allotropy

An element can exist in more than one form in the same physical state. This property of the element is called allotropy and the different forms of the same element are called allotropes.

Allotropes have different physical properties but same chemical properties.

Carbon exhibit allotropy. Allotropes of carbon are of two types namely crystalline form and amorphous form. Graphite and diamond are the two crystalline forms of carbon while coal, charcoal, and lampblack are the amorphous forms of carbon. Graphite is black, soft and slippery. Diamond is the hardest among the naturally occurring substance. In 1985 another allotrope of carbon namely buckminster fullerene was discovered.

7.3.1 Structure of graphite and diamond

Structure of graphite:

In graphite the carbon atoms are arranged in flat layers. Each layer is made up of hexagonal rings containing carbon atoms Each carbon atom is connected to three other carbon atoms. The bonds between the atoms within a layer of graphite are strong. But the bonding forces between the layers are weak Vanderwaals forces. These layers can slide over each other. Due to this reason graphite is soft and slippery. This property makes it useful as lubricant in machinery. Arrangement of atoms in a crystal of graphite is shown in the figure 7.1.

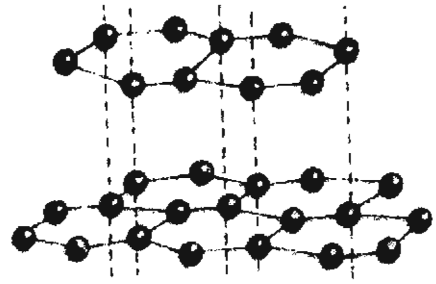


Fig. 7.1 Arrangement of carbon atoms in graphite

Structure of diamond

In diamond, each carbon atom is bonded with four other carbon atoms by strong forces. Such bonding of carbon extends to three dimensional rigid network of atoms throughout the crystal. This makes diamond the hardest among the naturally occurring substances. Figure 7.2 shows the rigid structure of diamond.

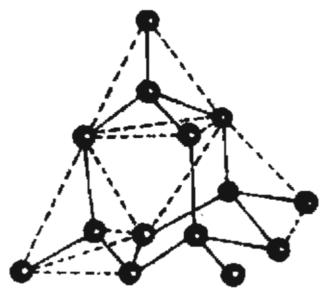


Fig. 7.2 Arrangement of carbon atoms in diamond

7.3.2 Properties and uses of graphite and diamond

Properties of graphite

1. Graphite appears dark grey.
2. It is soft and slippery.
3. It conducts electricity.
4. Melting point of graphite is 3700^{0}C.
5. Density of graphite is 2.3 g/cm^3.

Uses of graphite

1. Graphite is used as electrode in batteries.
2. It is used as a lubricant in the fast moving machinery.
3. It is used in making 'pencil lead'.
4. Graphite is used as neutron absorber (moderator) in nuclear reactors.
5. It is used as a pigment in paints.

Properties of diamond

1. Diamond is colourless and transparent. Polished diamond reflect and refract light and so it sparkles in light.
2. Density of diamond is 3.5 g/cm^3.
3. It is the hardest known natural substance.
4. It does not conduct electricity.

Uses of diamond

1. Diamond is used in jewellery since it sparkles in light.
2. Black diamond is used for cutting glass, sawing marbles and drilling rocks.
3. Diamond is used in high precision thermometers.

7.4 Fullerenes - Nature of carbon

Fullerenes are spherical molecules of carbon that are attached to each other in solid state. In 1985, chemists

Table 2 Differences between diamond and graphite

Sl. No.	Graphite	Diamond
1	Soft and slippery	Hardest natural substance
2	Density is 2.3 g/cm^3	Density is 3.5 g/cm^3
3	Black and opaque	Colourless and transparent
4	Good conductor of electricity	Non conductor of electricity
5	It does not sparkle in light	It sparkles in light

chemists prepared this new allotrope of carbon by heating graphite to extremely higher temperatures. They named it buckminster fullerene, after the American architect buckminster fullerene. This fullerence molecule C_{60} contains 60 carbon atoms. The shape of this molecule looks like buckyball (Fig. 7.3).

Geologists have discovered fullerenes in nature in the meteorites and ancient rocks. C_{32}, C_{50}, C_{70}, C_{90} and C_{120} are some of the other fullerenes which have been discovered, recently. In future, materials containing fullerenes are going to be widely used.

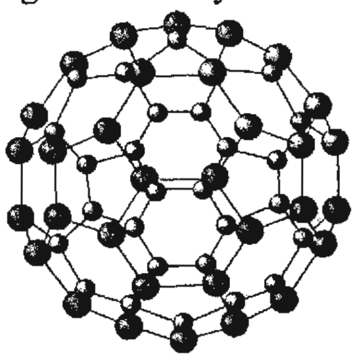


Fig. 7.3 Fullerene (C_{60})

7.5 Carbondioxide

Carbondioxide is an important constituent of air. It is also an important product of respiration, combustion of fossil fuels, fermentation and decay of organic matter. Carbondioxide is used in during photosynthesis by plants.

Carbon burns in excess of oxygen to give carbondioxide

$$C + O_2 \rightarrow CO_2$$

7.5.1 Preparation of carbondioxide

When calcium carbonate reacts with dilute hydrochloric acid, carbondioxide is produced

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$$

Take a woulfe's bottle containing some marble chips ($CaCO_3$). Close it with a one holed cork. Fix a delivery tube and thistle funnel as shown in the figure 7.4. Pour some dilute hydrochloric acid through the thistle funnel. Carbondioxide produced in the reaction is collected in a gas jar by the upward displacement of air.

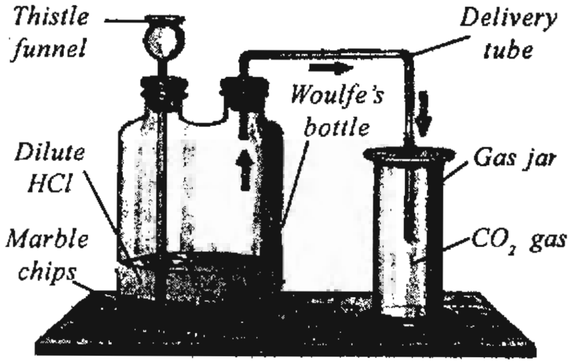


Fig.7.4 Preparation of CO_2

7.5.2 Properties of carbondioxide

Physical properties of carbondioxide

1. It is a colourless and odourless gas.
2. It is heavier then air.
3. It is sparingly soluble in water.
4. When cooled below -78^0C, it directly changes into a white ice like solid called dry ice. Dry ice does not melt but directly changes into gaseous CO_2.

Chemical properties of carbondioxide

1. It is acidic in nature. It dissolves in water to give carbonic acid which turns blue litmus into red.

   $CO_2 + H_2O \rightarrow H\ CO_3$

2. It reacts with sodium hydroxide solution to form the salt sodium carbonate and water.

   $2NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O$

3. It turns lime water milky. This is due to the formation of calcium carbonate.

   $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

4. Green plants synthesise glucose from carbondioxide and water using sunlight during photosynthesis.

   $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

7.5.3 Uses of carbondioxide

1. Carbondioxide is used as a fire extinguisher.
2. It is used for making aerated soft drinks
3. It is used in manufacture of sodium carbonate (washing soda) and sodium bicarbonate (baking soda)
4. Dry ice is used as a refrigerant.
5. It is used by green plants during photosynthesis.
6. Liquid CO_2 is used in sugar industry.

7.6 Methane

Methane is the simplest hydrocarbon. It is also called as marsh gas. Coal gas contains 30% methane. Natural gas contains about 80% methane.

Methane is a covalent molecule. One carbon atom is connected to four hydrogen atoms tetrahedrally as shown in figure 7.5.

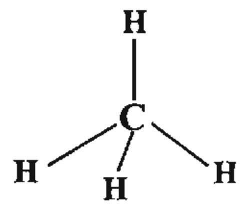


Fig. 7.5 Structure of methane

Laboratory preparation of methane:

When a mixture of anhydrous sodium acetate and soda lime (mixture of sodium hydroxide and calcium oxide) is heated in a hard glass tube methane gas is produced (Fig.7.6).

$$CH_3COONa + NaOH \xrightarrow{\Delta} Na_2CO_3 + CH_4$$

Since methane is insoluble in water it is collected by the downward displacement of water.

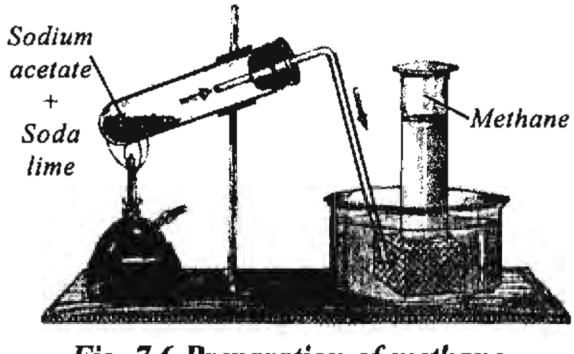


Fig. 7.6 Preparation of methane

Properties of methane

1. It is a colourless and odourless gas
2. It is insoluble in water
3. It is lighter than air
4. It burns in air with a blue flame
   $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

Uses of methane

1. Combustion of methane gives a large amount of heat. Hence it is used as a fuel.
2. It is used for making carbon black.
3. Methane is used for the preparation of a number of organic compounds like formaldehyde, methyl alcohol and chloroform.
4. Now a days natural gas is also used as a fuel in automobiles.
5. Methane as a part of biogas is used as a domestic fuel.

SELF EVALUATION

I. Choose the correct answer

1. Allotropes have
   (a) the same physical properties but different chemical properties
   (b) the same chemical properties but different physical properties
   (c) the same physical and chemical properties
   (d) different physical and chemical properties

2. The binding force between the layers in graphite is
   (a) Vander waal's force (b) Covalent bond
   (c) ionic bond (d) coordinate bond.

3. Which of the following is not the use of graphite
   (a) used in making pencil lead
   (b) used as a moderator in nuclear reactor
   (c) used as a lubrican
   (d) used for cutting glass, marbles and rocks

4. Which of the following is not a fullerene
   (a) C_{60} (b) C_{50} (c) C_{120} (d) C_2

5. Dry ice is
   (a) Solid CO_2 (b) liquid CO_2
   (c) gaseous CO_2 (d) CO_2 dissolved in water.

II. Fill in the blanks

6. Percentage of CO_2 in atmosphere is ________.
7. ________ and ________ are the crystalline allotropes of carbon.
8. The hardest known natural substance is ________.
9. The allotrope obtained by heating graphite to extremely higher temperature and which is also found in nature in meteorities and ancient rocks is ________.
10. Soda lime is a mixture of ________.

III. Match the following

11.	CH_4	–	Diamond
12.	Electrode	–	Dry ice
13.	C_{60}	–	Marsh gas
14.	Solid CO_2	–	Graphite
15.	Non conductor of electricity	–	Fullerenes

IV. Give short answer

16. In what way carbon is important for the survival of living organisms?
17. What is allotropy? Give example.
18. What is dry ice? How is it obtained?
19. What happens when carbondioxide gas is bubbled through lime water? Give equation.
20. Write a note on structure of methane.
21. Write the chemical equation of the photosynthesis.
22. Mention any three uses of methane.
23. Mention the uses of diamond.
24. Mention any three uses of carbondioxide.
25. Why is graphite used as a lubricant?

V. Give detailed answer

26. How is methane prepared in the laboratory?
27. How is carbondioxide prepared in the laboratory?
28. Give the differences between graphite and diamond.
29. Explain buckminster fullerene.
30. Mention the uses of graphite.
31. Explain the structure of graphite.
32. Explain the structure of diamond.

8. Centre of Gravity, Simple Machines and Friction

Mechanics is a branch of physics. It deals with the study of action of forces on bodies. The two branches of mechanics are 1) Dynamics and 2) Statics.

Dynamics deals with the study of motion of bodies and statics deals with the study of bodies at rest.

In this chapter, we shall study about centre of gravity, stable and unstable equilibrium, friction, types of friction, simple machines, pulleys and inclined plane.

8.1 Centre of gravity

Any object comprises of a large number of particles. Each particle is pulled towards the earth due to the force of gravity. Thus, the forces on the particles are equal, parallel and act in the same direction. These forces will have a resultant which acts through a particular point G (Fig. 8.1). This fixed point G is called the centre of gravity.

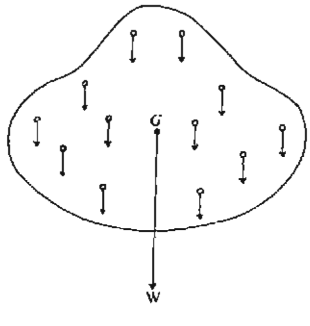


Fig. 8.1 Centre of gravity

The centre of gravity of an object is defined as a fixed point through which the entire weight of the body acts irrespective of the position of the body.

Activity 1

Centre of gravity of a metre scale

Set a metre scale horizontally on a knife edge. The weight of the scale(W) now acts vertically downwards through the knife edge. An equal force acts upwards in the knife edge as reaction(R). These two forces are equal in magnitude but opposite in direction. They act in the same straight line (Fig. 8.2).

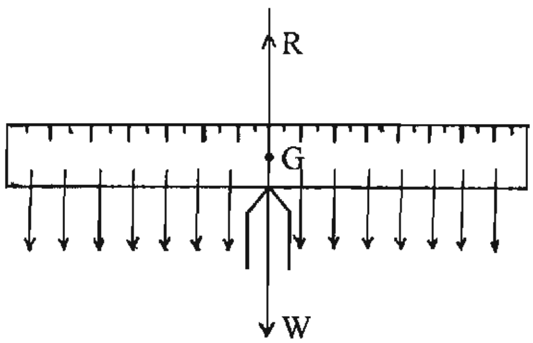


Fig. 8.2 Centre of gravity of a metre scale

If we consider the scale containing large number of particles, each one has weight acting vertically downwards. These forces have a resultant force acting at a point G in the centre of the scale. This point G is called the centre of gravity of the metre scale.

8.2 Centre of gravity of regular objects.

Centre of gravity of a body is a fixed point. The position of the centre of gravity depends on the shape or size of the body.

8.2.1 Determination of Centre of gravity of a uniform rod

Consider a uniform rod AB. Let G be its middle point. Let the rod be divided into large number of small equal elements. Consider the element at one end A and another similar element at the other end B (Fig. 8.3).

The weights of these two elements are equal and form two like parallel forces. The resultant force should pass through G, which is the mid point of AB.

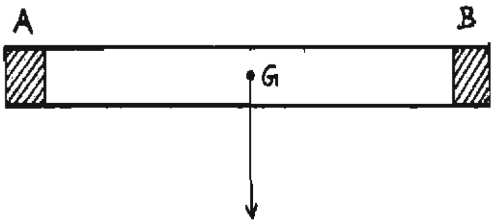


Fig. 8.3 Centre of gravity of a uniform rod

Hence considering the whole rod, the resultant of the weights of the various elements should pass through G. *Therefore, the centre of gravity of a uniform rod lies at its mid point.*

8.2.2 Centre of gravity of various bodies

1. Square lamina: Draw the diagonals AC and BD. They intersect at a point G which is the centre of gravity (Fig. 8.4).

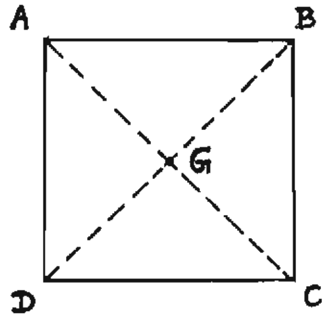


Fig. 8.4 Centre of gravity of a square lamina

2. Rectangular lamina: Draw the diagonals AC and BD. They intersect at a point G, which is the centre of gravity (Fig. 8.5).

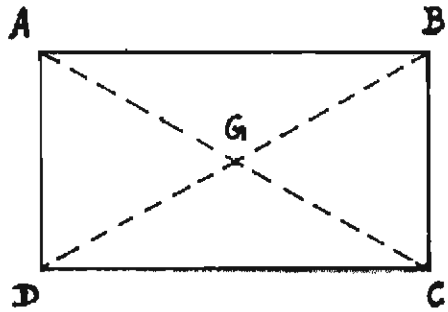


Fig. 8.5 Centre of gravity of a rectangular lamina

3. Circular lamina: The centre of gravity of a circular lamina lies at its centre (Fig. 8.6). If we draw any two diameters, they meet at the centre G which is the centre of gravity.

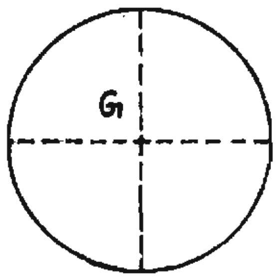


Fig. 8.6 Centre of gravity of a circular lamina

4. *Triangular lamina:* The centre of gravity G of a triangular lamina is the point of intersection of the medians AE, BF and CH (Fig. 8.7).

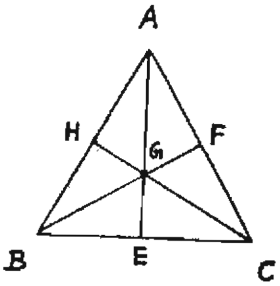


Fig. 8.7 Centre of gravity of a triangular lamina

5. *Uniform circular disc:* The centre of gravity G of a uniform circular disc will be its centre (Fig. 8.8).

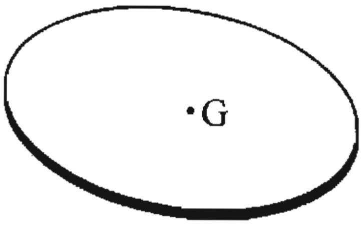


Fig. 8.8 Centre of gravity of uniform circular disc

6. *Sphere and hollow sphere:* The centre of gravity G of a sphere (or a hollow sphere) will be the geometric centre of the sphere (Fig. 8.9).

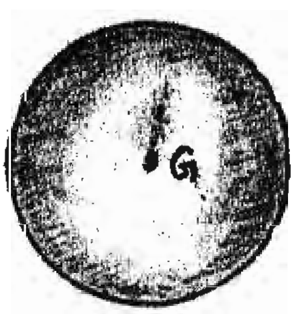


Fig. 8.9 Centre of gravity of a sphere

7. Solid Cone: The Centre of gravity G of a solid cone lies on its axis at a distance of h/4 from its base where h is its vetical height (Fig. 8.10).

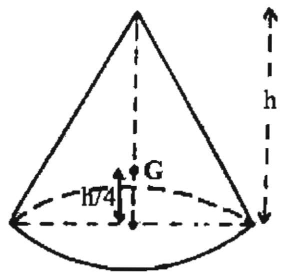


Fig. 8.10 Centre of gravity of a solid cone

8. When two identical cones are joined together at the base, the centre of gravity of this combination now lies at G_1 (Fig. 8.11),which is the centre of the base of either cone.

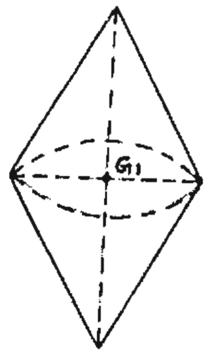


Fig 8.11 Centre of gravity of the combined cones

Activity 2

Centre of gravity of an irregular lamina

Take a thin irregular cardboard of uniform thickness and make three holes A, B and C near its perimeter. Suspend the lamina from the hole A by means of piece of a thread. From the same point suspend a small plumb line.

When it is in equilibrium, trace the vertical line indicated by the plumb line on the lamina (Fig. 8.12).

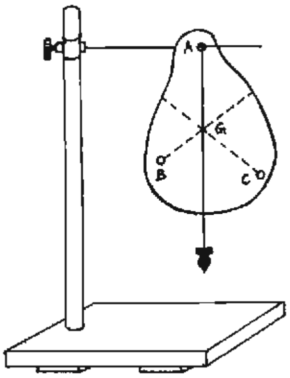


Fig. 8.12 centre of gravity of an irregular lamina.

Repeat the experiment by suspending the lamina from the other holes. The point of intersection of these lines is the centre of gravity of the irregular lamina.

8.3 Stability

The position of centre of gravity of a body determines the stability of the body.

Conditions for the stability of an object

1. The object should have a broad base

For example, in the case of a solid cone, the cone has a broad base (Fig. 8.13).

2. The centre of gravity should be as low as possible

For example, in the solid cone, the centre of gravity is very low (Fig. 8.13).

3. The vertical line drawn from the centre of gravity should fall within the base.

For example, in a solid cone, the vertical line drawn from the centre of gravity falls within the base (Fig. 8.13).

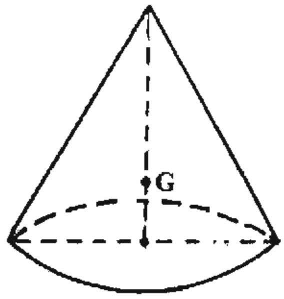


Fig.8.13 Conditions for stability of a solid cone

8.3.1 Some examples of stability of objects

1) Tanjavur doll

When the Tanjavur doll is tilted to a large angle and released, it goes to its initial position (Fig. 8.14). But all the bodies do not behave like the Tanjavur doll. Why?

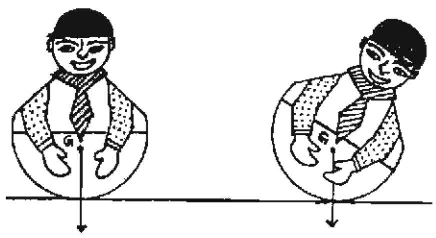


Fig. 8.14 Tanjavur doll

In the case of Tanjavur doll, the centre of gravity is low and the vertical line drawn from the centre of gravity always fall within the base even if it is tilted.

2. Pisa tower in Italy

Pisa tower in Italy is one of the seven wonders existing in the world. Even though it is slightly inclined or tilted, it is in stable condition. This is due to the vertical line drawn from the centre of gravity falling within the base of the tower.

3. Racing Cars

We know that the stability of a body increases, when its centre of gravity is low and its base broad. To achieve these conditions, the racing cars are low and their wheels are apart.

8.4 Stable and unstable equilibrium

Lowering the centre of gravity of an object is an important factor for stability.

In **double-decker buses**, if the passengers are allowed to stand in the upper deck, the centre of gravity will be raised. The vertical line from the centre of gravity will not fall within the base of the bus when it travels on a rough road. That is why the passengers are not allowed to stand in the upper deck of the double-decker buses to avoid toppling.

8.4.1. Types of equilibrium

The three types of equilibrium are

1. Stable equilibrium
2. Unstable equilibrium and
3. Neutral equilibrium

Let us study these three types of equilibrium in detail.

1. Stable equilibrium

Place a funnel with its base on a table. Tilt it slightly and release. It comes back to its initial position. When it is tilted, the vertical line drawn from the centre of gravity passes through its base (Fig. 8.15). This is called stable equilibrium of the funnel.

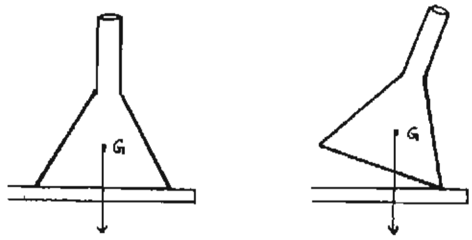


Fig. 8.15 Stable equilibrium of the funnel

2. Unstable equilibrium

Place the funnel with its stem on the table. Tilt the funnel to a large angle and release. It falls. Now the vertical line drawn from the centre of gravity falls outside the base (Fig. 8.16). Now the funnel is in unstable equilibrium.

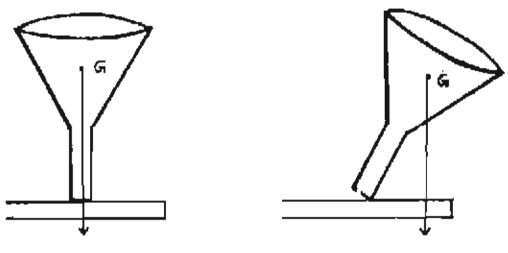


Fig. 8.16 Unstable equilibrium of the funnel

3. Neutral Equilibrium

Place the funnel with its curved surface on the table. If it is slightly disturbed, the centre of gravity is neither raised nor lowered. The vertical line from the centre of gravity always passes through the base. The funnel is now in neutral equilibrium (Fig. 8.17).

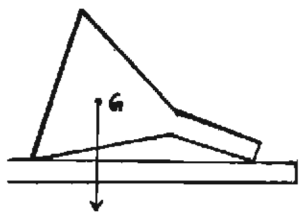
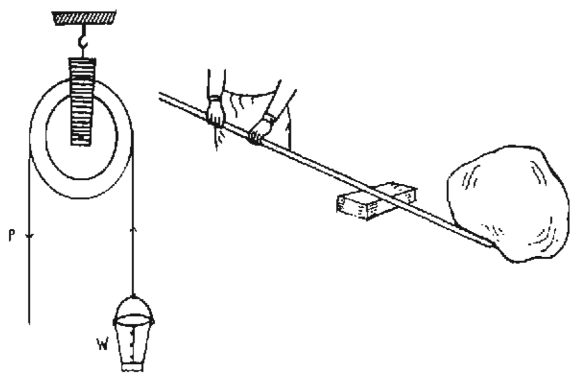


Fig. 8.17 Neutral equilibrium of the funnel

> ***Do You know?***
>
> *Persons in a boat are not allowed to stand. Why? When they stand in a boat, the centre of gravity of the boat and the persons is raised. Thus, the stability of the boat becomes less.*

8.5 Simple machines

For lifting a load or overcoming a resistance, we use the appliances like crowbar, pulleys, inclined planes, wedge, wheel and axle, motor car jack etc.(Fig. 8.18). These appliances are called simple machines.



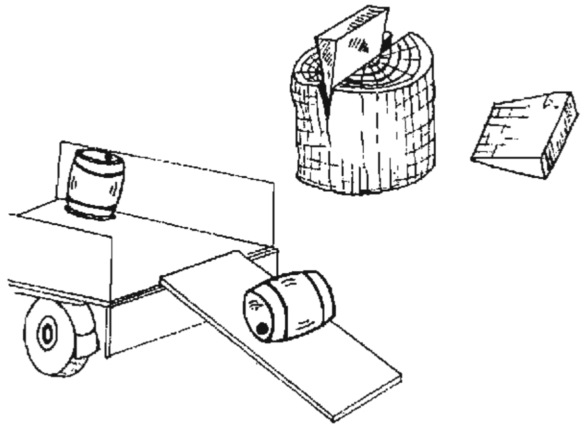


Fig. 8.18 Some simple machines

A simple machine is a device in which a force applied at some point in one direction is made available at some other point, altered in magnitude or direction or both.

8.5.1 Mechanical advantage, velocity ratio and efficiency

The force applied to the simple machine is called power (P). The force overcome by the power is called the load (W)(Fig. 8.19).

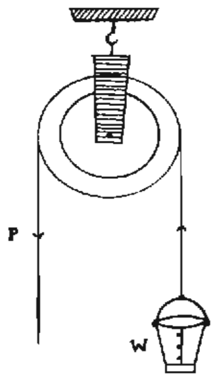


Fig. 8.19 Pulley-power and load

Mechanical Advantage

In a simple machine, when the power P balances a load W, the ratio of the load to the power is called the *mechanical advantage* of the machine.

Mechanical advantage (MA)

= Load / Power = W / P

Velocity ratio

The velocity ratio of a simple machine is defined as the ratio of the distance(x) through which the point of application of the power moves to the distance(y) through which the point of application of the load moves in the same time. That is, velocity ratio = x / y.

Efficiency

Efficiency of a simple machine is the ratio of the work done by the machine to the work done on the machine.

8.5.2 Relation between Mechanical advantage, velocity ratio and efficiency

Let P be the power applied. Due to this the point of application of the power moves through a distance x. Let W be the load. Due to the application of the power, the point of application of the load moves through a distance y (Fig. 8.20).

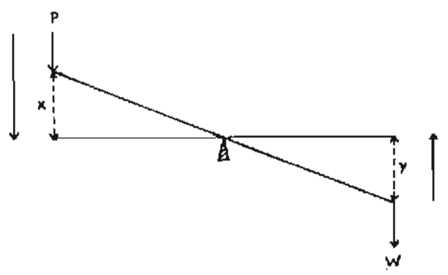


Fig. 8.20 Relation between the mechanical advantage, the velocity ratio and the efficiency

Work done by the power = P × x. This is the work done on the machine.

Work done by the load = W × y. This is the useful work done by the machine.

Efficiency

$$= \frac{\text{Work done by the machine}}{\text{Work done on the machine}}$$

$$= \frac{W \times y}{P \times x} = \frac{W}{P} \div \frac{x}{y}$$

Therefore, efficiency

$$= \frac{\text{Mechanical advantage}}{\text{Velocity ratio}}$$

Usually efficiency is expressed as a percentage.

Hence, efficiency

$$= \frac{\text{Mechanical advantage}}{\text{Velocity ratio}} \times 100$$

Problem 1

A person is able to lift a stone of 200 kg wt by applying a force of 10 kg wt. Calculate the mechanical advantage.

Mechanical advantage

$$= \frac{\text{Load}}{\text{Power}} = \frac{200}{10} = 20$$

Problem 2

The mechanical advantage and the velocity ratio of a simple machine are 4 and 8 respectively. Calculate the efficiency of the machine.

Efficiency

$$= \frac{\text{Mechanical advantage}}{\text{Velocity ratio}} \times 100$$

$$= \frac{4}{8} \times 100 = 50\%$$

Problem 3

The mechanical advantage and the velocity ratio of a simple machine are 5 and 5 respectively. Calculate the efficiency of the machine.

Efficiency

$$= \frac{\text{Mechanical advantage}}{\text{Velocity ratio}} \times 100$$

$$= \frac{5}{5} \times 100 = 100\%$$

8.5.3 Levers

The law of levers:

The law of lever states that

Load $\times$ load arm = Power $\times$ power arm

The distance of the load from the fulcrum is called the load arm. The distance of the power from the fulcrum is called the power arm (Fig. 8.21).

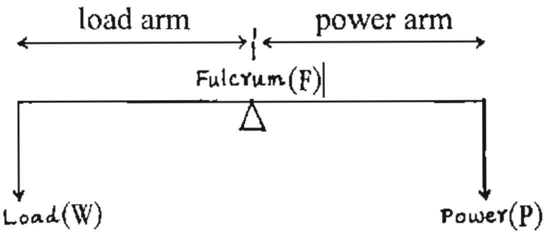


Fig. 8.21 Law of levers

A lever allows to lift or move a large load with a small effort or power. A simple example of a lever is a crowbar.

8.5.4 Classification of levers

Depending on the positions of fulcrum, load and power, levers are classified into three classes.

First order levers:

In this type the fulcrum is between the load and the power (Fig. 8.21). (e.g.) A pair of scissors, see-saw, crowbar etc., (Fig. 8.22).

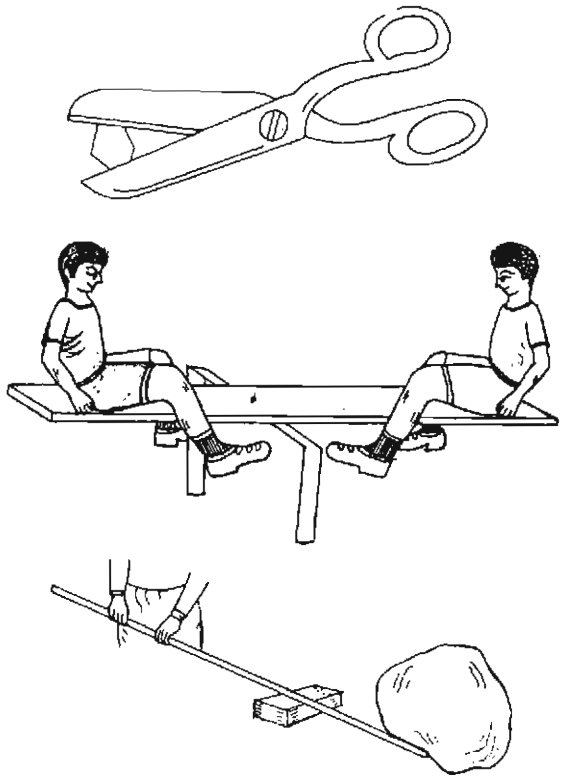


Fig. 8.22 First order lever and examples

Second order levers:

In this type, the load lies between the fulcrum and the power. (e.g.) Paper sheet cutter, bottle opener, Wheel barrow, etc., (Fig. 8.23).

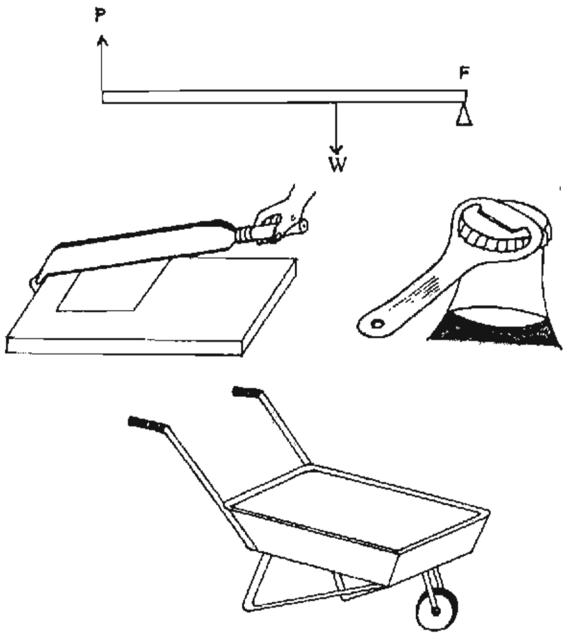


Fig. 8.23 Second order lever and examples

Third order levers:

In this type, the power lies between the fulcrum and the load (e.g.) the human fore arm, forceps, broom etc. (Fig. 8.24).

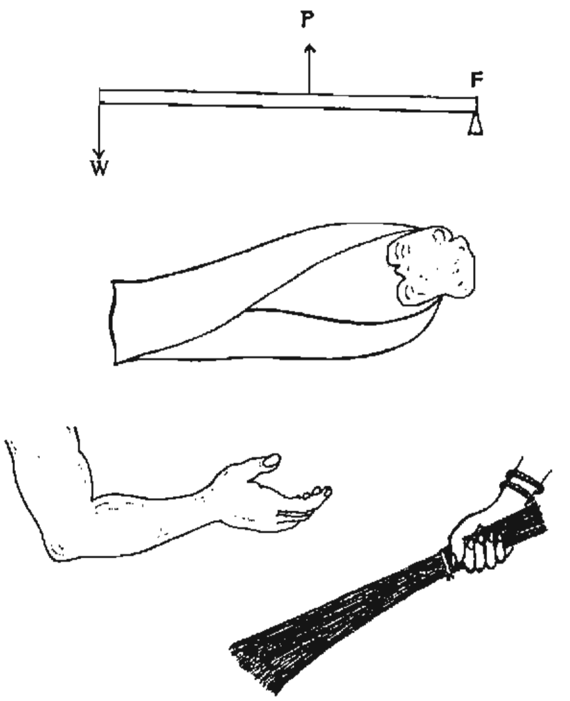


Fig. 8.24 Third order lever and examples

8.6 Pulleys

A pulley is a simple machine used to change the direction of application of a force. It consists of a small wheel, with a groove cut round its rim. A light rope passes over the grooved rim. It can rotate about an axle passing through its centre. The axle of the pulley is supported by a block (Fig. 8.25).

8.6.1 Single fixed pulley

If the block of a pulley is fixed, it is called fixed pulley. A simple fixed pulley is used to draw water from a well. The load (W) is attached to one end of the rope and the effort or power (P) is applied at the other end (Fig. 8.25). The mechanical advantage of a fixed pulley is one because the power applied is equal to the load.

Mechanical Advantage = $\frac{W}{P} = 1$

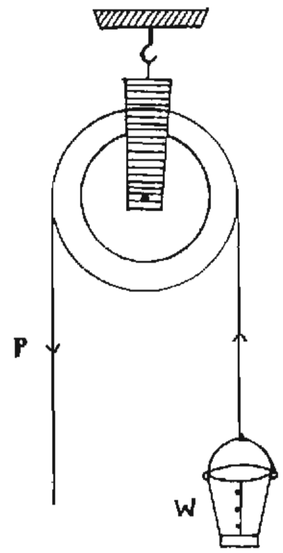


Fig. 8.25 Single fixed pulley

8.6.2 Single movable pulley

In a single movable pulley, one end of a string is attached to a fixed support and the string passes through the grooved rim of the pulley. The Power (P) is applied at the other end of the string. The load (W) is attached to the block of the pulley (Fig. 8.26).

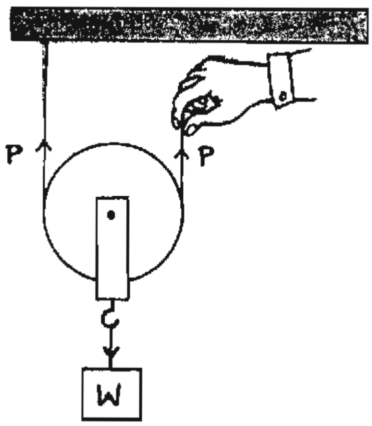


Fig. 8.26 Single movable pulley

The load W is balanced by the tensions P and P which act along the rope in the upward direction.

Therefore, 2 P = W

Hence, the mechanical advantage $= \frac{W}{P} = 2$

8.6.3 Block of pulleys

In order to obtain a greater mechanical advantage than that obtained with a single movable pulley, a number of movable pulleys are used.

In a particular system as shown in figure 8.27 there are two blocks, one of which is used as the fixed block while the other is used as a movable block. If the number of pulleys in the two blocks are equal, one end of the string is tied to the upper block and the power is applied at the free end of the string.

Since 6 parts of the same string support the lower block and the load W, we have for the equlibrium of the lower block.

$$6P = W$$

$$MA = \frac{W}{P} = 6$$

In general, if there are n pulleys in both the blocks, MA = n.

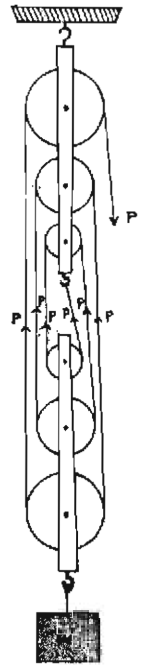


Fig. 8.27 Block of pulley

8.7 Inclined Plane

It is difficult to raise a heavy load vertically against the force of gravity. Inclined planes are mainly used to lift heavy loads from a lower level to a higher level by rolling them up. It is used to overcome a large force by applying a smaller force while raising the heavy loads.

Heavy barrels are loaded into trucks by pushing them along an inclined plane made of wooden plank.

Staircases, over-bridges and ghat roads are based on the principle of inclined plane.

8.7.1 Experiment to find Mechanical advantage of the inclined plane

Two wooden planks are joined together at one end such that the inclination between them may be changed. A glass plate is fixed to the top surface of the inclined plane to reduce friction. One end of a string is tied to a metal roller and the string is passed through a small pulley fixed at the top of the inclined plane. A light weight pan is tied to the other end of the string. Suitable weights are added to the pan so that the roller (load W) just starts moving upwards (Fig. 8.28). The weight in the pan which raises the load is called the power or effort (P).

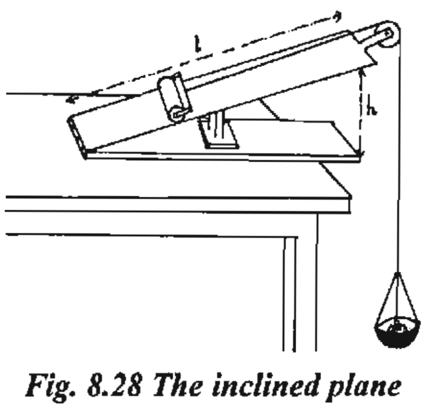


Fig. 8.28 The inclined plane

Let h be the height of the inclined plane and l be the length of the inclined plane.

Work done on the load = $W \times h$

Work done by the effort = $P \times l$

Here,

$$W \times h = P \times l$$

$$\frac{W}{P} = \frac{l}{h}$$

Mechanical advantage of the inclined plane

$$= \frac{\text{Load(W)}}{\text{Power(P)}} = \frac{l}{h}$$

i.e., Mechanical advantage

$$= \frac{\text{Length of the inclined plane}}{\text{Height of the inclined plane}}$$

Activity 3

Take a wooden block and measure its weight using a spring balance. Now make an inclined plane using a cardboard on a pile of books (Fig. 8.29a) Place the wooden block on the inclined plane.

Calculate the mechanical advantage by applying an effort on the wooden block by the spring balance so that the block just moves up the inclined plane.

Now decrease the angle of inclination of the plane by removing some books (Fig. 8.29b) and calculate the mechanical advantage. You can observe that the mechanical advantage *of the inclined plane increases as the height decreases.*

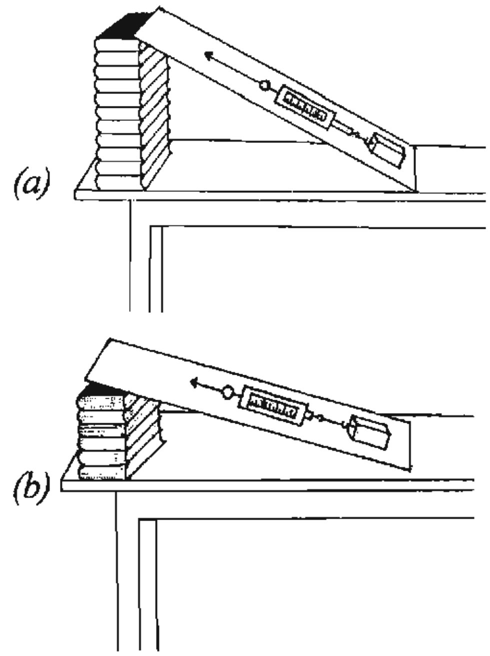


Fig. 8.29 Increasing the mechanical advantage of the inclined plane

8.8 Friction

Friction is defined as the opposing force offered to a body sliding on the surface of another body.

Consider a ball rolling down an inclined plane. It stops after moving a distance on the ground. If the ground is smooth, the distance covered by the ball would be more than what it covered earlier. The ball stops due to a force acting between the ball and the ground in a direction opposite to the direction of motion of the ball. This force is called the *frictional force.*

From the above experiment, it is clear that the force of friction is less if the surfaces are smooth and the force of friction is large if the surfaces are rough.

8.8.1 Factors affecting friction

The following are the factors that affect the friction.

1. The kind of materials of which the surfaces are made.
2. The nature of the two surfaces in contact.
3. The weight of the body sliding over a surface.
4. The nature of motion of the body i.e. whether it is sliding or rolling.

8.8.2 Sliding friction

When one body moves slowly or slides over another body, the force of friction is known as the dynamic friction or sliding friction.

8.8.3 Rolling friction

When a body rolls over the surface of another body, the friction is called rolling friction.

Activity 4

Place a book on a table and make it to move (Fig. 8.30a). Now place a few round pencils below the book and try to move the book (Fig. 8.30b). Repeat the activity with a few small steel balls below the book (Fig. 8.30c).

It can be seen that it is easier to roll than to slide the book.

From this activity, it is clear that the rolling friction is much smaller than the sliding friction.

(a)

(b)

(c)

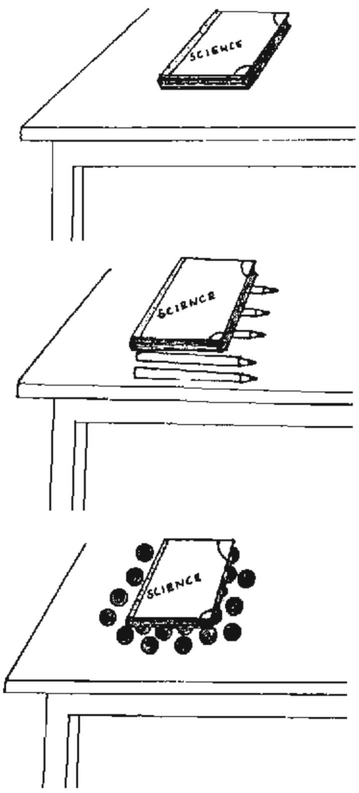


Fig. 8.30 The rolling friction is much smaller than the sliding friction

> ***Do you know?***
>
> *A suitcase fitted with wheels at the bottom can be easily moved on the floor and it is quite difficult to slide a suitcase without wheels.*

8.8.4 Advantages of friction

Some of the advantages of friction in our daily life are as follows

1. It is only because of the frictional force between the feet and the floor we are able to walk and run on the floor.
2. The friction between the sole of a shoe and the ground is increased by providing spikes. This is done to avoid slipping.
3. The tyres of cycles and motor vehicles have grooves on them to increase friction between the wheel and the road.
4. The brake shoes make contact with the rotating wheel of a moving vehicle to reduce its speed.
5. Friction is useful in lighting matches.
6. Friction helps us to hold objects.
7. Nails and screws stick to the surfaces due to friction.

8.8.5 Disadvantages of Friction

1. Friction is produced between the moving parts of a machine and this frictional force produces wear and tear and heat. Hence, the efficiency of the machine is affected.
2. When the tyre of a vehicle is deflated, the sliding friction between the tyre and the road increases which makes it difficult to move.
3. The footwear worn out due to friction of walking; but if there is no friction between the feet and the floor, we cannot walk or run.

4. The frictional force between the tyres of moving vehicle and the road, causes wear and tear in the tyres.

8.8.6 Control of friction

Sometimes there is a need to reduce friction between two surfaces. Some of the methods to reduce the friction are as follows:

1. Polishing

Polishing and smoothening of rough surfaces reduce the friction.

2. Lubricants

Due to friction there is wear and tear of the moving parts of machines. To reduce friction, lubricants like oil, grease etc., are used between these parts.

3. Ball bearings

Friction can be reduced by using ball bearings. A ball bearing consists of steel balls placed between two metal surfaces (Fig. 8.31). These balls are lubricated and free to move smoothly one over the other. Ball bearings are used in machines such as cycles, fan, motor vehicles and rotating machines. Some of the machines use cylindrical bearings.

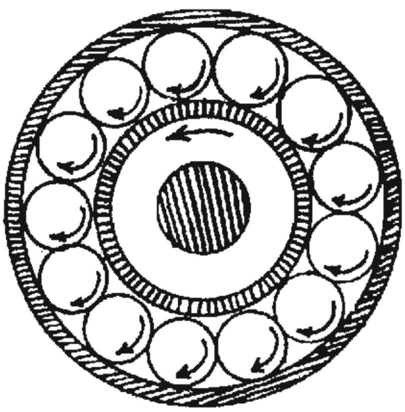


Fig. 8.31 Ball bearings

4. Stream lining

When a train, car or an aero plane moves fast through the atmospheric air, friction is produced. This frictional force opposes its motion and reduces its speed. The shape of these vehicles are suitably designed to reduce friction due to air. The front portion of ships, submarines etc. are pointed to reduce the friction offered by the fluid.

This type of shaping a body so as to reduce friction is called streamlining.

SELF EVALUATION

I. Choose the correct answer

1. The centre of gravity of a solid cone lies on its axis at a distance of ________ from its base, where h is its vertical height.

   (a) 3h/4 (b) h/2 c) h/4 (d) h

2. In neutral equilibrium the centre of gravity is

   (a) lowered (b) raised

   (c) lowered and raised (d) neither raised nor lowered

3. In simple machines, the mechanical advantage is equal to

   (a) load × power (b) power / load

   (c) load / power (d) none of the above

4. An example for second order levers is

   (a) a pair of scissors (b) wheel barrow (c) see saw (d) forceps

5. In a single movable pulley, the mechanical advantage is equal to

   (a) 1 (b) 3 (c) 2 (d) 4

II. Fill in the blanks

6. Dynamics deals with the study of ________.
7. The ratio of the mechanical advantage to the velocity ratio is called ________.
8. The position of centre of gravity of a body determines the ________ of the body.
9. In third order levers between the fulcrum and the load, ________ lies.
10. Polishing and smoothening of rough surfaces reduce ________.

III. Match the following

11.	A funnel with its base on a table	–	reduces the friction
12.	Load $\times$ load arm	–	$\frac{\text{length of the inclined plane}}{\text{height of the inclined plane}}$
13.	Pulley	–	stable equilibrium
14.	Mechanical advantage	–	changes the direction of force
15.	Lubricant	–	power $\times$ power arm

IV. Give short answer

16. Define : centre of gravity.
17. How will you determine the centre of gravity of a triangular lamina?
18. Where is the centre of gravity of two identical cones joined together at the base?
19. State the conditions for the stability of an object.
20. Why do racing cars are low and their wheels apart?
21. Name the types of equilibrium .
22. What is a simple machine?
23. Define : mechanical advantage of a simple machine.
24. Define : velocity ratio if a simple machine.
25. Define : efficiency of a simple machine.
26. State the law of levers.
27. What is a pulley?
28. Give a few examples of inclined plane.
29. How do the inclined planes make our task easier?
30. What is sliding friction?
31. What is rolling friction?
32. Give any two factors affecting friction.

33. Give any two disadvantages of friction.
34. Why do we use ball bearings in wheels?
35. What is meant by streamlining?

V. Give detailed answer

36. How will you determine the centre of gravity of a uniform rod?
37. How will you determine the centre of gravity of the following bodies?
    1) square lamina 2) circular lamina 3) triangular lamina
    4) sphere and 5) solid cone
38. Explain the method to determine the centre of gravity of an irregular lamina.
39. Explain the various types of equilibrium with examples.
40. Derive the relation between mechanical advantage, velocity ratio and efficiency.
41. Explain the various types of levers with some examples.
42. Derive an expression for the mechanical advantage of a single fixed pulley.
43. Derive an expression for the mechanical advantage of a single movable pulley.
44. Explain the method to calculate the mechanical advantage of an inclined plane.
45. Give some examples where friction is essential? How can we control the friction?

Problems

46. The mechanical advantage and the velocity ratio of a simple machine are 2 and 8 respectively. Calculate the efficiency of the machine.
47. A person is able to lift a stone of 250 kg wt by applying a force of 5 kg wt. Calculate the mechanical advantage.

9. Light

Introduction

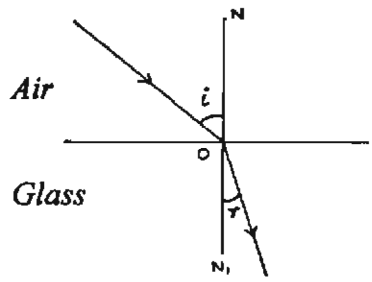
The part of the electromagnetic spectrum that the human eye can detect is called the visible light. You already know that light rays travel in straight line. You have also studied the laws of reflection. In this unit, we shall study about the refraction of light, dispersion of light, some optical instruments, the human eye and defects of eye and corrections using lenses.

9.1 Refraction of Light

When a ray of light travels through a medium, it travels in a straight line. However, when light passes from one medium to another medium, a change is produced in its path.

Refraction is the bending of a light ray as it passes from one medium to another medium.

When the light ray passes from rarer medium to denser medium, for example from air to glass, it is refracted towards the normal NON_1 (Fig. 9.1) so that $\angle r < \angle i$

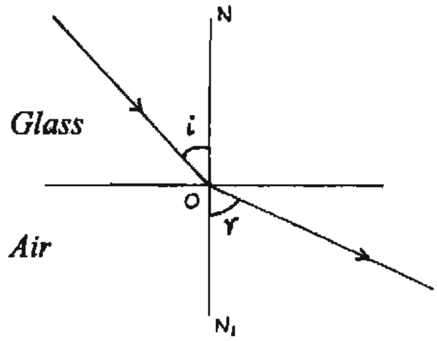


$\angle i$ – angle of incidence

$\angle r$ – angle of refraction

Fig. 9.1 Refraction of light from rarer to denser medium

When the light ray passes from denser to rarer medium, for example from glass to air, it is refracted away from the normal NON_1 (Fig. 9.2) so that $\angle r > \angle i$



$\angle i$ – angle of incidence

$\angle r$ – angle of refraction

Fig. 9.2 Refraction of light from denser to rarer medium

Activity 1

Take an empty cup and place a coin at the bottom. Watch the coin through the edge of the cup as shown in the figure 9.3. The coin is just invisible.

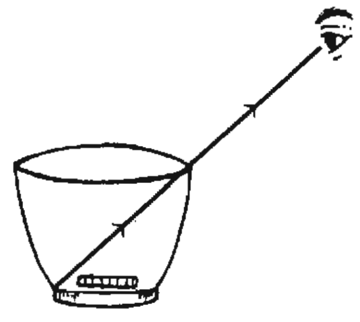


Fig. 9.3 Coin at the bottom of the cup just invisible

Now fill the cup with water. The coin placed at the bottom of the cup appears raised as shown in the figure 9.4 and the coin is now visible.

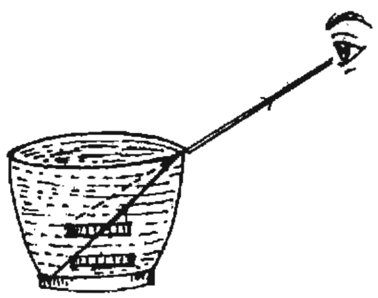


Fig. 9.4 Coin appears raised in water

Thus, the objects in water appear to be at a lower depth due to refraction.

Activity 2

Place a metal rod BC in a vessel of water. Look at the rod from the side. The rod appears to be bent as BC due to refraction (Fig. 9.5).

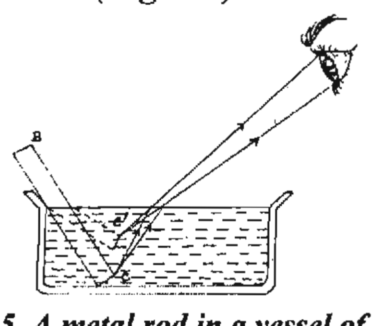


Fig. 9.5 A metal rod in a vessel of water

9.1.1 Refraction through a glass slab

Take a drawing board and fix a white paper on it. Place a glass slab on the paper and mark its boundary with a pencil.

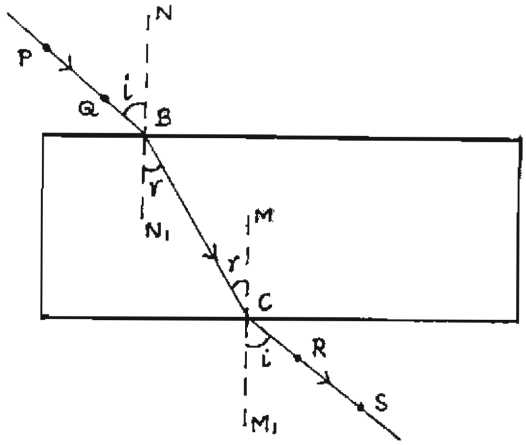


Fig. 9.6 Refraction through a glass slab

Fix two pins P and Q on the incident ray PB as shown in the figure 9.6. View the pins through the opposite face of the slab. Place two more pins at R and S in line with the images of P and Q. Mark the positions of the pins. Remove the glass slab. Join the positions S and R to meet the glass slab at C. Draw normals NN_1 and MM_1 through B and C. BC is the refracted ray in the slab. It may be noted that the direction of the incident ray PB is laterally shifted along CS by the slab. The angle ***i*** is the angle of incidence and the angle ***r*** is the angle of refraction. Measure the angles with a protractor. Repeat the experiment for different angles of incidence. Calculate the ratio sin***i***/sin***r*** in ach case.

S.No	Angle of Incidence *i*	Angle of refraction *r*	Sin *i*/Sin *r* = constant
1			
2			
3			
4			

It can be seen from the above experiment that,

1. The incident ray, the refracted ray and the normal lie in the same plane.

2. The ratio of the sine of the angle of incidence to the sine of angle of refraction is a constant and this constant is called the ***refractive index*** of the material of the slab. (This is called ***Snell's law of refraction***)

The above two statements are known as ***laws of refraction***.

Activity 3

Refraction of light through a glass prism

Take a drawing board and fix a white paper on it. Place a glass prism on the paper and mark its boundary ABC with a pencil.

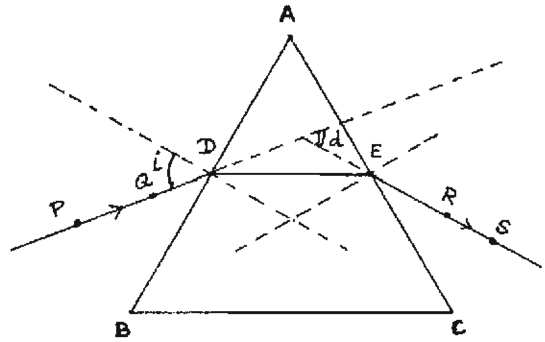


Fig. 9.7 Refraction of light through a prism.

Fix two pins P and Q on the incident ray PD as shown in the figure 9.7. View the pins through the other refracting face AC of the prism. Place two more pins at R and S in line with the images of P and Q. Mark the positions of the pins. Remove the prism. Join the positions S and R to meet the refracting face AC at E. DE is the refracted ray inside the prism. ES is the emergent ray.

*It may be noted that the incident ray PD is deviated by the prism through an angle **d**, called the **angle of deviation**. Repeat the experiment for different angles of incidence **i** and measure the corresponding angles of deviation **d** in each case.*

Note that, when the angle of deviation is minimum for a particular angle of incidence called angle of minimum deviation, the refracted ray DE inside the prism is parallel to the base BC of the prism.

9.2 Why refraction occurs?- Explanation

Refraction takes place because the velocity of light is different in different media. Light travels with a greater velocity in a rarer medium like air and with a lesser velocity in a denser medium like glass. Consider a glass slab in air as shown in the figure 9.8. When a light ray AB is incident on the slab, it bends a little towards the normal and reaches C along the path BC in the same time when it shall reach C′ in the absence of the slab (Fig. 9.8).

The lesser the velocity of light in a medium, the greater is it's bending.

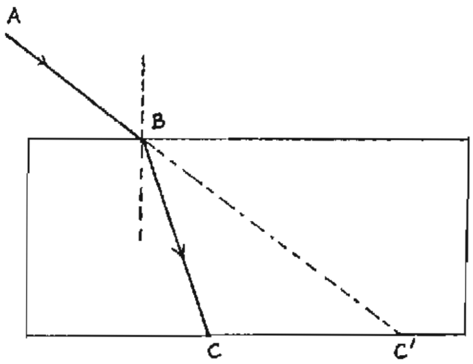


Fig. 9.8 Refraction of light in a glass slab

9.2.1 Velocity of light in different media

You know that the velocity of light in air is 3×10^8 m/s. The velocity of light is different in different media. The velocity of light in a denser medium is less than that in a rarer medium. The following table gives the velocity of light in various media.

Table 1 Velocity of light in different media

Medium	Velocity of light in m/s
Air	3×10^8
Water	2.25×10^8
Kerosene	2.08×10^8
Glass	1.96×10^8
Diamond	1.24×10^8

9.2.2 Refractive index

The ratio of the velocity of light in air to the velocity of light in another medium is called the ***refractive index*** of the medium.

i.e., Refractive index of the medium = velocity of light in air / velocity of light in the medium.

Do you know?

Refraction of starlight through the earth's atmosphere causes twinkling stars.

Problem 1

If the velocity of light in water is 2.25×10^8 m/s, calculate the refractive index of water.

Refractive index of the medium = velocity of light in air / velocity of light in the medium.

∴ Refractive index of water = velocity of light in air / velocity of light in water = $3x10^8 / 2.25x10^8$

∴ Refractive index of water = 1.33 (no unit)

Problem 2

If the refractive index of kerosene is 1.44, calculate the velocity of light in kerosene.

Refractive index of kerosene = velocity of light in air / velocity of light in kerosene.

∴ The velocity of light in kerosene = velocity of light in air / refractive index of kerosene.

$= 3 \times 10^8/1.44$

$= 2.08 \times 10^8$ m/s.

∴ The velocity of light in kerosene = $2.08x10^8$ m/s.

9.3 Dispersion of light

When a beam of white light passes through a prism, it is split up into its constituent colours and this is called ***dispersion of light*** (Fig. 9.9).

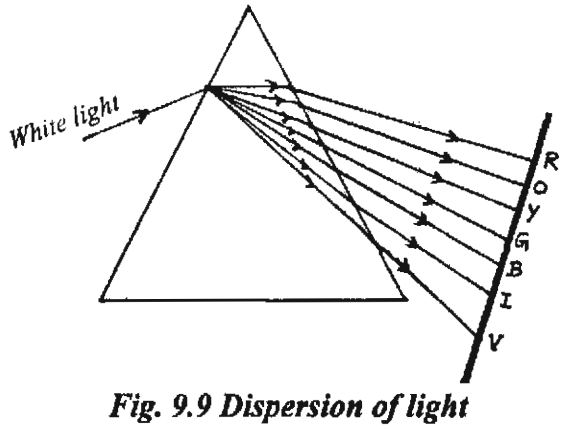


Fig. 9.9 Dispersion of light

Activity 4

Pass a beam of sun light through one side of an equilateral glass prism and observe the colours of the light emerging from the other side of the prism. The prism splits the incident ray into seven colours. This is called ***dispersion of light.***

9.3.1 Spectrum

The coloured patch of light produced by passing a beam of white light through a prism is called a ***spectrum*** (Fig. 9.9).

The spectrum consists of seven colours of light given by the word **VIBGYOR** (Violet, Indigo, Blue, Green, Yellow, Orange and Red). When dispersion takes place in a glass prism, the red ray travels faster than the violet ray and therefore, the red ray emerges first and the violet ray emerges last. Hence, the violet colour gets deviated more than the other colours.

Activity 5

Place a plane reflecting mirror obliquely in a beaker filled with water and keep it in a dark room. Allow a narrow beam of sun light to fall on the plane mirror (Fig. 9.10). Observe the band of colours formed on the wall of the room.

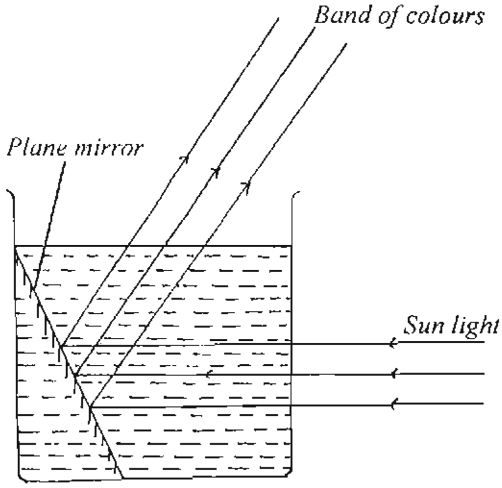


Fig. 9.10 Formation of spectrum with a plane mirror

> ***Do you know?***
>
> *Sunlight is dispersed by tiny droplets of rain clouds to produce enchanting rain bows.*

9.4 Lenses

A lens is a portion of a transparent medium bounded by two surfaces both of which are usually spherical or one surface spherical and the other plane.

There are two types of lenses. They are 1) convex lens and 2) concave lens.

Convex lens

A convex lens is thick at the middle and thin at the outer region. A parallel beam of light rays after refraction through a convex lens converges. Therefore, this lens is called as ***converging lens*** (Fig. 9.11).

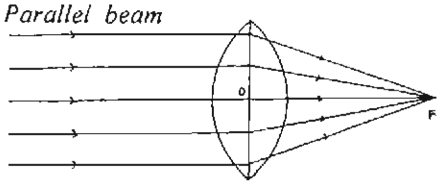


Fig. 9.11 Convex lens

Concave lens

A concave lens is thin at the middle and thick at the outer region. A parallel beam of light rays after refraction through a concave lens diverges. Therefore, this lens is called as ***diverging lens*** (Fig. 9.12).

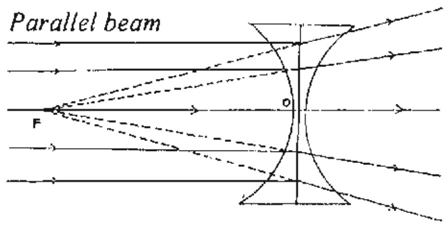


Fig. 9.12 Concave lens

Activity 6

Place a comb in between the torchlight and the convex lens. Adjust the lens and observe that the light rays converge at a point (Fig. 9.13a). In the case of concave lens, the rays appear to diverge from a point (Fig. 9.13b).

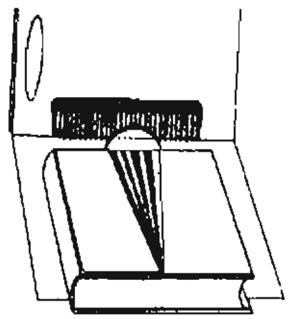


Fig. 9.13a Convex lens - converging effect

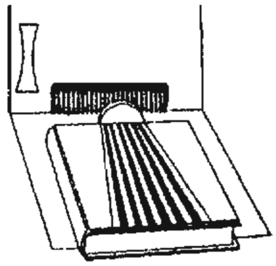


Fig. 9.13b Concave lens - diverging effect

9.4.1 Definitions of the terms used in lenses

Optic centre (O)

The geometric centre of the lens is called the optic centre (Fig. 9.14).

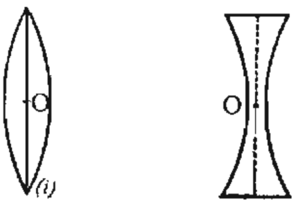


Fig. 9.14 O-The optic centre

Centre of curvature

It is the centre of the sphere of which its surface forms a part (Fig. 9.15).

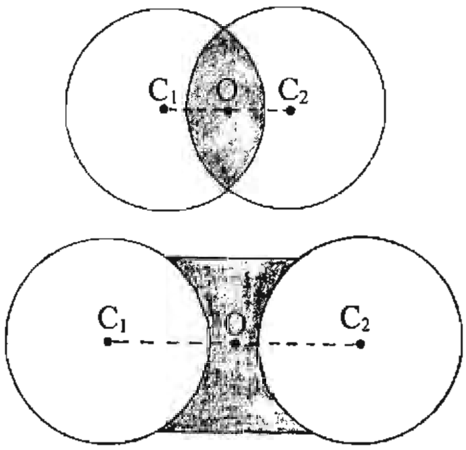


Fig. 9.15 C_1, C_2 - Centres of curvature
Shaded portion refers to the lens

Radius of curvature (R)

It is the radius of the sphere of which the lens is a part (Fig. 9.16).

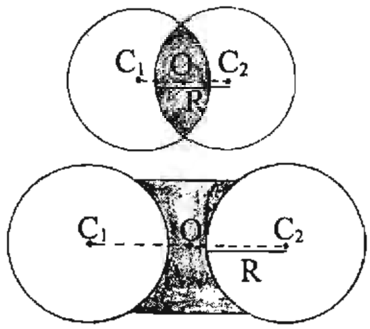


Fig. 9.16 R- Radius of curvature
Shaded portion refers to the lens

Principal axis

The straight line passing through the optic centre and the centres of curvature C_1 and C_2 of the two surfaces of the lens is called ***the principal axis*** (Fig. 9.17).

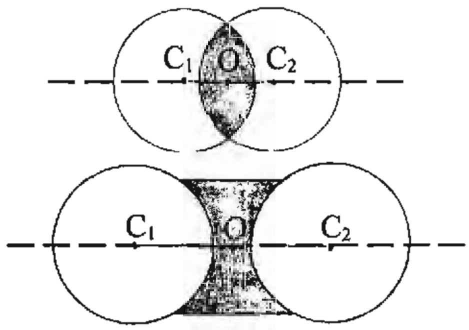


Fig. 9.17 Principal axis
Shaded portion refers to the lens

Principal focus (F)

In a convex lens, the light rays coming parallel to the principal axis after refraction will converge to a point F on the principal axis. This point is called ***the focal point or principal focus*** of the convex lens (Fig. 9.18).

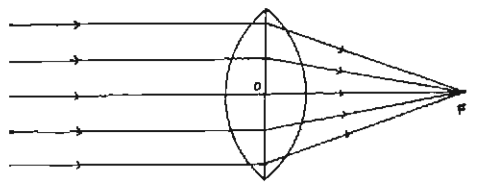


Fig. 9.18 Principal focus of a convex lens

In a concave lens, the light rays coming parallel to the principal axis after refraction will appear to diverge from a point F on the principal axis. This point is called ***the focal point or principal focus*** of the concave lens (Fig. 9.19).

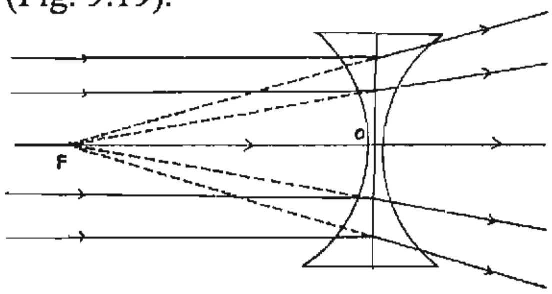


Fig. 9.19 Principal focus of a concave lens

Focal length (f)

The distance between the principal focus (F) and the optic centre (O) of the lens is called the focal length of the lens (Fig. 9.20a and Fig. 9.20b).

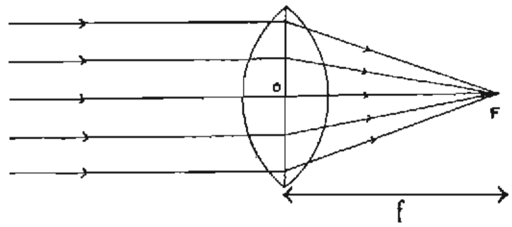


Fig. 9.20a - Focal length of a convex lens

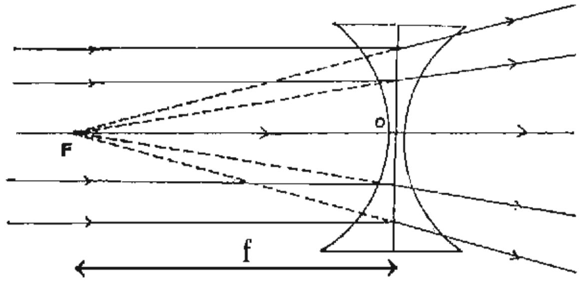


Fig. 9.20b - Focal length of a concave lens

Table 2 Images formed by convex lens and concave lens – rules

S.No	Convex lens	Concave lens
1	An incident ray, which is parallel to the principal axis after refraction, passes through the principal focus on the other side of the lens.	An incident ray which is parallel to the principal axis, after refraction, appears to diverge from the principal focus on the same side of the lens.
2	An incident ray which passes through the principal focus, after refraction, emerges parallel to the principal axis	An incident ray which proceeds towards the principal focus, after refraction, emerges parallel to the principal axis.
3	An incident ray which passes through the optic centre goes straight.	An incident ray which passes through the optic centre goes straight.

Table 3 Position and nature of images for various positions of the object in a convex lens.

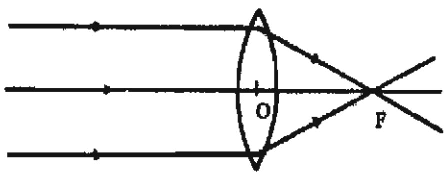
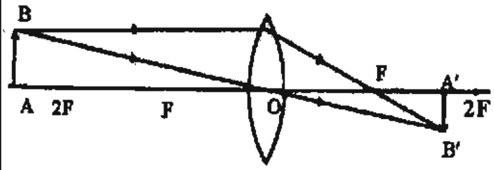
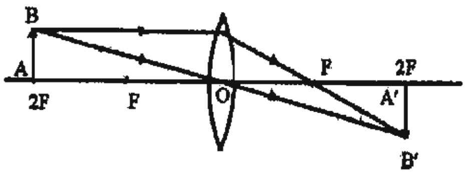
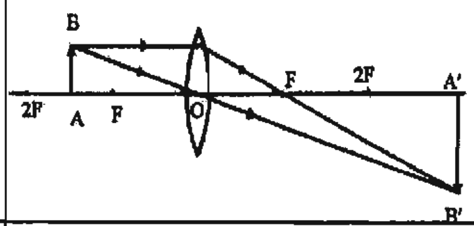
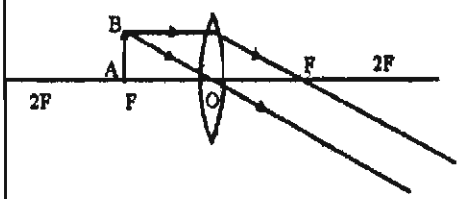
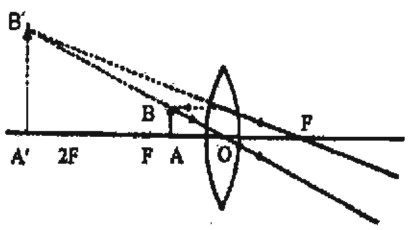
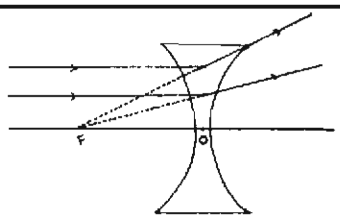
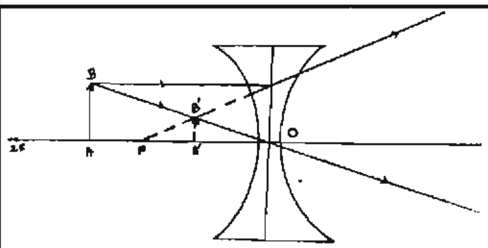
S.No	Figure	Position of the object	Position of the image	Nature and size
1		At infinity	At F	Real, point sized
2		Beyond 2F	Between F and 2F	Real, diminished and inverted
3		At 2F	At 2F	Real, same sized and inverted.
4		Between 2F and F	Beyond 2F	Real, enlarged and inverted
5		At F	At infinity	Real, infinitely large and inverted.
6		Between F and O	On the side of the object	Virtual, enlarged and erect

Table 4 Position and nature of image for various positions of the object in a concave lens

S.No	Figure	Position of the object	Position of the image	Nature and size
1		At infinity	At F	Real, point sized
2		Between infinity and O	Between F and O	Virtual, erect and diminished

Activity 7

Determination of the focal length of a convex lens by distant object method.

The given convex lens is mounted on a lens holder and placed in front of a distant object. A screen is placed on the other side of the lens and it is adjusted till a clear, well defined and inverted image is formed on the screen. The distance between the lens and the *screen gives the approximate focal length of the given convex lens (Fig. 9.21).*

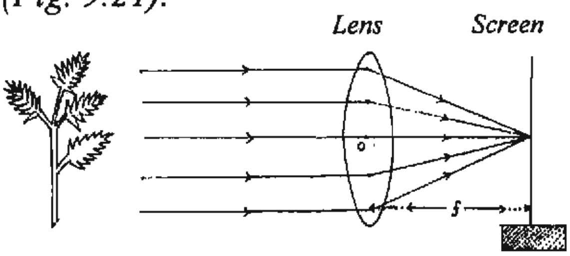


Fig. 9.21 Focal length of a convex lens by distant object method

Activity 8

Take a convex lens. Allow a parallel beam of sun light to fall on the convex lens. The light rays are brought to focus on the head of a match stick. What do you observe? The matchstick burns due to the heat produced (Fig. 9.22).

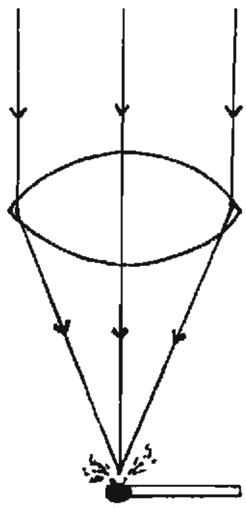


Fig. 9.22 Burning of a matchstick using a convex lens

9.4.2 A few drawbacks of focusing effect of a convex lens

1. It is unwise to look at the sun directly owing to the following reason. When a parallel beam of sun light falls on the eye lens, it is brought to focus on the retina. The large intensity and heat of sun rays produced on the retina will cause severe damage to the retina and hence to the vision.

2. It is not wise to leave glass bottles in the forest owing to the following reason. When a beam of sun light falls on glass bottles, left in the forest, the surfaces act as a converging lens. Hence, it is brought to focus at a point where the dry leaves and plants if present get heated and burnt, causing forest fires.

9.5 Applications of lenses

Some of the optical instruments that use the lenses are

1. Simple microscope or magnifying glass
2. Compound microscope
3. Camera and
4. Telescope.

Let us study these instruments in detail.

9.5.1 Simple microscope

When an object AB is placed within the principal focus of a convex lens, a magnified, erect and virtual image A_1B_1 is formed (Fig. 9.23).

A convex lens of short focal length used like this is called a simple microscope.

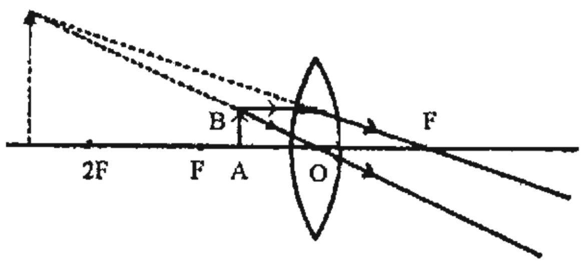


Fig. 9.23 Simple microscope

Uses:

1. Watch repairers and finger print analysts use the convex lens as simple microscope.
2. It is used as reading lens.

9.5.2 Compound microscope

The compound microscope consists of two convex lenses. The lens of short focal length is known as the objective lens (O) and the lens of large focal length is known as the eye-piece (E).

The object AB is placed very near the objective lens between F_0 and $2F_0$. The image A_1B_1 formed by the objective lens lies beyond $2F_0$. This image lies within the principal focus F_e of the eye-piece. The final image

A_2B_2 is highly magnified, virtual and inverted (Fig. 9.24).

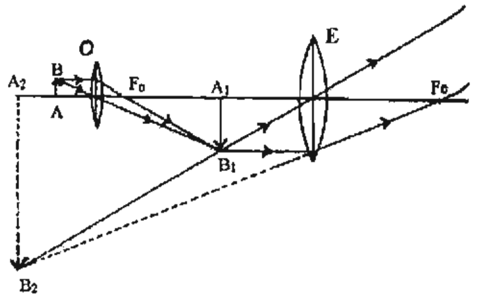


Fig. 9.24 Compound microscope

Uses:

In biology, this is used to magnify very tiny objects like bacteria and cells.

9.5.3 Telescope

The telescope consists of two convex lenses – an objective lens of longer focal length and an eye-piece of short focal length. These lenses are fixed at the ends of a co-axially arranged tubes. The objective lens forms a diminished image I_1M_1 of a distant object. This image I_1M_1 acts as an object for the eye–piece and lies within the principal focus F_e of the eye-piece. I_2M_2 is the final image which is virtual, inverted and greatly magnified (Fig. 9.25).

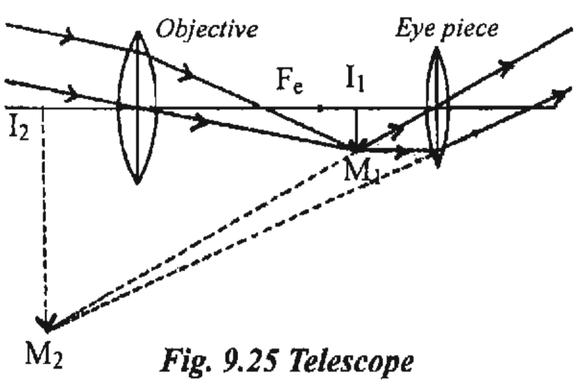


Fig. 9.25 Telescope

Uses:

A telescope is used to see the distant objects like moon, planets, stars, galaxies etc.

> ***Do you know?***
>
> *The 200 inch Hale telescope on Mt. Palomar has photographed very distant faint celestial objects.*

9.5.4 Camera

The camera consists of a convex lens supported at one end of a light – proof box and a light sensitive film at the other end. The distance between the lens and the film can be adjusted. There is a shutter behind the lens.

When we click our camera, the shutter opens and the light from the object passes through the lens. The lens forms a real, diminished and inverted image on the film. A diaphragm of variable aperture is also provided so that the amount of light entering the camera can be controlled.

The various parts of the camera are as shown in the figure 9.26.

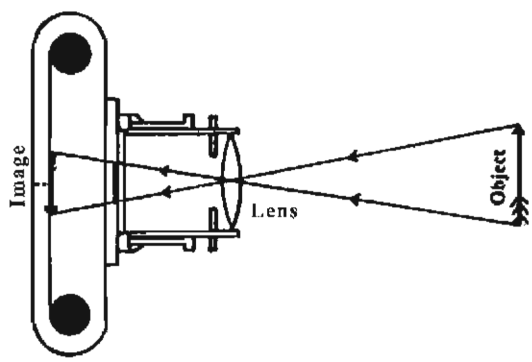


Fig. 9.26 The camera

9.6 The human eye

Activity 9

Make a small hole in the middle of the black card- board. Place it on one side of a round bottomed flask containing water. Place a candle in front of the black card – board. Adjust a screen on the other side of the flask to get a clear image of the candle. Observe that the image is small and inverted. The same principle involves in the functioning of the eye (Fig. 9.27)

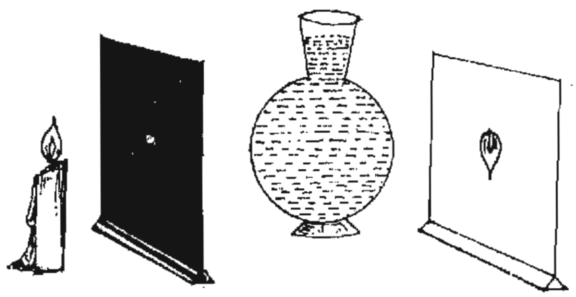


Fig. 9.27 Working of the eye

The structure of the human eye

Eyes are the organs of sight. The eyeball consists of three layers namely outer layer, middle layer and inner layer (Fig. 9.28).

Outer layer:

It consists of a transparent part called **cornea** and an opaque region known as **sclerotic layer.**

Middle layer:

It contains choroid layer, ciliary muscles, iris and the eye lens.

Inner layer:

It includes the **retina** which has the light sensitive cells (rods and cones). In retina, rods and cones may be highly concentrated at **fovea** and they are absent at **blind spot**. Eyeball is filled with a fluid known as **vitreous humour** between the eye lens and the retina. Similarly between the eye lens and the cornea **aqueous humour** is present. These fluids give a shape to the eye.

Perception of sight:

Light from the objects is refracted by the cornea through the aqueous humour, iris and pupil onto the eye lens. The eye lens focuses the image through the vitreous humour onto the retina. These images are received by the light sensitive cells of the retina and they transmit the impulses to the brain through the optic nerves.

The ciliary muscles change the shape of the lens and adjust the focal length according to the distance of the objects. Normally the focal length of the eye lens will be about 2.5 cm.

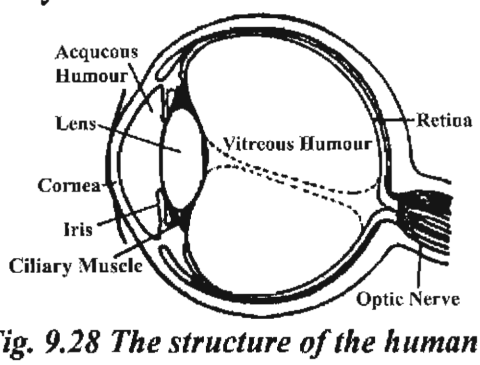


Fig. 9.28 The structure of the human eye

9.7 The defects of the eye

The two common defects of the eye are as follows.

1. Short sight or Myopia and
2. Long sight or Hypermetropia

Let us study these defects in detail.

9.7.1 Short sight or Myopia

The person having the short sight can see only the nearer objects.

The eyeball of the person having short sightedness is longer than the normal sighted eye. When a parallel beam of light from the distant object is incident on the eye, the rays are brought to focus in front of the retina. Hence, the image is not formed on the retina (Fig. 9.29a).

A concave lens of suitable focal length can rectify this defect (Fig. 9.29b).

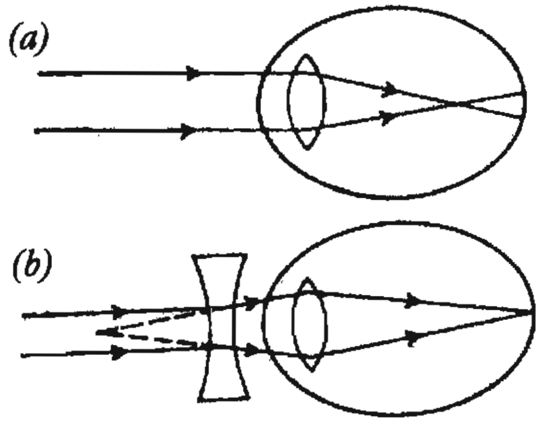
9.7.3 Comparison between the human eye and the camera

Similarities

S.No	The eye	The camera
1	A real and inverted image is formed on the retina	A real and inverted image is formed on the photographic film
2	The iris controls the amount of light entering the eye.	The diaphragm controls the amount of light.
3	The time of exposure of light is controlled by the eye lids.	The time of exposure of light is controlled by the shutter.

Differences

S.No	The eye	The camera
1	The focal length of the eye lens can be changed by the action of ciliary muscles	The focal length of the lens can not be changed.
2	The retina retains the image only for a short time.	The film retains the image of the object permanently.
3	The convex lens of the eye is made of a transparent and flexible substance	The convex lens is made of a glass.



a) Defective eye b) Rectified eye

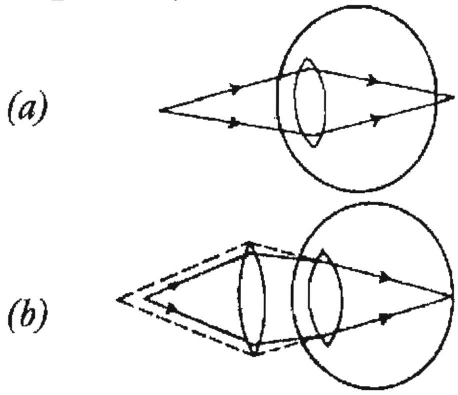
Fig. 9.29 Short sight

9.7.2 Long sight or hypermetropia

The person having the long sight can see only the distant objects.

The eyeball of the person having long sightedness is shorter than the normal sighted eye. When the light from the nearer object is incident on the eye, the rays are focused behind the retina. Hence, the image is not formed on the retina (Fig. 9.30a).

A convex lens of suitable focal length can rectify this defect (Fig. 9.30b).



a) Defective eye b) Rectified eye

Fig. 9.30 Long sight

Why do the eyes of animals such as cats, cattle etc sparkle in the night ?

In the case of animals like cats, cattle etc., there is a reflecting layer containing crystals of quanine, behind the retina of their eyes called ***tapetum.*** This layer reflects the light back on to the retina. This improves the vision and causes the eyes of these animals to sparkle in the night.

SELF EVALUATION

I. Choose the correct answer

1. The part of the electromagnetic waves that the human eye can detect is called
   a) ultraviolet rays b) infrared rays c) x rays d) visible light

2. In a prism, the angle between the incident ray and the emergent ray is called
   a) angle of incidence b) angle of refraction
   c) angle of deviation d) angle of prism

3. The velocity of light in water is
   a) $3x10^8$m/s b) $1.24x10^8$m/s c) $2.25x10^8$m/s d) $1.96x10^8$m/s

4. The geometric centre of the lens is called

   a) centre of curvature   b) radius of curvature

   c) optic centre   d) principal focus

5. In retina, rods and cones may be highly concentrated at ________.

   a) blind spot   b) fovea   c) cornea   d) pupil

II. Fill in the blanks

6. A metal rod placed in water appears to be bent due to ________.
7. The lesser the velocity of light in a medium, the greater is its ________.
8. The coloured patch of light produced by passing a beam of white light through a prism is called ________.
9. The concave lens is called as ________ lens.
10. When an object lies at F of a convex lens, the image is formed at ______.

III. Match the following

11. Refractive index of water	–	concave lens
12. VIBGYOR	–	converging lens
13. Convex lens	–	Snell's law
14. $\frac{Sin\ i}{Sin\ r}$ = a constant	–	1.33
15. Short sight	–	spectrum

IV. Give short answer

16. What is refraction?
17. Why objects in water appear to be at a lower depth?
18. State Snell's law of refraction.
19. Define : the refractive index.
20. Calculate the velocity of light in glass of refractive index 1.5.
21. What is dispersion of light?

22. Explain why violet colour gets deviated the most in dispersion of white light by a prism?
23. Define : principal axis of a lens.
24. Define : principal focus of lens.
25. Define : the focal length of a lens.
26. Why it is unwise to look at the sun directly?
27. Why it is unwise to leave glass bottles in a forest?
28. Give the uses of a simple microscope.
29. What is the nature of images formed by a telescope and a microscope?
30. Why do the eyes of animals like cats and cattle sparkle in the night?

V. Give the detailed answer

31. Explain the refraction of light through a glass slab.
32. Tabulate the position and nature of images for various positions of the objects in a convex lens.
33. Explain the working of a simple microscope.
34. Explain the working of a compound microscope.
35. Explain the working of a telescope.
36. Explain the different parts of a camera.
37. Explain the structure of human eye.
38. Write a short notes on short sight.
39. Write a short notes on long sight.
40. Give the similarities and differences between the eye and the camera.

10. Magnetism and Electricity

10.1 Magnetism

A mineral discovered in the town of Magnesia was found to have a strange property. It could attract pieces of iron towards it. This mineral is named Magnetite after the place where it was discovered. Later, it was found that magnetite is mainly composed of oxides of iron (Fe_3O_4).

These are now known as Magnets. The study of magnetic properties is called Magnetism.

10.1.1 Lodestone

A magnet has two specific properties

1. It attracts small pieces of iron
2. When suspended freely from its centre , it always comes to rest in the north-south direction. For this property, it was given the name 'lodestone'.

Substances which possess these two properties by nature are called natural magnets. Magnets that are made artificially are called artificial magnets.

10.1.2 Bar Magnet

Artificial magnets are of different shapes. If the magnet is in the shape of a bar, it is known as a bar magnet.

When a bar magnet is placed near the filings of iron, the small pieces cling to the ends of the bar magnet as shown in the figure 10.1. The end regions where the magnetism is more concentrated are called the Magnetic Poles. In the case of a freely suspended bar magnet, the pole pointing towards the geographical north is called North Pole. The pole pointing towards the geographical south is called South Pole. A small magnet may be considered as a dipole. Isolated magnetic poles do not practically exist. But, however, for theoretical discussions we can assume isolated magnetic poles.

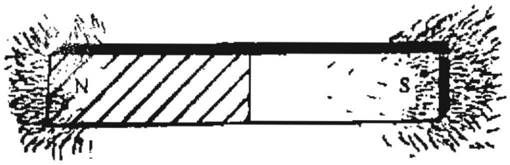


Fig. 10.1 Poles of the bar magnet

The line passing through the north pole and the south pole is called magnetic axis of the bar magnet. The distance between the poles is called the magnetic length of the bar magnet.

Activity 1

Take some materials like iron nail, eraser, paper, etc., Bring the material near the pole of the bar magnet. Repeat the same activity for *the other materials. What do you observe? You will find that some materials are attracted by bar magnet and some other materials are not attracted.*

Materials which are attracted by magnets are called magnetic materials. Iron, Nickel, Cobalt etc., are some examples of magnetic materials.

10.1.3 Properties of magnet

Some of the main properties of magnet are

(i) Property of attraction of magnetic substances

A bar magnet is brought very near to a box containing iron filings. The magnet attracts iron filings. Hence, magnet has the property of attraction of substances like iron.

(ii) Property of direction of magnetic axis

A bar magnet is suspended freely from its centre. The magnet sets itself with its length along north-south direction. Hence magnet has the property of direction.

Activity 2

Take a bar magnet and suspend it freely with the help of a wooden stand as shown in figure 10.2. Make sure that the bar magnet is horizontal and can rotate freely. Wait till the bar magnet comes to rest. Observe the position of the two ends of the bar magnet. Rotate the magnet slightly. Wait till the bar magnet again comes to rest. What do you observe? You will find that the bar magnet comes to rest in the same direction as before. You will also find that the bar magnet always comes to rest in the north-south direction.

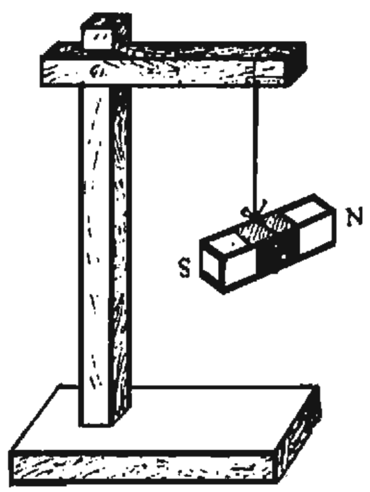


Fig. 10.2 A freely suspended bar magnet aligns itself in N-S direction

(iii) Property of attraction and repulsion between two magnets

A magnet is suspended freely by a thread tied to its centre as shown in figure 10.3. When the north pole of another magnet is brought near the north pole of the suspended magnet, it is repelled. But when the north pole of the magnet is brought near the south pole of the suspended magnet, it will be attracted. So we find that unlike poles attract each other and like poles repel each other.

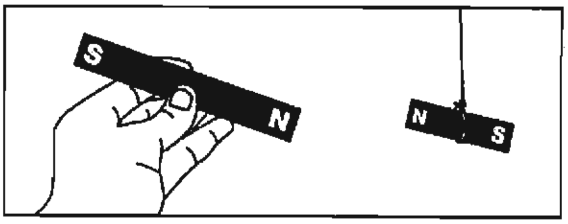


Fig. 10.3 Like poles repel each other

(iv) Property of having poles in pairs

If we break a bar magnet into two or more smaller pieces even the smallest possible magnet has both north and south poles. We cannot obtain isolated magnetic poles (Fig. 10.4).

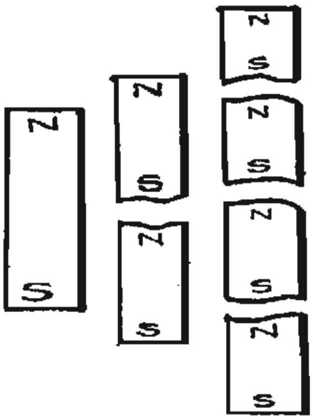


Fig. 10.4 Dividing a bar magnet would still produce magnets

Figure 10.4 shows that dividing a bar magnet successively would still produce tiny magnets each with its north pole and south pole.

10.1.4 Magnetic lines of force

The magnetic line of force is the path taken by a unit north pole, if it is free to move in a magnetic field. The magnetic field contains a number of lines of force.

Activity 3

Place a bar magnet below a white sheet. Sprinkle some iron filings on the sheet. Gently tap the sheet. What do you observe? You will find that the iron filings arrange themselves in a pattern as shown in figure 10.5. You will also find that these lines represent the magnetic lines of force due to the magnetic field of the bar magnet.

Fig. 10.5 Magnetic Field of the bar magnet

Properties of magnetic lines of force

1. Magnetic lines of force are directed from the North Pole towards the South pole.
2. They do not cross each other.
3. They are more crowded near the poles than at any other region in the field.
4. They are closed curves.
5. In a uniform magnetic field, the lines of force are parallel to one another.

10.1.5 Compass Needle

Compass Needle is a device used to trace the magnetic lines of force due to a bar magnet. This device as shown in figure 10.6 consists of a small pivoted magnetic needle at the centre in a round box covered with transparent glass. When placed on a flat surface like a table top, the magnetic needle comes to rest pointing in the north-south direction.

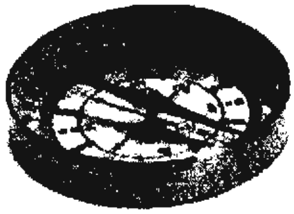


Fig. 10.6 Compass Needle

Plotting of magnetic lines of force

A white sheet is fixed on a drawing board. At the centre of the sheet a bar magnet is placed. The compass needle is kept near the north pole of the bar magnet. When the magnetic needle of the compass needle comes to rest, the position of north pole of the magnetic needle on the white sheet is marked by a pencil mark. The compass needle is then moved so that its south pole faces the pencil mark. The position of north pole of the magnetic needle is marked. The same activity is repeated till the compass needle reaches the south pole of the bar magnet. A curve is drawn from north pole to south pole of the bar magnet by joining the pencil marks. It gives one line of force as shown in the figure 10.7. In the same way, plot the other lines of force around the magnet by keeping the magnetic compass at various points.

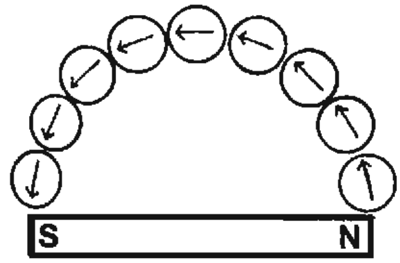


Fig. 10.7 Plotting of magnetic line of force

10.2 Magnetic induction

Magnetic induction or induced magnetism is the phenomenon in which a magnet can induce magnetic properties on materials like iron.

A thin iron nail is taken and fixed to a wooden stand as shown in figure 10.8. The head of the nail is touched by a bar magnet. One iron pin is brought near one end of the nail. The nail attracts the first pin. A second pin is brought near the first pin. The second pin gets attracted to th first pin. A few more pins are brought near. Each pin added to the chain, magnetises the next one by induction. The bar magnet is removed away from the iron nail. When the magnet is removed, all the pins fall off. This is

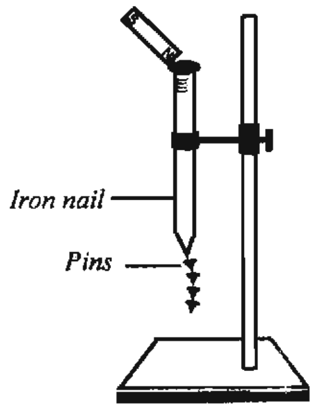


Fig. 10.8 Magnetic Induction

because, the iron nail loses its magnetism when the bar magnet is removed. Iron pins behave like magnets only when they are in contact with the magnet and thereby attract other pins.

Activity 4

Take a bar magnet. Place the same size of a strip of steel and a strip of soft iron side by side in contact with a bar magnet as shown in figure10.9. What do you observe? You will observe that both the strips are magnetised by the bar magnet. Dip the free ends of the strip of steel and the strip of soft iron into a bowl of iron filings. You will observe that soft iron attracts more iron filings than steel.

Remove both the strips from the bar magnet. What do you observe? You will observe that all the iron filings fall from the soft iron and few fall from the steel. It shows that induced magnetism in soft iron is temporary and in steel is permanent.

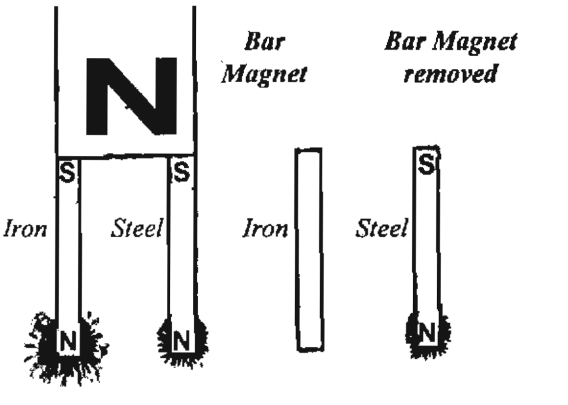


Fig. 10.9 Temporary and permanent magnet

10.2.1 Methods of magnetisation

The method in which the magnetic power is induced on a substance is called as magnetisation. The methods that are used in making magnets are stroking method and electrical method.

A. Stroking method

(i) Single touch method

A steel bar is placed on a table. It is rubbed from one end to the other by a particular pole, say north, of the bar magnet. Now, the bar magnet is again brought back and rubbed from one end to the other as earlier. The end of the steel bar in which the north pole of the magnet is rubbed becomes north pole and other end as south pole (Fig. 10.10).

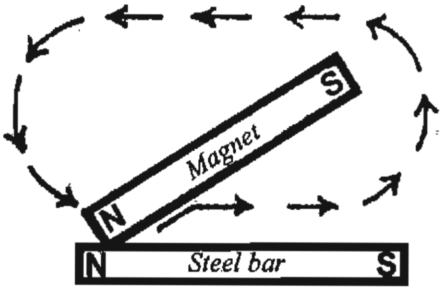


Fig. 10.10 Single touch method

(ii) Double touch method

A steel bar is placed on a table which is to be magnetised. Two bar magnets are taken and the opposite poles of the two magnets are kept inclined at the middle of the steel bar. Now, the poles are simultaneously drawn away from each other rubbing the steel bar. On reaching the ends, two bar magnets are lifted and again placed in the middle. The same process is repeated about 10 times. The end of the steel bar where the south pole of the magnet leaves, becomes the north pole and the end where the north pole of the other magnet leaves, becomes the south pole (Fig. 10.11).

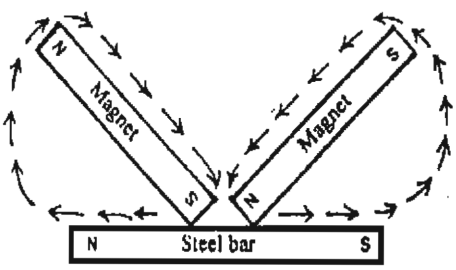


Fig. 10.11 Double touch method

B. Electrical Method

An insulated copper wire is wound on a soft iron core. The ends of the wire are connected to a battery. Now current passes through the wire. If the iron pieces are brought near the soft iron core, they get attracted by the soft iron core. If the current in the coil is cut off, the soft iron core fails to attract the small iron pieces. So, the soft iron core behaves like a magnet only as long as current passes through the coil. Such a magnet is called an electromagnet (Fig. 10.12).

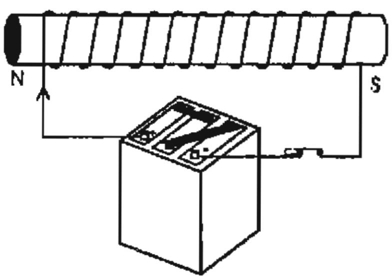


Fig. 10.12 Electrical Method

10.2.2 Methods of demagnetisation

The process of removing magnetic power from the magnetised substance is called demagnetization. This occurs on hammering and heating the magnetic substances.

(i) Hammering

When a magnet is hammered or dropped or handled roughly several times it loses its magnetic power.

(ii) Heating

Heating and cooling causes demagnetisation in a magnet. The temperature at which a magnet loses its magnetic power is known as Curie point. For iron the Curie point is 770^0C.

10.2.3 Earth's magnetic Field

The earth itself behaves like a big bar magnet. When a bar magnet is freely suspended, it always rests pointing almost in the geographic north-south direction. The north pole of a magnet will point towards geographic north only when there is the earth's south pole at the geographic north. Thus , in the geographic north, there must be the earth's south pole and in the geographic south there must be earth's north pole (Fig. 10.13).

The earth's magnetic axis does not coincide with its geographic axis and is inclined at an angle of about 17^0.

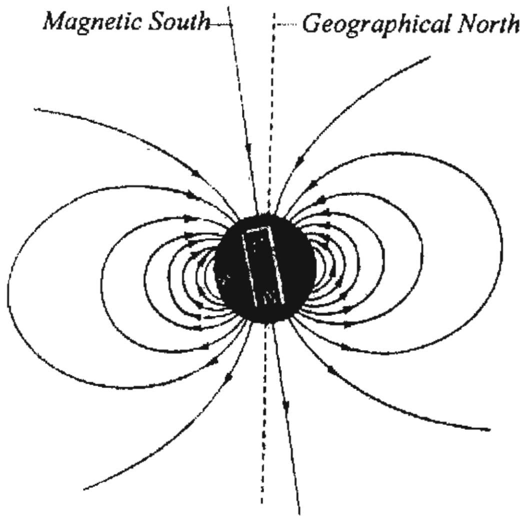


Fig. 10.13 Earth's magnetic field

(i) Angle of dip

The angle between the direction of the earth's magnetic field and the direction of its horizontal component is called the angle of dip. It is also called as angle of inclination. Angle of dip is zero at the magnetic equator and 90^0 at the magnetic poles. The angle of dip will be different at other places. Dip circle is the instrument used to measure the angle of dip at a place.

(ii) Angle of declination

The vertical plane passing through the geographical north and south poles at a place is called geographical meridian. The vertical plane passing through the axis of a freely suspended magnet is called magnetic meridian. The angle between the geographic meridian and magnetic meridian is called the angle of declination at that place. The angle of declination also differs from place to place.

10.3 Molecular theory of magnetism

Scientist James Ewing worked on Weber's ideas and gave his theory called Molecular Theory of Magnetism. According to this theory, the molecules in every magnetic substance behave like little magnets known as molecular magnets.

In a demagnetised piece of iron, molecular magnets are oriented in all possible directions and they form closed chains as shown in figure 10.14 (a). The effect of south and north poles cancel each other. So, there is no net magnetic field. In the case of a magnet the molecular magnets are regularly arranged with their north poles pointing in one direction and their south poles pointing in the opposite direction as shown in figure 10.14(b).

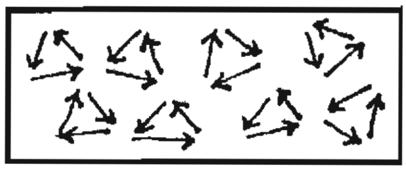


Fig. 10.14(a) Molecular magnets in demagnetised substance

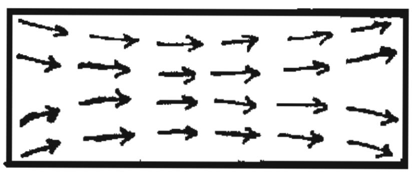


Fig. 10.14(b) Molecular magnets in a magnet

The following are the few facts in support of molecular theory of magnetism.

1. When a magnetising force is applied on a piece of iron, the chains are broken and finally all the molecular magnets are aligned orderly. It provides magnetism in the piece of iron. The magnetism reaches a maximum value at saturation point. Beyond the saturation point the magnetism does not increase.
2. When a magnet is broken into two or more parts, each part is a complete magnet.
3. Rough handling and hammering, demagnetise a magnet. This is due to the fact that molecular magnets are disturbed from their orderly arrangement.

10.4 Simple electric circuits

10.4.1 Electricity

The term "electricity" comes from the Greek word "electron", which means "amber". A Greek philosopher, Thales, noticed that a strange thing happened when he rubbed a piece of amber with a woollen cloth. As a result of friction, the amber acquired the property of attracting small particles of dust etc. In other words, the amber becomes charged or electrified. We know that electric charge is quantity of electricity. There are two kinds of charges namely, positive and negative.

10.4.2 Electric current

The flow of electric charge through the wire constitutes an electric current or simply current. The flow of charge is due to the transfer of negatively charged particles called electrons. The electric current in the metal wire, therefore is due to the flow of electrons. However, conventionally the direction of electric current is taken as opposite to the direction of motion of electrons.

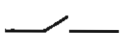
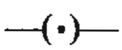
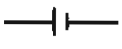
Daniel cell, Dry Cell, Battery etc., are the common sources of electric current.

10.4.3 Simple Electric Circuit

An electrical network containing electrical components like cells, bulbs, resistors etc., is called an Electric Circuit. When the circuit is closed, electric current flows through it.

Drawing electric circuit which shows cells and bulbs, as they actually look like, is cumbersome. So, symbols are used to describe different components of electric circuit. A few symbols of components used in electric circuit diagrams are given in Table 1.

Table 1

Symbol	Electric component
	Electric bulb
	Open press key
	Closed key
	Plug key
	Cell
	Battery
	Resistor

In the symbol for electric cell, the long line represents the positive terminal and the short line the negative terminal of the cell.

When two or more cells are connected together we get a battery.

Activity 5

Take a torch bulb with holder, a key, dry cell with holder and piece of connecting wire. Connect the bulb and dry cell through the key with connecting wires as shown in figure 10.15. Press the key to complete the circuit. What do you observe? You will observe that the bulb begins to glow.

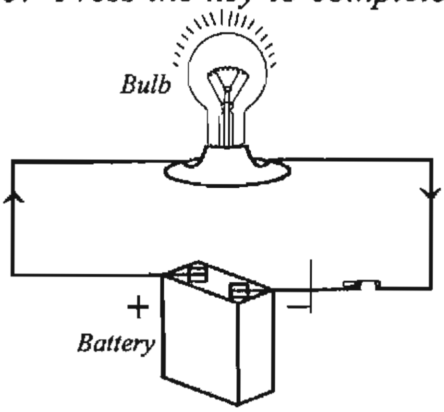


Fig. 10.15 An electric circuit

The bulb begins to glow as soon as the electric circuit is closed. This is so because when you press the key electrons flow through the bulb. The flow of electrons constitute electric current that makes the bulb to glow. Here, the bulb, connecting wires and the key provide path of electric current from the positive terminal of the dry cell to negative. We say that the circuit is closed.

When the key is opened or the wires are disconnected at any point the bulb stops glowing. The circuit is said to be broken or opened.

Conductors and Insulators

Activity 6

Take a torch bulb with holder, a key, dry cell with holder and piece of connecting wire. With the help of these components, set up an electric circuit as shown in figure 10.16. You will observe that the bulb begins to glow as soon as the key is pressed. Now remove the key. Hold a match stick at the free ends of the two wires. You see that the bulb does not glow. Repeat the same activity by connecting substances like eraser, plastic, mica, graphite etc., at the free ends of the two wires. Find out whether a given material is a conductor or insulator.

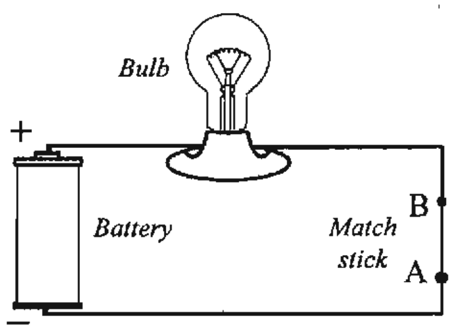


Fig. 10.16 Testing whether a material conducts electricity

You will find that the substances which allow electric current to pass through are called Conductors. On the other hand, substances which do not allow the electric current to pass through are called Insulators.

10.4.4 Series and Parallel circuits

Series Circuit:

A series circuit is one in which same current passes through different bulbs or electrical appliances, one after the other completing the circuit.

Three bulbs with holders are connected by wire one after another. The positive terminal of the battery is connected to free terminal of the first holder and the negative terminal of the battery to the free terminal of the third holder. They are said to be in series circuit as shown in figure 10.17. Here, the same electric current flows through each bulb. So, all the bulbs begin to glow. If any one connection is removed, there is a break in the electric circuit. Bulbs do not glow. It indicates that no current flows in the circuit.

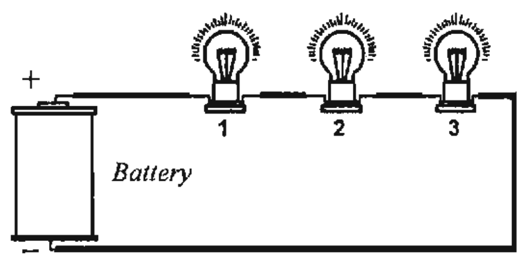


Fig. 10.17 Series circuit

Parallel Circuit:

A parallel circuit is one in which different current passes through different bulbs or electrical appliances simultaneously completing the circuit.

For example, one terminal of the holder with bulb is connected to the positive terminal of the battery and other terminal of the same holder to the negative terminal of the battery . In the same way, other terminals of two holders with bulbs are connected with the battery by separate connecting wires. They are said to be in parallel circuit as shown in figure 10.18. The bulbs are burning brightly. If any bulb is removed, other two bulbs continue to glow. It indicates that current flows in the rest of the circuit.

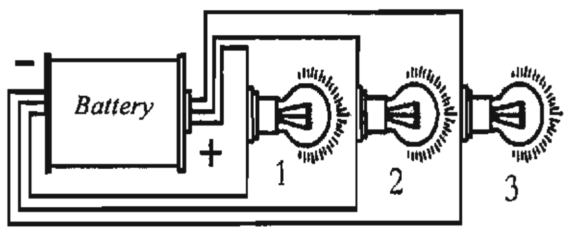


Fig. 10.18 Parallel Circuit

By the use of parallel circuits, different electrical appliances at home can be turned off or on independently.

10.5 Magnetic properties of current carrying conductors

When electric current is passed through a conductor, magnetic effect is produced.

10.5.1 Oersted's Experiment

Hans Christian Oersted observed the magnetic effect of current in 1820. He observed that when a straight conductor carrying a current was placed parallel to a compass needle, the needle was deflected. On reversing the current the needle was deflected in the opposite direction.

This can be illustrated by the following experiment.

The current is passed through a conductor which is placed in the north-south direction. A pivoted magnetic needle is placed below it. The magnetic needle will be found to deflect in one direction. When the direction of current is reversed, the magnetic needle will deflect in the opposite direction. The direction of deflection also reversed when the needle is placed above the conductor instead of below as shown in figure 10.19. This shows that magnetic field is associated with a conductor carrying current.

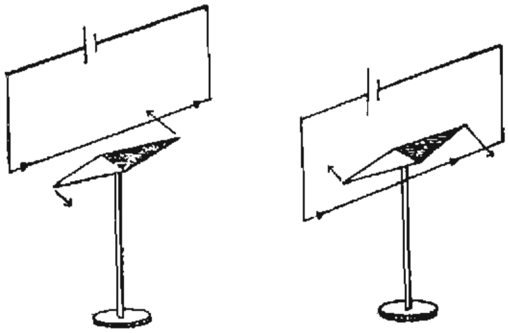


Fig. 10.19 Oersted's Experiment

It is now established that the magnetic field of a magnet is also the result of the motion of electrons around the nucleus of the atom.

10.5.2 Right hand thumb rule

The direction of the magnetic field due to current carrying conductor is given by Right hand thumb rule.

It states that if a conductor carrying current is held in the right hand such that the thumb points in the direction of the current, then the direction of the bend of the rest of the fingers gives the direction of the magnetic field.

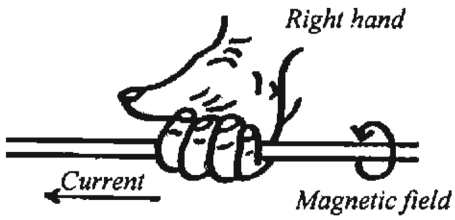


Fig. 10.20 Right hand thumb rule

10.5.3 Magnetic field due to current in a straight conductor

The magnetic field associated with a current carrying straight conductor can be demonstrated by the following experiment.

A thick straight copper wire is passed vertically through a smooth cardboard held horizontally. The ends of the copper wire are connected to a battery. Iron filings are sprinkled uniformly on the cardboard. When the key is plugged electric current flows through the copper wire. The cardboard is gently tapped. It is found that iron filings are found to arrange themselves in concentric circles round the wire as shown in figure 10.21. That is , the magnetic lines of force are concentric circles. This clearly indicates that there exists a magnetic field around the straight conductor carrying current.

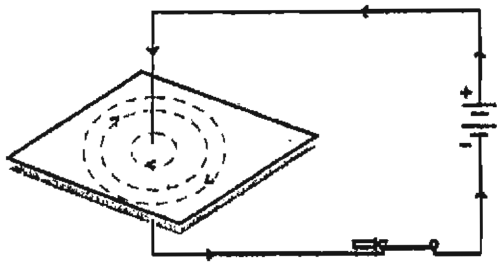


Fig. 10.21 Magnetic field around a current carrying straight conductor

10.5.4 Magnetic field due to a circular coil

A thick long copper wire is passed through a thin cardboard and formed a circular coil. The ends of the copper wire are connected to a battery. Iron filings are sprinkled on the cardboard and key is pressed. Electric current flows through the circular coil and the cardboard is gently tapped. The iron filings arrange themselves in a specific pattern as shown in figure 10.22, depicting the magnetic lines of force.

The following facts are observed.

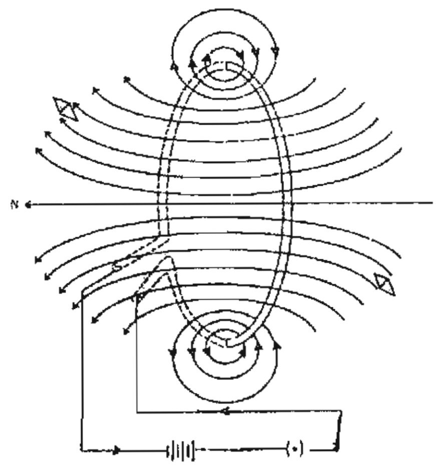


Fig. 10.22 Magnetic filed due to a circular coil

1. The magnetic lines of force are concentric circles near the wire.
2. The circles straighten themselves as their distance from the wire increases.
3. At the centre of the coil, the magnetic lines of force are straight.

10.5.5 Electromagnets

The piece of soft iron nail is placed inside a circular coil. Here, soft iron nail is called core as shown in figure10.23. When current is passed through the coil, the soft iron nail becomes magnetised. If the iron filings are brought near the soft iron nail, then the iron filings cling to the nail. On the other hand, the soft iron nail is demagnetised, when the current is stopped in the coil. This arrangement is called an electromagnet. The electromagnet is thus a temporary magnet. The strength of electromagnet will depend on

a) number of turns in the coil
b) the strength of the current
c) the nature of core material.

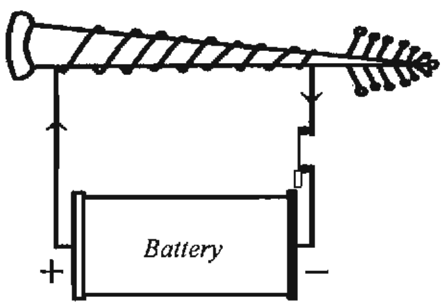


Fig. 10.23 Electromagnet

Uses of electromagnets

1. Electromagnet is an essential part of electric generators, motors, telegraph instruments, loudspeakers, earphones and telephone receivers.
2. Electromagnets are also used in electric bells and tape recorders.
3. Electromagnets attached to cranes are used to lift huge loads.
4. Electromagets are used for making new magnets or remagnetising the old ones.

10.5.6 The Electric Bell

Construction

The electric bell consists of an electromagnet. In front of the electromagnetic poles, there is a soft iron piece. The soft iron piece is attached to the vibrator. Vibrator is a rigid metallic strip having a hammer at its free end. The gong is fixed against the hammer. Also, platinum strip is fixed to the vibrator. By adjusting screw in contact-maker, contact is made with a platinum strip at a point. This point is called contact point. Electrical connections are shown in figure 10.24.

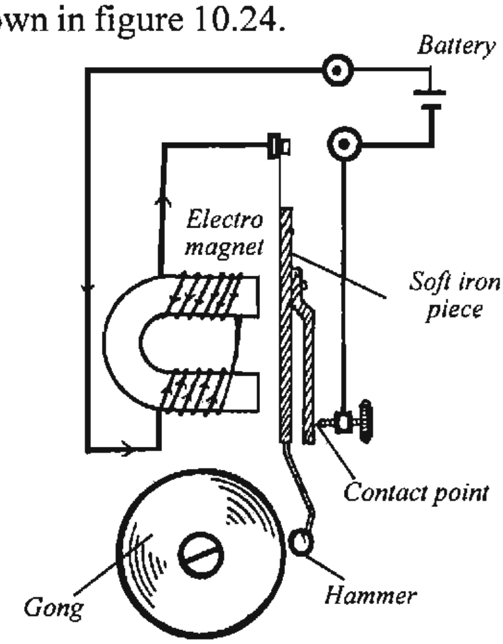


Fig. 10.24 The electric bell

Working

1. When key is pressed, the electric circuit is completed and the current flows through the electromagnet.

2. The electromagnet becomes magnetised and attracts the soft iron piece. When the soft iron piece is attracted, the hammer strikes the gong. The gong produces the sound.
3. This movement breaks the circuit at the contact point between the screw and platinum strip, so that the current stops flowing. The electromagnet gets demagnetised and thereby the soft iron piece is released.
4. The soft iron piece falls back to the original position and makes contact with the screw. The electric circuit is completed again. The above process keeps on repeating. Therefore the soft iron piece keeps on vibrating and giving rise to the continuous ringing of the bell.

Electric bells are used as door bells and buzzers.

10.6 Electromagnetic Induction

Michael Faraday discovered electromagnetic induction in 1831.

The electromagnetic induction is one of the methods to generate the electric power. It is the most important and is the only method used for commercial generation of electric power. Dynamos or generators work on the principle of the electromagnetic induction.

10.6.1 Faraday's Experiment

Faraday connected a sensitive galvanometer to a coil of wire. He observed that if a magnet is moved towards the coil of wire, the galvanometer shows deflection in one direction as in the figure 10.25(a). When the magnet is moved away from the coil of wire, the galvanometer shows deflection in the other direction as in the figure 10.25(b). The same effect is also obtained, if the magnet is kept Stationary and the coil is moved.

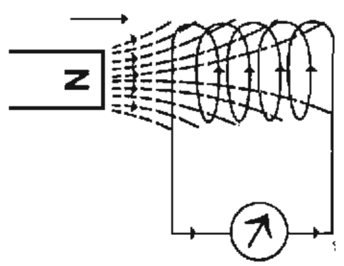


Fig. 10.25(a) Magnet is moved towards the coil

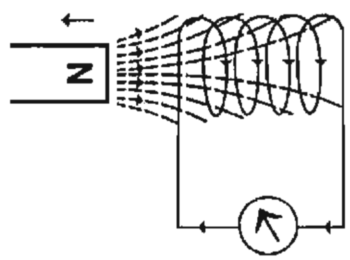


Fig. 10.25(b) Magnet is moved away from the coil

Whenever the magnet is moved towards a coil or a coil is moved towards a magnet, there is a change in magnetic field, and a current is induced in the circuit. This is known as induced current. This process of producing induced current is called electromagnetic induction.

SELF EVALUATION

I. Choose the correct answer

1. Magnet was discovered in the place of

   (a) Africa (b) Europe (c) America (d) Magnesia

2. Unlike poles of two bar magnets when brought near

   (a) attract each other (b) repel each other
   (c) either attract or repel (d) neither attract nor repel

3. The north pole of the earth's magnetic field lies in the

   (a) centre of the earth (b) equatorial line
   (c) geographical North (d) geographical south

4. The most important method used for commercial generation of electric current is

   (a) chemical action (b) thermocouple
   (c) electromagnetic induction (d) none of the above

5. An example of conductor is

   (a) mica (b) plastic (c) copper (d) paper

6. Electromagnetic induction was discovered by

   (a) Michael Faraday (b) Oersted
   (c) Ampere (d) Fleming

II. Fill in the blanks

7. A freely suspended bar magnet will always come to rest in the ________ direction.
8. The magnetic attraction of a bar magnet is greatest at its ________.
9. The device used to trace the magnetic lines of force is ________.
10. ________ discovered the magnetic effect of current.
11. At the center of the coil, the magnetic lines of force are ________.
12. An electromagnet is demagnetized when the current is switched ________.

III. Match the following

13.	Oxide of iron	–	Cobalt
14.	Earth	–	Insulator
15.	Magnetic Material	–	Electron
16.	Source of electric current	–	Big bar magnet
17.	Negatively charged particle	–	Drycell
18.	Mica	–	Fe_3O_4

IV. Give short answer

19. Name three magnetic materials.
20. Name the three methods of making a magnet.
21. What is meant by induced magnetism?
22. Define angle of declination.
23. What is an electric current?
24. Name any three good conductors of electricity.
25. What type of electric circuit is used in houses?
26. Give two applications of electromagnet.
27. What is electromagnetic induction?
28. State Right hand thumb rule.

V. Give detailed answer

29. Explain the properties of magnet.
30. How would you distinguish between a magnetic and non-magnetic substance?
31. Define magnetic lines of force. Mention their properties.
32. Explain the three methods of making a magnet.
33. Explain the magnetic field of circular coil carrying a current.
34. Explain the magnetic field due to current in a straight conductor.
35. Explain Faraday's experiment.
36. Explain the construction and working of Electric bell.

11. Sources of Energy

11.1 Solar energy

Sun is the most important source of thermal energy. Sunlight illuminates the earth's surface. So, the earth receives the energy from the sun in the form of heat and light. A part of this energy is reflected into the space by the atmosphere. Ice caps in polar region of the earth also reflect some parts of solar energy into the space. Sunlight warms the earth's surface during day time. Hence, a major part of the solar energy is absorbed by the earth's surface. Some of the heat absorbed by the earth is given off at night as it cools down.

11.1.1 Production of energy in the sun

Nuclear fusion reaction of lighter nuclei into heavy nucleus in the interior of the sun continuously liberate enormous amount of energy. It emits radiant energy continuously in all directions but only a part of the energy about 0.000000045792% is directly received by the earth. From the amount of energy received by the earth, the temperature of the sun can be estimated. The temperature of the interior of the sun is about 1.4×10^7K. The total energy radiated by the sun is 3.8×10^{26}J/s. And the sun has been emitting energy at this rate for billions of years.

The radiation from the sun besides heat and visible light, also carries energy in the form of ultraviolet and gamma rays. The solar energy reaching the earth's atmosphere is considered to be constant for all practical purposes.

11.1.2 Conversion of solar energy into hydro and wind energy

The solar energy that reaches the earth's surface is mostly in the form of heat and visible light. What happens to this solar energy? The land and water on the surface of the earth absorb a part of the solar energy which in turn, gives rise to many natural phenomena, like blowing of wind, rain and snow. During these processes, some part of the solar energy gets converted into different forms. For example, the energy of wind and flowing water are due to solar energy.

The absorption of heat by the oceans and land causes continuous evaporation of water. This water vapour in air is carried upwards and then to distant places by the convection current in the air. A part of this solar energy gets converted as the potential energy of water vapour in air. Clouds are formed due to the combustion of water vapour in air. It ultimately brings water back to the surface of the earth in the form of rain and snow. When this water flows through river, it has both kinetic as well as potential energy.

Similarly, the convection current in the air is the cause of wind or cyclone depending on the speed with which air moves. Therefore, the energy of wind is also energy in another form of solar energy.

Activity 1

Collect pictures and reports on solar cooker, heater and photo voltaic cell. You will find that these devices concentrate the heat and light of the sun into small areas and heating is done efficiently. In photo voltaic cell, solar energy is directly converted into electrical energy on a limited scale. These are used in calculator, traffic lights and for the transmission of radio and television programmes. These cells are also used to generate electricity in satellites and in far off places such as Ladakh.

11.1.3 Wind energy

The uneven heating of earth's surface by the sun causes winds. Winds are convection currents in the air. So, wind energy is the kinetic energy associated with the movement of atmospheric air. The direction and speed of wind keeps on changing at every place in the earth. But, the pattern of changes in wind speed and its direction at any given place is constant over the years. The speed of wind usually increases in hilly areas. It is greater over the sea and in coastal areas. The energy of moving air or the wind energy has been used for running windmill as shown in figure 11.1 Electricity can be generated using the windmills.

Fig. 11.1 A wind mill

The electricity produced by a single windmill is very small. So it cannot be used for commercial purposes. Therefore, a number of windmills are erected over a large area. This arrangement is known as Wind energy farm. The energy output from all windmills are coupled together to get electricity for commercial purposes.

In our country, Tamilnadu and Gujarat lead in the field of wind energy. In Tamilnadu, electricity is generated using the wind energy in Kayathar of Thirunelveli District and Aralvaimozhi of Kanyakumari District.

Activity 2

Make models of a windmill

11.2 Hydro-electric energy

The energy of falling water is used for generating electricity in hydro-electric power plants. The electricity generated in this way is known as hydel power. Hydro-electric power plants have the least operating cost. They are free from environmental problem among the other types of power plants. However, hydro-electric power plants cannot be located everywhere. Firstly, there must be an ample quantity of water at sufficient head. Secondly, a suitable site must be available. The amount of electric power that can be developed depends on the quantity of water available, the rate at which it is available, the head, etc. (Fig.11.2).

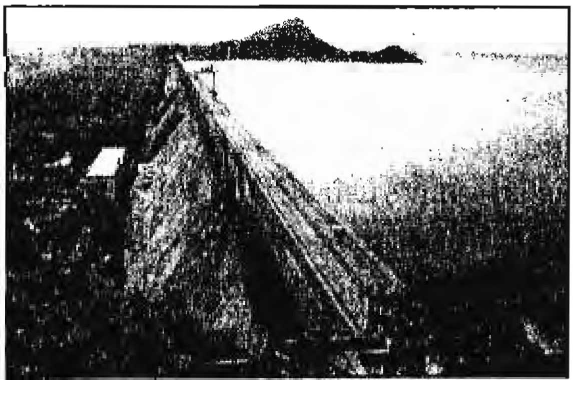


Fig. 11.2 Mettur dam

In hydro-electric power plants, turbines are used to convert the energy of falling water into mechanical energy, which is further utilised for driving the electric generators. This is done by constructing dams on rivers or lakes. In the dam, the water from the top is made to flow downhill through large tunnels.

11.2.1 Hydro electric power stations in Tamilnadu

In Tamilnadu, several of the major irrigation schemes draw water from three rivers: the Cauvery river in the central zone; the Pennaiyar river in the north; and the Vaigai river which is adjacent to Cauvery river. The Tamilnadu Electricity Board has completed investigations and pre-feasibility studies for mini-hydro projects at irrigation dams at Lower Bhavani, Amaravaty, Thirumurthy, Sathanur, Pechiparai, Perunchani and Aliyar.

In Tamilnadu, hydro power station is located at Mettur Dam. Also, hydropower stations have been commissioned on Lower Bhavani Dam, Pykara Dam and Vaigai Dam.

Pumped storage power plant

Pumped storage power plant is one type of hydro-electric power plant. In pumped storage power plants, reversible turbines are used which operate as turbine for power generation during peak load hours and as pump for pumping water during peak-off hours. In Tamilnadu, pumped storage power plant is located at Kadampari.

11.2.2 Bicycle dynamo

Bicycle dynamo is a device used to convert mechanical energy into electrical energy. It is based on the principle of electromagnetic induction.

The electricity is generated by electromagnetic induction in the bicycle dynamo which contains armature coil moving in a magnetic field of the magnet. When the wheel rotates and sets armature of the dynamo into rotation, the bulb glows.

11.2.3 Thermal power plants

Thermal power plants provide the major share of electric energy in India as well as in other countries. In thermal power plants, the heat of combustion of fossil fuels (coal, oil, or gas) are utilized by the boilers to raise the steam to high pressure and temperature. The steam, so produced is used in driving the steam turbines or sometimes steam engines coupled to generators and thus in generating electricity

In Tamilnadu, thermal power plants, are located at Neyveli, Ennore, North Chennai, Mettur and Tuticorin. Also the preliminary work has been started to set up a new thermal power plant at Jayankondam in Perambalur district.

11.3 Nuclear energy

Nuclear energy results from the changes occurring in the nucleus of atoms. Scientists and Engineers have found many uses for the nuclear energy, especially in producing electricity.

11.3.1 The production of nuclear energy

A nucleus makes up most of the mass of every atom. This nucleus is held together by an extremely powerful force called nuclear force. Because of this force, a large amount of energy is concentrated in the nucleus.

Any process in which a particle penetrates a nucleus and changes it to produce nuclear energy is called nuclear reaction. In nuclear reaction, nuclear energy is produced by two processes namely nuclear fission and nuclear fusion.

11.3.2 Nuclear fission

The process of breaking up of the nucleus of a heavy atom into two or more smaller nuclei with the release of a large amount of energy is known as nuclear fission. The energy produced is known as nuclear energy.

The nuclear energy is produced

because of the original mass of the nucleus being greater than the sum of the masses of the products produced after nuclear fission. The difference between these masses before and after the nuclear fission is converted into nuclear energy.

For example, the nuclear energy released by nuclear fission of 1kg of Uranium – 235 is 2.26 x 10^7kwh. (1 kwh = 3.6 x 10^6J).

11.3.3 Nuclear reactor

In nuclear fission, a very large amount of nuclear energy is liberated within an extremely small interval of time. Consequently, it is not possible to direct the nuclear energy for any useful purposes. So, a device becomes necessary to control the reaction in nuclear fission. Such a device is called nuclear reactor.

The nuclear energy from nuclear fission has many uses. A nuclear power plant produces electric power from the nuclear energy of nuclear fission (Fig. 11.3).

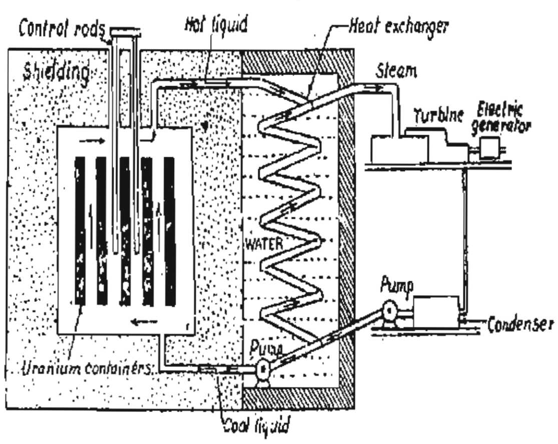


Fig. 11.3 Power reactor

11.3.4 Atom bomb

The working principle of atom bomb is nuclear fission. Here, an uncontrolled fission reaction takes place. When the bomb explodes large quantity of energy in the form of heat, light and radiation is released. A temperature of millions of degrees and a pressure of millions of atmospheres are produced. Human life is impossible under such explosion. These bombs were used in World War II and were exploded over Hiroshima and Nagasaki in Japan.

11.3.5 Nuclear reactors in India

In India, at present, a number of nuclear reactors are in operation for research purposes and production of electricity.

The nuclear reactors located at Bhaba Atomic Research Centre (BARC) for research purposes are 1) Apsara, 2) Cirus, 3) Zerlina and 4) Purnima.

The nuclear reactors located at Tarapur (Maharashtra), Rana Pratap Sagar (Rajasthan) and Kalpakkam (Tamilnadu) are for production of electricity.

Another Atomic Power Station is being commissioned at Kudankulam in Tamilnadu.

Activity 3

Collect pictures and reports on Indian nuclear projects.

11.3.6 Nuclear Fusion

Nuclear Fusion is a process in which two or more light nuclei combine to form a heavy nucleus. The difference in mass is converted into energy. The energy liberated is called thermo-nuclear energy.

For example, the energy production in the sun and stars is due to the nuclear fusion. In sun, four hydrogen nuclei combine to form a helium nucleus at very high pressure and temperature. Also, hydrogen bomb works by the principle of nuclear fusion. It is more powerful than an atom bomb.

SELF EVALUATION

I. Choose the correct answer

1. Which of the following power plants has the least operating cost?
   (a) Hydro-electric (b) Thermal
   (c) Nuclear (d) Gas turbine

2. The Photo-voltaic cell converts
   (a) chemical energy into electric energy
   (b) solar energy into electric energy
   (c) solar energy into sound energy
   (d) sound energy into electric energy

3. Mettur dam is located in
   (a) Maharashtra (b) Madhya Pradesh
   (c) Karnataka (d) Tamilnadu

4. Major share of electricity generated in India is through
   (a) hydro-electric plants (b) nuclear power plants
   (c) thermal power plants (d) gas turbine power plants

5. Bicycle dynamo is a device used to convert
   (a) mechanical energy into electric energy
   (b electric energy into mechanical energy
   (c) solar energy into electric energy
   (d) heat energy into electric energy

II. Fill in the blanks

6. The total energy radiated by the sun is __________.
7. For satellites the source of energy is __________.
8. In Tamil nadu, pumped storage power exists in __________.
9. The working principle of atom bomb is __________.
10. Nuclear fusion reaction takes place in __________.

III. Match the following

11. Coal	–	Hydro-electric power station
12. Wind	–	Nuclear power plant
13. Water in a dam	–	Thermal power station
14. Kalpakkam	–	Nuclear fusion
15. Sun	–	Windmill

IV. Give short answer

16. Where is nuclear power station located in Tamilnadu?
17. Name some hydroelectric and thermal power stations in Tamilnadu.
18. Where are the wind mills located in Tamilnadu?
19. State the principle of hydrogen bomb.
20. Define nuclear energy.

V. Give detailed answer

21. How is energy produced in the sun?
22. Explain the conversion of solar energy into hydro energy.
23. Write a note on wind energy.
24. Explain the conversion of mechanical energy into electrical energy using bicycle dynamo.
25. Write a note on nuclear fission and fusion.

12. Levels of Organisation

12.1 Basics of classification

12.1.1 Need for classification

Introduction

What are the different things we see around us everyday? We see plants, animals, stones, grass, wood, human beings, insects, birds, sand and other common objects. How can we learn more about them? Firstly, by using our own observation and then studying the facts already available to us.

Since there are so many different kinds of objects, we need to study them in groups by classifying them. We can classify these objects into two main groups namely

1. Living things and
2. Non-living things.

Grouping of organisms is called classification.

Basics of classification

Living organisms are so large in number that they need to be classified into smaller groups. Classification of living organisms is made on the basis of their characteristics and similarities.

In any classification we attempt to discover the relation between various organisms that belong to one group. Classification of the plant kingdom helps us to identify the different plants and study their individual characteristics.

Need for Classifications

1. Classification helps us to identify the plants easily.
2. It helps us to learn about different kinds of plants, their features, similarities and differences.
3. It helps us to study plants and animals (living organisms) in an orderly way.
4. It enables us to understand how complex organisms evolve from simple ones.
5. By classifying, we are able to understand the diversity and variety of organisms.

12.1.2 Plant kingdom and animal kingdom

Characteristics of plants and animals

Characteristics of plants

1. Generally all the plants are green in colour due to chlorophyll. Plants are autotrophic organisms.
2. Plants are generally branched except coconut like trees.
3. The organs of plants such as roots, leaves, stem, flowers are external.

4. Sense organs and nervous system are absent.
5. Excretory organs are absent.
6. It contains special growing regions such as shoot tip and root tip.
7. Indefinite growth is seen.
8. New organs, roots, leaves, etc., continue to be formed throughout the life. Secondary growth can occur in several plants.
9. The cell is covered with cell wall.
10. Plant cells possess plastids. Some of the plastids contain green pigments.
11. Large central vacuole is present in plant cell.
12. Centrosome is absent.
13. Plants take food in liquid form. They are holophytic in nutrition.
14. The starch is the main form of reserve food.
15. Food of the plants usually contains inorganic materials like carbondioxide, water and minerals.
16. Plants are fixed to the soil and do not move from place to place except some lower kind of plants. (e.g.) Chlamydomonas.
17. Plants can tolerate the changes in weather conditions.
18. Plants are slow or indirectly respond to the external stimulus.
19. Reproduction takes place by vegetative, asexual and sexual methods.
20. Regeneration is frequent.

Characteristics of animals

1. Animals are multicellular-heterotropic organisms.
2. Chlorophyll is absent but can have various colours.
3. They do not show branching-exceptions-sponges and corals.
4. The organs are internal (e.g.) heart, lungs, etc.,
5. Nervous system, sense organs are present
6. Well developed excretory organs are found in animals.
7. Growing regions are not specific.
8. Growth is limited.
9. No new organs are added in their life time.
10. Cell membrane or plasmalemma is the outermost covering of the cell.
11. Except Euglena plastids are absent.
12. Animals usually take food in solid form and these are holozoic in nutrition.

13. Glycogen is in the form of reserve food.
14. Almost all animals except corals and sponges, move from place to place in search of food with the help of special locomotor organs.
15. Reproduction takes place by asexual and sexual methods.

Plant Kingdom

Plants are multicellular, autotrophic organisms.

Division Bryophyta

Bryophytes are plants without true roots, stems, or leaves, but they often possess structures which resemble these parts of higher plants. Their life cycle consists of two alternating generations:

1. Sexual or gametophyte generation, and
2. Asexual or sporophyte generation. The gametophyte is dominant, but often bears the sporophyte as a parasite.

The main classes are

Class 1: Hepaticae (liverworts)

Bryophytes in which the plant body is flattened and liver like in shape. (e.g.) Marchantia

Some plants possess a stem with two parallel rows of leaf like structures. The sporophyte is short lived. (e.g.) pellia

Class 2: Anthocerotae

The plant consists of horn like sporophyte with flattened leaf like gametophyte. (e.g.) Anthoceros

Class 3: Musci (Mosses)

These are Bryophytes with structures resembling 'roots', 'stems' and 'leaves'. The sporophyte is long-lived. (e.g.) Polytrichum, Sphagnum.

Division Pteridophyta (ferns)

These plants have true roots, stems and leaves but no flowers. The sporophyte generation is dominant and bears sporangia on the lower surface of the leaves. (e.g.) Nephrolepis

Division Spermatophyta (seed plants)

These are plants with a complex and highly organized plant body. They produce seeds.

The main classes are:

Class-Gymnospermae (Naked seeded plants)

They are seed plants without flowers. Seeds are not enclosed within a fruit but they are naked. (e.g.) cycas, cupresses, pine.

Class: Angiospermae (Closed seeded plants)

They are seed plants with flowers. Seeds develop within the ovary. The wall of the ovary becomes the wall of the fruit. Monocotyledons are plants which germinate with one seed leaf or cotyledon. (e.g.) grasses, coconut, paddy.

Dicotyledons are plants which germinate with two seed leaves. (e.g.) Mango, Groundnut, Bean.

Animal Kingdom

Animals are multicellular heterotrophic organisms.

Phylum Chordata

Chordates are animals with a notochord which becomes the backbone in higher types, a hollow dorsal nerve cord, a ventral heart and gill slits at some stage in their development.

Sub-Phylum Vertebrata (Vertebrates)

These are chordates with a backbone or Vertebral column.

The main classes are

1. Class Chondrichthyes.
   (e.g.) Dogfish, Sharks, Rays.
2. Class Osteichthyes.
   (e.g.) Stickleback, Cod.
3. Class Amphibia.
   (e.g.) Frogs, Newts, Salamanders.
4. Class Reptilia.
   (e.g.) Terrapin.
5. Class Aves (birds)
   (e.g.) Sparrow, Penguin, Kiwi.
6. Class Mammalia (mammals).
   (e.g.) Monkeys, Apes, Man.

12.1.3 Viruses and bacteria - position

Viruses are submicroscopic structures which grow and multiply only within the living cells. Viruses are structurally simpler than other organisms. Outside of the living cells viruses are inactive and particles like structure. However inside the living cells viruses show some of the characteristics of living things. The combination of these facts causes many people, to wonder whether viruses are alive. Viruses show both living and non living characters. So it comes under the special category in the classification. It does not come under, five kingdom classification. According to recent classification by some botanists, the kingdom Monera includes bacteria.

12.1.4 Carolus Linnaeus and his contribution

Carolus linnaeus was a great Swedish naturalist. He was born on 23rd May 1707 at Rashult, a small village of Southern Sweden. He became interested in the study of natural history since his child hood (Fig. 12.1).

Fig. 12.1 Carolus linnaeus

He described hundreds of plants and animals known in that time. He recognized the stamens as male part and gynoecium as female part of the flower in a plant. The plants were classified on the basis of number of stamens and other characters of stamens in a flower. His classification is called as sexual system of classification. It is also known as artificial sexual system of classification.

He recognized 24 classes of plants. His system of classification was published in his book called 'Systema Naturae' in 1735 and again in Genera plantarum' in 1737.

Linnaeus published a book called 'Species Plantarum' in the year 1753. In this book Linnaeus used two words to refer a plant name. The first word denotes generic name and the second word denotes species name. This system of naming plants is known as Binomial system of Nomenclature. It is a scientific system of naming plants which is universally followed even to day. He is rightly known as the 'father of modern botany'.

12.2 Five Kingdoms Concept

A new five-kingdom arrangement of organisms was proposed by Whittaker (Fig. 12.2a and Fig. 12.2b). In this arrangement the separation into five kingdoms is made on the following principles

1. Cell Structure
2. Organization of body
3. Type of nutrition

The Five kingdoms are:

1. Monera
2. Protista
3. Plantae (Plants)
4. Fungi and
5. Animalia (Animals)

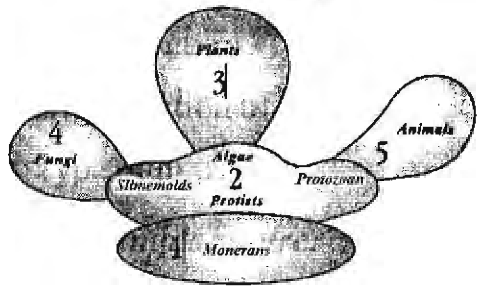


Fig. 12.2a Five Kingdoms

12.2.1 Conventional Types of Classification

Living things are divided into two groups namely Plants and Animals.

They are classified in to many groups;

Plants

- Cryptogams
  - Thallophyta (Algae, Ulothrix)
  - Bryophyta (Riccia, Marchantia)
  - Pteridophyta (Fern, Nephrolepis)
- Phanerogams (spermatophytes)
  - Gymnosperm
  - Angiosperm
    - Monocotyledon
    - Dicotyledon

Animals

- Vertebrates
  - Phylum-Chordata
    - Pisces (Mugil)
    - Amphibia (Frog)
    - Reptilia (Calotes)
    - Aves (Pigeon)
    - Mammalia (Rat)
- Invertebrates
  1. Phy: Protozoa (Amoeba)
  2. Phy: Porifera (Sponges)
  3. Phy: Coelenterata (Hydra)
  4. Phy: Platyhelminthes (Tapeworm)
  5. Phy: Aschelminthes (Ascaris)
  6. Phy: Annelida (Earthworm)
  7. Phy: Arthropoda (Cockroach)
  8. Phy: Mollusca (Pila)
  9. Phy: Echinodermata (Starfish)

12.2.2 General Characters of Five Kingdoms

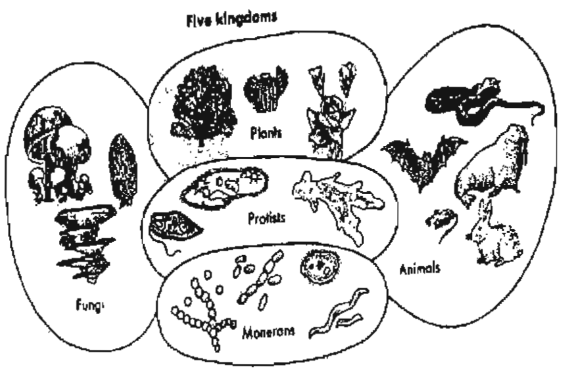


Fig. 12.2b Five Kingdoms

General characters of Monera:

All prokaryotes belong to the kingdom Monera. Cells of prokaryotes do not have a nuclear membrane or any membrane bound organelles, (e.g.) Bacteria and Blue green algae are Monerans. Most bacteria are heterotrophic, but some are autotrophic. Bacteria play an extremely important role in nature as chemical recyclers.

General characters of Protista:

The Kingdom Protista includes unicellular and a few simple multicellular eukaryotes. Recall that eukaryotic cells have nuclei and organelles that are surrounded by membranes. The cells of multicellular protists are not specialized to perform specific function in the organism.

There are two main groups of protists. The plant like protists are photosynthetic and are commonly called algae (Singular-alga). Algae include unicellular and multicellular types. Animals like protists are often called protozoans. Protozoans include Amoeba and Paramecium like animals.

General characters of Fungi:

Fungi are eukaryotic, and mostly are multicellular. The cells of fungi have cell walls that contain a material called chitin and fungus cellulose. These organisms are heterotrophic and obtain their nutrients by releasing digestive enzymes into a food source. They absorb the food after it has been digested by the enzymes. Fungi act either as decomposers (decay-causing organisms) or as parasites in nature. Kingdom Fungi includes molds, mildews, mushrooms, yeast, and many relatives.

General characters of plantae:

Plantae (plants) are multicellular eukaryotes that carry out photosynthesis. The cells of plants have cell walls that contain the polysaccharide cellulose. Plant cells have specialized functions, such as photosynthesis, the transport of materials and support. Kingdom plantae includes mosses, ferns, cone-bearing plants and flowering plants.

General characters of Animalia:

Animalia (animals) are multicellular, eukaryotic and hetero-trophic animal. The cells have no cell wall. Most members of the animal kingdom can move from place to place. However, some animals, such as adult sponges and barnacles, are permanently attached to a surface. Most of these, however, retain the ability to move parts of the body, and they are usually mobile at some point in their lives.

Fish, birds, reptiles, amphibians, and mammals including humans-belong to the kingdom Animalia. This kingdom also includes sponges, jellyfish, several phyla of worms, star fish and their relatives, insects, and other organisms.

12.3 Classification of Angiosperms

Classification - Angiosperms

Plant taxonomy may be defined as

a branch of Botany which deals with the classification, identification, description and naming of plants being discovered through surveys. So there is a need to arrange the plants in to groups.

Angiosperm includes more than 2,86,000 already known species. Now a days classification of plants helps us in many ways.

It helps us to know the range of variations in form and structure of plants.

It helps us to know the simple form of plants and complex form of plants.

It helps us to know the evolutionary relationship among plants.

The angiosperms are vascular plants that produce seeds enclosed and protected by a fruit. Angiosperms are flowering plants. All angiosperms produce flowers and seeds.

One way of distinguishing among the many types of angiosperms is by counting the number of seedleaves or cotyledons in the plant's embryo. Angiosperms with only one cotyledon are called monocot. Lilies, orchids, corn and other grasses are monocots.

A dicot is an angiosperm whose embryo has two cotyledons. (e.g.) Mango, Tamarind.

12.3.1 Types of classification

There are various systems of classification. They may be placed under the following four categories

1. Artificial systems
2. Natural systems
3. Phylogenetic systems (Phylogeny – Evolutionary history of one species)
4. Modern or recent systems.

1. Artificial system

It is based on one or a few characters. The main defect of this system is that closely related plants are very often placed in widely separated groups. Similarly plants quite different from one another are often placed in the same group.

The best example of artificial system is the one proposed by the Swedish Botanist Carolus Linnaeus.

2. Natural Systems

In the natural system all the important characters of plants are taken into consideration and the plants are classified according to their related characters. It helps to determine the relationship of various plant groups. However a natural system of classification does not attempt at bringing out phylogenetic or evolutionary relationships.

Bentham and Hooker's system is a good example for natural system of classification.

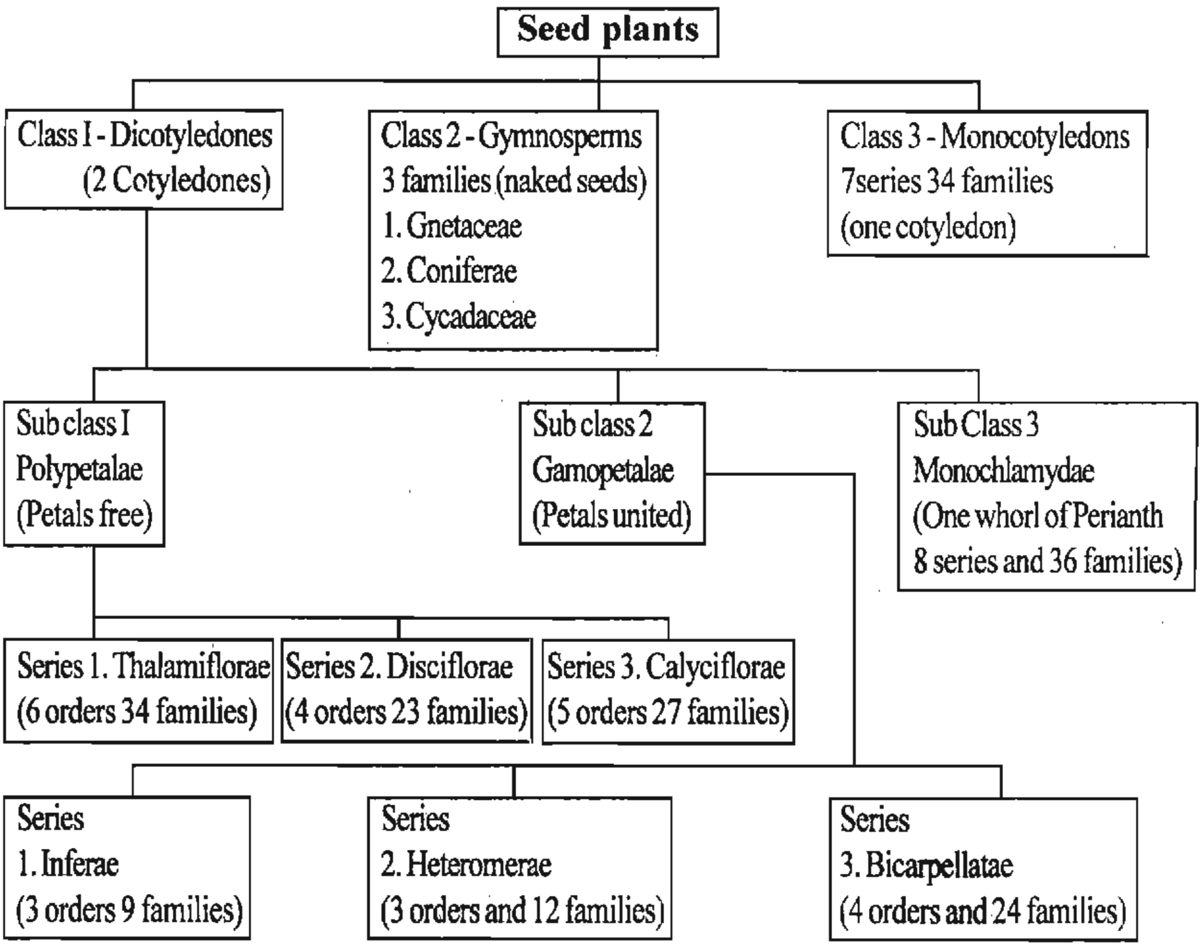
3. Phylogenetic System of Classification based on evolution

After Darwin's theory of organic evolution came to be widely accepted by biologists, attempts were made to classify plants according to their evolutionary developments. Several new systems of plant classification were published claiming to be phylogenetic systems. The most important among such system is the one proposed by the two German Botanists Adolf Engler and Karl Prantl.

4. Modern System of Classification

The above systems of classification are based mostly on morphological characters. Thus in framing recent systems of classification, characters of vegetative anatomy, floral anatomy, paleontology, embryology are also considered. Similarly cytogenetical

12.3.2 An Outline of Bentham and Hooker's System (Table 1)



characters, bio chemical characters are also taken into account. Thus these systems are exhaustive and broad based.

Arthur Cronquist has proposed the modern system of classification.

Bentham and Hooker's System Of Classification

George Bentham (1800-1884) and Sir Joseph Dalton Hooker (1817-1911), two great botanists associated with Royal Botanical Gardens Kew (England) jointly proposed a system of plant classification. They published their system of classification in three volumes called "Genera Plantarum"

12.3.2 Bentham and Hooker's System of Classification - Outline

Bentham and Hooker's system of classification includes only seed plants. They described 97,205 species of seed plants, placing them under 202 orders (now referred to as families). Bentham and Hooker's system of classification of phanerogams or seed plants may be summarized as given in table 1.

12.3.3 Merits of Bentham and Hooker's System

1. Every genus and species included in this system was studied from the actual specimen and their description was based on detailed studies by either of the authors. So the information given in the description is highly reliable.
2. It is a very useful system because it is easily workable and simple in classification and identification of plants.

Demerits of the System

1. Placing of gymnosperms between monocotyledon and Dicotyledon.
2. It fails to bring about evolutionary relationship among plants.

12.3.4 Taxonomic hierarchy - importance

Taxonomic hierarchy is a scientific frame work of any classification. Hierarchy means a group of things ranked one above another. Species, genus, family, order, class, phylum and kingdom designate the seven important categories or ranks in the hierarchy. Each unit of classification is referred to as a taxon (Pl. taxa). So, taxon is a convenient term used to refer any unit of classification at any level. In the taxonomic hierarchy the highest taxon is plant kingdom and the lower most taxon is the species.

In plants the classification is made usually on the basis of floral or reproductive characters.

A species is a collection of individual plants resembling one another in all characters both vegetative and reproductive. The individuals of the same species breed among themselves. Species is a category or taxon in the hierarchy. A collection of species bearing close similarities to one another in their vegetative and reproductive characters is termed a genus. Genus is the taxon of a higher rank next to the species.

Taxonomic hierarchy:

Kingdom

Division

Class

Order

Family

Genus

Species

(e.g) Mango

Kingdom	:	Plantae
Division	:	Spermatophyta
Class	:	Dicotyledon
Order	:	Sapindales
Family	:	Anacardiaceae
Genus	:	Mangifera
Species	:	indica

12.4 Animal Phyla

General characters

After having studied the diversity among the animals and the basis of their classification, let us now try to understand the salient features of each phylum under Animal kingdom.

12.4.1 Phylum Protozoa

1. Protozoans are unicellular or acellular animals. The body of the protozoan has the structure of a typical cell consisting of the cytoplasm, the nucleus and the cell membrane. Though they are unicellular, the protoplasm is differentiated functionally into organelles.
2. They are microscopic, occurring all over the world in fresh and salt waters and in damp places. Some are parasitic like Plasmodium.
3. Special locomotor organs like pseudopodia, flagella and cilia are present except in some parasitic forms.
4. Mode of nutrition is by
   a) Holophytic - (e.g.) Euglena
   b) Holozoic - (e.g.) Amoeba
   c) Saprophytic - (e.g.) Euglena
   d) Parasitic - (e.g.) Plasmodium
5. Respiration is by diffusion.

6. Excretion is through contractile vacuole.

7. Reproduction takes place by fission, or by conjugation.

   (e.g.) Entamoeba histolytica, Amoeba, Vorticella, Paramoecium (Fig. 12.3).

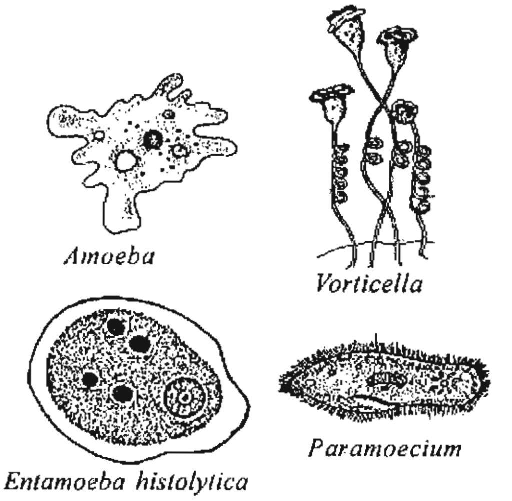


Fig. 12.3 Protozoans

Phylum Porifera

1. Porifera means "Pore - Bearers". Sponges constitute the phylum porifera. Though they are multicellular, the cells are loosely aggregated without any tissue formation.

2. They are sessile and mostly marine, though some are also found in lakes and ponds. They grow by branching in a plant like manner.

3. Sponges have a skeleton formed of spicules.

4. The nervous and sensory cells are absent.

5. The body functions are carried on by the cells more or less independently with little coordination.

6. The interior of the body is provided with numerous canals.

7. The animals completely depend on this canal system for their nutrition, respiration, reproduction etc.,.

8. These animals do not have the excretory, muscular, respiratory and nervous cells.

9. Reproduction takes place both sexually and asexually. The members show a remarkable power of regeneration.

   (e.g.) Leucosolenia, Spongilla, Olynthus etc., (Fig. 12.4).

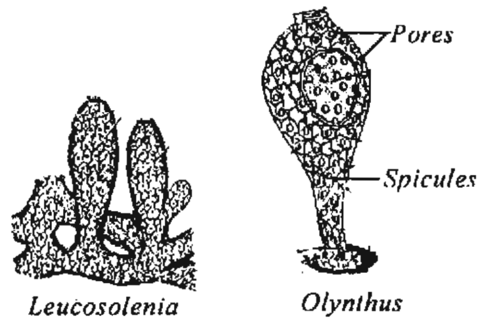


Fig. 12.4 Poriferans

Phylum Coelenterata

1. The Animals included in the phylum coelenterata are multicellular with a tissue grade of organization.

2. They have a central cavity known as gastrovascular cavity

communicating with the exterior by the mouth.

3. There is no anus.
4. The body wall consists of two cell layers, hence these are said to be diploplastic. Between the two layers is a jelly like material, the mesoglea.
5. Most coelenterates exhibit radial symmetry.
6. They are found mostly in the sea but a few occur in fresh water.
7. They may be solitary or colonial.
8. The ectoderm contains stinging cells called nematocysts.
9. They reproduce both asexually and sexually.

(e.g.) Sea anemone, Hydra, Jelly fish, corals etc., (Fig. 12.5).

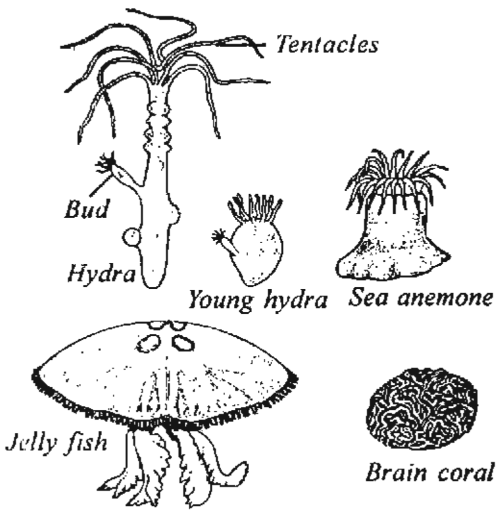


Fig. 12.5 Coelenterata

Phylum Platyhelminthes

1. This phylum includes flatworms.
2. These are acoelomates without a body cavity.
3. The body cavity is filled with parenchyma tissue
4. The alimentary canal is either absent or very simple.
5. Excretion and osmoregulation occurs through flame cells.
6. There is no circulatory system.
7. These worms are mostly hermaphrodites, having both male and female reproductive organs in the single individual.

(e.g.) Planaria,Tapeworm, Liver fluke, Blood fluke (Fig. 12.6).

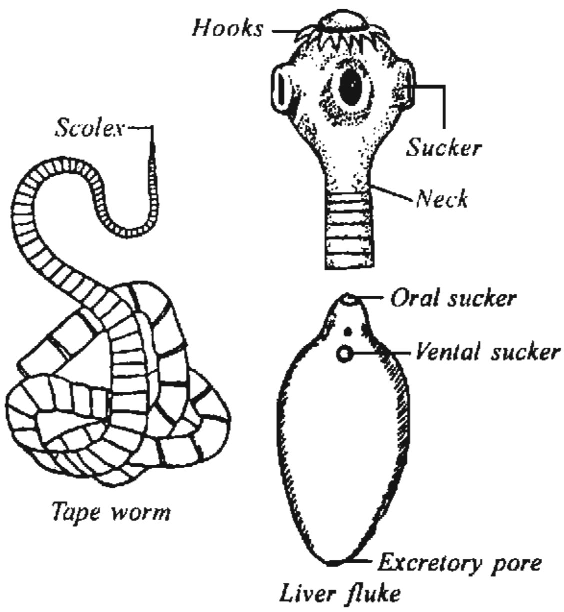


Fig. 12.6 Flatworms

Phylum Nematoda

1. The nematodes include the round worms and thread worms.
2. They are all unsegmented and

have a thread like body, tapering at both ends and provided with a thick cuticle.

3. The mouth and the anus are present.
4. The alimentary canal is a straight tube.
5. Sexes are distinct and the male is always smaller than the female.
6. The majority of nematodes are free living.
7. Many are plant parasites. Some cause diseases in animals and man.

(e.g.) Ascaris lumbricoides (Fig. 12.7).

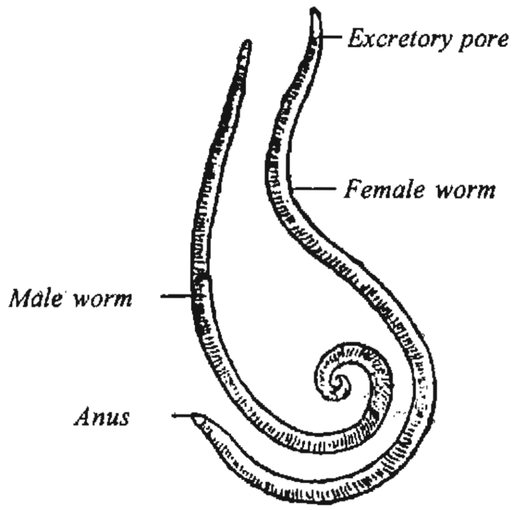


Fig. 12.7 Ascaris lumbricoides

Phylum Annelida

1. These are bilaterally symmetrical and triploblastic.
2. The body is elongated and metamerically segmented.
3. Externally the body wall is covered by a thin cuticle.
4. The body wall may have body setae or parapodia which help in locomotion.
5. The body wall and the wall of the intestine have both longitudinal and circular muscles.
6. The body cavity is a true coelom.
7. The circulatory system is closed type.
8. Excretion and osmoregulation are carried out by nephridia.
9. Respiration is effected by the epidermis or gills.
10. There is a central nervous system consisting of a brain and a double ventral nerve cord, which extends throughout the length of the body.
11. The head formation is seen for the first time.
12. The sexes may be united or separate.

(e.g.) Earthworm, Nereis, Leech (Fig. 12.8).

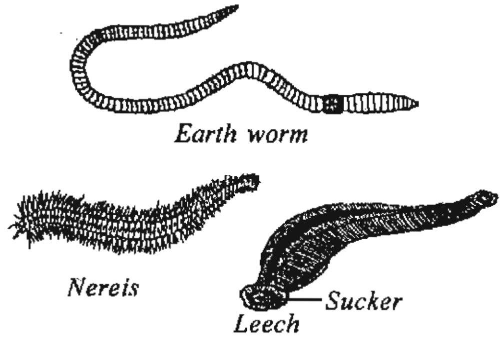


Fig. 12.8 Annelids

Phylum Arthropoda

1. They are all bilaterally symmetrical with a segmented body.
2. The body is covered with a thick chitinous cuticle forming an exoskeleton.
3. The legs or paired appendages are jointed.
4. The body cavity is filled with blood. Hence the body cavity is called haemocoel.
5. The circulatory system is of open type and the blood is colourless.
6. Respiration is effected by gills, trachea, book lungs or body surface.
7. Excretion is effected by coxal or green glands or malpighian tubules.
8. The nervous system has a pair of dorsal ganglia, connectives and a pair of double ventral nerve cord.
9. The sense organs include antennae, simple and compound eyes.
10. These are unisexual, exhibiting sexual dimorphism.
11. The phylum Arthropoda includes animals like crab, prawn, lobster, millipede, centipede, insects, scorpion, tick, and spider. These are the most successful group of animals (Fig. 12.9).

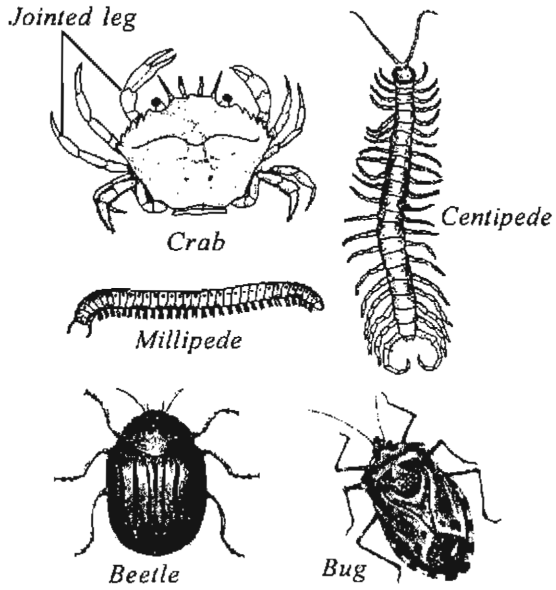


Fig. 12.9 Arthropods

Phylum Mollusca

The phylum Mollusca includes animals like the mussel, the oyster, the snail, the slug, cuttle fish, Pila etc.,

1. These are soft bodied animals without segmentation.
2. The body is divided into head, muscular foot and visceral mass.
3. The body is covered by a fold of skin called the mantle, which secretes the shell.
4. Presence of calcareous shell is the characteristic feature of this phylum. Shell may be external or internal. In some animals, shell is totally absent.
5. Gills serve as respiratory organs.
6. Coelom is reduced.
7. The nervous system consists of a series of ganglia and their connectives.