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NIRANTAR SCIENCE & TECHNOLOGY

Class 10

Author
Dinesh Yadav

Nirantar Prakashan
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Author : Dinesh Yadav

Publisher : Nirantar Prakashan
Putalisadak, Kathmandu-29, Nepal

Contact : www.nirantarprakashan.com.np
Email: nirantaredu@gmail.com
facebook page: nirantar prakashan
Tel. 01-4546384, 9851172230, 9851100000

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PREFACE

Nirantar Science & Technology as a series I-X grade has been prepared strictly in a line to the recently upgraded syllabus and curricula issued by Curriculum Development Centre, Sanothimi, Bhaktapur, under the ministry of education, and the government of Nepal for the learners of basic level to secondary level with regard to educational framework 2076 B.S.

The series aims at providing both theoretical and practical cognitivity to the students of far and wide having some flair to science, scientific facts and processes with ample activities considering their needs, level, aptitude, intelligence and age factor by creating interest through proper selection and gradation of the subject matter to be taught and learnt. The entire desk of authors and editors claims that the series has come to adopt a thematic and activity centred approach, abundant illustrations and so on in order to make an understanding of science more effective and comprehensive.

The new curriculam 2078 and updated version in your hand is solemnly dedicated to those scholars far and wide with a provision of richly sophisticated but only relevant pictures, diagrams, table, charts, fact files, reasons and logics, etc. as the soul of science. Apart from these, several other efforts have been put forward collectively in order to make the book more concise and student friendly so as to address the requirement of a perfect book to many students and teachers who like to culminate real practice in science in the days to come. Beside this, our another attempt through this presentation is to eradicate some misconceptions to science appeared in the growing mind of students especially in the classroom context by illuminating them in terms of these salient features incorporated within each book of the series.

Home Assignments/Worksheets: The revision exercises at the end of every chapter can be given as home assignments after teaching particular concepts.

Varieties of Questions: Objective type questions like, true or false, fill in the blanks, choose the correct answer, etc. are given in the exercises at the end of every chapter in this book, in order to fulfill the objectives of each lesson.

Activities : Numerous activities in the classroom can provide platform for active involvement of students in application of their theoretical knowledge and learning. Thus, interesting activities are given so as to arouse interest of the students in science.

Projects: Lots of activities in the book are dedicated to investigate research projects with information gathering and deducing. Some of these can be individual research projects and others assigned to group of students with an aim to make them more participatory.

- Author

NIRANTAR
SCIENCE &
TECHNOLOGY

Book 10

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Chapter 1

Scientific Study

Total Estimated pariods (Th. 4+ Pr. 1=5)

Student's Learning Outcomes

After studying this unit, the students will be able to :

- identify independent variables, dependent variables, and controlled variables in scientific studies and understand the importance of controlling extraneous variables
- distinguishing between fundamental and derived units
- find out the fundamental units involved in the derived unit
- use fundamental units to check unit wise homogeneity in physical equations

James Watt, (born January 19, 1736, Greenock, Renfrewshire, Scotland—died August 25, 1819, Heathfield Hall, near Birmingham, Warwick, England), Scottish instrument maker and inventor whose steam engine contributed substantially to the Industrial Revolution. Watt was also known for patenting the double-acting engine and an early steam locomotive. He was elected fellow of the Royal Society of London in 1785. The unit of power, the watt, has been named in his honour. The watt is a commonly used as derived unit.

1.1 Introduction

Scientists use an experiment to search for cause and effect. There are many items that could be altered to test the reaction of another. These changing quantities are called **variables**. A variable is any factor, trait, or condition that can exist in differing amounts or types. An experiment usually has three kinds of variables: independent, dependent, and controlled. The independent variable is the one that is changed by the scientist. To insure a fair test, a good experiment has only one independent variable. As the scientist changes the independent variable, he or she records the data that they collect. The dependent variable is the item that responds to the change of the independent variable. The dependent variable depends/changes when the independent variable is changed. For example, if you open a faucet (the independent variable), the quantity of water flowing (dependent variable) changes in response--you observe that the water flow increases. The number of dependent variables in an experiment varies, but there is often more than one. The controlled variables are quantities/items that you want to remain constant, and must observe them as carefully as the dependent variables. For example, if we want to measure how much water flow increases when we open a faucet, it is important to make sure that the water pressure (the controlled variable) is held constant. That's because both

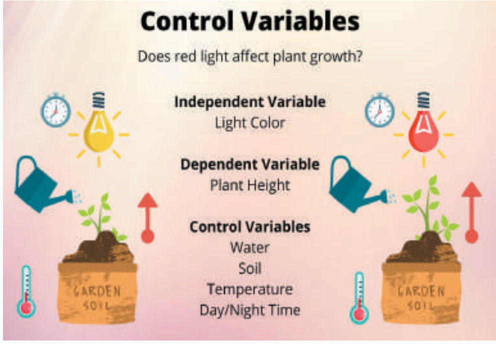


Fig. 1.1

the water pressure and the opening of a faucet have an impact on how much water flows. If we change both of them at the same time, we can't be sure how much of the change in water flow is because of the faucet opening and how much because of the water pressure. In other words, it would not be a fair test. Most experiments have more than one controlled variable. Some people refer to controlled variables as 'constant variables.' Variables are elements, characteristics, or properties that have a direct or indirect relationship during experimental work.

Variables of Scientific Research

The scientific method is a powerful tool used by scientists to test hypotheses on a wide range of topics. Let's break the scientific method down to understand its effectiveness in science. The first step always begins with a question. For example, what is the optimum amount of water per week for a tomato plant to grow more efficiently? Questions arise through observations by scientists. Next, scientists will research the question for possible answers from other researchers. If the search is unsuccessful, a scientist will prepare an experiment to answer the question. To better set up the experiment, researchers answer the question with a testable explanation or hypothesis. For instance, a fertilizer company's research team wants to test the effectiveness of their new fertilizer on the growth of plants. They hypothesize that plants that use their new fertilizer will grow two times faster than other leading brands. The next step is to set up and conduct an experiment to test if the hypothesis is valid or invalid. Setting up an experiment is extremely important because many factors can alter the collected data at the end. Scientists call these factors variables. Variables are anything that can change or be changed within an experiment. Researchers can manipulate variables to ensure that the desired outcome is reached.

Types of Variables

The three most essential variables in an experiment are :

i. Independent variable, ii. Dependent variable, iii. Control variable.

Independent	Dependent	Controlled
The one thing you change. Limit to only one in a experiment.	The change that happens because of the independent variable.	Everything you want to remain constant and unchanging.
Example: The liquid used to water each part	Example: The height of health of the plant.	Example: Type of plant used, amount of liquid, soil type, amount of sunlight, etc.

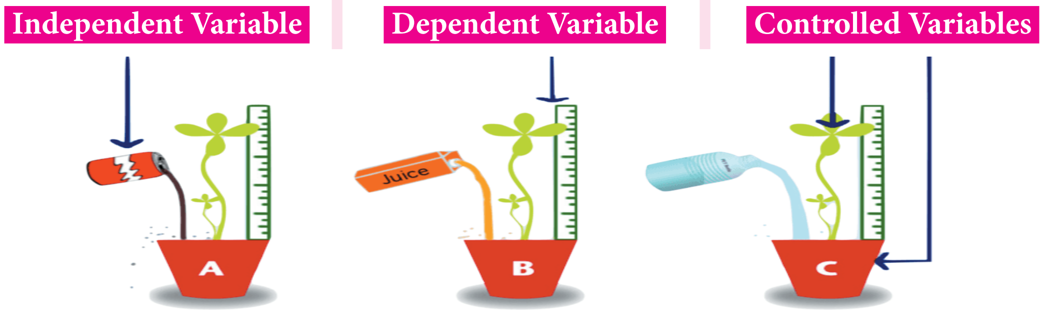


Fig. 1.2

i. Independent variable

The independent variable is the one that is changed by the scientist. Why just one? Well, if you changed more than one variable, it would be hard to figure out which change caused what you observed. For example, what if our scientific question was: "How does the size of a dog affect?" and "How much food does it consume?" You then changed the dogs' size and diet during your feeding experiments, as well as the time of day they were fed. The data might get a bit confusing—did the larger dog eat less food than the smaller dog because of size or because it was the middle of the day and dogs prefer to eat more in the morning? Sometimes it is impossible to just change one variable, and in those cases, scientists rely on more-complicated mathematical analysis and additional experiments to try to figure out what is going on.

ii. Dependent variable

The dependent variables are the things that the scientist focuses his or her observations on to see how they respond to the change made to the independent variable. In our dog example, the dependent variable is how much the dogs eat. This is what we are observing and measuring. It is called the "dependent" variable because we are trying to figure out whether its value depends on the value of the independent variable. If there is a direct link between the two types of variables (independent and dependent) then you may be uncovering a cause and effect relationship. The number of dependent variables in an experiment varies, but there can be more than one.

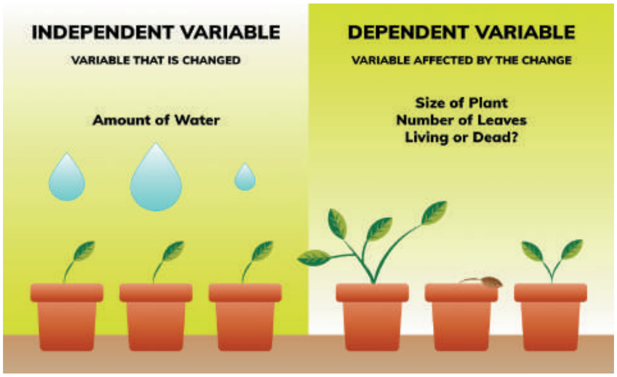


Fig. 1.3

Activities 1.1

i. Suppose you are a scientist. As a scientist, how would you distinguish the independent and dependent variables in the following situations?
A scientist is testing the effect of light and dark on the behavior of moths by turning a light on and off.
In this case,
The independent variable is................
The dependent variable is.........................

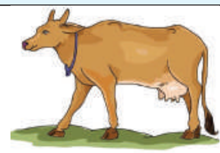
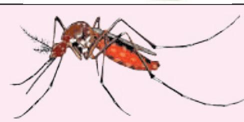
ii. In a study to determine the effect of temperature on plant pigmentation-
In this case,
The independent variable is.............
The dependent variable....................

iii. Control variable.

Controlled variables are quantities that a scientist wants to remain constant, and she or he must observe them as carefully as the dependent variables. For example, in the dog experiment example, you would need to control how hungry the dogs are at the start of the experiment, the type of food you are feeding them, and whether the food was a type that they liked. Why? If you did not, then other explanations could be given for differences you observe in how much they eat. For instance, maybe the little dog eats more because it is hungrier that day, maybe the big dog does not like the dog food offered, or maybe all dogs will eat more wet dog food than dry dog food. So, you should keep all the other variables the same (you control them) so that you can see only the effect of the one variable (the independent variable) that you are trying to test. Similar to our example, most experiments have more than one controlled variable. Some people refer to controlled variables as "constant variables."

Activities 1.2

Write the independent and dependent variables based on the scenario given below.

Scenario		Independent Variable	Dependent Variable
1. A cow is given a growth hormone and then compared to another cow that was not given a growth hormone. Both cows were weighed at 2 years.			
2. Mosquito repellent is sprayed on one arm and the other arm is not sprayed. The number of mosquito bites is counted after 2 hours.			

Examples of Variables

Question	Independent Variable (What I change)	Dependent Variables (What I observe)	Controlled Variables (What I keep the same)
How much water flows through a faucet at different openings?	Water faucet opening (closed, half open, fully open)	Amount of water flowing, measured in liters per minute	• The faucet • Water pressure, or how much the water is "pushing" "Different water pressure might also cause different amounts of water to flow and different faucets may behave differently, so to ensure a fair test, I want to keep the water pressure and the faucet the same for each faucet opening that I test."
Does heating water allow it to dissolve more sugar?	Temperature of the water measured in degrees Celsius	Amount of sugar that dissolves completely, measured in grams	• Stirring • Type of sugar "More stirring might also increase the amount of sugar that dissolves, and different sugars might dissolve in different amounts, so to ensure a fair test I want to keep these variables the same for each cup of water."
Does fertilizer make a plant grow bigger?	Amount of fertilizer, measured in grams	• Growth of the plant, measured by its height • Growth of the plant, measured by the number of leaves	• Same type of fertilizer • Same pot size for each plant • Same plant type in each pot • Same type and amount of soil in each pot • Same amount of water and light • Make measurements of growth for each plant at the same time

			"The many variables above can each change how fast a plant grows, so to ensure a fair test of the fertilizer, each of them must be kept the same for every pot."
Does an electric motor turn faster if you increase the voltage?	Voltage of the electricity, measured in volts	Speed of rotation, measured in revolutions per minute (RPMs)	• Same motor for every test • The motor should be doing the same work for each test (turning the same wheel, propeller, or whatever) "The work that a motor performs has a big impact on its speed, so to ensure a fair test, I must keep that variable the same."

Time as an Example of an Independent Variable

In some experiments, time is what causes the dependent variable to change. The scientist simply starts the process, then observes and records data at regular intervals.

Question	Independent Variable (What I change)	Dependent Variables (What I observe)	Controlled Variables (What I keep the same)
How fast does a candle burn?	Time measured, in minutes	Height of candle, measured in centimeters, at regular intervals of time (for example, every 5 minutes)	• Use same type of candle for every test • Wind—make sure there is none

The Independent Variable for Surveys and Tests of Different Groups

When a scientist performs a test or survey on different groups of people or things, those groups define the independent variable. For example:

Question	Independent Variable (What I change)	Dependent Variables (What I observe)	Controlled Variables (What I keep the same)
Who listens to music the most: Teenagers or their parents?	Groups receiving the survey: Teenagers or parents	Amount of time that each person listens to music per day, measured in hours	Ask the question in exactly the same way to each individual

Activities 1.3

What Makes for Good Variables?	Your opinion
Is the independent variable measurable?	Yes / No
Can you change the independent variable during the experiment?	Yes / No
Have you identified all relevant dependent variables, and are they all caused by and dependent on the independent variable?	Yes / No
Are all dependent variable(s) measurable?	Yes / No
Have you identified all relevant controlled variables?	Yes / No
Can all controlled variables be held at a steady value during the experiment?	Yes / No

Note : For Good Variables, You Should Answer "Yes" to Every Question.

Importance of variable control

i. Control variables enhance the internal validity of a study by limiting the influence of confounding and other extraneous variables. This helps you establish a correlational or causal relationship between your variables of interest.

ii. If extraneous variables are not controlled they may become confounding variables, because they could go on to affect the results of the experiment.
iii. By controlling variables, you increase the internal validity of your research.
iv. In experiments, a researcher or a scientist aims to understand the effect that an independent variable has on a dependent variable. Control variables help ensure that the experiment results are fair, unskewed, and not caused by your experimental manipulation.
v. We need to control the variables as much as possible, especially those that have a potential an influencing the outcomes of the research. e.g. in establishing causal relationships, we must be able to attribute the result of the cause to an identified variable(s).

1.2 Fundamental and derived Unit

The units of physical quantities are devided into two types. They are :

i. Fundamental Unit   ii. Derived Unit

i. Fundamental Unit

Unit of mass is kilogram. Unit of time is second. Unit of length is meter. The physical quantities like mass, length, time, etc. have their own existence. These units do not dependend on each other and do not affect to any other units. These units are also called basic units. So, fundamental units can be defined as "the units which have their own existence and do not depend on other units.

There are seven fundamental units of fundamental quantities. They are given below:

S.N.	Physical quantity	Unit name	Symbol
1	Length	meter	m
2.	mass	kilogram	kg
3.	Time	second	s
4.	Temperature	kelvin	K
5.	Electric current	ampere	A
6.	Luminous intensity	candela	cd
7.	Amount of substance	mole	mol

For the measurement of different physical quantity, different devices are used. For the measurement of mass, beam balance is used. Similarly, for the measurement of length, time, temperature and electric current, respectively, meter scale, watch, thermometer and ampere are used.

ii. Derived Unit

Unit of density is kg/m^3. Here, four fundamental units (one 'kg' and three 'm') are involved. Similarly, unit of force is newton (N or kg ms^{-2}). Unit of force involves, four fundamental units 'kg', 'm' and 's'. So, unit of density and force are made up of combination of two or more fundamental units. They completely depend on fundamental units. Such type of units are called derived units. Derived unit can be defined as: the unit which depend upon fundamental units and made up of two or more than two fundamental units.

In the study of science, number of derived units are used. Some important physical quantities and their derived units are given below.

Physical quantity	Formula	Fundamental units involved	Derived unit	Symbols
Area	Length × breadth	m × m	square metre	m^2
volume	Length × breadth × height	m × m × m	cubic meter	m^3
Density	$\frac{\text{mass}}{\text{volume}}$	$\frac{kg}{m \times m \times m}$	kilogram per cubic meter.	kg/m^3
Velocity	$\frac{\text{Displacement}}{\text{time}}$	$\frac{m}{s}$	meter per second	m/s
Acceleration	$\frac{\text{Velocity}}{\text{time}}$	$\frac{m}{s \times s}$	meter per square second	m/s^2
Force	mass × acceleration	$\frac{kgxm}{s \times s}$	Newton	N
Work	Force x distance	$\frac{kg \times m \times m}{s \times s}$	Joule	J
Power	$\frac{\text{Work}}{\text{Time}}$	$\frac{kg \times m \times m}{s \times s \times s}$	watt	W
Pressure	$\frac{\text{Force}}{\text{Area}}$	$\frac{kg}{m \times s \times s}$	Pascal	Pa
Moment	Force x distance	$\frac{kg \times m \times m}{s \times s}$	Newton x meter	Nm
Frequency	$\frac{1}{\text{Time period}}$	$\frac{1}{s}$	Hertz	Hz
Potential difference	$\frac{\text{work done}}{\text{charge}}$	$\frac{kg \times m \times m}{s \times s \times A}$	volt	V

1. Why is unit of velocity a derived unit?

We have,

$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}} = \frac{\text{length}}{\text{Time}}$$

$$\therefore \quad \text{Unit of velocity} = \frac{\text{unit of length}}{\text{unit of time}} = \frac{m}{s}$$

As the unit of velocity contains two fundamental units i.e. meter and second, it is a derived unit.

2. What are the fundamental units in involved joule?

We have,

Work done (W) = force × displacement

$$= \text{mass} \times \text{acceleration} \times \text{displacement} \qquad [\because F = ma]$$

$$= \frac{\text{mass} \times \text{velocity} \times \text{displacement}}{\text{time}} \qquad [\because a = \frac{v}{t}]$$

$$= \frac{\text{mass} \times \text{displacement} \times \text{displacement}}{\text{time} \times \text{time}}$$

As mass, displacement and time are fundamental quantities, their units can be written as:

$$= \frac{kg \times m \times m}{s \times s} = kg\, m^2 s^{-2}$$

Thus, the fundamental units involved in joule are $kgm^2\, s^{-2}$

Activities 1.4

a. Complete the table, below:

Quantity	Name of unit	Symbol
length		
	kilogram	
		s
	ampere	
temperature		K
amount of substance		mol
luminous intensity	candela	cd

b. Complete the table, below:

Quantity	Symbol	Name of unit	Symbol for unit	Base units
speed or velocity	v		ms^{-1}	ms^{-1}
acceleration	a		ms^{-2}	ms^{-2}
force	F			$kgms^{-2}$
energy	E			kgm^2s^{-2}
power	P		W	kgm^2s^{-3}
pressure	p		Pa	$kgm^{-1}s^{-2}$
frequency	f	hertz	Hz	s^{-1}

Unitary analysis of physical equations

Homogeneous equations in physics means that the SI units on one side of the equation must be exactly the same as the other. Unit wise homogeneity is the quality of an equation having quantities of same units on both sides. An important skill is to be able to check the homogeneity of physical equations using the SI base units. The units on either side of the equation should be the same.

To check the homogeneity of physical equations:

- Check the units on both sides of an equation
- Determine if they are equal
- If they do not match, the equation will need to be adjusted

Some Examples

i. Let's say that you don't remember whether

1. time = speed/distance, or
2. time = distance/speed

We can check this by making sure the S.I. units on each side of the equations match.

Reducing both the equations to its fundamental units on each side of the equation, we get

1. $S = \frac{\cancel{m}s^{-1}}{\cancel{m}}$

$= S^{-1}$

$\therefore$ $S = S^{-1}$

L.H.S. = R.H.S.

(Wrong)

Where S = Second

m = meter

"Second" is S.I. Unit of time and meter is S.I. unit of length

2. $S = \frac{\cancel{m}s^{-1}}{\cancel{m}} = \frac{1}{S^{-1}} = S$

$\therefore$ L.H.S. = R.H.S. (Right)

ii. Check the correctness of physical equation $s = ut + ½ at^2$. In the equation, s is the displacement, u is the initial velocity, a is the acceleration and t is the time in which change occurs.

Solution :

s HAS A UNIT OF m

u HAS A UNIT OF ms^{-1} ($v = d/t = m/s = ms^{-1}$

t HAS A UNIT OF s

a HAS A UNIT OF of ms^{-2} ($a = v/t = ms^{-1}/s = ms^{-2}$

1/2 HAS A UNIT OF 'Nil' (a number)

S.I. unit of $ut + ½ at^2$

$= ms^{-1} \times s + ms^{-2} \times s^2$

$= m + m$

Unit of each term on the right hand side is the same as that of the term on left hand side. Hence given relation is correct

iii. Check the correctness of the physical equation $v^2 = u^2 + 2as$. In the equation, v is the final velocity, *u* is the initial velocity, *a* is the acceleration and *s* is the displacement.

Solution :

v HAS A UNIT OF ms^{-1} ($v = d/t = m/s = ms^{-1}$)

u HAS A UNIT OF ms^{-1} ($u = d/t = m/s = ms^{-1}$)

2 HAS A UNIT OF 'Nil' (a number)

a HAS A UNIT OF of ms^{-2} ($a = v/t = ms^{-1}/s = ms^{-2}$)

s HAS A UNIT OF m

S.I unit of $v^2 = u^2 + 2as$

$= (ms^{-1})^2 = (ms^{-1})^2 + 2\ ms^{-2} \times m$

$=m^2s^{-2} \quad = m^2s^{-2} + m^2s^{-2}$

Unit of each term on the right hand side is the same as that of the term on left hand side. Hence given relation is correct

We can check the homogeneity of physical equations by using Dimensions formula:

Dimensions: The powers, to which the fundamental units of mass, length and time written as M, L and T are raised, which include their nature and not their magnitude.

For example

Area = Length ×Breadth $[L^1] \times [L^1]=[L^2]=[M^oL^2T^o]$

Power (0,2,0) of fundamental units are called dimensions of area in mass, length and time respectively. e.g. Density = mass/volume

$= [M]/[L^3] \quad = [M^1L^{-3}T^0]$

Dimensional Formula: An expression along with power of mass, length & time which indicates how physical quantity depends upon fundamental physical quantity.

e.g. Speed = Distance/Time

$= [L^1] / [T^1] =[M^oL^1T^{-1}]$

It tells us that speed depends upon L & T. It does not depends upon M.

Dimensional Equation: An equation obtained by equating the physical quantity with its dimensional formula is called dimensional equation.

The dimensional equation of area, density & velocity are given as under-

Area = $[M^0L^2T^0]$ Density = $[M^0L^{-1}T^0]$ V elocity = $[M^0L^1T^{-1}]$

For example

Derive the dimensional formula of following Quantity & write down their dimensions. i. Density ii. Power

Sol. i. Density = mass/volume

$= (M]/(L^3] = [M^1L^{-3}T^0]$

ii. Power = Work/Time

= Force × Distance/Time

$= [M^1L^1T^{-2}]\times[L]/[T]$

$= [M^1L^2T^{-3}]$

Principle of homogeneity of dimensions

It states that the dimensions of all the terms on both sides of an equation must be the same. According to the principle of homogeneity, the comparison, addition & subtraction of all physical quantities is possible only if they are of the same nature i.e., they have the same dimensions.

If the power of M, L and T on two sides of the given equation are same, then the physical equation is correct otherwise not. Therefore, this principle is very helpful to check the correctness of a physical equation.

Example: A physical relation must be dimensionally homogeneous, i.e., all the terms on both sides of the equation must have the same dimensions.

In the equation, $S = ut + ½ at^2$

The length (S) has been equated to velocity (u) & time (t), which at first seems to be meaningless, But if this equation is dimensionally homogeneous, i.e., the dimensions of all the terms on both sides are the same, then it has physical meaning. Now, dimensions of various quantities in the equation are:

Distance, $S = [L^1]$

Velocity, $u = [L^1T^1]$

Time, $t = [T^1]$

Acceleration, $a = [L^1T^{-2}]$

1/2 is a constant and has no dimensions.

Thus, the dimensions of the term on L.H.S. is $S=[L^1]$ and

Dimensions of terms on R.H.S.

$$ut + \frac{1}{2}at^2 = [L^1 T^{-1}] [T^1] + [L^1T^{-2}] [T^2] = [L^1] + [L^1]$$

Here, the dimensions of all the terms on both sides of the equation are the same.

Therefore, the equation is dimensionally homogeneous.

Project Work

1. Collect some examples of variables in everyday life and discuss them with your classmates. How do you define them as independent variables, dependent variables, and control variables? Try writing out all three variables in a sentence like you discussed with your classmate, and check that they are all the right definitions.
2. Find the different units that were being used in the past and now to measure various physical quantities and write them in tabular form as given below. Which are more reliable one ? Present them with reason.

Physical Quantities	Units used in the past	Units being used now
Lenght		
Mass		
Time		

3. In your copy, write any ten physical equations or formulas used in physics. For this, you can use this science book. Now check the correctness of the formulas you have collected and present them in the classroom.s

Exercise

A. Choose the correct answers the followings :–

i) In science, a _________ is any factor, trait, or condition that can exist in differing amounts or types.
   a. fundamental unit b. derived unit c. variable d. physical eqation

ii. How many types of variables
   a. Five b. Four c. Three d. Two

iii. Which is correct for independent variable ?
   a. variable affected by the change
   b. the variable that is changed or controlled in a scientific experiment

c. quantities that a scientist wants to remain constant

d. anything that can change or be changed within an experiment

iv. Which of the following unit is not a fundamental unit :

a. second b. metre c. Newton d. kilogram

v. Which is not correct :

a. area = m^2 b. velocity =m/kg c. density=kg/m^3 d. acceleration=ms^{-2}

vi. Which of the following is a correct unit of force ?

a. $kgm^{-1}s^{-2}$ b. kgm^2s^{-2} c. $kgms^{-2}$ d. kgm^2s^{-3}

vii. Which of the following is a correct unit of Temperature ?

a. Ampere b. Candela c. Mole d. Kelvin

B. Name the physical quntities which are measured in the given units :

i. N ii. W iii. J iv. Pa

v. Cd vii. K viii. A

C. Write the fundamental unit of following physical quntities :

a. Mass b. Time c. Electric current

d. velocity of light e. Length

D. Name the physical quantity related to the following unit. How are they related to fundamental unit ?

i. Joule ii. Pascal iii. Watt iv. Newton v. Hertz

E. For each experiment, write down the independent variable (IV), dependent variable (DV), and control.

i. Sushant wanted to figure out what type of liquid worked best for growing beans. He watered on with coca-cola, one with lemonade and one with just water. After a week, he measured how high they had grown.

a. Independent Variable (IV).: ____________________

b. Dependent Variable (DV): ____________________

c. Control : ____________________

ii. Naresh wanted to find out what fertilizer worked best for growing marigold. He put Miracle Grow on one, Urea fertilizer on one, and no fertilizer on another.

a. Independent Variable iv.: ____________________

b. Dependent Variable (DV): ____________________

c. Control : ____________________

iii. Monica wanted to see if eating apples would help her do better on her classwork. The first day, she didn't eat apples. On day 2,she ate one apple ;on day 3, she ate 2 apples;and on day 4, she ate 3 apples. Each day, she recorded the grades she got on her science work.

a. Independent Variable (IV): ____________________

b. Dependent Variable (DV): ____________________

c. Control : ____________________

iv. Saurav wanted to find out what toothpaste made teeth the cleanest. Everyday he brushed his teeth with different product and then took a plaque test to see how much plaque was left. He used Crest, Colgate, Close-up, and water.

a. Independent Variable (IV): ____________________

b. Dependent Variable (DV): ____________________

c. Control : ____________________

F. Answer the following questions.

i. What are Variables?
ii. How many types of variables ? Write down their names too.
iii. Define a Independent variable.
iv. What do you mean by dependent variable ?
v. What is control variable ?
vi. Find out the independent variable, dependent variable, and control variable of the following statements:
   a. Pillbugs are placed in a container where they have a choice of a wet or a dry environment. Researchers record how much time was spent on each side.
   b. A stapler is used to staple 100 papers, it jams 5 times during the trial. A different brand of stapler performs the same test; it jams 22 times.
   c. Cockroaches are exposed to a pesticide. After 3 hours, 95% of the insects are dead.
   d. Two plants are grown using the same light and pots. One plant is given water that has been microwaved and the other plant is given regular tap water. Their height is measured after 2 weeks.
   e. The blood pressure of a soldier is measured while he is resting. The soldier is then exposed to a stressful environment and his blood pressure is measured again.
   f. An apple is cut into slices. Half of the slices are sprayed with lemon juice. All slices are stored in a sealed plastic bag. After 4 days, they are observed to see how brown they turned.
   g. The respiration rate of a goldfish is measured. The goldfish is then placed in cold water and the respiration rate is measured again.
   h. Bacteria are grown in a petri dish. One side of the dish is sprayed with an antibiotic. After a week, the number of bacteria colonies are counted on each.
vii. Define a fundamental unit.
viii. What are the fundamental unit in S.I system ? Name them along with their symbols.
ix. Explain the meaning of the derived unit with the help of one example ?
x. Classify the following units into fundamental and derived units.

a	Kelvin (K)
b	Newton(N)
c	Pascal (Pa)
d	Mole (mol)

e	Second (s)	
f	Volt (V)	
g	Hertz(Hz)	
h	Kilogram(kg)	

xi. Write the alternative name for the following units
   a. Newton per kilogram : ______________________________
   b. Newton meter : ______________________________
   c. Joules per second : ______________________________
   d. Newton per meter squared: ______________________________
   e. Kilogram-meter per second squared : ______________________________
xii. Write down the differences between the fundamental unit and derived unit.

H. Calculations :

i. Check the correctness of the physical equation $s = \frac{v+u}{2} \times t$. In the equation, s is the displacement, v is the final velocity, u is the initial velocity and t is the time .

ii. Check the correctness of the physical equation $s = \frac{v^2-u^2}{2a}$. In the equation, s is the displacement, v is the final velocity, u is the initial velocity and a is the acceleration.

iii. Check the correctness of the physical equation $v = u + at$. In the equation, v is the final velocity, u is the initial velocity, a is the acceleration and t is the time.

iv. Check the correctness of the physical equation $v^2 = u^2 + 2gh$. In the equation, v is the final velocity, u is the initial velocity, g is the acceleration and h is the height.

v. Urmila says that the formula for power (P) is mv^2, and the formula for pressure (P) is mv/A. Validity check of Urmila's formula from unit analysis?

I. Diagrammatic questions

i. Find out the variables as colour or flavour and size in the following diagram.

a. The variable is ______________________

b. The variable is ______________________

c. The variable is ______________________

ii. Which type of variable is shown in the following figure ? Write an appropriate reason too.

the factor measured in an experiment

iii. Identifying variables : If fertilizer is used on a plant, then the plant will grow bigger in size. Write the name of the variable with appropriate clues which are given in the table.

The amount of fertilizer used measured in grams	Growth of the plant(height.	Same size pot for each plant, Same type of plant Same type of soil Same amount of water

Chapter 2

Classification of Living Beings

Total Estimated pariods (Th. 7+ Pr. 2=9)

Student's Learning Outcomes

After studying this unit, the students will be able to :

- classifying plants and animals according to the five kingdom systems and describing the characteristics of their divisions or phylums with examples
- classifying angiosperm subdivisions and comparing them between classes
- classifying subphylum Vertebrata into classes and compare them
- explain the relationship between evolution and the classification of organisms

Robert Harding Whittaker (December 27, 1920 – October 20, 1980) was an American plant ecologist, active in the 1950s to the 1970s. He was the first to propose the five kingdom taxonomic classification of the world's biota into the Animalia, Plantae, Fungi, Protista, and Monera in 1969. During the late twentieth century, Robert Whittaker's five-kingdom system was a standard feature of biology textbooks, serving as an important organizing scheme for discussing biodiversity. The five-kingdom system was only a minor part of his work, it reflected two of Whittaker's fundamental interests. The first was the structure and function of communities and ecosystems.

2.1 Introduction

The system of assembling organisms into groups or sets on the basis of likenesses and variances is called classification. It simplifies the study of a wide variety of organisms in a very systematic manner.

R.H. Whittaker proposed the five-kingdom classification in 1969. This classification was based upon certain characters like mode of nutrition, thallus organization, cell structure, phylogenetic relationships and reproduction. This form of kingdom classification includes five kingdoms Monera, Protista, Fungi, Plantae and Animalia.

The five-kingdom classification that we see today was not the initial result of the classification of living organisms. Carolus Linnaeus first came up with a two-kingdom classification, which included only kingdom Plantae and kingdom Animalia.

The two-kingdom classification lasted for a very long time but did not last forever because it did not take into account many major parameters while classifying. There was no differentiation of the eukaryotes and prokaryotes; neither unicellular and multicellular; nor photosynthetic and the non-photosynthetic.

Putting all the organisms in either plant or animal kingdom was insufficient because there were a lot of organisms which could not be classified as either plants or animals.

All this confusion led to a new mode of classification which had to take into account cell structure, the presence of cell wall, mode of reproduction and mode of nutrition. As a result, R H Whittaker came up with the concept of the five-kingdom classification.

The five-kingdom classification of living organisms included the following kingdoms:

Kingdom Monera

Bacteria are categorized underneath the Kingdom Monera. Bacteria occur everywhere and they are microscopic in nature. They possess a cell wall and are prokaryotic.The cell wall is formed of amino acids and polysaccharides. Bacteria can be heterotrophic and autotrophic. The heterotrophic bacteria can be parasitic or saprophytic. The autotrophic bacteria can be chemosynthetic or photosynthetic.

Types of Monerans

Bacteria can be classified into four types based on their shape:
Coccus (pl.: cocci) – These bacteria are spherical in shape
Bacillus (pl.: bacilli) – These bacteria are rod-shaped
Vibrium (pl.: vibrio) – These bacteria are comma-shaped bacteria
Spirillum (pl.: spirilla) – These bacteria are spiral-shaped bacteria
Monera has since been divided into Archaebacteria and Eubacteria.

Kingdom Protista

Protista are unicellular and eukaryotic organisms. Some of them have cilia or flagella for mobility.Sexual reproduction is by a process of cell fusion and zygote formation. Kingdom Protista is categorized into subsequent groups:
Chrysophytes: The golden algae (desmids) and diatoms fall under this group. They are found in marine and freshwater habitats.
Dinoflagellates: They are usually photosynthetic and marine. The colour they appear is dependent on the key pigments in their cells; they appear red, blue, brown, green or yellow.
Euglenoids: Most of them live in freshwater habitation in motionless water. The cell wall is absent in them, instead, there is a protein-rich layer called a pellicle.
Slime Moulds: These are saprophytic. The body moves along putrefying leaves and twigs and nourishes itself on organic material. Under favourable surroundings, they form an accumulation and were called Plasmodial slime moulds.
Protozoans: They are heterotrophs and survive either as parasites or predators.

Kingdom Fungi

The kingdom fungi include moulds, mushroom, yeast etc. They show a variety of applications in domestic as well as commercial purposes. The fungi are filamentous, excluding yeast (single-celled).Their figure comprises slender, long thread-like constructions called hyphae. The web of hyphae is called mycelium. Some of the hyphae are unbroken tubes which are jam-packed with multinucleated cytoplasm. Such hyphae are labelled Coenocytic hyphae. The other type of hyphae has cross-walls or septae.The cell wall of fungi is composed of polysaccharides and chitin. Most of the fungi are saprophytes and are heterotrophic. Some of the fungi also survive as symbionts. Some are parasites. Some of the symbiont fungi live in association with algae, like lichens. Some symbiont fungi live in association with roots of higher plants, as mycorrhiza.

Kingdom Plantae

The kingdom Plantae is filled with all eukaryotes which have chloroplast. Most of them are autotrophic in nature, but some are heterotrophic as well. The Cell wall mainly comprises cellulose. Plants have two distinct phases in their lifecycle. These phases alternate with each other. The diploid saprophytic and the haploid gametophytic phase. The lengths of the diploid and haploid phases vary among dissimilar groups of plants. Alternation of Generation is what this phenomenon is called.

Kingdom Animalia

All multicellular eukaryotes which are heterotrophs and lack cell wall are set aside under this kingdom. The animals are directly or indirectly dependent on plants for food. Their mode of nutrition is holozoic. Holozoic nutrition encompasses ingestion of food and then the use of an internal cavity for digestion of food. Many of the animals are adept for locomotion. They reproduce by sexual mode of reproduction.

The five-kingdom classification of living organisms took a lot into consideration and is till now the most efficient system. The older system of classification was based only on one single characteristic according to which two highly varied organisms were grouped together. For example, the fungi and plants were placed in the same group based on the presence of the cell wall. In the same way, unicellular and multicellular organisms were also grouped together.

Therefore, all the organisms were classified again into the five kingdoms known as the five-kingdom classification, starting with Monera, where all the prokaryotic unicellular organisms were placed together.

Following that, all the eukaryotic unicellular organisms were placed under the kingdom Protista.

The organisms were then classified based on the presence and absence of a cell wall. The ones without the cell wall were classified under kingdom Animalia and the ones with cell wall were classified under kingdom Plantae. The organisms under kingdom Plantae were further classified into photosynthetic and non-photosynthetic, which included Plantae and fungi respectively.

2.1 Classification of plant kingdom

The Plant Kingdom is defined as a multicellular, eukaryotic living organism where the cell wall contains chlorophyll, imparting green color to the plants. They are autotrophic as they can prepare their own food by photosynthesis. The cell wall of cell are made up cellulose. It includes both flowering and non flowering plants. Broadly, the plant kingdom is divided into two classifications:

i. **Cryptogams:** The plants **that reproduce by spores without flowers or seeds**. The reproductive organs are not visible.Examples of cryptogam are mosses, ferns, liches, algae and so on.

ii **Phanerogams:** The plants that have reproductive organs, flowers and seeds. The reproductive organs are clearly visible. Examples of Phanerogams are mango, conifers, banyan dicot and so on.

Furthermore, it is divided into:

i. Algae	ii. Bryophytes	iii. Tracheophyta
a. Pteridophytes	b. Gymnosperms	c. Angiosperms

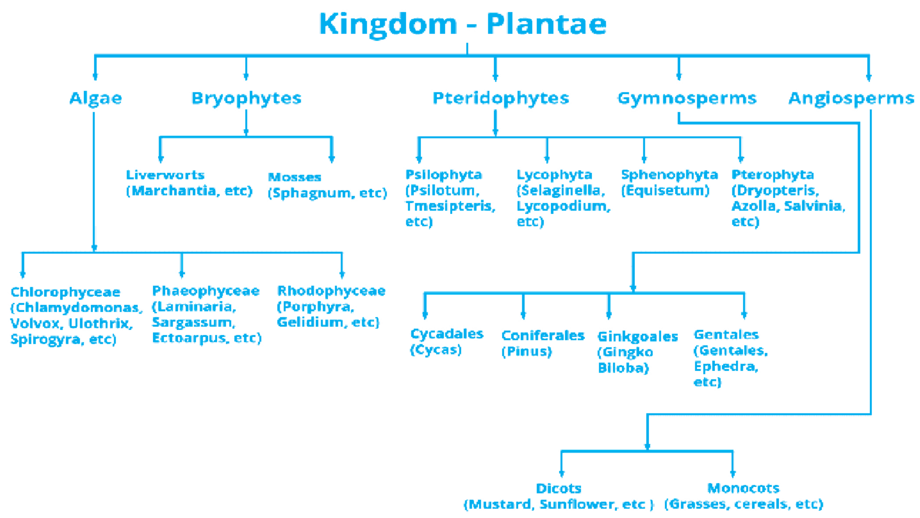


Fig. 2.1

i. Algae

These plants are most primitive and the simplest green plants. They have a simple thallus-like body which has numerous commercial benefits. They are of three types: Red, Brown and Green Algae. Algae are sources of nutrition in some countries (*Sargassum)* and also a rich source of iodine (*Fucus).*

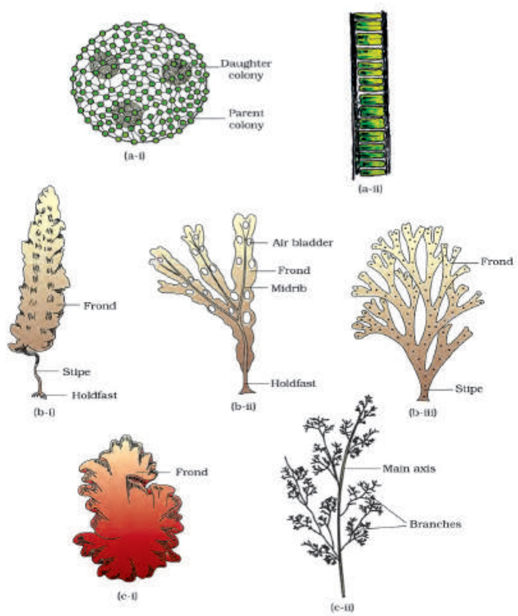


Fig. 2.2

Figure Algae :

a. Green algae

i. Volvox ii. Ulothrix

b. Brown algae

i. Laminaria ii. Fucus iii. Dictyota

c. Red algae

i. Porphyra ii. Polysiphonia

Characteristics of algae:

1. The body is unicellular, filamentous, or parenchymatous, colonial.
2. Algaes do not have any vascular tissue.
3. The plant body belongs to thallus style.

4. Algae are usually found in aquatic areas, but a few of them are found in moist terrestrial habitats such as moist soil and wet rocks.
5. They reproduce in the following ways:
    - Vegetative fragmentation
    - Asexually by zoospores
    - Sexually by Isogamous or Oogamous or Anisogamous

    Examples : Chlamydomonas, Spirogyra, Volvox, Ulothrix, Nostoc etc.

ii. Bryophytes

They are also called as amphibians of the plant kingdom as they grow in moist and shady regions. They live on soil and require water for reproduction, just like the amphibians of the animal kingdom.

Bryophytes - Examples

Riccia   Marchantia   Sphagnum   Polytrichum

Fig. 2.3

1. The Characteristics of Bryophytes in plant kingdom is as follows:
2. They majorly grow on rocks, walls, and damp soil.
3. The body type is free-living and does not contain any roots.
4. They have "rhizoids" instead of roots which helps the plant to anchor to surface.
5. They reproduce by following methods:
    - Vegetative reproduction by tubers, buds, and fragmentation
    - Asexual reproduction is through gammae, a specialized reproduction structure.
    - Sexual reproduction is between males (antheridium) and females (archegonium).

    Examples : Liverworts, Mosses, Riccia, Marchantia etc.

iii. Tracheophyta

This division includes higher and developed plants. They bear vascular tissues i.e.xylem and phloem. This divisions is further divided into three sub-divisions viz: pteridophyta, gymnosperm and angiosperm.

a. Pteridophytes

Pteridophytes (pteron= feather, phyton= plant, i.e. plants with feather like leaves). Before the flowering plants, the landscape was dominated with plants that looked like ferns for hundreds of millions of years. Pteridophytes show many characteristics of their ancestors. Unlike most other members of the Plant Kingdom, pteridophytes don't reproduce through seeds, they reproduce through spores instead. These are vascular plants with differentiated parts like roots, leaves, and stems. They are further classified into Psilopsida, Lycopsida, Sphenopsida, Filicopsida.

Peteridophytes - Examples

Psilotum

Selaginella

Pteris

Adiantum

Fig. 2.4

Characteristics of Pteridophytes:

1. They contain the vascular system. However, companion cells, xylem vessels, and sieve tubes are absent.
2. They have leaf-like appendages that extend the sporangia of the plant. These appendages are called sporophylls.
3. They are cryptogams and seedless.
4. They reproduce by the following methods:
   - The mother cells undergo meiosis to produce spores, which germinates to produce thallus.
   - Sexual reproduction in water conditions, where male organs called antheridia and female organs called archegonia fertilizes.
5. They show true alternation of generations.
   The sporophyte generation and the gametophyte generation are observed in Pteridophytes. The diploid sporophyte is the main plant body.
   Examples : Fern, horse tail, Whisk Fern, Dicksonia,Selaginella, Lycopodiu, Equisetum, Pteris, Dryopteris, Adiantum, Man fern, Silver fern etc.

b. Gymnosperms

Fig. 2.5

Gymnosperms are flowerless plants that produce cones and seeds. The term gymnosperm literally means "naked seed," as gymnosperm seeds are not encased within an ovary. Rather, they sit exposed on the surface of leaf-like structures called bracts. Gymnosperms are vascular plants of the subkingdom Embyophyta and include conifers, cycads, ginkgoes, and gnetophytes. Some of the most recognizable examples of these woody shrubs and trees include pines, spruces, firs, and ginkgoes. Gymnosperms are abundant in temperate forest and boreal forest biomes with species that can tolerate moist or dry conditions.. They are believed to be the first vascular plants to inhabit land appearing in the Triassic Period around 245-208 million years ago. The development of a vascular system capable of transporting water throughout the plant enabled gymnosperm land colonization. Today, there over one thousand species of gymnosperms belonging to four main divisions: Coniferophyta, Cycadophyta, Ginkgophyta, and Gnetophyta.

Characteristics of Gymnosperms:

1. They have branched stems (*Pinus)* and unbranched (*Cycas)*. Their roots are generally tapping roots and, in some genera, have mycorrhiza, a form of fungal association (*Pinus)*, while some have specialized roots (*Cycas)*, and a few have nitrogen-fixing bacterial roots called coralloid roots.

2. The leaves are simple or compound. The *Cycas* have pinnate leaves for a few years, while in *Conifers*, the leaves have a needle-like structure with reduced surface area. The leaves are well-developed and adapt to varying climatic conditions. The leaves have a sunken stoma, which reduces water loss from the surface of the leaves.
3. The ovary is not enclosed inside the ovary wall and is always exposed.
4. They reproduce by following methods:

   - Produces haploid microspore and megaspore.
   - The male and female do not have an independent existence.
   - The transfer of pollens (pollination) is via air, and the zygote develops into embryos. The embryos then develop into naked seeds.

   Examples : Cycas, Pinus,Araucaria,Thuja,Cedrus,Picea,Abies,Juniperus, Larix etc.

c. Angiosperms

Angiosperms are vascular plants with stems, roots, and leaves. The seeds of the angiosperm are found in a flower. These make up the majority of all plants on earth. The seeds develop inside the plant organs and form fruit. Angiosperm is also called flowering plant, any of about 300,000 species of flowering plants, the largest and most diverse group within the kingdom Plantae. Angiosperms represent approximately 80 percent of all the known green plants now living.

Angiosperms are the most advanced and beneficial group of plants. They can grow in various habitats as trees, herbs, shrubs, and bushes. The plants have flowers, where the male and female organs are developed into separate structures, and pollination occurs through air or insects.

Characteristics of Angiosperms:

i. They are found in water and land.
ii. They have seeds enclosed in fruits.
iii. They are mostly bisexual.
iv. Pollination takes place with the help of wind, water and animals.
v. They have flat and broad leaves.
vi. They have well- developed flowers that produce fruits.

Examples : Wheat, rice, apple, tomato, lotus, maize etc are the examples of angiosperms. Angiosperms are further divided into two classes on the basis of the number of cotyledons in the seeds. They are.

i. Monocotyledon, and ii. Dicotyledon

Class: Monocotyledon

i. They have single cotyledon in their seeds.
ii. They have long narrow leaves with parallel venation.
iii. Stems are generally hollow with nodes.
iv. They have fibrous root system.
v. They are found in both water and land.
vi. Maize, sugarcane, wheat, bamboo, rice etc. are some examples of monocotyledons.


Maize Sugarcane

Fig. 2.6

Class: Dicotyledon


Mustard


Pea

Fig. 2.7

i. They have two cotyledons in their seeds.
ii. They have flat and broad leaves with reticulate venation.
iii. They have tap root system.
iv. The stems have vascular bundles arranged in a ring.
v. The stems may be strong and weak.
vi. Mustard, pea, beans, sunflower, mango, gram, pumpkin, etc are some examples of dicotyledons.

Difference between Monocotyledons and Dicotyledons

Monocotyledons	Dicotyledons
i. The have single cotyledon in their seeds.	i. They have two cotyledons in their seeds.
ii. They have fibrous rood.	ii. They have tap root.
iii. Vascular bundles are scattered in the stem.	iii. Vascular bundles arranged in a ring.
iv. Their leaves have parallel venation. e.g. Maize, rice, wheat etc.	iv. Their leaves have reticulate venation e.g. Gram, mango, orange etc.

Difference between Gymnosperm and Angiosperm.

Gymnosperm	Angiosperm
i. They bear cones instead of true flower.	i. They have well developed flowers.
ii. They have naked seeds.	ii. They have enclosed seeds in the fruits.
iii. They are usually unisexual.	iii. They may be unisexual or bisexual.
iv. They are shrubs and trees.	iv. They are herbs, shrubs and trees.

Example of classification of plants

i. Spirogyra

Kingdom : Plantae
Division: Algae
Type: *Spirogyra*

ii. Pine

Kingdom: Plantae
Division: Tracheophyta
Sub- Division : Gymnosperms
Type: Pine

iii. Fern

Kingdom: Plantae
Division: Tracheophyta
Sub- division: Pteridophyta
Type: Fern

iv. Mustard

Kingdom: Plantae
Division: Tracheophyta
Sub- division: Angiosperms
Class: Dicotyledon
Type: Mustard.

Activities 2.1

i. Collect different plants near your home or in the school garden. The plants you collect should include flowering and non-flowering plants. Separate those plants into angiospermic and non-angiosperic and let them fill up the table given below:

S.N.	Angiospermic plants with local names	Non-angiospermic plants with local names
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		

ii. Collect different plants such as maize, wheat, paddy, pea, gram,mustard, etc. with roots, stems, and flowers from near your home or agriculture farm. Distinguish dicotyledonous plants from monocotyledous plants with the features given below :

Parts of Plants	Dicotyledonous Plants	Monocotyledonous Plants
Roots		
Stem		
Leaves		
Flowers		

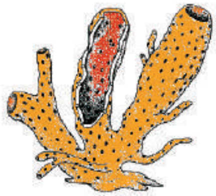
2.2 Kingdom : Animalia

Multicellular animals are classified into two major groups on the basis of absence or presence of backbone- invertebrates and vertebrates.

Invertebrate : Invertebrate, any animal that lacks a vertebral column, or backbone, in contrast to the cartilaginous or bony vertebrates. More than 90 percent of all living animal species are invertebrates. Invertebrates are generally soft-bodied animals that lack a rigid internal skeleton for the attachment of muscles but often possess a hard outer skeleton (as in most mollusks, crustaceans, and insects) that serves, as well, for body protection.

a. Phylum: Porifera (Pore bearer)

i. They are the first multi cellular animals.
ii. Their body surface has numerous tiny pores called ostia.
iii. They are called sessile as they are attached to the stone or rock at the bottom of sea and can not move.
iv. Water enters inside the body through ostia and passes out through osculum.
v. Their body consists of two layers- endoderm and ectoderm. So, they are called diploblastic animals.



Sponge
Fig. 2.8

vi. They reproduce by both sexual and asexual methods. Sycon, sponge, spongilla, etc. are the examples of porifera.

b. Phylum: Coelenterate (Hollow cavity)


Hydra


Jelly fish

Fig. 2.9

i. Their body has hollow cavity called coelenterons.
ii. They have mouth but no anus.
iii. They are diploblastic animals.
iv. Mouth is surrounded by tentacles which helps them for locomotion and capturing the prey.
v. They have stinging cells called nematocyst (endoblast) responsible for offence and defense.
vi. Reproduction takes place by both sexual and asexual methods.
vii. Hydra, sea anemone, jelly fish, coral, obelia etc. are some examples of coelenterate.

Phylum coelentenata is classified into three classes. They are

hydrozoa e.g. Hydra, Obelia (sea fur), Physalid (portugese man of war) etc.

Scyphozoa e.g. - Aurelid (Jelly fish)

Anthozoa e.g. - Adamsia (sea anemone), corals

C. Phylum: Platyhelminthes (Flat body)

i. They have dorso - ventral flat body like a leaf or a tape.
ii. Their head contains hook for attachment and sucker for absorption of blood from the host.
iii. They are triploblastic animals because the body contains three layers- endoderm, mesoderm and ectoderm.
iv. They are called hermaphrodites as male and female sex organs are present in the same individual.
v. They are usually parasites, some of them may be free- living.
vi. They have no respiratory and circulatory systems.
vii. They reproduce by both sexual and asexual methods.
viii. Tapeworm, liver fluke, planarian, blood fluke etc. are some examples of platy helminthes.

Triploblastic : Animals whose body is made up of three layers namely: ectoderm, mesoderm and endoderm are called triploblastic animals.

The phylum platyhelminthes is classified into three classes. They are

Turbellarid e.g. Planaria

Trematoda e.g. : *Fasciola hepatica* (Sheep, liver fluke)

cestoda e.g. : *Taenia solium* (pork tapeworm)


Liver fluke


Tapeworm

Fig. 2.10

d. Phylum: Nemathelminthes (Round body)

i. They have cylindrical elongated and unsegmented body.
ii. They are usually unisexual.
iii. Both mouth and anus are present in their body.
iv. Their body is bilaterally symmetrical and covered with thick cuticle.
v. The circulatory and respiratory systems are absent in their bodies.
vi. They reproduce by sexual method only.
vii. They are mostly parasitic but some of them are free-living too.

viii. Ascaris, Pinworms, hookworms etc. are some examples of nemathelminthes.

The phylum nemathelminthes is classified into five classes. They are rotifera, gastrotricha, kinorhycha, nematomorpha and nematoda.

The class nematoda is divided into two groups. They are

phasmida e.g. Ascaris (roundworm), Wuchereria (filarial worm) etc.

Aphsmida, e.g. Rotifers (Thread worm)

Roundworm *Hookworm*

Fig. 2.11

e. Phylum; Annelida (Ring like worms)

i. They have cylindrical elongated and segmented body.
ii. Moist skin which helps them in reproduction.
iii. They are triploblastic and bilaterally symmetrical.
iv. They have well developed alimentary canal, circulatory and nervous systems.
v. They are mostly unisexual but earthworm is bisexual (hermaphrodite).
vi. Excretion takes place through nephrone.
vii. Locomotion takes place through setae, sucker.
viii. Earthworm, leech, nerris, etc. are some examples of annelida.

The phylum annelida is classified into four classes. They are

Polychaeta e.g. Nereis

Oligochaeta e.g. Earthworm

Hirutinea e.g. : Leech

Archiannelida e.g. : Poligordius

Earthworm *Leech*

Fig. 2.12

f. Phylum: Arthropoda (Jointed legs)

i. They have generally three parts of joined legs and two parts of wings.
ii. Body is divided into head thorax and abdomen.
iii. Head contains compound eyes and antennae.
iv. Sexes are separate.
v. Respiration takes place through gills or trachea.
vi. They have well developed mouthparts for suckling, piercing and chewing.
vii. Their life cycle completes in four stages : egg, larva, pupa, and adult.
viii. Their body is covered externally with exoskeleton.
ix. Butterfly, prawn, spider, crab, Lobster, silkworm, bee, mosquito, scorpion, etc are some examples of arthropoda.

The phylum arthropoda is the most diversified group of animals, which are divided into four classes. They are

Crustacea e.g. prawn

Insecta e.g. butterfly

Myriapoda e.g. : millipede

Arachnida e.g. spider

Butterfly *Spider*

Fig. 2.13

Arthropoda is the largest phylum of invertebrates because they are found in all different types of habitat: air water and land and produces a large number of youngs.

g. Phylum : Mollusca (Soft body)

i. They have soft body covered with hard shell made up of calcium carbonate.
ii. Respiration takes place through gills or lungs.
iii. They are unisexual.
iv. Head contains mouth, eyes, tentacles and other sense organs.
v. They have muscular feet for creeping and swimming.
vi. They have well developed digestive, excreting, nervous and blood vascular systems.

Slug, octopus snail, cuttlefish, unio, etc. are some example of mollusca.
The phylum mollusca is classified into 7 classes. They are
Gastropoda e.g. slug, Pila (Apple snail)
Scaphoda e.g. Dentalium (elephant's tusk shell)
Pelecypoda e.g. unio (Fresh water mussel)
Cephalopoda e.g. Sepia (cuttle fish)
Aplacophora e.g. Neomenia
Monoplacophora e.g. Neopillina (living fossel)
Polyplacophora e.g. chiton


Snail


Octopus

Fig. 2.14

h. Phylum: Echinodermata (Spiny skinned)

i. They have thorny or spiny body.
ii. They are marine animals.
iii. They do not have distinct head.
iv. They are unisexual.
v. They have tube feet for locomotion.
vi. Their body is divided into oral (lower) and above (upper) sides.
vii. Their body may be star shaped, elongated or globular or like a flower.
viii. They reproduce through sexual method.
ix. Their mouth is located on the oral side and anus on the amoral side.

Starfish, sea- urchin, sea- cucumber, sea lily etc. are the examples of echinodermata.
The phylum echinodermata is classified into five classes. They are


Starfish


Sea-urchin

Fig. 2.15

Asteroidea e.g. Starfish
Ophiuroidea e.g. Ophioderma
Echinoidea e.g. Echinus
Holothuroidea e.g. Helothuria
Crioidea e.g. sea lily

i. Phylum : Chordata

Animals with backbones are called vertebrates. They are the most advanced group of animals. They belong to phylum chordata and sub-phylum vertebrata. The phylum chordata has four sub-phyla. They are Hemichordata, Urochordata, Cephalochordata and vertebrata.

i. They have notocord at the embryonic stage. It is replaced later by backbone in higher animals but it persists throughout the life in lower organisms.

ii. Body is bilaterally symmetrical with distinct triploblastic body wall.
iii. They have well developed heart placed ventrally.
iv. They have red blood due to presence haemoglobin.
v. Breathing takes place through gills or lungs.
vi. They have well developed brain and spinal chord.
vii. They have closed circulatory system.
viii. They have internal skeleton covered with muscles and skins.

Sub-phylum : vertebrata

Among the four sub-phyla of chordata vertebrata is the most important. Animals of this sub-phylum are called vertebrata. They may be cold blooded or warm blooded.

i. Vertebrates have a vertebral column that supports the body.
ii. They have a nervous system with well developed brain. The brain is enclosed in a brain box called cranium.
iii. They have a postnatal tail and gill slits.
iv. Their heart is present at the ventral surface.
v. The circulatory system is of closed type. Blood is red in colour due to the prerence of iron containing pigment called haemoglobin (Hb).
vi. Pair of kindneys are the main excretory organs.
vii. They have a bilaterally symmetrical body and an endorkeleton.

Sub-phylum vertebrata is further divided into five classes. They are.

a. Pisces　　b. Amphibia　　c. Reptilia
d. Aves　　e. Mammalia

a. Pisces

They belong to fishes. They are the first vertebrates found in water.

i. They have flat elongated and boat shaped body.
ii. They are aquatic animals and body is covered with water-proof scales.
iii. Respiration takes place through gills.
iv. They are cold blooded animals.
v. They have two chambered heart. One auricle and one ventricle.
vi. They are oviparous and fertilization is external.
vii. They have fins for locomotion and balancing body. For example, Rohu, sea- horse, shark, eel, etc.


Fish


Seahorse

Fig. 2.16

b. Amphibia

They are the first land vertebrates. They live on both land and in water. They need water to lay eggs and for early development of their life.

i. They live both on the land and in water.
ii. They are cold blooded animals with three chambered heart.
iii. Gills are the respiratory organs in tadpole stage and skin and lungs in adult stage.
iv. They are oviparous and fertilization is external.
v. They have two pairs of limbs for walking or jumping on the land and swimming in water.


Frog


Salamander

Fig. 2.17

vi. Their body is covered with thin, soft and most skin.

For example, frog, salamander, toad, hyla etc.

c. Reptilia

They are the first fully land vertebrates. They crawl on the ground.

i. Their body is divided into head, trunk and tail.
ii. They heave two parts of limbs except snakes.
iii. Respiration takes place through lungs.
iv. They are oviparous and fertilization is internal.
v. Their body is covered with hard, dry and horny scales.
vi. They are cold blooded animals.
vii. They have three chambered heart (except crocodile which has four chambered heart).

Snake Wall lizard

Fig. 2.18

For examples, snakes, crocodile, wall-lizard, tortoise, turtle etc.

d. Aves

They show the aerial mode of life. They are also called glorified reptiles.

i. Body is covered with feathers.
ii. Body is divided into head, neck, trunk and tail.
iii. Their fore limbs are modified into wings which help them to fly.
iv. They are warm blooded animals.
v. They have four chambered heart.
vi. They respire through lungs.
vii. They are oviparous and fertilization is internal.
viii. They have light and spongy bones filled with air called pneumatic bones.
ix. Mouth is surrounded by horny beak without teeth.

Sparrow Parrot

Fig. 2.19

For example : dove, parrot, pigeon, crow, crane, owl, eagle etc.

e. Mammalia

They are highly developed animals. They give direct birth to their young ones and suckle their breast.

i. They have mammary glands on their body.
ii. They are warm blooded animals.
iii. They have four chambered heart.
iv. They give direct birth to their young ones i.e. viviparous and fertilization is internal.
v. They have two pairs of limbs, generally each limb with five digits.
vi. They breathe through lugs.
vii. They have one pair of external ear called pinnae.
viii. Their body is divided into head, neck, trunk and tail.
ix. Their body is covered with hair and the skin is rich in glands.

Dolphin Cow Woman

Fig. 2.20

For example, Buffalo, cow, dog, horse, dolphin, elephant, man, woman, rabbit, etc.

Activities 2.2

i. Complete the following table :

Animal	Lives where? (land/sea/air)	Type of skin?	Size? (bigger/smaller than a person)	Kind of babies? (living or eggs)
cow	land	hide with short fur	bigger	live babies
bear				
fish				
bird				
whale				
horse				

ii. Collect names and pictures of 5–5 flowering, non-flowering, monocotyledon, and dicotyledon plants with the help of various means, including the internet and books. Draw the labelled figures and classify them according to their three characteristics.

iii. Collect the names and pictures of 5–5 vertebrates and invertebrates with the help of various means, including the internet and books.Draw the labelled figures and classify them according to their three characteristics.

iv. Get to know me-

a. I am diploblastic and acoelomate. Which phylum do I belong to ?

b. My body is radially symmetrical. Water vascular system is present in my body. I am referred as fish though I am not. What is my name?

c. I live in your small intestine. Pseudocoelom is present in my thread like body. In which phylum will you include me?

d. Though I am multicellular, there are no tissues in my body. What is the name of my phylum?

Examples of classification of invertebrates.

i. Hydra

Kingdom: Animalia Sub- Kingdom: Invertebrata Phylum: Coelenterata Type: Hydra

ii. Ascaris (Roundworm)

Kingdom: Animalia Sub- Kingdom: Invertebrata. Phylum: Nemathelminthes

Type: Ascaris

Examples of classification of some animals (Vertebrates)

i. Seahorse

Kingdom: Animalia Phylum: Chordata Sub- phylum : Vertebrata Class: Pisces Type: Sea horse

ii. Frog

Kingdom: Animalia Phylum: Chordata Sub - phylum : Vertebrata Class: Amphibia Type: Frog

Activities 2.3

i. Classified the following invertebrates:
Housefly, starfish, snail, spider,roundworm

ii. Classified the following vertebrates:
Snake, parrot, man, bat, frog, seahorse, catfish, cat

2.3 The relationship between evolution and the classification of living beings

Evolution and classification are two branches of biology. One deals with figuring out how organisms evolve, how new species are born from old ones, and classification deals with figuring out how closely related two species are.We know that biodiversity refers to the diversity of living things on earth. Scientists and taxonomists brought many new ideas for the classification of these species. Some are similar in their body design but differ in other characteristics. Where do these millions of species come from? Time had a role to play. Over thousands and millions of years, different species evolved from one or more ancestors. This is called evolution. Evolution took place and resulted in biodiversity.Let's learn more about classification and evolution. Classification is generally defined as the method of distinguishing and arranging different types of living and fossil species into a hierarchical, multi-level classification.

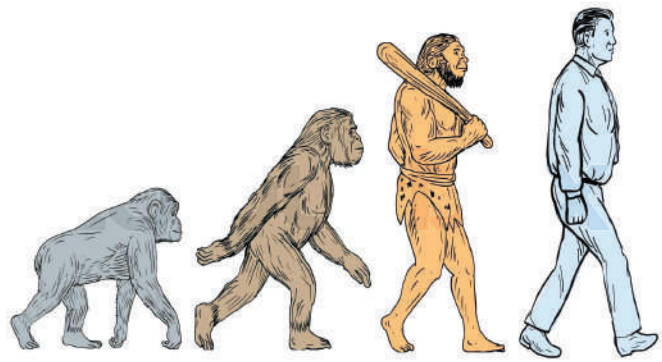


Fig. 2.21

According to Scientists' estimations, there are about 8.7 million living species, which is still increasing. Among these, some are known, while some are unknown. For the ease of study and identification of these organisms, they have been classified into different groups based on different criteria. This procedure of arranging the organisms in a hierarchical series of groups is termed Biological classification.There were different criteria to be followed in the arrangement of organisms into categories. Every classification started with a basic design, characteristics, similarities, dissimilarities, etc.

During the 18th century, most scientists had a wrong belief that both Earth and all the living organisms present on it had been created suddenly. The introduction of the modern taxonomy system by Carolus Linnaeus, it had changed all their thoughts and their view of evolution.

Evolution says that the life forms that exist today are better versions of early life forms. In 1859, 'The Origin of Species' a book by Charles Darwin mentioned the term evolution for the first time. According to Darwin's contribution to the theory of evolution, the organisms which existed years ago had undergone certain changes for better survival and new life forms have arisen from them.

Evolutions have laid an elementary stone or pathway for classification. Even though evolution took place, when we classify organisms, some sort of species still have their ancestry body designs. They didn't change completely. While another set of organisms developed a new advanced body design different from their ancestor. The former ones are called primitive or lower organisms and the latter group is called advanced or higher organisms. But these terms, do not justify the evolutionary differences. We can call primitive ones, 'older organisms' and advanced ones 'young organisms'. Older organisms have simple body designs while young organisms have complex body designs. Thus, evolution has resulted from simple older organisms to complex young organisms.The diversity of life on Earth today is the result of evolution. Life began on Earth at least 3.5 to 4 billion years ago, and it has been evolving ever since. At first, all living things on Earth were simple, single-celled organisms. Much later, the first multicellular organisms evolved, and after that, Earth's biodiversity greatly increased.

Evolution is a change in the characteristics of living things over time. As described by Darwin, evolution occurs by a process called **natural selection**. In natural selection, some members of a species, being better adapted or suited to their environment, produce more offspring than others, so they pass "advantageous traits" to their offspring. Over many generations, this can lead to major changes in the characteristics of the species. Evolution explains how living things are changing today and how modern living things have descended from ancient life forms that no longer exist on Earth. As living things evolve, they generally become better suited for their environment. This is because they evolve adaptations. An **adaptation** is a trait that helps an organism survive and reproduce in a given environment.

The method of arranging organisms into groups on the basis of similarities and differences is called classification. Evolution on the other hand refers to a slow, gradual and continuous process by which the previously existing organisms develop into existing living organisms.

Activities 2.4

Collect the tree diagram of organisms prepared based on the classification of Linnaeus through various means, including the internet. Have a group discussion about the tree diagram in the classroom, find out the answers to the following questions, and come to a conclusion. i. Which of the organisms belonging to Monera and Protista evolved first, and why?ii. How are the five kingdoms arranged in the tree diagram you have collected? Write a report on the relationship between evolution and the classification of organisms.

Evolution of Vertebrate Classes

Amphibians, reptiles, mammals, and birds evolved after fish. The first amphibians evolved from a lobe-finned fish ancestor about 365 million years ago. They were the first vertebrates to live on land, but they had to return to water to reproduce. This meant they had to live near bodies of water.The first reptiles evolved from an amphibian ancestor at least 300 million years ago. They laid amniotic eggs and had internal fertilization. They were the first vertebrates that no longer had to return to water to reproduce. They could live just about anywhere.ammals and birds both evolved from reptile-like ancestors. The first mammals appeared about 200 million years ago and the earliest birds about 150 million years ago.

Project Work

i. Make a chart of the classification of the plant kingdom and animal kingdom on cardboard paper and paste it in the classroom.
ii. Make any five plant samples (herbarium, musium specimens) and present them in the classroom with their kingdom, division, class, and characteristics.

Exercise

A. Choose the correct answers the followings :–

i. Who proposed the five-kingdom classification.
   a. R.H.Whitaker b. C.Linnaeus c. Charles Darwin d. James Watt.

ii. Classification was not based upon certain characters :
   a. mode of nutrition b. thallus organization
   c. cell structure d. Not phylogenetic relationships and reproduction.

iii. Bacteria are categorized underneath the Kingdom :
   a. Monera b. Fungi c. Plantae d. Animalia.

iv. The kingdom ______ is filled with all eukaryotes which have chloroplast.
   a. Monera b. Fungi c. Plantae d. Animalia.

v. All multicellular eukaryotes which are heterotrophs and lack cell wall are set aside under this kingdom:
   a. Fungi b. Monera c. Animalia d. Plantae

vi. Animal with soft body covered with hard shell velong to phylum:
   a. Annelida b. Mollusca c. Coelenterata d. Porifera

vii. Earthworm belongs to phylum:
   a. Annelida b. Arthopoda c. Echinodermata d. Porifera

viii. Which two characters out of (a)-(d) given below are common to dog, humans, squirrel, bat, camel and monkey?
   a. scales on the skin b. wings
   c. external ears d. give birth to young ones

ix. Which among the following produce seeds?
   a. Thallophyta b. Bryophyta c. Pteridophyta d. Gymnosperms

x. Which among the following have scales? i. Amphibians ii. Pisces iii. Reptiles iv. Mammals
   a. i. and iii. b. iii. and iv. c. ii. and iii. d. i. and ii.

xi. Find out the false statement
   a. Aves are warm blooded, egg laying and have four chambered heart
   b. Aves have feather covered body, fore limbs are modified as wing and breathe through lungs
   c. Most of the mammals are viviparous
   d. Fishes, amphibians and reptiles are oviparous

B. Rearrange the following phyla into their proper sequence on the basis of evolution. Write two proper examples of these phyla and classify them with lebell diagrammes.

Pisces, Amphibians, Mammals, Reptiles, birds and fish.

C. Complete the table :

Characters	Phylum	Any three examples
Soft body		
Spiny skinned		
Joint legs		
Round body		

Hollow cavity		
Pore bearer		
Flat body		
Ringlike worms		

D. Complete the sentences

i. They have flat elonged and boat shapped body ___________
ii. They are the first vertebrates ___________
iii. They have two parts of limb except ___________
iv. Birds are also called glorified ___________
v. Salamander,frog, toad and hyla are examples of ___________

E. Write one main character based on the structure of the body of given living beings and write the name of its appropriate Kingdom, Sub-Kingdom, Phylum/ Division, Sub-Phylum/Sub-division and class:

i. Parrot	ii. Housefly	iii. Mustard	iv. Pine
v. Jellyfish	vi. Star fish	vii. Silver-fish	viii. Roh-fish
ix. Roundworm	x. Earthworm	xi. Sea horse	xii. Horse

F. Give reason :

i. Amphibians were the first vertebrates to live on land.
ii. Aves are also called glorified reptiles.
iii. A bat possesses wings but it is a mammal.
iv. Silver fish belongs to phylum arthopoda but starfish belongs to phylum echinodermata.
v. Sea horse is a fish but horse is a mammal.
vi. Whale is a mammal but silver carp is a fish.
vii. Bryophyta are called amphibian plants.
viii. Jellfish is not a fish.
ix. Ferns are known as vascular cryptogams
x. Mango is a dicotyledons plants

G. Write the difference:

i. Division and Phylum
ii. Pea and Paddy
iii. Mushtard and Maize
iv. Fern and Fir
v. Gymnosperm and Angiosperm
vi. Pteridophyta and Bryophyta
vii. Monocotyledons and Dicotyledons

H. Answer the following questions.

i. Name two basic characteristic for classifying living beings.
ii. What is five kingdom system in classification of living beings ?
iii. Why is classification need for living beings ?
iv. Write the characteristics of the animal kingdom with examples.

v. Write the characteristics of the plant kingdom with examples.

vi. Write the characteristics of the mammals with examples.

vii. Make a classification chart of the five Kingdom systems.

viii. Write any two non- vascular plants.

ix. Name the five classes of vertebrates.

x. Mention any four characteristics of angiosperm.

xi. Write any four characteristics of phylum annelida.

xii. With the help of a diagram describe the morphological characteristics of any angiospermic plants.

xiii. Write economic importance of angiospermic plants for human life.

xiv. Compare the anatomical structure of a Monocot stem with a dicot stem.

xv. Write down the essay about The relationship between evolution and the classification of living beings.

xvi. Draw a lebelled diagrams for the following :

a. Frogs	b. Fish	c. Butterfly
d. Elephant	e. Mustard Plants	

xvii. X, Y and Z are living organisms.

a. Identify the kingdom, phylum, sub-phylum,class and group to which they belong on the basis of following features.

i. X —the body is unicellular, filamentous, or parenchymatous, colonial.

ii. Y — Vegetative reproduction by tubers, buds, and fragmentation.

iii. Z — they contain the vascular system but companion cells, xylem vessels, and sieve tubes are absent.

b. Which amongst the above is most advanced ?

c. Name one organism each belonging to the groups of X, Y and Z.

xviii. a. Why are angiosperms so called ? In which structures do the seeds develop? Why are cotyledons considered an important part of seed ?

b. Differentiate between the two categories of angiosperms giving an example of each.

xix. a. Identify three features possessed by all chordates.

b. Name the classes of vertebrates which have the following characteristics:

i. Animals that have streamlined body and gills for breathing.

ii. Animals that are found both on land and in water.

iii. Animals that have mammary glands for the production of milk to nourish their young ones.

xx. a. How do poriferan animals differ from coelenterate animals ?

b. What are the differences between amphibians and reptiles ?

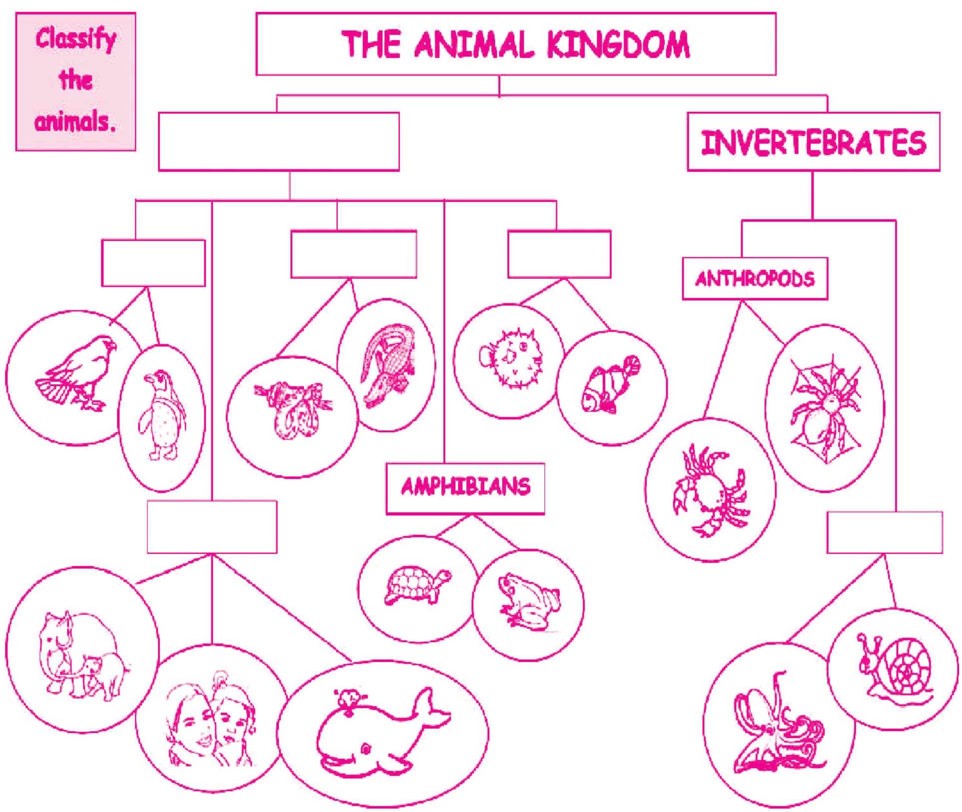
I. Classify the following living beings with important diagnostic features :

Moss, Rice, Fern, Mango, Pinus, Whale, Rabbit, Prawn, Sycon, Ascaris, Leech, Duck, Octopus, Starfish, Butterfly, Wheat.

J. Diagrammatic questions :

i. Study the given pictures and identify which kingdom these living beings belong to. Also write down three characteristics of each.

iii. Classify the animals :



Chapter 3

Life Cycle

Total Estimated pariods (Th. 3+ Pr. 1=4)

Student's Learning Outcomes

After studying this unit, the students will be able to :

- describe the life cycle of bees
- explain the utility of bees

Karl Ritter von Frisch (20 November 1886 – 12 June 1982) was a German -Austrian ethologist who received the Nobel Prize in Physiology or Medicine in 1973, along with Nikolaas Tinbergen and Konrad Lorenz.

His work centered on investigations of the sensory perceptions of the honey bee and he was one of the first to translate the meaning of the waggle dance. His theory, described in his 1927 book Aus dem Leben der Bienen (translated into English as The Dancing Bees), was disputed by other scientists and greeted with skepticism at the time. Only much later was it shown to be an accurate theoretical analysis.

Introduction

Fig. 3.1

All honeybees of the genus Apis are obligate social organisms that exist in colonies usually containing a single reproductive female, the queen, and many thousands of facultatively sterile females, the workers. 'Apis', which is Latin for 'Bees'. Most of the European honey bees fall under Apis Mellifera; with 'Mellifera' being the Latin word for "honey-bearing". The process of managing and breeding honey bees for acquiring honey and beeswax is known as apiculture or beekeeping. Apiculture is an old tradition that started with hunters in the forest in search of sweet honey.

Hundreds to a few thousand males are produced during the spring and summer months in temperate climates, but they die or are driven from the hive in the autumn. During the spring and summer, the queens of the species most commonly used commercially, Apis mellifera, may lay up to 2,000 eggs or more per day. If the eggs are fertilized, they develop into diploid females, while unfertilized eggs develop into haploid males. If the egg-laying rate of the queen begins to falter, the workers will feed some of the diploid larvae a special diet that causes them to develop into queens, whereas the remainder of the diploid eggs develop into smaller, less reproductively capable females whose egg laying is suppressed by queen pheromones.

Workers typically live about five weeks during the summer, but have a longer life expectancy during the winter. The queen is capable of living for up to five years, but is typically killed by a replacement queen within two years. During late spring and early summer when colony numbers are at their highest in temperate climates, the workers rear replacement queens and the old queen leaves with a portion of the colony members in a swarm. In this way, colony reproduction is achieved. A similar type of colony dynamic occurs in tropical regions, but the seasonal variation is much reduced

From filling the honeycombs with sweet honey to stinging us if we dare take them, honeybees have always amazed us with their ability to create the best food substance – honey. They belong to the insect order Hymenopterans, which comprises the majority of the insects. Amongst the insect order, bees are considered to be social insects as they live in colonies. Bees are paramount for agriculture as they facilitate pollination, in fact, ⅓ of the world's food supply pollinated by the bees.

Worker bee *Queen bee* *Drone bee*

Fig. 3.2

Queen Bee

queen bee

Fig. 3.3

A queen bee is easily distinguished from other bees in a colony. She has longer body. She is the largest bee. Each colony has one queen bee. She lays all the eggs that maintains the hive population. She produces both fertilized and unfertilized eggs. A queen bee is constantly fed royal jelly by worker bees. She can lay up to 1500 egg per day. She can live for five years but average productive life span is 2 to 3 years. She also produces pheromones (abele perfume), which works as special glue in a colony to unify and help each other.

After about a week it emerges from a queen cell, she leaves the hive to mate with several drone bees in flight. After mating, she returns to hive and starts laying eggs at about 48 hours. When an old queen is accidently killed, lost or removed, the bees select younger worker larvae to produce emergency queen.

Drone Bees

drone bee

Fig. 3.4

A drone bee is a male bee. Its body size is greater than that of worker bee but smaller than the queen bee. It is produced from unfertilized egg so they have only sixteen chromosomes (half than queen and worker). They are fatherless bee. They have no stingers. They do not collect nectar and pollen. The main responsibility of drone bee is to mate with a new fertile queen. Mating of bees occurs in flight. Drone bees die soon after mating.

Worker Bees

worker bee

Fig. 3.5

Worker bees are the smallest bees. They are female bees produced from fertilized egg but lack of reproductive capacity. They form majority within a hive. Their body is divided into head, thorax and abdomen. They collect nectar and pollen in the hive. They work as cleaner, nurse builder, soldier and porter for their colony in the hive.

Their legs have also a pollen basket to collect nectar. They are known as the busiest and hard working bees. They help to take care of the larvae produced by the queen, regulate temperature within the colony and leave the colony to search for nectar and pollen, make bee hive and protect the colony from enemies. They live for about 6-7 weeks. The young worker bees begin their adult life by cleaning up their birth cells. It then assumes the duties of a worker bee. A worker works for a week or more. They spend the second week within the hive for constructing a new honey comb, producing wax and repositioning food and nectar stores. When they are constantly fed royal jelly, they convert into queen bees.

Activities 3.1

Read and answer the questions.

Who live in a colony ?

		
Queen	**Worker**	**Drone**
There is just one queen in the hive. Her job is to lay eggs and preside over the hive.	All worker bees are female. Their role is to collect food and water. Care for the larvae and guard the hive.	Drones are the only males in the hive. Unlike the queen and the workers. Drones do not have stingers.

i. How many types of bees are there in a hive?
ii. Which types of bees are there in a hive?
iii. How many queens are there in the hive?
iv. What do workers do ?
v. Are workers males or females?
vi. Do drones has sting?

3.1 Life cycle of honey bees

The life cycle of bees has four main distinct stages. They are: egg, larva, pupa and adult. The colony of bees consists of three castes, i.e. queen, drones and worker. A queen bee lays eggs, drones produce sperm and worker are non- reproductive female bees.

Fig. 3.6 life cycle of bee

Eggs : Egg is the first stage of development in the life cycle of bees. The queen bees lay eggs in the cell of honeycomb. An egg is a small cylindrical shape. It has about 1.6 mm length and 0.4 mm in diameter. Eggs have opening that enable the sperm to pass in. Eggs can last for three days. After 3 days eggs hatch into white legless larvae.

Fig. 3.7

Larva : Larvae are found coiled at the bottom of cells. They have head, thoracic and abdominal segments on the body. Larvae are fed royal jelly for the first 3 days by nurse bees. Royal jelly is protein rich whitish milky fluid produced by worker bees from their head glands. After 3 days, they are fed bee bread. Larva stage lasts for about 6 days. At this stage the cell is sealed over with a porous covering of wax and pollen. Larva develops into a pupa inside the sealed cell. Larva changes their skin 4 -5 times.

Fig. 3.8

Pupa : Pupa is the non- feeding stage. Worm - like body of pupa has three distinct parts. In this stage, the eyes, legs, and wings are developed in pupa body. Its body is covered by small hairs. This pupal stage lasts for 8 days for queen bee, 12 days for worker bees, and 14 days for male drone bees.

Fig. 3.9

Adult : The bee chews always out from the capped cell. It becomes free and moves away from the cell. In this stage bees are fully developed. A queen bee needs 15 -16 days, a worker bee needs 20- 21 days and a drone bee needs 22- 24 days to come in this stage. A colony of bees has 50,000 to 60,000 worker bees, 600 to 1000 drone bees and only one queen bee.

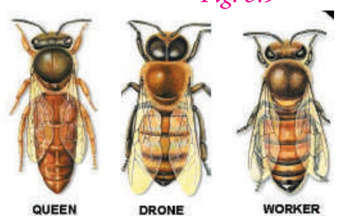


Fig. 3.10

Developmental periods of honey bee

Bee	Eggs	Larva	Pupa	Total Days
Queen	3	5.5	7.5	16
Worker	3	6	12	21
Drone	3	6	14.5	23.5

Activities 3.2

Watch the audio visuals about the life cycle of bees on the internet and prepare a report on its various stages and present it in the classroom. On this basis, you also write about the life cycle of other insects.

How bees make honey

Worker bees collect plant nectar
Female workers are called foragers. They collect nectar from millions of blooming plants.

Nectar taken to the hive
Nectar is taken to the hives in a special organ called the honey stomach.

Nectar to honey conversion begins
Inside the hive. House bees begin the process of making honey. Enzymes are added to the nectar and chemical changes begin.

Ripening the honey
Nectar has a high moisture percent -honey does not. Bees place nectar/ honey on comb and fan wings to remove the excess moisture.

Honey is stored in honeycomb
Once the enzyme action is complete and the moisture level is low -ripe honey is stored in cells of honeycomb. A wax cap on top keeps it clean.

Types of bee and their work division

Bee and Age	Work/Functions	
1. Drone	Makes bee hive warm and copulates with queen.	
2. Queen	Laying eggs, control and management of hive by producing different smells.	
3. Worker	1 - 3 days	In this stage these bees are called baby bees. They are very weak. So, they start to walk, attach with hive, provide warmth to egg, larva, pupa. They eat surrounding foods and clean bee hives.
	4 - 6 days	They feed honey and bee bread to developing larva and they eat themselves too.

	7 - 11 days	Head glands are developed to produce royal jelly. Young larva and queen bee feed on royal jelly and they eat themselves too.
	12 - 17days	Head glands become dry. Four pairs of wax glands are developed in the abdomen to produce wax. Wax is used to make hive.
	18 - 20days	Glands become dry. Poison glands develop.
	21 days	They start to emerge out from hive and perform different activities like collect flower nectar, water, etc. from agricultural field and forest.

3.2 The utility of honey bees

Bees play a big role in agriculture. One mouthful in three of the foods you eat directly or indirectly depends on pollination by honey bees. Crops from nuts to vegetables and as diverse as apple, cranberry, pumpkin, and sunflower all require pollinating by honey bees. They pollinate crops, increase yields, and give rise to a lucrative honey industry. Bees are so important, in fact, that millions are spent renting hives to pollinate farmers' crops.

Over one third of the food we eat relies on pollination by bees, either directly or indirectly. Many fruits, nuts, and vegetables require pollination by bees and other insects in order to yield fruit, and without pollinators these crops could all but disappear from grocery store shelves.

We get honey from bees . Bees convert flower nectar into honey and store it inside their honey combs . Raw honey is rich with mineral and vitamins. Honey can be used as an alternative to sugar . It also helps to heal wounds by killing bacteria and preventing infections . It can help to reduce seasonal allergies. By selling raw honey and wax , income can be generated. It is also used to make different types of candy, cake and biscuits .

Honey is a syrupy liquid that honeybees make from plant nectar. Loved worldwide for its sweetness and depth of flavor, it's used in many foods and recipes. The smell, color, and taste of honey vary based on the type of flowers it's made from, so there are countless varieties available. Honey has a number of potential health benefits and plays a role in many home remedies and alternative medicine treatments.

According to the recent studies, the honey bee's venom contains a mixture of proteins which can potentially be used as a prophylactic to destroy HIV that causes AIDS in humans.

i. **Rich in nutrients:** Honey is rich in carbohydrates of natural origin, these are composed mainly of fructose and glucose. It is an ideal food to consume in the morning for breakfast or in the afternoon to give us energy. In addition, it contains a significant amount of vitamins and minerals such as vitamin B2, niacin, vitamin B6, folic acid, vitamin C, calcium, phosphorus, zinc, iron, potassium and magnesium. It also provides amino acids and organic acids, such as acetic acid and citric acid.

ii. **Antibacterial:** We can use honey as a powerful antibacterial given its important content of inhibins (hydrogen peroxide, flavonoids and phenolic acids).

iii. **Anti-inflammatory:** Honey is attributed anti-inflammatory properties, it can be used to reduce muscle inflammation and thus reduce the discomfort they cause.

iv. **Helps digestion:** Consuming honey with lemon juice facilitates the digestion of food, helps relieve acidity and promotes intestinal transit.

v. **Relieves cough and sore throat:** Honey together with an infusion or hot milk, helps us to calm coughs and sore throats, even many medicines include honey in their composition.

vi. **Antioxidant:** Antioxidants slow down cell breakdown and honey has a significant amount of them. By slowing down cellular breakdown, we also slow down skin aging.

vii. Bees are the diligent social insects that live in a colony with the division of labour.

viii. Honey bees (Apis mellifera) means "honey carrying bees". They are environment friendly insects and have vital role in pollination.

ix. Honey is the good food that includes most of the substance such as enzymes, vitamins, water and minerals necessary to sustain life. It also contains pinocembrin antioxidant associated with improved brain functioning.

Activities 3.3

i. Discuss the benefits of beekeeping to human life with your classmates. Write the results of the discussion on a piece of cardboard and paste them in the classroom.

ii. Write an essay on the utility of bees in agriculture and human life and present it in the classroom.

Project Work

i. Prepare a report on beekeeping process and its benefits by visiting the area where beekeeping is done.

ii. Visit a nearby beekeeping farm to collect different types of bees . Draw their diagram and study them in detail with your classmate

Exercise

A. Choose the correct one and put the tick mark(√)

i. Honey bees produce and store:
   a. sugar b. carbohydrates c. honey d. nutrients

ii. Honey bees are __________ creatures and live in colonies.
   a. group b. social c. individual d. helpful

iii. Which bee is easily distinguised from other bees in a colony .
   a. drone b. queen c. worker d. none of above

iv. A queen bee can lay up to__________egg per day .
   a. 15 b. 150 c. 1500 d. 1050

v. __________die soon after mating
   a. drone bee b. queen bee c. worker bee d. none of above

vi. Worker bee live for __________week.
   a. 6-7 b. 2-3 c. 4-8 d. 5-7

vii. The life cycle of bees has-
   a. 6 stages b. 5 stages c. 4 stages d. 3stages

viii. Which is 2st sage of life cycle of bee
   a. Pupa b. Egg c. Larva d. Adult

ix. Which is correct for drone bee -
   a. Laying eggs, control and management of hive by producing different smells.
   b. Makes bee hive warm and copulates with queen.
   c. Collect nectar and pollen in the hive
   d. Busiest and hard working .

x. Which is correct for queen bee -
   a. Laying eggs, control and management of hive by producing different smells.
   b. Makes bee hive warm and copulates with queen.
   c. Collect nectar and pollen in the hive
   d. Busiest and hard working .

xi. What type of bee is developed when its larva is fed only on royal jelly ?
   a. Queen bee b. Drone bee c. King bee d. Worker bee

xii. Bees play a big role in _________
   a. pollution b. agriculture c. desease d. industry

xiii. Which is not correct :
   a. Helps to heal wounds by killing bacteria and preventing infections.
   b. Over one third of the food we eat relies on pollination by bees, either directly or indirectly.
   c. Honey and wax is not sources of income .
   d. Honey has a number of potential health benefits.

B. Differentiate between these pairs.

i. Egg and Larva of honey bees
ii. Larva and Pupa of honey bees
iii. Queen bee and Drone bee
iv. Drone bees and Worker bees
v. Male bee and Female bee

C. Explain the following:

i. A queen bee is fed only royal jelly.
ii. Honey bees are vital pollinator .
iii. Honey is the good food for human being.
iv. Drones are fertile males .
v. Honey can be used as an alternative to sugar.
vi. Bees are the diligent social insects.

D. Answer the following questions :

i. How are the bees divided in a beehive? What work does each of them do?
ii. What is a Queen Bee?
iii. What are Worker Bees?
iv. What are Drones?
v. How long do honey bees live?
vi. How is the beehive constructed by the bees?
vii. What is bee bread?
viii. What is the Life Cycle of a Honey Bee?
ix. Which bee is the best pollinator?
x. What do honey bees attract?
xi. What are the advantages of beekeeping ?
xii. Write the role of worker bees in the hive .
xiii. What is the economic importance of honey bees ?
xiv. Write in brief about the queen bee with a neat and labelled diagram.
xv. Write the roles of the queen bee , the worker bee and the drone in hive .

xvi. Explain the life cycle of honey bees with diagrams in brief .
xv. Explain the utility of honey bees.
xvi. Write down the essay on utility of honey bees
xvii. X, Y, and Z are bees .
  a. Identify the group to which they belong on the basis of the following features.
    i. X — longer body, and discovered only one in the colony.
    ii. Y — female bees produce fertilized eggs but lack reproductive capacity, they form the majority within a hive.
    iii. Z — body size is greater than that of the Y bee but smaller than the X bee.
  b. Which of the above is the most advanced ?
  c. List the works and life spans of each animal starting with the letters X, Y, and Z.

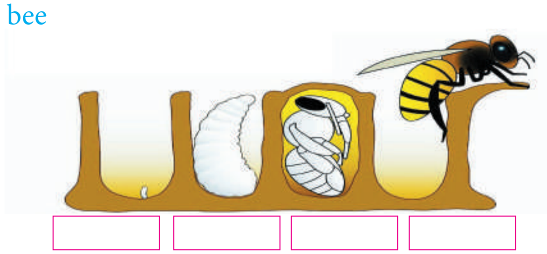
E. Diagrammatic Questions :

i. Draw a picture of honey bee and labelled too.

(eye, antenna, head, legs, body, wings)

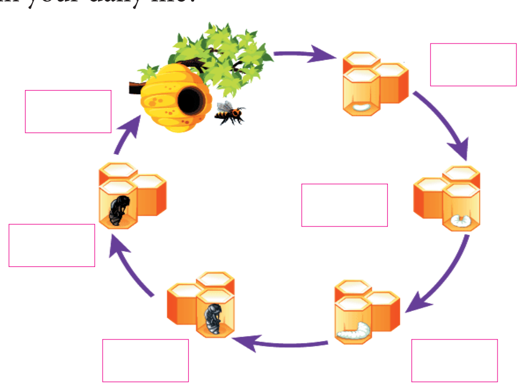
ii. Fill in the following boxes. Write down a short note about all of these.

The life cycle of a bee



iii. Identify the bees given below. How do you identify these bees? Write down a short note about all three types of bees.

i v. Complete the life cycle of the honey bee. What is the significance of honey bees? How do you use honey bees in your daily life?



Chapter 4

Heredity

Total Estimated pariods (Th. 14+ Pr. 2=16)

Student's Learning Outcomes

After studying this unit, the students will be able to :

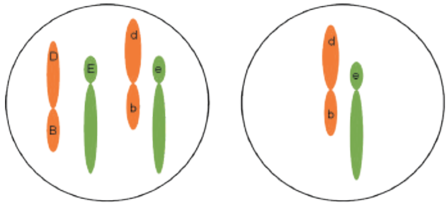
- describe the concept and importance of mitosis and meiosis in cell division.
- introduce chromosomes and heredity .
- differentiates between DNA and RNA based on structure and function and explains the importance of DNA testing in various investigations.
- describe the role of sex chromosomes in human sex determination.
- explain Mendel's laws related to monohybrid crosses.
- introduce genetic technology and inquire about its applications.

Walther Flemming, (born 1843, Sachsenberg, Mecklenburg [now in Germany]—died 1905, Kiel, Germany), German anatomist, a founder of the science of cytogenetics (the study of the cell's hereditary material, the chromosomes). He was the first to observe and describe systematically the behaviour of chromosomes in the cell nucleus during normal cell division (mitosis).

Introduction

Multicellular organisms such as plants and animals are composed of millions to trillions (1,000,000,000) of cells that work together. The cells that make up different tissues have different shapes and perform different functions for the plant or animal. Even though they have diverse functions, each somatic cell in the organism normally has the same chromosomes and therefore the same genetic makeup. Furthermore, the millions of cells that makeup a mature organism originated from a single cell formed when the male and female gametes from the parents of the organism fused. This single cell established the life of the organism.

The fundamental definition of 'Life' is a living creature that can grow and reproduce for the next generations. In other words, 'Cell division' is the fundamental behavior of living creatures. It is necessary for the growth of organisms, repair of damaged tissues, healing and regeneration, and reproduction.



Diploid Somatic Cell
Two of each kind of Chromosome

Haploid Gamete (Sex Cell)
One of each kind of chromosome

Fig. 4.1

Cell division is the process by which a parent cell divides into daughter cells. Cell division is critical for both single-cellular and multi-cellular organisms. For single-celled organisms like Amoeba or Paramecium, cell division can directly grow the number of their population. Cell division in multi-cellular organisms like us allows the organisms to grow in size by increasing the number of cells in their body. It also provides new cells to replace old cells or to repair damaged cells.

An allele is one of two or more versions of DNA sequence (a single base or a segment of bases) at a given genomic location. An individual inherits two alleles, one from each parent, for any given genomic location where such variation exists. If the two alleles are the same, the individual is homozygous for that allele. If the alleles are different, the individual is heterozygous.

Alleles are a pair of genes that occupy a specific location on a particular chromosome and control the same trait. Alleles may appear in pairs or in multiple forms of alleles, which affect a specific trait of the offspring. Locus is the location where a gene is found on a chromosome. A pair of alleles determine the same trait, for example, eye color; one allele codes for black eyes, and another allele codes for brown eyes. Similarly, we can undersdand alleles in chromosomes .

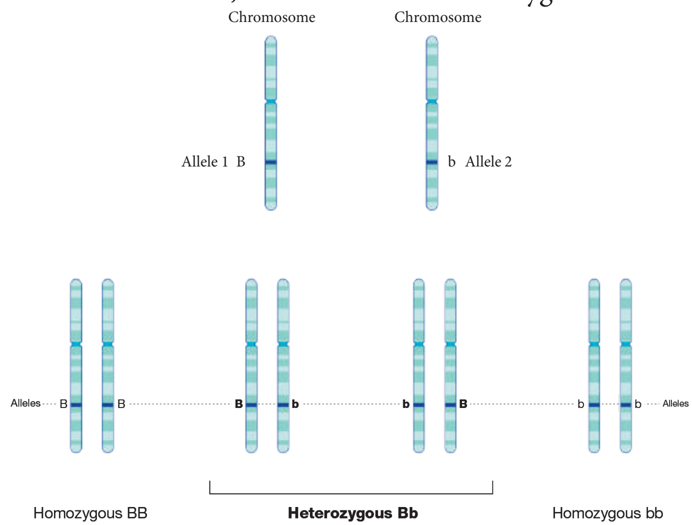


Fig. 4.2

4.1 Cell division

Cell division can be defined as a process by which a cell distributes its genetic material and cytoplasm and gives rise to new daughter cells. It is a part of the larger cell cycle and has a direct role in cell reproduction.

There are two types of cell division: Mitosis and Meiosis.

Mitosis is a cell division that one parent cell divides into two daughter cells. The two daughter cells inherit identical genetical information (DNA) from their parent cell. The cell division that we mentioned above to grow our body and repair damaged cells belongs to Mitosis.

On the other hand, Meiosis is a reduction division in which the daughter cells only carry half of the parent cells' genetic information. Meiosis only happens during the generation of sperms and eggs.

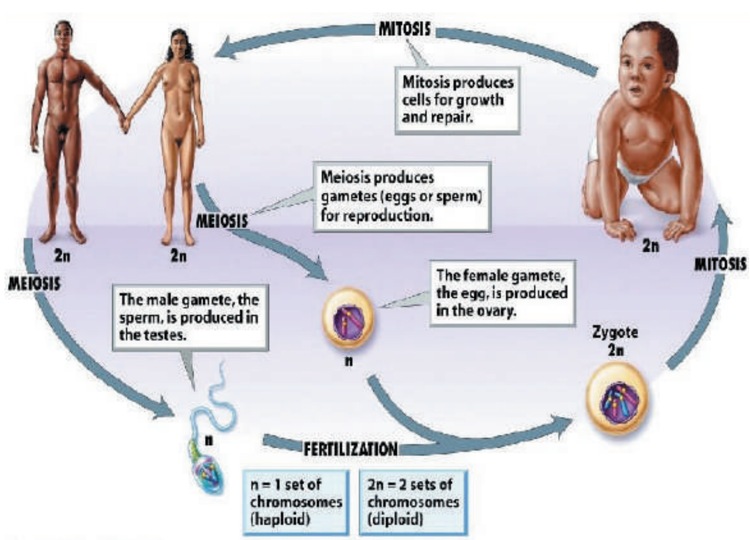


Fig. 4.3

During cell division, it is essential that DNA remain s intact and evenly distributed among cells. Chromosomes are a key part of the process that ensures DNA is accurately copied and distributed in the vast majority of cell divisions. A chromosome is a threadlike structure of nucleic acids and protein found in the nucleus of most living cells, carrying genetic information in the form of genes.

Meiosis and inheritance (also called heredity) are closely intertwined, as parental germ cells undergo meiosis and produce gametes that carry specific alleles, and two gametes unite during fertilization to form an offspring. It is the passing on of traits from parents to their offspring; either through asexual reproduction or sexual reproduction, the offspring cells or organisms acquire the genetic information of their parents.

4.1.1 The concepts of mitosis

Mitosis is a process of nuclear division in eukaryotic cells that occurs when a parent cell divides to produce two identical daughter cells. During cell division, mitosis refers specifically to the separation of the duplicated genetic material carried in the nucleus.

Mitosis: Somatic cell division

The objective of mitosis is to make two genetically identical cells from a single cell. In the cells of our body, we start with 46 chromosomes in a single cell and end up with 46 chromosomes in two cells. Obviously, replicating the chromosomes is a prerequisite to mitosis. Remember, replication takes place during interphase when the chromosomes are dispersed structures in the nucleus. Mitosis is an organized procession of activity in the cell that allows the replicated chromosomes to be properly divided into two identical cells. Chromosomes are important because they contain genes.

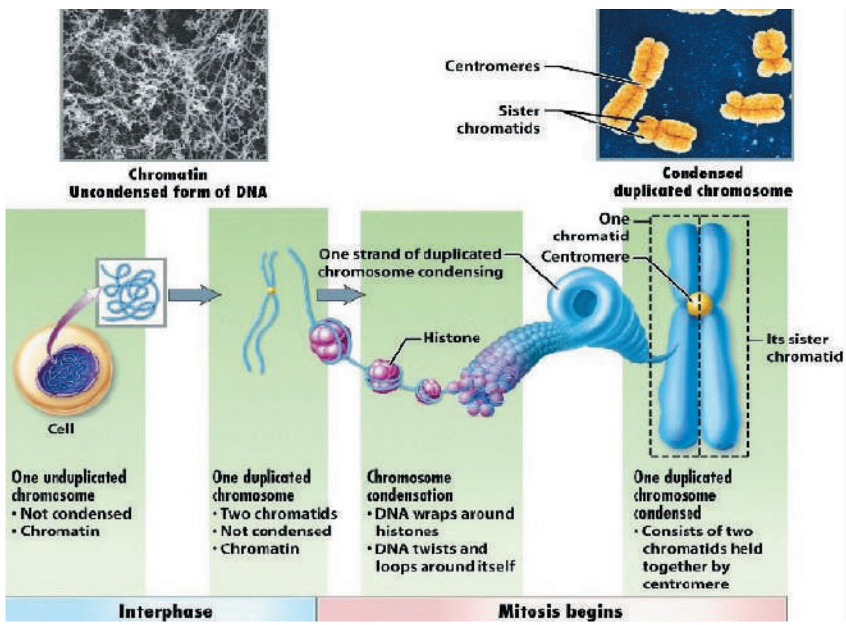


Fig. 4.4

Interphase is the longest part of the cell cycle. This is when the cell grows and copies its DNA before moving into mitosis. During mitosis, chromosomes will align, separate, and move into new daughter cells. Interphase is important for cell division because it allows the cell to grow, replicate its DNA, and make final preparations for cell division, or mitosis. This phase was thought to represent the resting stage between subsequent cell divisions, but new research has shown that it is a very active phase

Mitosis: Prophase

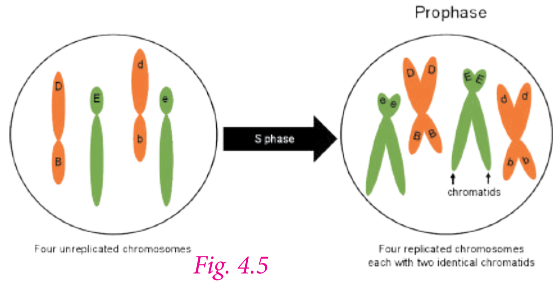


Fig. 4.5

Prophase is the beginning of mitosis. During interphase, the chromosomes look like a plate of spaghetti in the nucleus. It is difficult to pick out an individual chromosome because they are each so spread out. The chromosomes in the nucleus change from being loosely dispersed to becoming more condensed. This change in chromosome structure makes them easier to move around the cell, an important issue for what is about to happen. As the chromosomes condense, they get shorter and thicker and can be seen through the microscope as individual structures . The chromosomes at prophase will consist of two identical parts called sister chromatids that stay connected at the centromere. It is now clear that the chromosomes have been replicated. Chromosome replication occurs during the S-phase of interphase . Next, the nucleus is dissolved. At the end of prophase the **replicated** chromosomes are moved by the spindle apparatus to the center of the cell.

Mitosis: Metaphase

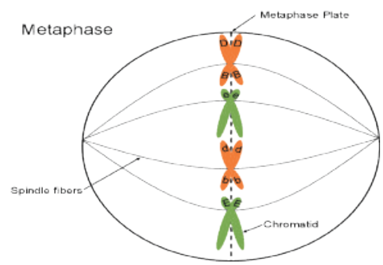


Fig. 4.6

When the chromosomes are maneuvered to the center of the cell, metaphase begins . The spindle fiber network connects the centromere of the replicated chromosome to the outer part of each cell. The chromosomes now resemble the line of scrimmage of a football team, poised and waiting for some cellular signal to begin the next phase.

Mitosis: Anaphase

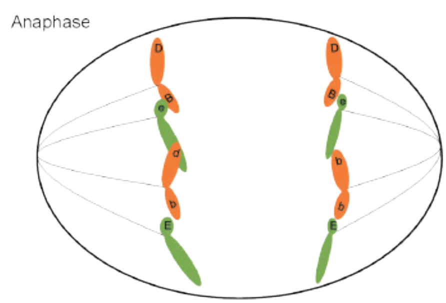


Fig. 4.7

At anaphase, the chromatids making up each chromosome are pulled apart and begin to move away from each other under the control of the spindle fibers. Once they are pulled apart, the chromatids are now considered individual chromosomes. As anaphase progresses, the chromosomes on each end of the cell are pulled into a bundle. When they stop moving, telophase begins.

Mitosis: Telophase

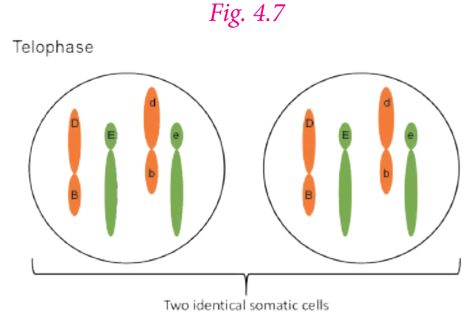


Fig. 4.8

The final stage of mitosis is telophase . A nuclear envelope will form around each bundle of chromosomes. The cell will undergo cytokinesis and the cytoplasm is split between the two identical daughter cells. Cell membranes (and cell walls in plants) form between the two cells. The chromosomes begin to decondense. They loosen up and spread around the nucleus because they no longer will need to move around. The new cells have now begun their lifecycle.

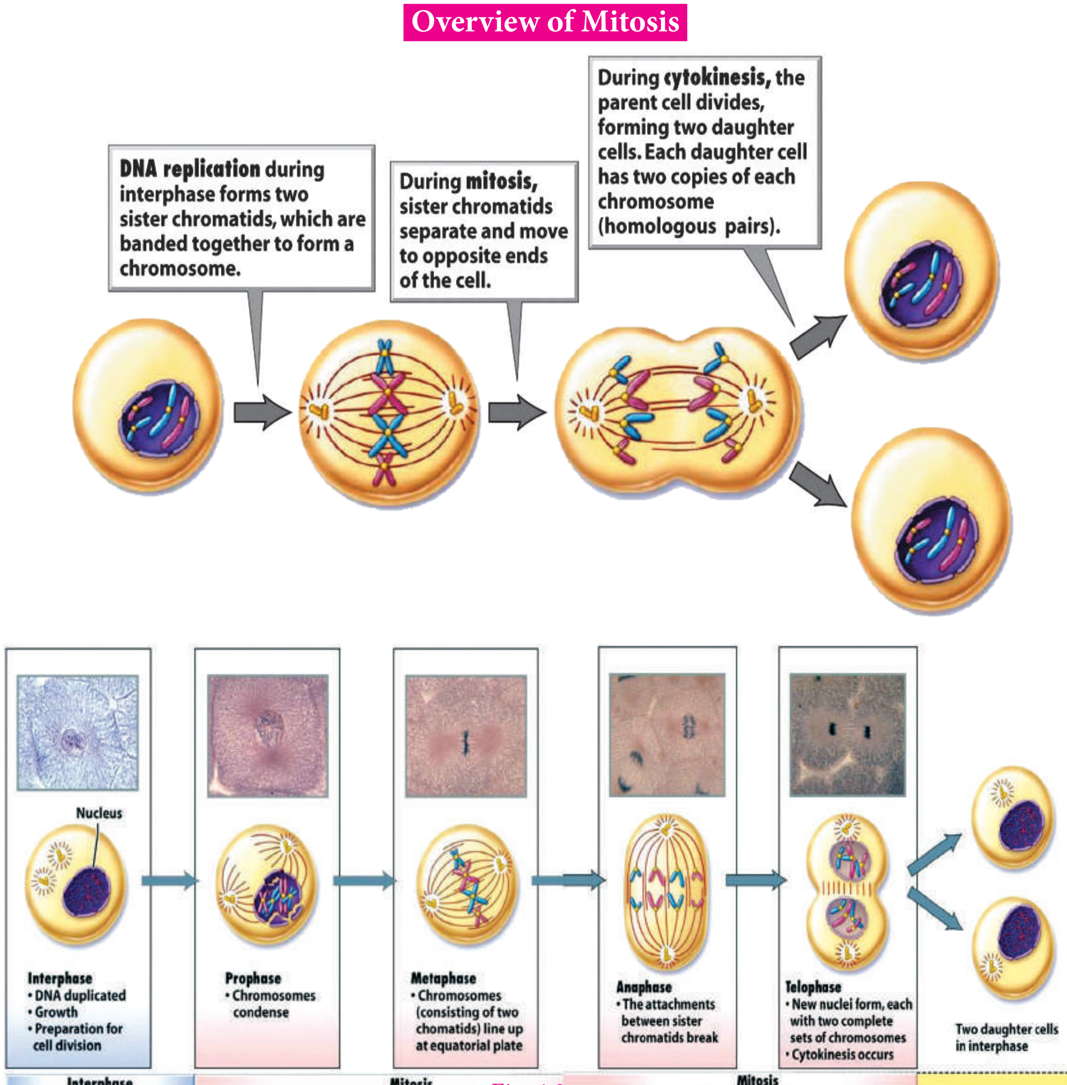


Fig. 4.9

4.1.2 The concepts of meiosis

Meiosis is a type of cell division that reduces the number of chromosomes in the parent cell by half and produces four gamete cells. This process is required to produce egg and sperm cells for sexual reproduction.

Meiosis: Gamete formation

The objective of meiosis is to make four cells from a single somatic cell. The four cells each have half the chromosome number found in the somatic cell. In our human bodies, the four gametes will each have 23 chromosomes which means the 46 chromosomes in the somatic cell must replicate during interphase prior to meiosis just as they would before mitosis. Meiosis occurs in specialized cells of the body called germline cells.To appreciate meiosis and gamete formation it is important to first understand two ideas, chromosome sets and homologous chromosomes.

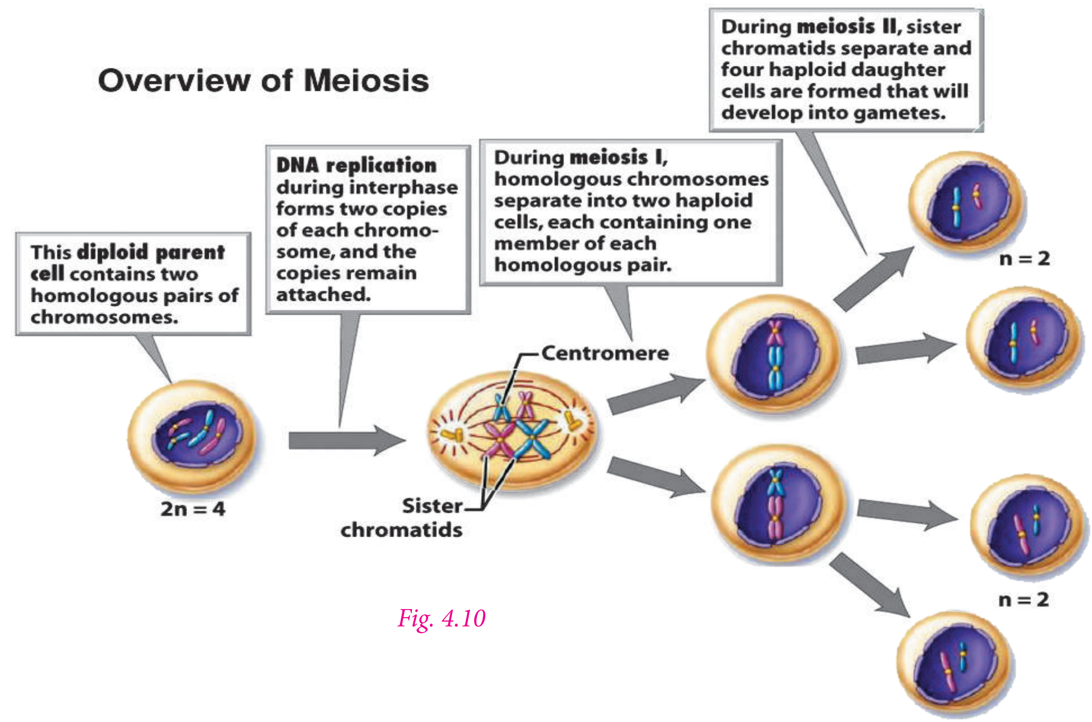


Fig. 4.10

Chromosome sets: The 46 chromosomes you have consist of two sets. You are a diploid organism ('di' means two and 'ploid' means sets). One set of chromosomes came from each parent when their gametes fused. Therefore, human gametes are haploid (one set).

Homologous chromosomes: The 46 chromosomes in a somatic cell can be arranged into 23 homologous or similar pairs. One chromosome from each pair came from the male parent, the other from the female. Homologous chromosomes have the same genes although in heterozygous people the genes would be different alleles (**A,a**). The exception to this would be the sex (X and Y) chromosomes. Passing on a complete set of human genes requires one chromosome from each pair to end up in each gamete.

Meiosis: Prophase I

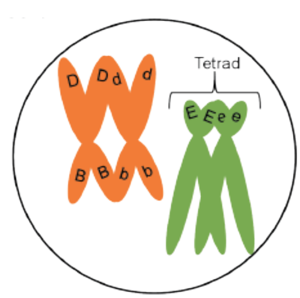


Fig. 4.11

This stage starts meiosis and is the same as prophase of mitosis with one important change. As the chromosomes condense, they form groups of four chromatids called tetrads or bivalents. Close inspection reveals that each chromosome is replicated and consists of two sister chromatids. The two chromosomes in each cell that are homologous and have the same genes (but perhaps different alleles if the organism is heterozygous) will pair closely. This close association, or synapsis, allows the homologous chromosomes to crossover and exchange identical parts. The impact of crossing over is that genes that are on the same chromosome can be recombined so that they are not always inherited together. The tetrad or bivalent formed during synapsis remains assembled as prophase progresses. The tetrad therefore moves as a unit to the center of the cell.

Meiosis: Metaphase I

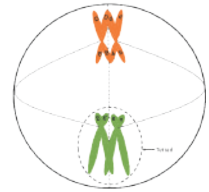


Fig. 4.12

Metaphase I starts when the tetrads are at the center of the cell . The tetrads have stayed together which insures that during the first division, each cell will get one chromosome from each homologous pair. The chromosomes remain at the center of the cell until the homologous pairs are ready to move away from each other.

Meiosis: Anaphase I

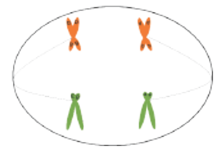


Fig. 4.13

The chromosomes that make up each tetrad separate during anaphase I . However, the sister chromatids will stay connected at the centromere. Anaphase I proceeds until the chromosomes are pulled into a bundle at opposite ends of the cell.

Meiosis: Telophase l

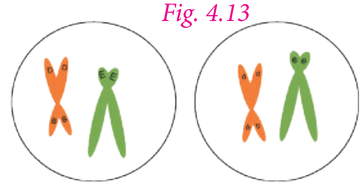


Fig. 4.14

The cell divides into two cells during telophase I . The bundle of chromosomes may have a nuclear envelope develop around them. The germline cells in some organisms such as human females, go through the first four stages of meiosis prior to birth. The **germline cells** remain at telophase I for some time. The second round of division occurs when the gamete is needed for reproduction. In other situations, telophase I is an abbreviated stage, and the second round of division proceeds without delay.

Meiosis: Prophase II

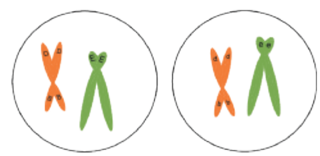


Fig. 4.15

If the chromosomes became dispersed in telophase I, they will condense again at prophase II. The spindle apparatus moves the chromosomes to the middle of the cell. Look! The centromeres are still holding the sister chromatids together .

Meiosis: Metaphase II

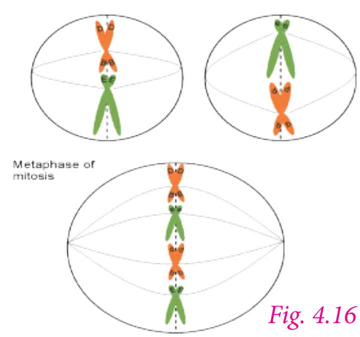


Fig. 4.16

In metaphase II the chromosomes are aligned at the center of the cell . This time there are not homologous chromosomes to be paired with. This metaphase looks similar to metaphase of mitosis but there is a key difference. What is the difference?

Meiosis: Anaphase II

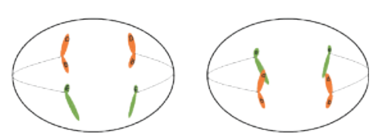


Fig. 4.17

During anaphase II, the chromatids are pulled apart by the spindle fibers. Now they are classified as chromosomes, not chromatids. The chromosomes move apart to opposite ends of the cell .

Meiosis: Telophase II

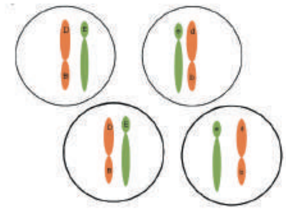


Fig. 4.18

In the final stage of meiosis, telophase II, the nucleus forms around the bundle of chromosomes . The cell divides. Now four cells exist that originated from one germline cell. Each cell is a gamete with half the number of chromosomes and genes as a somatic cell.

Parallel Behavior and the Chromosome Theory

The successful completion of mitosis or meiosis requires the cell to move large objects with precision and control many detailed events. The process surpasses any engineering accomplishments of NASA. The importance of mitosis and meiosis to an organism is obvious when we consider that genes are a part of the chromosome and the genes must be copied and distributed properly to produce viable daughter cells. The mechanisms of these events are far from being completely understood. From our current understanding, we can appreciate how the principles of segregation and independent assortment are controlled by the mechanics of meiosis.

When cell division was first observed and described by cytogeneticists, biologists were just beginning to accept the idea that genes were tiny objects that controlled traits and existed in the cells of living things. Two biologists, a German named Boveri and an American graduate student named Sutton, recognized that chromosome behavior during meiosis matched Mendel's principles of gene behavior. Both scientists proposed the idea that while genes had not yet been directly observed, they must be a part of the chromosome. Sutton and Boveri are both given credit for proposing this chromosome theory; genes are a part of chromosomes. Segregation predicts gene behavior that matches the chromosome behavior observed by cytogeneticists. Genes are in pairs because chromosomes are in pairs. The gene pairs associate during gamete formation when the homologous chromosomes pair in prophase I. The gene pairs separate when the homologous pairs separate in anaphase I followed by chromatid separation in anaphase II. Thus, chromosome behavior dictates the gene's segregation behavior.

Independent assortment of gene pairs also correlates with chromosome behavior. Let us consider a dihybrid individual with the genotype **BbEe**. How many kinds of gametes can it make? The four possible combinations (**BE**, **bE**, **Be** and **be**) are made at equal frequencies. We can understand why this occurs if we think about what happens to chromosomes at metaphase I of meiosis. The chromosome pair that carries the '**E**' and '**e**' genes will be moved independently from the chromosome pair with the '**B**' and '**b**' chromosomes. When the chromosomes arrive at the center of the cell at metaphase I, the two tetrads may be aligned so that the '**E**' and '**B**' genes move to one cell and the '**e**' and '**b**' genes move to the other during the first division. In the other half of the cells that go through meiosis, the tetrads will line up so that the '**E**' genes will be passed on with the '**b**' genes and the '**e**' genes will go with the '**B**' genes. Keep

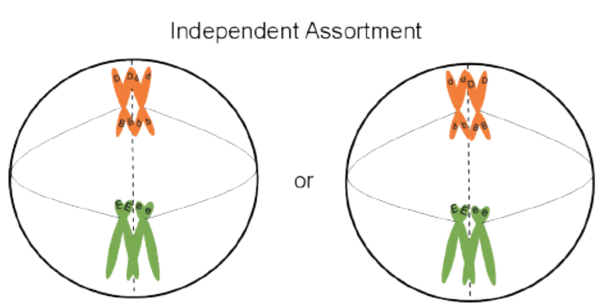


Fig. 4.19 Nonhomologous chromosomes are independent

in mind that organisms that make gametes make thousands of them. The chance alignment of the tetrads at metaphase I therefore dictates the overall frequency of gametes with different combinations of genes when the genes are on separate chromosomes.

When more gene pairs are considered, the same scenarios described above will be true as long as the genes are on separate chromosomes. When genes are on the same chromosome, the role of crossing over on gene inheritance needs to be considered in more detail. We will cover the inheritance of genes on the same chromosome in a later lesson.

Activities 4.1

i. Can you do this? Write the correct answer under each column. If you find difficulty, review the lesson on mitosis and meiosis.

Basis of Comparison	Mitosis	Meiosis
1. Type of cell where the process occure		
2. Number of cell division		
3. Number of chromosomes (2sets/1set)		
4. Number of daughter cells produced per parent cell		

ii. Draw figures of all phases of mitotic cell division and present them to the class.

iii. Draw figures of all phases of meiotic cell division and present them to the class.

4.1.3 The Significance of Mitosis cell division

i. It helps to maintain linear heredity of an organism by keeping the chromosome number constant in daughter cells.

ii. It helps in the development of an organism from zygotic stage to adult stage.

iii. It is the means of repair and regeneration of cells.

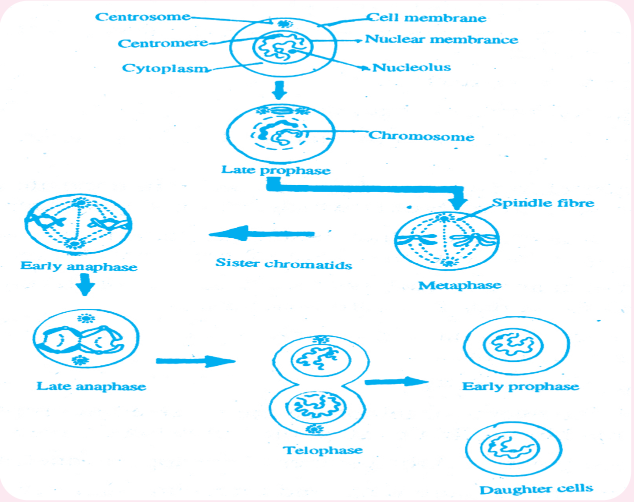
iv. Asexual reproduction is accomplished only through mitosis.

v. Details of mitosis are similar in all organisms which emphasizes the unity of life.

Activities 4.2

i. The diagrammatic summary represents which cell division? Make this picture on cardboard paper and present it to the classroom with a brief explanation of each stage.

ii. Write down the difference between Early anaphase and Late anaphase.



4.1.4 The Significance of Meiosis cell division

i. Meiosis is responsible for the formation of sex cells or gametes that are responsible for sexual reproduction.

ii. It activates the genetic information for the development of sex cells and deactivates the sporophytic information.

iii. It maintains the constant number of chromosomes by halving the same. This is important because the chromosome number doubles after fertilization.

iv. In this process independent assortment of maternal and paternal chromosomes takes place. Thus the chromosomes and the traits controlled by them are reshuffled.

v. The genetic mutation occurs due to irregularities in cell division by meiosis. The mutations that are beneficial are carried on by natural selection.

vi. Crossing over produces a new combination of traits and variations.

Activities 4.3

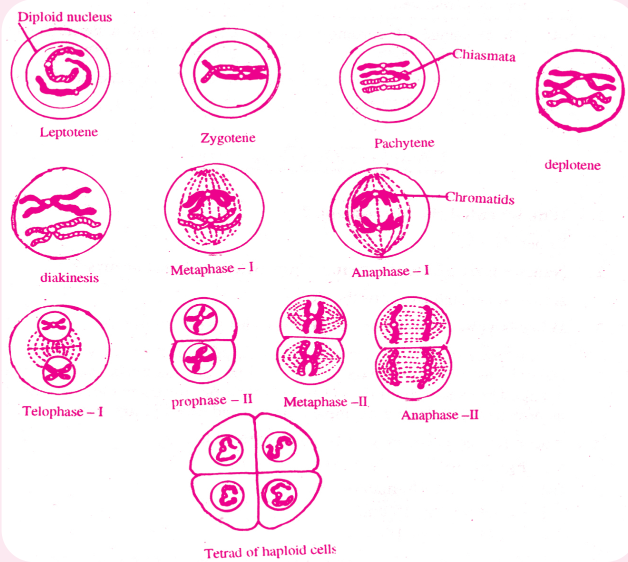
i. The diagrammatic summary represents which cell division? Make this picture on cardboard paper and present it to the classroom with a brief explanation of each stage.

ii. Define the following.

a. Leptotene

b. Zygotene

c. Pachytene



The difference between mitosis and meiosis cell division

S.N.	Differences	Mitosis	Meiosis
1	Type of Reproduction	Asexual	Sexual
2	Genetically	Similar	Different
3	Crossing Over	No, crossing over cannot occur.	Yes, mixing of chromosomes can occur.
4	Number of Divisions	One	Two
5	Pairing of Homologs	No	Yes
6	Mother Cells	Can be either haploid or diploid	Always diploid
7	Number of Daughter Cells produced	2 diploid cells	4 haploid cells
8	Chromosome Number	Remains the same.	Reduced by half.

S.N.	Differences	Mitosis	Meiosis
9	Chromosomes Pairing	Does Not Occur	Takes place during zygotene of prophase I and continue upto metaphase I.
10	Creates	Makes everything other than sex cells.	Sex cells only: female egg cells or male sperm cells.
11	Takes Place in	Somatic Cells	Germ Cells
12	Chiasmata	Absent	Observed during prophase I and metaphase I.
13	Spindle Fibres	Disappear completely in telophase.	Do not disappear completely in telophase I.
14	Nucleoli	Reappear at telophase	Do not reappear at telophase I.
15	Steps	Prophase, Metaphase, Anaphase, Telophase.	(Meiosis 1) Prophase I, Metaphase I, Anaphase I, Telophase I; (Meiosis II) Prophase II, Metaphase II, Anaphase II and Telophase II.

Project Work

i. Prepare visual chart of Mitosis cell division

You need :

Pieces of yarn of two different colours (red and green) , cotton thread of three different colours (blue, yellow and brown) , glue , forceps, card sheets of full size , brown coloured thread .

Procedures :

a. Cut the full size card sheet into equal parts and get 6 sheets of this size .
b. Use the card sheets to represent different stages of mitotic division cycle ,
c. Use the brown thread to represent the outer boundary of the cells and fix it to the border of the card sheet applying glue .
d. Use the blue thread to represent the nuclear membrene and fix it in the card shet applying glue. You may use the forceps to fix the thread in good condition .
e. Cut out one large (about 4 cm) and one small(about 3cm) piece of green and red yarn and fix it within nucleus to represent the chromosomes. The two sets of colour depict that one is trabsmitted from father and another from the mother.
f. To represent the centriole, cut out a small circle from a yellow coloured paper and stick it to the proper place.
g. You can use yellow thread to represent the spindle fibers extending from the two poles.
h. To represent the centromere that joins the two chromatids, you can use a black ink mark at the point of connection.
    i. Now keeping the above instructions in your mind , proceed to prepare the different stages of the the mitotic cycle as illustrated diagrammatically above.

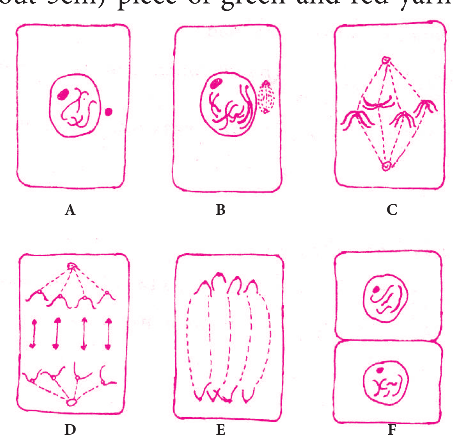


Fig. 4.22

4.2 Chromosomes

Chromosomes are threadlike structures made of protein and a single molecule of DNA that serve to carry the genomic information from cell to cell. In plants and animals (including humans), chromosomes reside in the nucleus of cells. Humans have 22 pairs of numbered chromosomes (autosomes) and one pair of sex chromosomes (XX or XY), for a total of 46. Each pair contains two chromosomes, one coming from each parent, which means that children inherit half of their chromosomes from their mother and half from their father. Chromosomes can be seen through a microscope when the nucleus dissolves during cell division.

4.2.1 Introduction of DNA

Deoxyribonucleic acid, more commonly known as **DNA**, is a complex molecule that contains all of the information necessary to build and maintain an organism. All living things have DNA within their cells. In fact, nearly every cell in a multicellular organism possesses the full set of DNA required for that organism.

However, DNA does more than specify the structure and function of living things — it also serves as the primary unit of heredity in organisms of all types. In other words, whenever organisms reproduce, a portion of their DNA is passed along to their offspring. This transmission of all or part of an organism's DNA helps ensure a certain level of continuity from one generation to the next, while still allowing for slight changes that contribute to the diversity of life.

DNA Structure

The DNA structure can be thought of as a twisted ladder. This structure is described as a double-helix, as illustrated in the figure above. It is a nucleic acid, and all nucleic acids are made up of nucleotides. The DNA molecule is composed of units called nucleotides, and each nucleotide is composed of three different components such as sugar, phosphate groups and nitrogen bases.

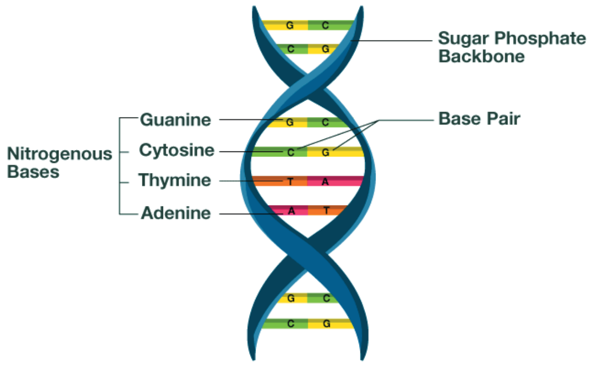


Fig. 4.23 DNA diagram representing the DNA structure

The basic building blocks of DNA are nucleotides, which are composed of a sugar group, a phosphate group, and a nitrogen base. The sugar and phosphate groups link the nucleotides together to form each strand of DNA. Adenine (A), Thymine (T), Guanine (G) and Cytosine (C) are four types of nitrogen bases.

These 4 Nitrogenous bases pair together in the following way: **A** with **T,** and **C** with **G**. These base pairs are essential for the DNA's double helix structure, which resembles a twisted ladder.

The order of the nitrogenous bases determines the genetic code or the DNA's instructions.

Among the three components of DNA structure, sugar is the one which forms the backbone of the

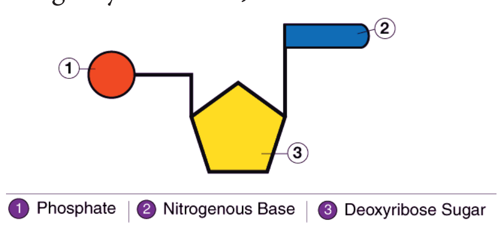


Fig. 4.24 Componets of DNA Structure

DNA molecule. It is also called deoxyribose. The nitrogenous bases of the opposite strands form hydrogen bonds, forming a ladder-like structure.

The DNA molecule consists of 4 nitrogen bases, namely adenine (A), thymine (T), cytosine (C) and Guanine (G), which ultimately form the structure of a nucleotide. The A and G are purines, and the C and T are pyrimidines.

The two strands of DNA run in opposite directions. These strand hydrogen bond that is present between the two complementary bases. The strands are helically twisted, where each strand forms a right-handed coil, and ten nucleotides make up a single turn.

The pitch of each helix is 3.4 nm. Hence, the distance between two consecutive base pairs (i.e., hydrogen-bonded bases of the opposite strands) is 0.34 nm.

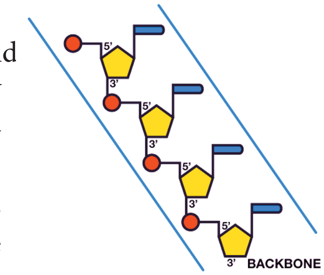


Fig. 4.25 DNA Structure Backbone

The DNA coils up, forming chromosomes, and each chromosome has a single molecule of DNA in it. Overall, human beings have around twenty-three pairs of chromosomes in the nucleus of cells. DNA also plays an essential role in the process of cell division.

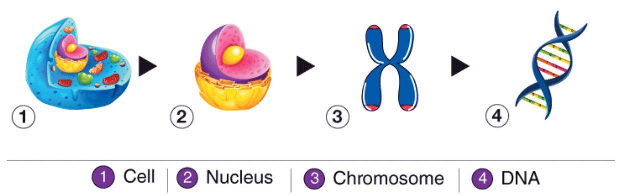


Fig. 4.26

DNA Functions

DNA is the genetic material which carries all the hereditary information. Genes are the small segments of DNA, consisting mostly of 250 – 2 million base pairs. A gene code for a polypeptide molecule, where three nitrogenous bases sequence stands for one amino acid.

Polypeptide chains are further folded in secondary, tertiary and quaternary structures to form different proteins. As every organism contains many genes in its DNA, different types of proteins can be formed. Proteins are the main functional and structural molecules in most organisms. Apart from storing genetic information, DNA is involved in:

i. Replication process: Transferring the genetic information from one cell to its daughters and from one generation to the next and equal distribution of DNA during the cell division
ii. Mutations: The changes which occur in the DNA sequences
iii. Transcription
iv. Cellular Metabolism
v. DNA Fingerprinting
vi. Gene Therapy

4.2.2 Introduction of RNA

Ribonucleic acid (abbreviated RNA) is a nucleic acid present in all living cells that has structural similarities to DNA. Unlike DNA, however, RNA is most often single-stranded. An RNA molecule has a backbone made of alternating phosphate groups and the sugar ribose, rather than the deoxyribose found in DNA. Attached to each sugar is one of four bases: adenine (A), uracil (U), cytosine (C) or guanine (G). Different types of RNA exist in cells: messenger RNA (mRNA), ribosomal RNA (rRNA) and transfer RNA (tRNA). In addition, some RNAs are involved in regulating gene expression. Certain viruses use RNA as their genomic material.

Basic Structure of RNA

The basic structure of RNA is shown in the figure below-

The ribonucleic acid has all the components same to that of the DNA with only 2 main differences within it. RNA has the same nitrogen bases called the adenine, Guanine, Cytosine as that of the DNA except for the Thymine which is replaced by the uracil. Adenine and uracil are considered as the major building blocks of RNA and both of them form base-pair with the help of 2 hydrogen bonds.

RNA resembles a hairpin structure and like the nucleotides in DNA, nucleotides are formed in this ribonucleic material(RNA). Nucleosides are nothing but the phosphate groups which sometimes also helps in the production of nucleotides in the DNA.

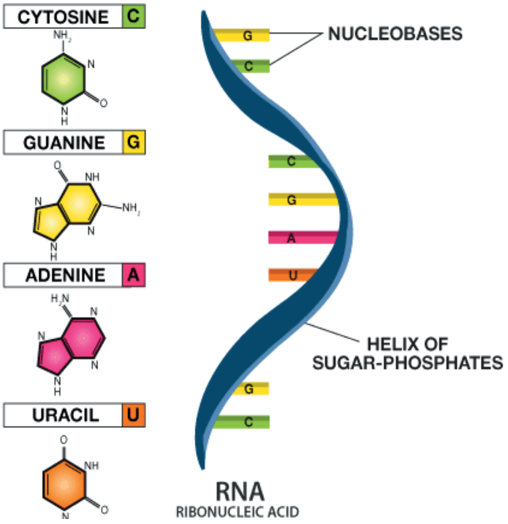


Fig. 4.27

Functions of RNA

The ribonucleic acid – RNA, which are mainly composed of nucleic acids, are involved in a variety of functions within the cell and are found in all living organisms including bacteria, viruses, plants, and animals. These nucleic acid functions as a structural molecule in cell organelles and are also involved in the catalysis of biochemical reactions. The different types of RNA are involved in various cellular process. The primary functions of RNA:

i. Facilitate the translation of DNA into proteins.
ii. Functions as an adapter molecule in protein synthesis.
iii. Serves as a messenger between the DNA and the ribosomes.
iv. They are the carrier of genetic information in all living cells
v. Promotes the ribosomes to choose the right amino acid which is required in building up of new proteins in the body.

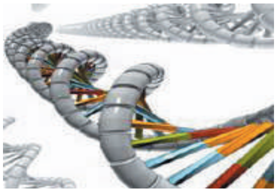


Fig. 4.28

4.2.3 Differences between DNA and RNA

Deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) are perhaps the most important molecules in cell biology, responsible for the storage and reading of genetic information that underpins all life. They are both linear polymers, consisting of sugars, phosphates and bases, but there are some key differences which separate the two[1]. These distinctions enable the two molecules to work together and fulfil their essential roles. Here, we look at 5 key differences between DNA and RNA. Before we delve into the differences, we take a look at these two nucleic acids side-by-side.

DNA vs. RNA – A comparison chart

comparison	DNA	RNA
Full Name	Deoxyribonucleic Acid	Ribonucleic Acid
Function	DNA replicates and stores genetic information. It is a blueprint for all genetic information contained within an organism.	RNA converts the genetic information contained within DNA to a format used to build proteins, and then moves it to ribosomal protein factories.
Structure	DNA consists of two strands, arranged in a double helix. These strands are made up of subunits called nucleotides. Each nucleotide contains a phosphate, a 5-carbon sugar molecule and a nitrogenous base.	RNA only has one strand, but like DNA, is made up of nucleotides. RNA strands are shorter than DNA strands. RNA sometimes forms a secondary double helix structure, but only intermittently.
Length	DNA is a much longer polymer than RNA. A chromosome, for example, is a single, long DNA molecule, which would be several centimetres in length when unravelled.	RNA molecules are variable in length, but much shorter than long DNA polymers. A large RNA molecule might only be a few thousand base pairs long.
Sugar	The sugar in DNA is deoxyribose, which contains one less hydroxyl group than RNA's ribose.	RNA contains ribose sugar molecules, without the hydroxyl modifications of deoxyribose.
Bases	The bases in DNA are Adenine ('A'), Thymine ('T'), Guanine ('G') and Cytosine ('C').	RNA shares Adenine ('A'), Guanine ('G') and Cytosine ('C') with DNA, but contains Uracil ('U') rather than Thymine.
Base Pairs	Adenine and Thymine pair (A-T) Cytosine and Guanine pair (C-G)	Adenine and Uracil pair (A-U) Cytosine and Guanine pair (C-G)
Location	DNA is found in the nucleus, with a small amount of DNA also present in mitochondria.	RNA forms in the nucleolus, and then moves to specialised regions of the cytoplasm depending on the type of RNA formed.
Reactivity	Due to its deoxyribose sugar, which contains one less oxygen-containing hydroxyl group, DNA is a more stable molecule than RNA, which is useful for a molecule which has the task of keeping genetic information safe.	RNA, containing a ribose sugar, is more reactive than DNA and is not stable in alkaline conditions. RNA's larger helical grooves mean it is more easily subject to attack by enzymes.
Ultraviolet (UV) Sensitivity	DNA is vulnerable to damage by ultraviolet light.	RNA is more resistant to damage from UV light than DNA.

4.2.4 Introction of Chromosomes

All living organisms are made up of cells. Cells are the structural and functional units of life. Multiplication and enlargement of cells causes development of any organism. Nucleus is the most important part of a cell. It plays vital role in cell division. Nucleus contains nucleolus and chromosomes which are surrounded by a porous nuclear membrane. Chromosomes are long, thick, coiled thread like microscopic structures. They are genetic substance that transfer characters from parents to offsprings. Chromosomes are made up of deoxyribonucleic acid (DNA) that transfer character from parents to off spring. Genes and protein forms DNA. Genes are the smallest units of DNA. Genes control the biological characteristics of organisms.

Chromosomes are known to be hereditary materials because they transfer the genetic character from parents to the offspring from a generation to other generation.

There are two types of chromosomes in the nucleus of the cells. They are autosomes and sex chromosomes. Sex chromosomes carry genes for the determination of sexes. Human beings have 22 pairs of autosome and one pair of sex chromosomes. Sudden change in the number of chromosome causes genetic disorders. In this unit, we study about chromosomes and sex determination.

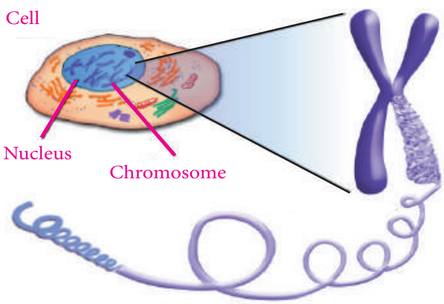


Fig. 4.29 chromosome of cell

The particular arrangement of chromosomes that an individual possesses is called a karyogram and the set of chromosomes is called a karyotype.

Chromosomes

Chromosomes are thread like coiled structure. They are located inside the nucleus of cell. The size of chromosomes varies from species to species. Chromosomes are present in pair. Chromosomes are made up of DNA and proteins.

The two parts of chromosomes are called chromatids. The chromatids are held together at a point called centromere. Centromere may be at any point of the chromosomes. During cell division centromere moves on different points of chromosomes on the basis of the position of centromere.

Structural Features of Chromosomes

1. Chromosome consists of a fine greatly coiled thread or filament called chromonema. The chromonema, in fact, is a coiled chromatin containing a single chemical molecule of double- standed deoxyribonucleic acid (DNA). The DNA is coiled tightly around proteins called histones. These proteins provide structural support to a chromosome and allow the very long DNA molecule to from a compact shape and fit inside the nucleus of a cell.
2. The other structures of chromosome are centromeres, secondary constrictions, nucleolar organizers telomeres and satellite.
3. The association between DNA, chromation and chromosome is based upon differential coiling.
4. The telomere or chromosomal end primary constriction or centromere along with chromatin near the centromere and satellite region of a chromosome contain heterochromatin.
5. A chromosome is made up of large amount of euchromatin and less amount of heterochromatin and they are present in different parts of a chromosome.
6. An exact copy of the DNA molecule in a chromosome is made so that at nuclear division the

chromosome is a double structure, containing two indentical DNA molecules. These two-part structures of chromosome are called chromatids with each chromatid of the pair containing one of the centromere. The centromere may occur anywhere along the length of the chromosome. Centromere is the only active part of chromosome during cell division.

Activities 4.4

Make models of DNA and RNA using various objects found locally and present them to the class.

Homologous Chromosomes

Out of two sets of each chromosome of a diploid cell, half or one of the pairs is derived from the mother and the other from the father. The chromosome which is derived from the mother is called maternal chromosome. The chromosome which is derived from the father is called paternal chromosome. The paired paternal and maternal chromosome is called homologous chromosome. In other words, homologous chromosomes are chromosome pairs. One from each parent, which are similar in structure i.e. similar in length, gene position and centromere location. Sister chromatids are the replicas of a single chromosome held together by a common centromere after DNA replication.

In humans, there are 23 pairs of chromosomes. The reason is that one set of chromosomes comes from the female parent though the egg and the other set of chromosomes comes from the male parent through sperm during fertilization. When the sperm cell fuses with the egg cell the resulting cell is called a zygote and it contains two sets of homologous chromosomes. Thus, the homologous chromosomes are a pair of the paternal and maternal chromosomes

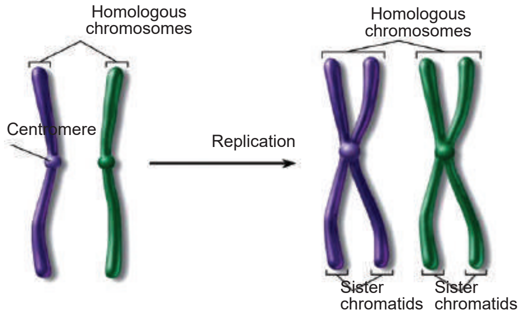


Fig. 4.30 homologous chromosomes

Function of Chromosomes

i. Chromosomes play a key role in cell division
ii. Play role in inheritance of hereditary characters from parents to their offspring.
iii. Chromosomes also help in growth and metabolism.

Diploid and Haploid Cells

There are two types of cells in the body of plants and animals. They are diploid cells and haploid cells. The diploid cells contain two complete sets of chromosomes or a pair of chromosomes. They are represented by 2n. Somatic cells such as skin cell, muscle cell and plant cells; like parenchyma cell, reproductive cell or meiocytes, zygote, spore mother cell, etc. are the examples of diploid cells.

Haploid cells have half the number of chromosomes compared to diploid cell. i.e. haploid cells contain only one complete set of chromosomes. They are represented by n. They are formed as a result of meiosis cell division; a type of cell division in which a diploid cell (2n) divides into four haploid cells (n). Spores, male gametes or sperm, egg etc. are the examples of haploid cells.

There are four types of chromosomes according to the position of centromere.

i. **Metacentric chromosomes**

Chromosomes having centromere in the medium position with equal arms are called meta central chromosomes. They are V shaped chromosomes.

ii. **Sub- meta centric chromosomes**

Chromosomes having centromere in sub- median region with unequal arms. One slightly longer than other are called sub- meta centric chromosomes.

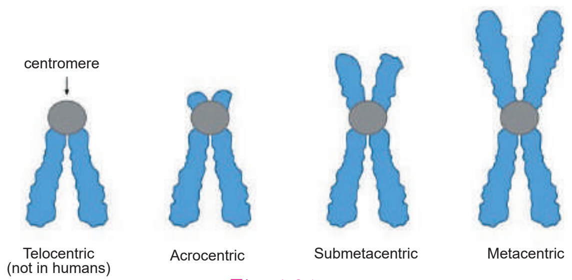


Fig. 4.31

iii. **Acrocentric chromosomes**

Chromsomes having centromere in the sub terminal region with unequal arms. One arm is very shorter than other are called acrocentric chromosomes.

iv. **Telocentric chromosomes**

Chromosomes having centromere at one end of chromosome are called telocentric chromosomes.

Activities 4.5

Construct a model of a chromosome using various objects found locally and present it to the class.

Number of Chromosomes

All the plants and animals have fixed number of chromosome in their cells. Number of chromosomes in cell varies from organism to organism, Animals and plants have two types of cells - somatic cell and reproductive cells (gametes). Somatic cells of plants and animals have diploid chromosomes. But gametes have haploid chromosomes. The paired paternal and maternal chromosome is called homologous chromosome.

Number of chromosomes present in some plants and animals are given in the table below.

S. N.	Plants / Animals	No. of Chromosomes (pair)
1	Sugarcane	40
2	Pea	7
3	Onion	8
4	Mucor	1
5	Human being	23
6	Frog	13
7	Dog	39
8	Mouse	20
9	Lion / tiger	19
10	Monkey	27
11	Horse	32
12	Housefly	6
13	Honey bee Queen/worker	32
	Drone bee	16

4.2.5 The role of sex chromosomes in sex determination in humans

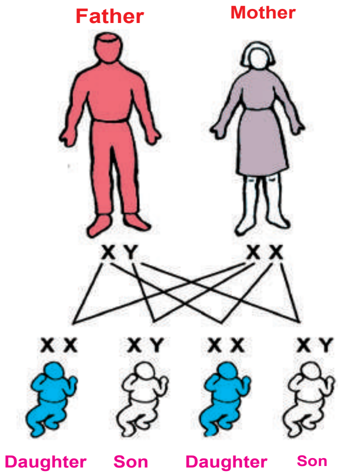


Fig. 4.32

There are two types of chromosomes - autosomes and sex chromosomes. Autosomes regulate the growth and development of the body. Sex chromosomes carry genes for the determination of sexes. Sex is determined at the time of fusion of male and female gametes.

In a human female, there are 22 pairs of autosomes and one pair of X - chromosome (44 + XX). In human males there are 22 pairs of autosomes and one X and another Y sex chromosomes is found (44 + XY). Males are heterogametic and females are homogametic organisms. An egg with X - chromosomes (22 + X) fertilized by the sperm having Y - chromosome (22 + Y) forms a zygote with XY - sex chromosomes (44 + X Y). This zygote develops into a male child similarly, an egg with X- chromosome (22 + X) fertilizes by the sperm having X - chromosome (22 + X) forms a zygote with XX - sex chromosomes (44 + XX). This zygote develops into female child. The XY sex determination system is found in unisexual or dioecious organisms like humans.

4.3 Heredity

A gene is the basic physical and functional unit of heredity. Genes are made up of DNA. Some genes act as instructions to make molecules called proteins. However, many genes do not code for proteins.

In eukaryotes (such as animals, plants, and fungi), genes are contained within the cell nucleus. The mitochondria (in animals) and the chloroplasts (in plants) also contain small subsets of genes distinct from the genes found in the nucleus. In prokaryotes (organisms lacking a distinct nucleus, such as bacteria), genes are contained in a single chromosome that is free-floating in the cell cytoplasm. Many bacteria also contain plasmids—extrachromosomal genetic elements with a small number of genes.

The number of genes in an organism's genome (the entire set of chromosomes) varies significantly between species. For example, whereas the human genome contains an estimated 20,000 to 25,000 genes, the genome of the bacterium Escherichia coli O157:H7 houses precisely 5,416 genes. Arabidopsis thaliana—the first plant for which a complete genomic sequence was recovered—has roughly 25,500 genes; its genome is one of the smallest known to plants. Among extant independently replicating organisms, the bacterium Mycoplasma genitalium has the fewest number of genes, just 517.

There are various type of plants and animals around us. They are similar with each other in some aspects. It is commonly found that, members of a species are largely alike. A dog resembles other dogs, a rose plant looks like other rose plants and children resemble their parents. It is not absolutely true that the offspring are exactly the same as their parents. There may occur certain variation in the offspring.

The process through which the parental characters transmit into the next generation is called heredity.

The branch of biology that deals with study of heredity and variation is called genetics. Gregor Johann Mendel is known as father of genetics. The hereditary characters of parents pass from one generating to another generation according to the particular law. Johann Mendel had developed this law by performing experiment on a pea plant.

Mendel used pea plant in his experiment due to following reasons.

1. Pea plant has a number of pairs of contrasting characters. They are as follows:

1)	Height of pea plants :	Tall (T) and short (t)
2)	Position of flower :	Axial (A) and terminal (a)
3)	Colour of seed :	Yellow (Y) and green (y)
4)	Colour of flower :	Purple (P) and white (p)
5)	Colour of pod :	Green (G) and yellow (g)
6)	Shape of seed :	Round (R) and wrinkle (r)
7)	Shape of pod :	Inflated i. and constricted i.

(Here, the characters denoted by T,A, P,Y G, R, and I are dominat characters denoted by t, a, p, y, g, r and i are recessive characters)

2. It is naturally self - pollinated as well as artificial cross - pollination which is possible on it.
3. It has short life cycle which makes possible to observe many successive generations.
4. It is easy to cultivate anywhere.
5. It gives fertile hybrid plants after cross - pollination.
6. It can produce a large number of offsprings at a time.

Some Terms Used in Genetics

a. **Unit character :** Definite external character in an individual of a cross is called its unit character. Each organism consists of its own type of characters. For example, a rose plant has its own type of leaf, flower, stem, etc. which acts as a unit character for it.

b. **Monohybrid and dihybrid cross**

Monohybrid cross: When only one unit character is involved in a cross, it is called monobybird cross. For example, across is made between tall and dwarf pea plants. The character involved in this cross is the height of the plant.

Dihybrid cross: When two unit characters are involved in a cross, it is called dihybrid cross. For example, across is made between a round yellow seeded pea plant and a wrinkled green seeded pea plant. Two characters involved in this cross are shape and colour of the seed.

c. **Dominant and recessive characters**

Dominant character: In a cross the character which express externally in the offspring by covering the other character is called dominant character. Dominant characters are represented by the first letter of the word of the dominant character in the capital form. For example, 'Tall' is a dominant character which is represented by the letter 'T'.

Recessive character: In a cross the character which are present in the gene but cannot express externally in the offspring due to the presence of dominant character is called recessive character. Recessive character is represented by the first letter of the word of the contrasting dominant character in a small form. For example, dwarf is represented by 't'.

d. **Allele or allelomorph :** A pair of genes controlling a pair of contrasting characters is usually known as a allelic pair. The members of allelic pair are said to represent alleles of each other.

For example, in the allelic pair Tt, 'T' is allele of 't' and vice versa.

e. **Phenotype and genotype :** The morphological appearance of an organism is called phenotype of that organism and genetic make-up of an organism is called genotype of that organism. For example, a pea plant having traits TT is both phenotypically and genotypically tall but another tall pea plant having traits Tt is phenotypically tall but genetically tall and dwarf both.

f. **Hybrid:** Hybrids are those organisms which have their phenotype and genotype different. For example, a pure tall father has the genotypic composition as TT in which T stands for tallness. Similarly, a pure dwarf mother is shown by tt in which t stands for dwarfness. The offspring formed by the couple will have the character of the father and the mother both but it is appeared tall, which is hybrid tall (Tt).

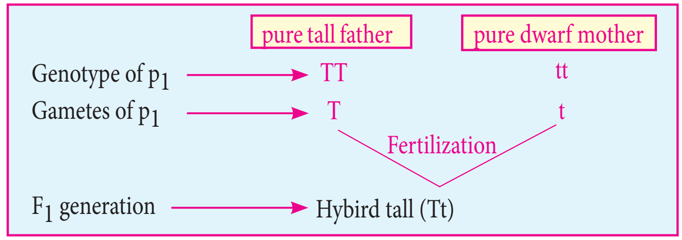


Fig. 4.33

Mendel's Experiment

Mendel selected pure tall and pure dwarf pea plants in a monohybrid cross. He had allowed pollination between them to find out how the characters transmit from parents to offsprings. The seeds produced by cross pollination were allowed to germinate and they were tall. He found that tall character is expressed and dwarf character is recessive characters.

Mendel allowed self pollination between hybrid plants of F_1 generation. He found 75% tall plants and 25% dwarf plants in the ratio of 3:1 in F_2 generation. In next generation one third (1/3) of tall plants produced tall and two third (2/3) of tall plants produced tall and dwarf plants. The pure dwarf plants produced pure dwarf plants. From the observation of third generation (F_3), he had concluded the following results.

1. Pure tall plants produce tall plants only.
2. Hybrid tall plants produce both tall and dwarf plants in the ratio of 3:1 .
3. Pure dwarf plants produce dwarf plants only.

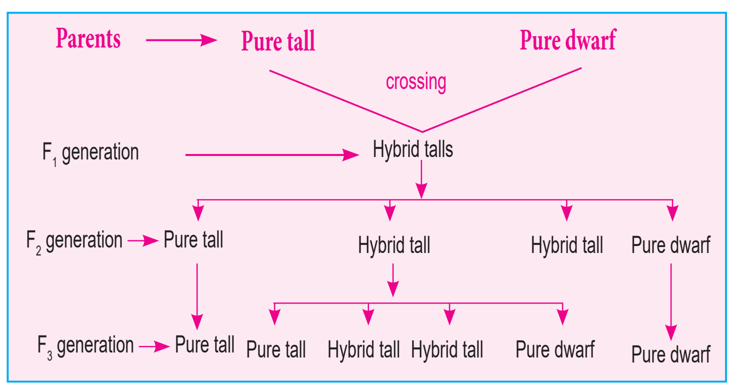


Fig. 4.34

While testing the seven pairs of contrasting characters of pea plants in his experiment, he found the same result in each case.

Some Examples of Mendel's Experiment

1. Draw a chart showing the result in first and second filial generation by monohybrid cross between red flowered pea plant with white flowered pea plant. What is the ratio dominant and recessive characters in F_2 generation?

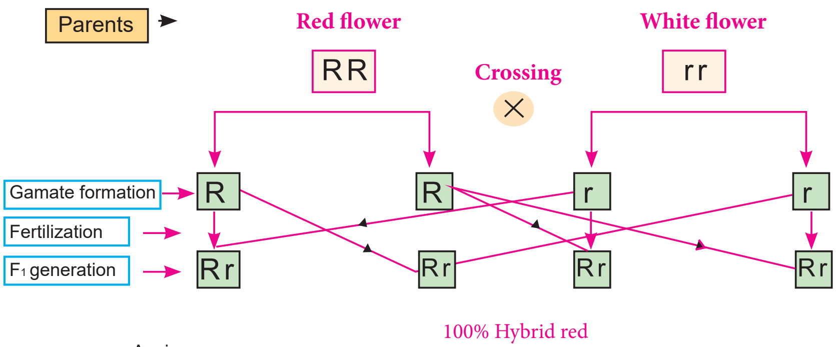


Fig. 4.35

Again,

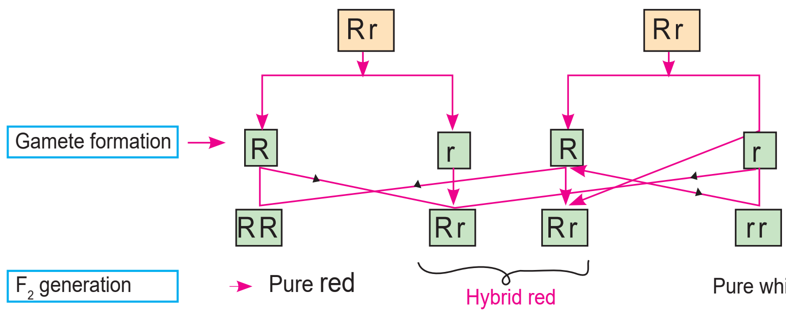


Fig. 4.36

When pure red and pure white flowered pea plants are crossed then 100% hybrid red pea plants is obtained in F_1 generation.

When two hybrids of F_1 generation are cross pollinated we get one pure red, two hybrid red and one pure white.

Here, the dominant character is red, therefore all plants of F_1 generation are red (hybrid). In F_2 generation, white colour, appears itself, which is the recessive character.

Therefore, the ratio of dominant and recessive character in F_1 generation (i.e. phonetype) is 3:1.

2. Draw a chart to show the result in the first and second filial generations of offspring of black father (BB) and write mother(bb).
Here, 'BB' is the pure black father and 'bb' is the pure white mother. The cross between them is given below.

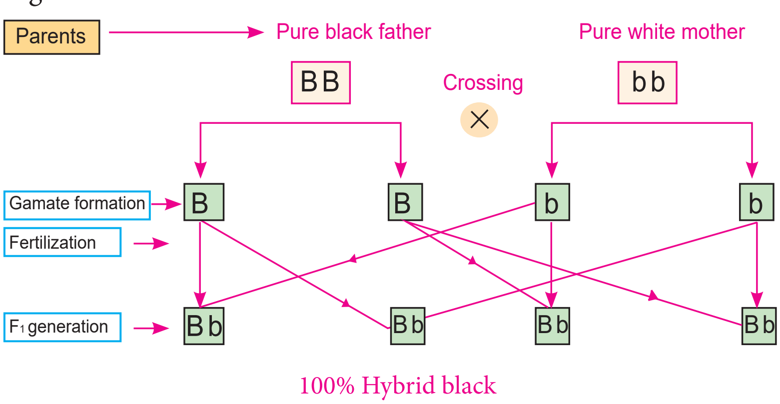


Fig. 4.37

Again,

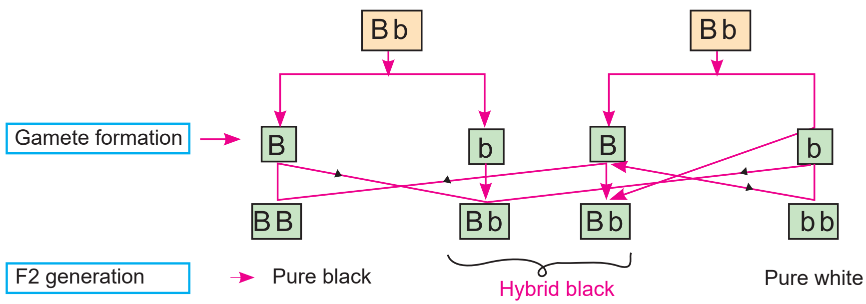


Fig. 4.38

Mendels' Law (Mendelism)

Mendel had proposed the following laws on the basis of result he had observed in his experiments on pea plants. This three law are know as:

- Law of dominance
- Law of purity of gametes
- Law of independent assortment

i. Law of dominance

This law states that when a cross is made between a pair of pure contrasting characters, only one of them is expressed phenotypically while the other remains hidden in F_1 generation.

The expressed character is called dominant character and hidden character is called recessive character. For example,

When a pure tall (TT) pea plant is cross pollinated with pure dwarf (tt) pea plants, all pea plants in F_1 generation become hybrid tall (Tt).

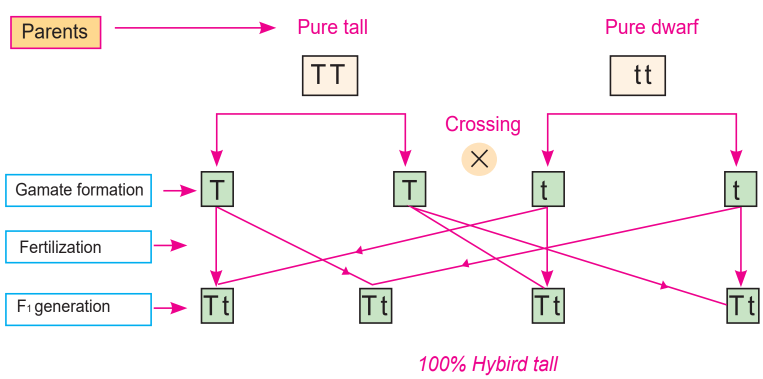


Fig. 4.3

ii. Law of purity of gametes

This law is also called law of segregation. It states that "In the hybrid obtained in F_1 generation contain two contrasting characters. These characters remain together but do not mix with each other and segregate at the time of gamete formation.

For example:

In Mendel's experiment when self pollination occur in two hybird pea plants obtained in F_1 generation, the tall and dwarf pea plants were found in the ratio of 3:1 phenotypically and 1:2:1 genotypically (one pure tall, two hybird tall, one pure dwarf). The reason of this result is that the tall and dwarf characters of pea plants get separated during the formation of gametogenesis.

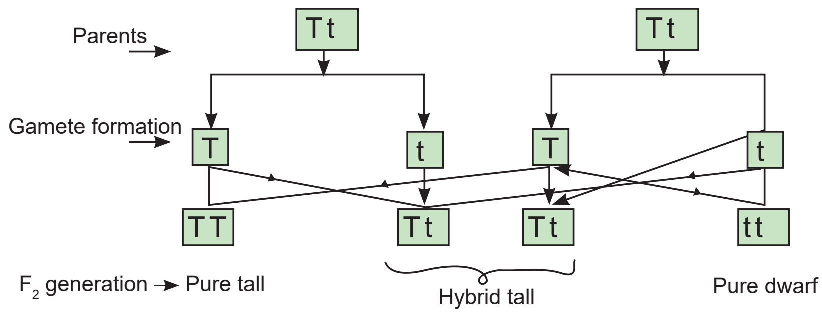


Fig. 4.40

Phenotype ratio → 3:1
Genotype ratio → 1:2 :1

Mendel's law is applicable for animals too. Thomas Hunt Morgan tested this law in fruit fly called drosophila. For this, he selected long winged and short-winged drosophila of F_1 generation. He found all the drosophila with long wing when drosophila of F_1 generation were crossed in F_2 generation. He found both long winged (75%) and short winged (25%) drosophila. In this way, it follows Mendel's law of dominance and law of purity of gametes.

Activities 4.6

How are genes separated in heredity?

You need :

Three glasses, black and white soybeans, and permanent markers.

Procedure :

Take 25/25 grains of white and black soybeans and mix them well. Put half and half in two glasses. Take three empty glasses and write the names 1, 2, and 3 with a marker. Close your eyes and take 1/1 soybeans from each glass. If both are white, then put them in a glass numbered 3; if both are black, then put them in a glass numbered 1; and if one is white and one black, put them in a glass numbered 2. After placing all the soybeans, put the soybeans in each glass separately. How much is the black pair? How many pairs of whites were found? Make notes in the exercise book. Write down the ratio of each black and white pair. What does the pair of black, white, and white-black represent in this activity? Finish by writing your conclusion.

iii. Law of Independent assortment

This is law states that in a dihybrid cross though the two characters remain in the same gene, the heritance of one of the characters is not affected by the inheritance of another .

Genetic Characteristics in Human Beings

There are many types of dominant and recessive characters in human beings.

Some dominant characters are:

1. No backward movement of thumb.
2. Rolling and bending of tongue.
3. Formation of dimple in check.
4. Curly hair.
5. Bending of thumb.

Some recessive character are:

1. Backward movement of thumb.

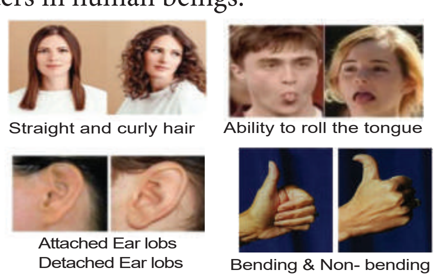


Fig. 4.41

2. Non rolling and non bending of tongue.
3. Non-formation of dimple in check.
4. Straight hair.
5. Non bending of thumb.

4.4 Genetic technology

Genetic technology is the term given to a range of activities concerned with understanding gene expression, taking advantage of natural genetic variation, modifying genes and transferring genes to new hosts.

This technology is also known as genetic engineering (genetic modification) provides ways to make changes to genes – the sets of instructions in the cells of all living creatures. There is a large amount of overlap between 'gene technology' and the newer term 'synthetic biology'. Traditional biotechnology has been practised for centuries. We've used conventional breeding to create new crops, new breeds of livestock and pets. We've harnessed yeast to make beer and bread, and rennet to make cheese. Gene technology is a modern branch of biotechnology that allows direct modification or removal of a gene, or the transfer of a gene from one species to another. When plants, animals and other organisms are changed using gene technology they are known as genetically modified organisms (GMOs). If the modification includes the introduction of a gene from another organism, then these are known as transgenic. For example, GM cotton often contains a gene from bacteria that produces an insecticide, reducing the need for crop spraying to control insect pests. When gene technology is used to create a GMO the use of that organism is regulated by the Gene Technology Regulator to protect people and the environment.

We know that, genes are found in all living organisms and are passed on from one generation to the next. They are the coded instructions an organism uses to make proteins, and it is these proteins that make up the structures and perform the functions of living things. Identifying genes and their function is an important application of gene technology and can lead to more efficient conventional breeding processes. Marker-assisted breeding is one example. Genetic markers for desirable traits such as colour or disease resistance are used to identify plants or animals for inclusion in a breeding program early in their development. This speeds up the selection process.

Gene technology today is an important part of modern biotechnology and is used, among other things, to give bacteria, plants and animals new properties. This is possible by inserting a gene from, for example, a bacterium, into a plant or animal (transgenes).

The techniques employed in genetic engineering have led to the **production of medically important products, including human insulin, human growth hormone, and hepatitis B vaccine**, as well as to the development of genetically modified organisms such as disease-resistant plants.

Traditional methods of selective breeding have been provided with several new tools including gene technology. We now have the potential to manipulate the actions of a gene or to take a gene from one organism and move it into another.

Gene technology not only gives us the potential to select the exact characteristics we want in an organism, but it also enables us to cross species barriers.

Producing enough food for the world's population without using up all the available land is an enormous challenge. One solution is to develop crops that yield more with fewer inputs; that are more resistant to diseases; that spoil less during storage and transport; that contain more useful nutrients; and that can grow in agricultural land that has been degraded. Gene technology is one of the tools that gives us the potential to do this.

4.4.1 The role of DNA testing in various investigations


Fig. 4.42

DNA profiling is a technique by which an individual can be identified at molecular level. The use of DNA evidence in criminal investigation has grown in recent years. DNA testing has helped low enforcement identify criminals and solve difficult crime such as rape, murder and murder with rape etc. The potential of DNA typing has made possible the resolution of immigration problems and complicated paternity testing when the father is not available. Rapid identification of individuals in mass-disaster (man- made such as-explosions) using DNA typing has also been possible .Computerized DNA database for the identification of criminal offenders have been created in some countries. DNA is a powerful investigative tool because, with the exception of identical twins, no two people have the same DNA. In other words, the sequence or order of the DNA building blocks is different in particular region of the cell, making each person's DNA unique. DNA tests are also used to identify those who have died in plane crashes. This tests are also used to identify unknown soldiers killed in war. DNA is also tested in immigration testing. DNA testing is also used by virgin mothers to win legal battles over the paternity of their children.

Project Work

Using the internet, search for DNA tests used in different fields and prepare a PowerPoint slide to present and discuss in class.

4.4.2 Convetional methods of selective breeding

The common methods for breeding self-pollinated species include **mass selection, pure line selection, pedigree, bulk population, single seed descent, backcrossing, multiline and composite**. Methods for breeding cross-pollinated species include mass selection, recurrent selection, family selection and synthetics .

Selective breeding is the traditional method for improving crops and livestock, such as increasing disease resistance or milk yield. Selective breeding can cause changes in animals and plants. It occurs when humans intervene. For this reason selective breeding is sometimes called **artificial selection**. Different varieties of plants and animals with desired characteristics can be developed by selective breeding. For example:

i. cows that produce lots of milk
ii. chickens that produce large eggs
iii. wheat plants that produce lots of grain

The new varieties may be economically important. For example, they may provide more or better quality food to feed people. Selective breeding takes place over many generations. These are the main steps involved:

i. decide which characteristics are important enough to select
ii. choose parents that show these characteristics
iii. choose the best offspring from parents to produce the next generation
iv. repeat the process continuously

And hence, selective breeding is the process of purposefully breeding plants and animals for the objective of obtaining particular genetic traits. The people who engage in selective breeding are known as breeders, and the bred animals are known as breeds. When you breed plants, the results are known as cultigens, cultivars or varieties. When there is a cross of animals, the results are referred to as crossbreeds, while a cross of plants results in hybrids. Similar methods are used in animal and plant breeding. When animals with desirable traits are selected, they are bred through the process of culling for particular for traits. Culling is the process of selecting livestock based on desired criteria, and destroying the others. This is how purebreds are produced. Purebreds with a recognizable lineage are known as pedigreed, while a mix of two separate purebreds will produce crossbreeds. The three methods of selective breeding are line breeding, inbreeding and outcrossing.

Line breeding is the process of breeding animals or plants that are closely related so as to "fix" or "set" desirable traits. For example, if a horse has some qualities that the breeder likes, the breeder could breed that horse with another relative so as to reinforce the desirable traits through a "pooling" of the genes. The idea is that if one animal has desirable qualities, mating it with a genetically related animal will increase those desirable traits. In human terms, linebreeding is like mating two close, but one-step-removed relatives, like first cousins, grandparent and grandchild, or uncle and niece.

Inbreeding is the mating of very closely related animals in the hopes of increasing the desired traits in the next generation. Inbreeding is similar to linebreeding only that in inbreeding, the animals would be as close as parents and offspring, or siblings. Inbreeding has some serious flaws because, while it may intensify the desired traits, it will also intensify any faults in the parents. Linebreeding is a little better, because the parents are one step removed. Still, it has similar drawbacks to inbreeding, because it is still that same small gene pool that is being passed from one generation to the next.

Outcrossing is the breeding of two animals or plants that are not related to each other. This means that the animals do not have any related ancestors in their pedigree for four generations or more. Outcrossing introduces new traits that are missing in the limited gene pools available in linebreeding and inbreeding. It can also "dilute" the effects of inbreeding by reducing the concentration of undesirable genes.

Problems with selective breeding

Future generations of selectively bred plants and animals will all share very similar genes. This could make some diseases more dangerous as all the organisms would be affected. Also, there is an increased risk of genetic disease caused by recessive alleles.

All the genes and their different alleles within a population is its **gene pool**. Inbreeding can lead to the loss of alleles from the gene pool, making it more difficult to produce new varieties in the future.

4.4.3 Introduction to Cross-breeding

Cross-breeding is the act or process of producing offspring by mating purebred individuals of different breeds or varieties. It is defined as the process or the act of producing offspring particularly through mating two purebred individuals but come from different breeds, varieties, or even species. When it is usually done with the intent of producing offspring that would acquire desired traits of the parent lineages the process is specifically referred to as designer cross-breeding. This is commonly practiced by breeders, especially when the desired traits would be beneficial to the offspring, such as when its biological fitness is enhanced. An example of such type of breeding is a cross between two known breeds of dogs. Through planned cross-breeding, crossbred dogs with increased vigor have become popularly referred to as *designer dogs*. Another example, creating a new breed of horse is often the main aim of crossbreeding in horses. One type of present-day horse crossbreeding technique is used to create many of the warmblood breeds of horses that we often see today at the horse track. Warmbloods are a type of horse that are increasingly used in popular equestrian events like dressage and charreada.

Although crossbreeding does result in producing better offspring and expanding the genetic pool, cautionary measures should still be upheld. An irresponsible cross-breeding may also produce animals of inferior quality and could weaken purebred gene pool. Cross-breeding is sometimes used synonymously with hybridization. In particular though, hybridization is a process to produce offspring (referred to as hybrid) by crossing two parents of different species.

Advantages of Cross-breeding

i. Used to improve genetics.
ii. Dominant genes mask recessive genes
iii. Hybrid vigor, or heterosis, occurs from the combination of genes.
iv. Cheaper to get started .
v. Weakness can be improved upon or eliminated by breedingan animal 'strong' in a particular trait to an animal that is considered to be lacking or 'weak' in that trait.
vi. The average productivity of the offspring is increased over either parents.
vii. Crossbreds are more fertile than their purebred parents
viii. Crossbreds wean heavier offspring than purebreds
ix. Crossbreds are more vigorous than purebreds.

Disadvantage of Cross-breeding

i. Often lack superior genes of purebreds.
ii. Must settle for market value at sale barn .
iii. Difficult to Predict Temperaments
iv. Hard to Predict Adult Size
v. Potential for High Risk Deliveries

Project Work

Prepare a brief report on selective breeding in various organisms by consulting your elders or searching the internet, and then present it to the class for discussion.

4.4.4 Introduction to in vitro fertilizations(IVF)

In vitro fertilization (IVF) is a medical procedure in which mature egg cells are removed from a woman, fertilized with male sperm outside the body, and inserted into the uterus of the same or another woman for normal gestation. It is also called test-tube conception . Although IVF with reimplantation of fertilized eggs (ova) has long been widely used in animal breeding, the first successful birth of a human child from IVF, carried out by British gynecologist Patrick Steptoe and British medical researcher Robert Edwards, did not take place until 1978.

In vitro fertilization is generally undertaken only after an exhaustive evaluation of infertility has been made. A number of the candidates for IVF are women who suffer from blocked or absent fallopian tubes; others are couples in which the male partner has a low sperm count or couples whose infertility is unexplained. The IVF procedure includes the recovery (by needle aspiration) of mature eggs and the incubation of the eggs in a culture medium, as well as the collection and preparation of sperm and its addition to the medium. In certain cases (e.g., low sperm count) intracytoplasmic sperm injection (ICSI) may be necessary. In this technique deoxyribonucleic acid (DNA) from sperm is injected via a needle into an egg. Fertilization generally occurs within 12 to 48 hours. The potential embryo is then placed in a growth medium, where it is observed periodically for division into two-cell, four-cell, and eight-cell stages. During this period the mother receives progesterone to prepare her uterine lining for implantation of the embryo. The embryo, which at this point is known as a blastocyst, is introduced through the cervix into the uterus, in which the blastocyst seems to float free for about three-and-a-half days. If the procedure is successful, the embryo implants itself in the uterine wall, and pregnancy begins.

Introduction to Artificial insemination(AI)

Artificial insemination (AI) is the process of collecting sperm cells from a male animal and manually depositing them into the reproductive tract of a female. It is among the most effective breeding methods that afford widespread propagation of genes carried by superior males . It is more profitable than the natural service method. The success of AI depends on several factors, including the technician and practices employed. Assessing technician's profile and their AI practices can be significant in improving AI success rate.

On the other hand, artificial insemination is the introduction of semen into the vagina or cervix of a female by any method other than sexual intercourse. The procedure is widely used in animal breeding and is used in humans when a male is sterile or impotent or when a couple suffers from unexplained infertility (when the cause of infertility cannot be identified). Impregnation of a woman through artificial insemination may also be used by women or men in same-sex partnerships who wish to produce children of their own.

Exercise

A. Choose the correct one and put the tick mark(√)

i. Cell division is the process by which a parent cell divides into _________ cells.
   a. father   b. mother   e. daughter   d. son

ii. The objective of mitosis is to make two genetically identical cells from a _________
   a. single cell   b. double cell   c. triple cell   d. none of above

iii. _________ is a form of cell division which results in the creation of gametes or sex cells.
   a. Mitosis   b. Meiosis   c. Miosis   d. None of the above

iv. The longest stage in the cell cycle is_________
   a. Interphase   b. Anaphase   c. Metaphase   d. None of the above

v. The spindle apparatus is formed during the _________ phase of mitosis.
   a. Telophase   b. Metaphase   c. Prophase   d. Anaphase

vi. Chromosome structure can be observed best during _________
   a. Anaphase   b. Metaphase   c. Prophase   d. None of the above

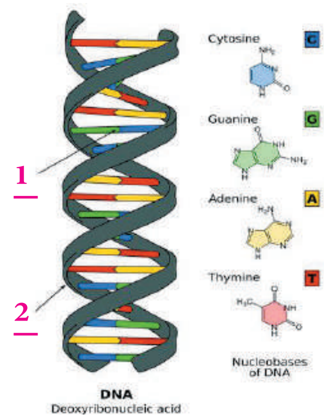
vii. Humans have _________ pairs of numbered chromosomes (autosomes) and one pair of sex chromosomes,
   a. 46   b. 23   c. 22   d. 44

viii. When only one unit character is involve in a cross
  a. single-hybrid cross b. monohybrid cross d. dihybrid cross c. None of above

ix. What is the character expressed in F1 generation called
  a. Dominant b. Recessive c. Heredity d. Both a and b

x. Which is correct for genetic technology-
  a. genetic modification b. In vitro fertilizer
  c. Cross-breeding d. artificial insemination

xi. What kind of structure is the molecule shown in the diagram?
  a. multi-strand b. ladder
  c. double helix d. double vertex



xii. The units of heredity that determine which traits, or characteristics, that children inherit from their parents are
  a. muscles. b. genes.
  c. birth. d. zygote.

xiii. The physical characteristics of an organism are its
  a. genetics. b. heredity.
  c. phenotype. d. genotype.

xiv. What is the long name for DNA?
  a. deoxynucleic acid
  b.deoxyribonucleic acid
  c. denatured ribonucleic acid
  d. deoxoribonuclear acid

xv. Males carry the combination of ________ sex chromosomes.
  a. XX b. AB c. XY d. YY

xvi. ________ is the process of making changes in the DNA code of living organisms.
  a. Cloning b. Inbreeding c. Genetic drift d. Genetic engineering

xvii. Human body cells have ________ chromosomes, or ________ pairs, that each parent contributes.
  a. 46; 23 b. 56; 28 c. 38; 19 d. none of the above

xviii. Varieties of purebred dogs are maintained by
  a. selective breeding. b. hybridization. c. inbreeding. d. genetic engineering.

B. Write down the full form :

i . DNA ii. RNA iii. GMO iv. IVF v. AI

C. Use the following words to fill in the blanks .

i. DNA os am annrevatopm for ____________________ ____________________
ii. DNA carries the infromation for making ____________________
iii. The building units on DNA are ____________________
iv. A nucleotide of DNA consists of ________ , ________ group and a ________ base.
v. There are only ________ typles of nitrogenous bases.

D. i. Complete the table to contrast the structures of DNA and RNA

	Sugar	Number of Strands	Bases
DNA			
RNA			

ii. Answer the questions 1-7 using the Punnett square shown below.

	B	b
B	BB	Bb
b	Bb	bb

a. What genotype do both parents have? __________
b. What letter represents the recessive gene? __________
c. What letter represents the dominant gene ? __________
d. What are the three genotypes an offspring could have? __________
e. If b is a recessive gene, list the offspring that will exhibit or show the recessive trait. __________
f. If B is dominant over b, list the offspring that will exhibit or show the dominant train. __________
g. Which genotype has a 50% chance of being inherited? __________

E. Differentiate between these pairs.

i. Mitosis and meosis
ii. Haploid and diploid cell
iii. Chromosome and Gene
iv. Metaphase and anaphase
v. Dominant and recessive characters
vi. F1 generation and F2 generation
vii. Selective breeding and cross-breeding
viii. DNA and RNA
ix. IVF and AI

F. Explain the following:

i. Mendel would not succeed in his experiment if he used frogs instead of pea plants.
ii. when tall and short pea plans are crossed , tall plants are seen in first generation .
iii. Between tall and short characters tall is dominant.
iv. Most of the characteristics of parents and children are the same.
v. Hardnata should not be a place for marriage.

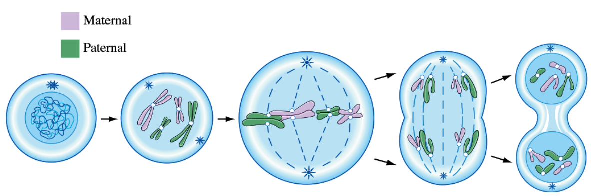
G. Answer the following questions :

i. What is cell division ?
ii. How many types cell division ?
iii. What is the difference between mitosis and meiotic cell division?
iv. Write five points about mitosis and meiosis in cell division.
v. Write down the difference between mitosis and meiosis based on the number of daughter cells.
vi. the number of chromosomes, and division.
vii. What is a chromosome? Write its importance and characteristics.
viii. Write a short introduction about DNA and RNA.
ix. Write about the role of sex chromosomes in sex determination in humans.
x. What is gene? Write its importance.
xi. Write down any three reasons why Mendel chose peas for his experiment.

xii. Give the definition of dominant character and recessive character. Write down any two examples of them.
xiii. Write Mendel's Law. Make a chart and present the rules related to monohybrid cross.
xiv. What is genetic technology? What is its significance?
xv. What is the role of DNA in various tests?
xvi. What is selective breeding? Prepare a list of methods used in this breeding.
xvii. What is cross-breeding? List its advantages and disadvantages with examples.
xviii. What is artificial insemination? Write briefly about its importance and challenges.
xix. What is IVF? Write its significance.
xx. What is artificial insemination? Describe its use and importance.
xxi. Explain mitosis with a neat labelled diagram.
xxii. Explain meiosis with a neat labelled diagram.

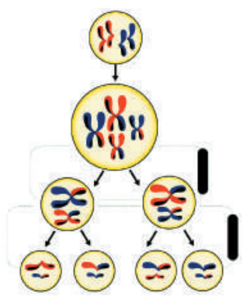
H. Diagrammatic Questions :

i. Which phases of cell division are shown in the pictures given below? What are the phases of a, b, c, d, and e? Copy the given picture in your exercise book and write the name of each one.

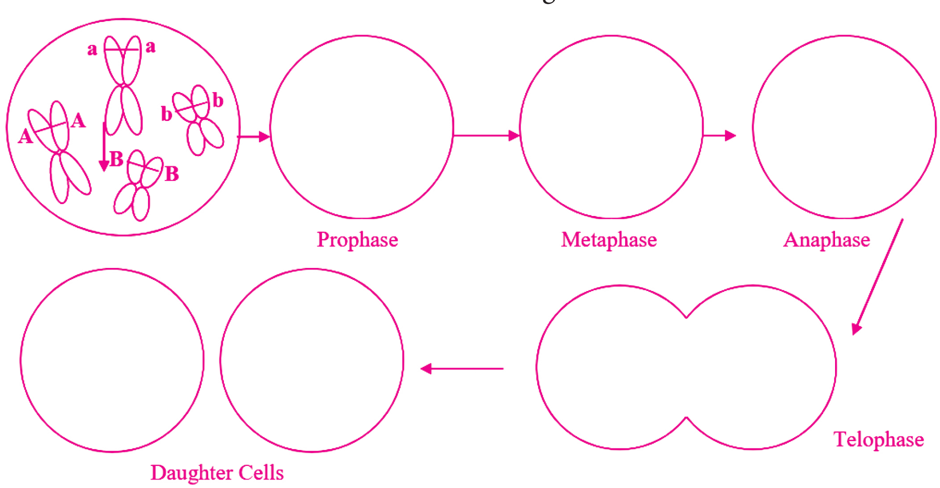


a b c d e

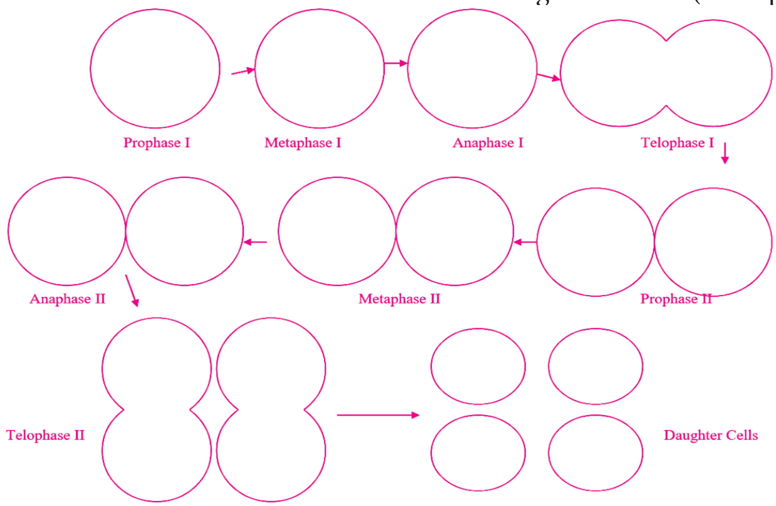
ii. Which phases of cell division are shown in the pictures given below? Copy the given picture in your exercise book and show the phases I and II with dotted lines.



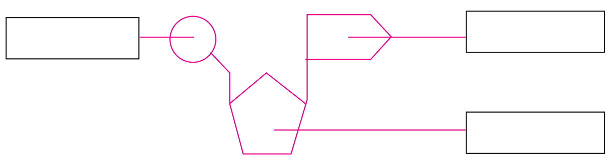
iii. a. Draw the chromosomes in the cell as it undergoes Mitosis:



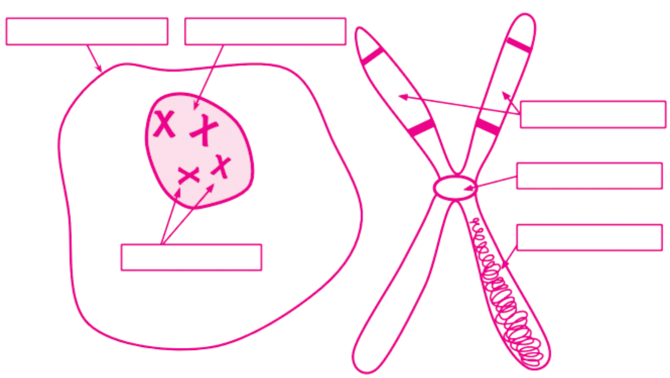
b. Draw the chromosomes in the cell as it undergoes Meiosis (same parent cell):



iv. Identify each component of the nucleotide below.



v. Chromosome Structure (Labeling)



Chromatid Chromosomes DNA
Centromere Cell Membrane Nucleus

vi. Result obtained by crossing two offspring is shown in the board along side . Answer these quetions on the board .

Male gametes		**T**	**t**
Female gametes	**T**	**TT**	**Tt**
	t	**Tt**	**tt**

a. Which types of cross are shown?
b. What is the ratio of dominant characters to recessive characters ?
c. To which filial generation does this result belong?

Chapter 5

Physical Structure and Life Process

Total Estimated pariods (Th. 9+ Pr. 3=12)

Student's Learning Outcomes

After studying this unit, the students will be able to :

- introduce the human circulatory system
- describe the structure and function of the human heart, blood vessels and blood
- describe the blood circulation in the human body with pictures
- introduce blood groups and emphasize the significance of their identification
- introduction to Blood Pressure, Blood Sugar, and Uric Acid, Symptoms of Abnormal Conditions Prevention, and Control Measures
- mention the introduction, causes, and methods of prevention and treatment of heart attacks

Karl Landsteiner, was born June 14, 1868, Vienna, Austrian Empire [Austria] and died June 26, 1943, New York, U.S.). He was Austrian American immunologist and pathologist who received the 1930 Nobel Prize for Physiology or Medicine for his discovery of the major blood groups and the development of the ABO system of blood typing that has made blood transfusion a routine medical practice. In 1900 Landsteiner found out that the blood of two people under contact agglutinates, and in 1901 he found that this effect was due to contact of blood with blood serum.

5. Life process

Living beings are the organisms which show all the characteristics of life i.e growth, movement, reproduction, respiration etc. Living beings are made up of cells, which form tissues, tissues form organs and organs form organ systems which ultimately form a living body and this organization should be maintained by movement of molecules around all the time as all the structures are made up of molecules. Life processes are the maintenance functions which take place even when the organisms are in rest to keep the living organisms alive. Nutrition, respiration, transportation, excretion are all basic life processes in order to remain alive.

5.1 Human circulatory system

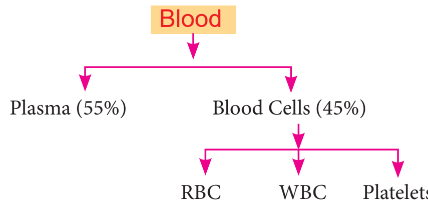
The circulatory system is a network that carries blood throughout the body. All animals except the simplest kinds have some type of circulatory system. The human circulatory system supplies the cells of the body with the food and oxygen needed to survive. At the same time, it carries carbon dioxide and other wastes away from the cells. The circulatory system also helps regulate body temperature and carries substances that protect the body from disease. In addition, the system transports chemical substances called **hormones**, which help regulate the activities of various parts of the body.

5.1.1 Blood

All the living beings need food, water, oxygen and hormone to live. During metabolism, different waste materials like carbondioxide, urea, etc. are produced in our body. Their accumulation in our body may be toxic. So, they should be regularly removed from the body. Blood circulation helps in transportation of nutrients and oxygen to different cells and collection of waste matter from them.

Circulation system includes heart, blood and blood vessels. Heart pumps the blood and maintains constant flow of blood throughout the body. Blood is circulated through 3 types of blood vessels.

Blood and its Composition



Blood is fluid connective tissue. It is made up of plasma (55%) and blood cell (45%). It is red coloured complex tissue. A healthy human body contains about 4.8 to 5.8 liter of blood . Blood is responsible for carrying nutrients, oxygen and hormones to all parts of the body and moving wastes products.

Plasma

Plasma covers 55% of blood by volume in human body. It is a transparent, pale yellow fluid. It contains anti bodies, hormones, water, protein, mineral, etc. About 90% of plasma is water, 8% proteins and 2% other dissolved substances.

Functions of plasma

i. It transports digested food and hormone to different parts of the body.
ii. It collects back waste materials for excretion.
iii. It maintains body temperature.
iuv. It helps in clotting of blood.

Blood cell

Blood cells are immersed in the plasma which covers about 45% of blood by volume. They are of three types: red blood corpuscles (RBC) white blood corpuscles (WBC), and platelets.

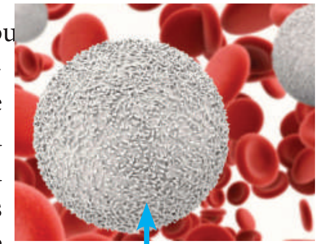
i. Red blood corpuscles (RBC) or Erythrocytes :

They are circular biconcave and disc-shaped cell having no nucleus. There are about 5 -5.5 millions RBCs per cubic millimeter in human blood. They are produced in the bone marrow of bones and destroyed in the liver and spleen. The life span of RBCs is about 120 days.

Fig. 5.1 red blood cells

Due to presence of haemoglobin, RBCs are red in colour. Haemoglobin contains iron due to which RBCs carry oxygen. The haemoglobin with oxygen is called oxyhaemoglobin (HbO). It is scarlet (bright red) in colour. When the numbers of RBC or their content in haemoglobin decreases, deficiency of RBC in blood leads to a disease called anaemia. Over secretion of RBC may lead the disease polycythemia. Some times, due to some reasons there is less amount of oxygen inside the body. They are also named as erythrocytes. Erythrocytes are called oxygen carriers as they carry oxygen from the lungs to the body tissues for respiration.

ii. White blood corpuscles (WBC)



white blood cell

Fig. 5.2

WBCs are colourless and irregular in shape. They have nuclei bu are also known as leukocytes. They may be of granular and non-granular type. Granular WBCs have multi-lobed nuclei while non-granular WBCs have nuclei. Neutrophils, eosinophils and basophils are granular leucocytes while lymphocytes and monocytes are non-granular. Each cubic mm of blood contains about 6,000 to 10,000 white blood cells. They are formed in the bone marrow and lymph glands. Their lifespan is about 15 days and are destroyed like the RBCs. If the number of WBC remains above normal in a person's body, it is called leukaemia, which is blood cancer.

WBCs help in the defense of the body by phagocytosis with the production of anti-bodies and by neutralizing the toxic substances produced by the germs. Neutrophils destroy bacteria, eosinophils increase and become active in the case of certain infections and allergies and basophils secrete anti-caagilant. Similarly, lymphocytes and monocytes are associated with the immune system. Lymphocytes produce antibodies and monocytes ingest non-bacterial foreign substances during infection. Immune power of the body decreases if the number of WBCs reduces below normal. The disease is called leukopenia.

iii. Platelets (thrombocytes)

They are known as thrombocytes. They are irregular, colourless, small blood cell. They have no nucleus. They are floating blood cells. The number of platelets in blood is about 2-4 lakhs per cubic mm. They are produced in bone marrow and die within 1-3 days in the spleen. Platelets help in clotting of blood and healing of cuts and wounds.

Distinction between RBC and WBC

RBC	WBC
i. They are small in size.	i. They are bigger in size.
ii. Their number is more.	ii. Their number is less.
iii. They are red in colours.	iii. They are white in colour.
iv. They can live for about 120 days.	iv.They can live for about 15 days.
v. They are oval biconcave and have no nucleus.	v. They are irregular and have nucleus.

Distinction between Blood Corpuscle and Plasma

Blood Corpuscles	Plasma
i. It contains haemoglobin.	i. It doesnot contain haemoglobin.
ii. It covers 45 % part of blood.	ii. It covers 55% part of blood.
iii. It is formed by blood cells like erythrocytes, leukocytes and platelets.	iii. It contains water, protein and other materials.
iv. It is red in colour.	iv. It is light yellow in colour.
v. Its function is to transport oxygen, defence against disease and clot blood at cuts.	v. It transport food, hormones and excretory materials.

Functions of Blood

Blood has mainly 3 functions. They are described briefly below.

1. Transportation

i. It transports the nutrients absorbed in intestines to all parts of the body.

ii. It also carries the hormones secreted by endocrine glands to different parts of the body.

iii. It returns back the waste products from the cells to the related excretory organs.

iv. It transports oxygen from lungs to different cells of the body and CO_2 from different parts of the body to the lungs for excretion.

2. Regulation

i. It maintains the body temperature.

ii. It also maintains different chemicals in the body.

iii. It regulates the amount of water in the body .

3. Protection

i. It produces antibodies and helps in defence system of the body.

ii. It helps in blood clotting and healing of wounds.

Activities 5.1

Observe permanent slides of blood smears with the help of a microscope in your school's laboratory. Based on the observation, write an introduction with pictures and present it to the class.

5.1.2 The blood circulation in the human body

Blood comes into the right atrium from the body, moves into the right ventricle and is pushed into the pulmonary arteries in the lungs. After picking up oxygen, the blood travels back to the heart through the pulmonary veins into the left atrium, to the left ventricle and out to the body's tissues through the aorta. There are two types of circulation within the body, namely pulmonary circulation and systemiccirculation.

Heart - Pump of the Circulatory system

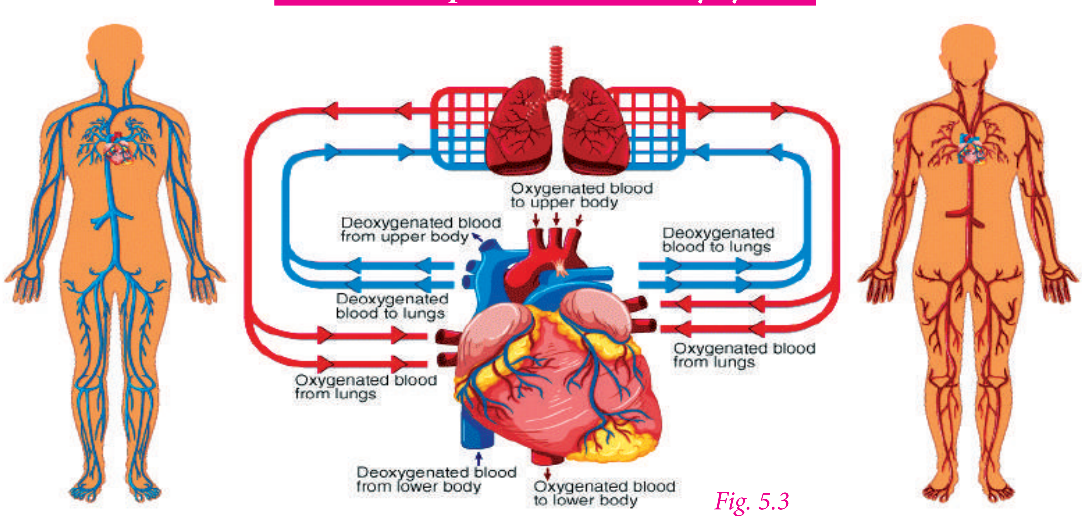


Fig. 5.3

i. Pulmonary circulation is a portion of circulation responsible for carrying deoxygenated blood away from the heart, to the lungs and then bringing oxygenated blood back to the heart. Pulmonary circulation provides the gaseous exchanges between the pulmonary alveoli and capillaries. This circuit extends from the heart to the lungs and back to the heart; 100% of cardiac output goes through it. Pulmonary circulation moves blood between the heart and the lungs. It transports deoxygenated blood to the lungs to absorb oxygen and release carbon dioxide. The oxygenated blood then flows back to the heart. Systemic circulation moves blood between the heart and the rest of the body.

ii. Systemic circulation is another portion of circulation where the oxygenated blood is pumped from the heart to every organ and tissue in the body, and deoxygenated blood comes back again to the heart. The systemic circulation provides the functional blood supply to all body tissue. It carries oxygen and nutrients to the cells and picks up carbon dioxide and waste products. Systemic circulation carries oxygenated blood from the left ventricle, through the arteries, to the capillaries in the tissues of the body.

Now, the heart itself is a muscle and therefore, it needs a constant supply of oxygenated blood. This is where another type of circulation comes into play, the coronary circulation.

- Coronary circulation is an essential portion of the circulation, where oxygenated blood is supplied to the heart. This is important as the heart is responsible for supplying blood throughout the body.
- Moreover, organs like the brain need a steady flow of fresh, oxygenated blood to ensure functionality.

In a nutshell, the circulatory system plays a vital role in supplying oxygen, and nutrients and removing carbon dioxide and other wastes from the body.

Activities 5.2

Draw a labeled diagram of the process by which blood circulates. See the material on the internet about this process in the presence of the teacher. Briefly present the information you have received in the classroom.

5.1.3 Blood groups

The term 'blood group' refers to the entire blood group system comprising red blood cell (RBC) antigens whose specificity is controlled by a series of genes which can be allelic or linked very closely on the same chromosome. 'Blood type' refers to a specific pattern of reaction to testing antisera within a given system. Over a period of time, our understanding on blood groups has evolved to encompass not only transfusion-related problems but also specific disease association with RBC surface antigens. There are 4 main blood groups (types of blood) – A, B, AB and O. Your blood group is determined by the genes you inherit from your parents.

i. **Blood group A** – has A antigens on the red blood cells with anti-B antibodies in the plasma
ii. **Blood group B** – has B antigens with anti-A antibodies in the plasma
iii. **Blood group O** – has no antigens, but both anti-A and anti-B antibodies in the plasma
iv. **blood group AB** – has both A and B antigens, but no antibodies

Blood group O is the most common blood group. Almost half of the UK population (48%) has blood group O. Receiving blood from the wrong ABO group can be life-threatening. For example, if someone with group B blood is given group A blood, their anti-A antibodies will attack the group A cells. This is why group A blood must never be given to someone who has group B blood and vice versa. As group O red blood cells do not have any A or B antigens, it can safely be given to any other group. Most people are able to give blood, but only 1 in 25 people actually do. You can donate blood if you:

i. are fit and healthy
ii. weigh at least 50kg
iii. are 17-66 years old (or 70 if you've given blood before)
iv. are over 70 and have given blood in the last 2 years

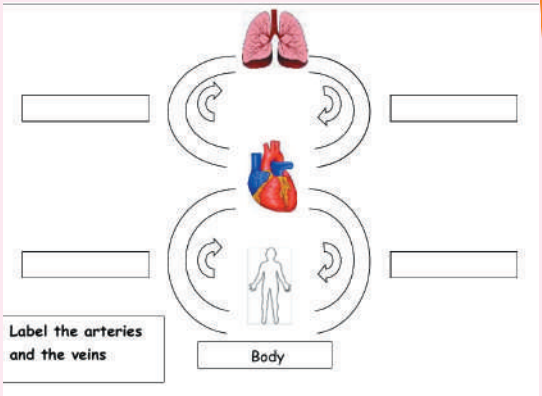
Patient Blood Group	Compatible Donor Red Cells	Compatible Donor Plasma
O-	O-	O-,O+,AB-,AB+,A-,A+B+,B-
O+	O-,O+	O-, O+, AB-, AB+
A-	O-,A-	O-,O+,AB-,AB+
A+	O-,O+,A-,A+	O-,O+,AB-,AB+
B-	O-,B-	B-,B+,AB-,AB+
B+	O-,O+,B-,B+	B-,B+,AB-,AB+
AB-	O-,A-,B-,AB-	AB-,AB+
AB+	O-,O+,A-,A+,B-B+,AB-,AB+	AB-,AB+

Activities 5.3

i. Complete the following worksheet :

The heart is part of the ____ system and is responsible of pumping ____ around the body. It is described as an ____ muscle and thre are 3 blood vessels that work with the heart to transport blood around the body. there are ____ , ____ and ____ . The ____ are responsible for carrying blood away from the heart. The ____ carry blood to the heart while the ____ are responsible for swapping gasses. Our muscles take in ____ as energy and give out ____ ____ as waste. If a blood vessel is high in Oxygen, it is called ____ blood. If the blood is rich in Carbon Dioxide, if is called ____ blood.

The swapping of these gases always takes place in the ____ and both gases are breathed in and out by the ____ The heart also has 4 chambers. Two on the top called ____ and two on the bottom called ____ .



Circulator	Oxygen
Dexygenated	Artiums
Blood	Capillaries
Involuntary	Veins
Arteries	Oxygenated
alveoli	Lungs
Ventricles	Carbon Dioxide

ii. Record the blood groups of all your classmates by asking them. Discuss the different blood groups of your friends, write a short note on blood donation, and present it in the classroom.

5.1.4 The significance of blood group identification

i. **For Blood transfusion :** The accurate grouping of blood is very important when it comes to having a blood transfusion. If blood is given to a patient that has a blood type that is incompatible with the blood type of the blood that the patient receives, it can cause intravenous clumping in the patient's blood which can be fatal. The patient's body can start producing antibodies that attack the antigens on the blood cells in the blood that was given to the patient, causing reaction and rejection.

ii. **For find out heredity:** Blood typing is particularly important for pregnant women, as blood groups are hereditary and can be passed from either the mother or father.

iii. **For medical reasons :**The most important reason to know your blood type is in case of an emergency. If you are in a situation where you require a blood transfusion, you'll need compatible blood. An incompatible blood group can cause blood cells to clump—which can be fatal.

iv. **To help others:** One of the best, and most selfless, reasons to know your blood type is to help others through blood donations. Medical facilities are always in need of blood donations, whether you are O or A.

v. **To plan a healthy pregnancy:** Knowing your blood type can help predict some conditions that can occur during pregnancy, such as Rh incompatibility between mom and baby.

vi. **To reduce your chances of developing certain health problems:** Most of the time, blood typing helps you safely donate and help others, but it can also let you know if you are at risk for certain health conditions in the future. Some studies suggest a connection between certain blood types and the risk of blood clots, bleeding, and kidney stones.Your blood type is just one factor that contributes to your risk of certain health conditions. Make sure you see your physician for regular check-ups and maintain a healthy lifestyle.

5.1.5 Blood vessels

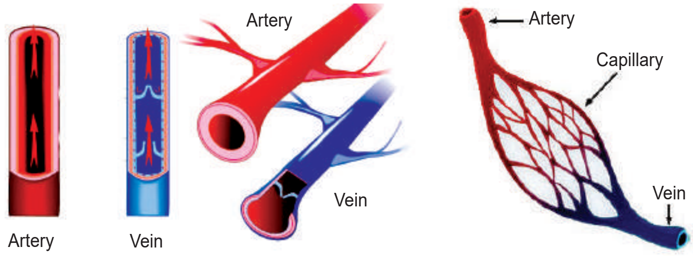


Fig. 5.4 blood vessels

The blood vessels form a complicated system of connecting tubes throughout the body. The three major types of blood vessels include: Arteries that carry blood from the heart, veins that return blood to the heart and capillaries that are extremely tiny vessels that connect the arteries and the veins. The exchange of nutrients and oxygen usually occurs in the capillaries. The blood consists chiefly of liquid called plasma and three types of solid particles known as formed elements. Plasma is made mostly of water, but it also contains proteins, minerals and other substances. The three types of formed elements are red blood cells, white blood cells and platelets. Red blood cells carry oxygen and carbon dioxide throughout the body. White blood cells help protect the body from disease. Platelets release substances that enable blood to clot. Platelets thus aid in preventing the loss of blood from injured vessels.

In organisms with closed circulatory systems, the blood flows within vessels of varying sizes. All vertebrates, including humans, possess this type of circulation. The external structure of the heart has many blood vessels that form a network, with other major vessels emerging from within the structure. The blood vessels typically comprise the following:

- **Veins** supply deoxygenated blood to the heart via inferior and superior vena cava, and it eventually drains into the right atrium.
- **Capillaries** are tiny, tube-like vessels which form a network between the arteries to veins.
- **Arteries** are muscular-walled tubes mainly involved in supplying oxygenated blood away from the heart to all other parts of the body. Aorta is the largest of the arteries and it branches off into various smaller arteries throughout the body.

Valves

Valves are flaps of fibrous tissues located in the cardiac chambers between the veins. They ensure that the blood flows in a single direction (unidirectional). Flaps also prevent the blood from flowing backwards. Based on their function, valves are of two types:

- **Atrioventricular valves** are between ventricles and atria. The valve between the right ventricle and right atrium is the tricuspid valve, and the one which is found between the left ventricle and left atrium is known as the mitral valve.
- **Semilunar valves** are located between the left ventricle and the aorta. It is also found between the pulmonary artery and the right ventricle.

5.1.6 The structure of the human heart

The heart is a hollow, muscular organ that pumps blood. It consists of two pumps that lie side by side. These pumps relax when taking in blood and contract as they send out blood. The left side of the heart is a stronger pump than the right side. The stronger pump receives blood from the lungs and sends it to cells throughout the body. The weaker pump receives blood from the cells throughout the body and sends the blood to the lungs.

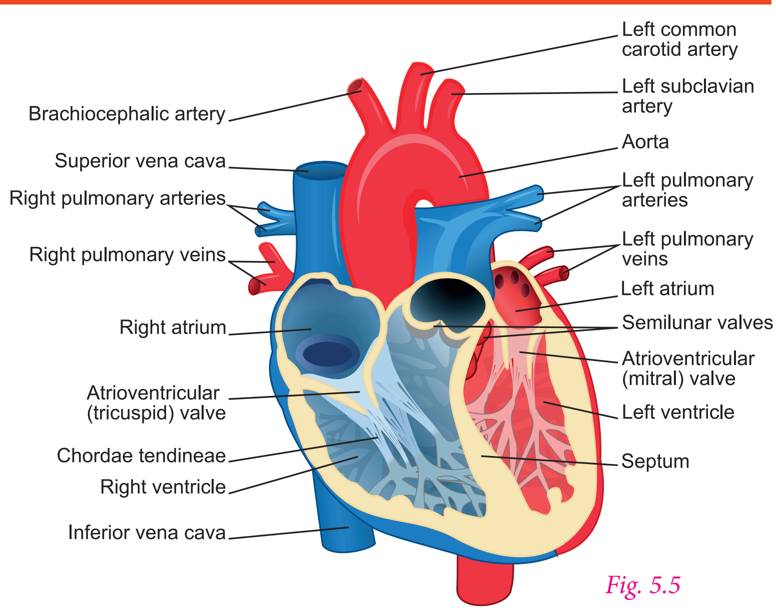


Fig. 5.5

The human heart is one of the most important organs responsible for sustaining life. The human heart functions throughout a person's lifespan and is one of the most robust and hardest working muscles in the human body. Besides humans, most other animals also possess a heart that pumps blood throughout their bodies. Even invertebrates such as grasshoppers possess a heart like pumping organ, though they do not function the same way a human heart does.

The human heart is about the size of a human fist and is divided into four chambers, namely two ventricles and two atria. The ventricles are the chambers that pump blood and the atrium are the chambers that receive blood. Among these both the right atrium and ventricle make up the 'right heart,' and the left atrium and ventricle make up the 'left heart'. The structure of the heart also houses the biggest artery in the body – the aorta.

The right and the left region of the heart are separated by a wall of muscle called the septum. The right ventricle pumps the blood to the lungs for re-oxygenation through the pulmonary arteries. The right semilunar valves close and prevent the blood from flowing back into the heart. Then, the oxygenated blood is received by the left atrium from the lungs via the pulmonary veins.

The human heart is located between the lungs in the thoracic cavity, slightly towards the left of the sternum (breastbone). It is derived from the embryonic mesodermal germ layer.

External Structure of Heart

One of the very first structures which can be observed when the external structure of the heart is viewed is the pericardium.

Pericardium

The human heart is situated to the left of the chest and is enclosed within a fluid-filled cavity described as the pericardial cavity. The walls and lining of the pericardial cavity are made up of a membrane known as the pericardium. The pericardium is a fibre membrane found as an external covering around the heart. It protects the heart by producing a serous fluid, which serves to lubricate the heart and prevent friction between the surrounding organs. Apart from the lubrication, the pericardium also helps by holding the heart in its position and by maintaining a hollow space for the heart to expand itself when it is full. The pericardium has two exclusive layers—

- **Visceral Layer:** It directly covers the outside of the heart.
- **Parietal Layer:** It forms a sac around the outer region of the heart that contains the fluid in the pericardial cavity.

Structure of the Heart Wall

The heart wall is made up of 3 layers, namely:

- **Epicardium –** Epicardium is the outermost layer of the heart. It is composed of a thin-layered membrane that serves to lubricate and protect the outer section.
- **Myocardium –** This is a layer of muscle tissue and it constitutes the middle layer wall of the heart. It contributes to the thickness and is responsible for the pumping action.
- **Endocardium –** It is the innermost layer that lines the inner heart chambers and covers the heart valves. Furthermore, it prevents the blood from sticking to the inner walls, thereby preventing potentially fatal blood clots.

Internal Structure of Heart

The internal structure of the heart is rather intricate with several chambers and valves that control the flow of blood.

Chambers of the Heart

Vertebrate hearts can be classified based on the number of chambers present. For instance, most fish have two chambers, and reptiles and amphibians have three chambers. Avian and mammalian hearts consists of four chambers. Humans are mammals; hence, we have four chambers, namely:

- Left atrium
- Left ventricle
- Right atrium
- Right ventricle

Atria are thin and have less muscular walls and are smaller than ventricles. These are the blood-receiving chambers that are fed by the large veins.

Ventricles are larger and more muscular chambers responsible for pumping and pushing blood out into circulation. These are connected to larger arteries that deliver blood for circulation.

The right ventricle and right atrium are comparatively smaller than the left chambers. The walls consist of fewer muscles compared to the left portion, and the size difference is based on their functions. The blood originating from the right side flows through the pulmonary circulation, while blood arising from the left chambers is pumped throughout the body.

5.1.7 The function of the human heart

The function of the heart in any organism is to maintain a constant flow of blood throughout the body. This replenishes oxygen and circulates nutrients among the cells and tissues.

Following are the main functions of the heart:
- One of the primary functions of the human heart is to pump blood throughout the body.
- Blood delivers oxygen, hormones, glucose and other components to various parts of the body, including the human heart.
- The heart also ensures that adequate blood pressure is maintained in the body

Activities 5.4

Draw a lebeled figure of a heart and present it in the classroom. Bring the heart model from the school laboratory to the classroom and discuss its various parts and write a brief note.

5.2 Introduction to Blood Pressure

Heartbeat

The rhythmic contraction and relaxation of the cardiac muscles of the heart is heart beat. The normal heart beat in an adult is about 72- 80 times per minute. The rate of heartbeat become faster during doing exercise, running and suffering from fever.

Blood Pressure

Force exerted by blood on the wall of artery is called blood pressure. It is measured by an instrument called sphygmomanometer. In a young normal person blood pressure is 120/80 mm of Hg. It may vary with the age, doing exercise and during excitement. The size of arteries, speed of blood flow, quantities of blood and pumping capacity of heart affect the blood pressure. Blood pressure is of two types: systolic and diastolic pressure.

Fig. 5.6

Systolic : When ventricles get contracted maximum pressure is exerted by blood on the wall of the artery. This pressure is called systolic pressure. It ranges 100 -140 mm of Hg in a healthy person.

Diastolic : When ventricles get relaxed minimum pressure is exerted by blood on the wall of the artery. This is called diastolic pressure. It ranges from 60- 90 mmHg in a healthy person.

Common diseases related to blood.

i. High blood pressure

Generally, 120 / 80 mm of Hg is the normal blood pressure. When the lower limit of blood pressure exceeds 90 mm of Hg and the upper limit of blood pressure exceed 140 mm of Hg, it is called high blood pressure. This condition is also called hypertension.

Causes of high blood pressure

- Smoking
- Consumption of alcohol
- Use of much salt in food
- Chronic kidney disease and thyroid disorder
- Lack of physical exercise
- Stress, old age and hereditary causes
- Overweight

5.2.1 Symptoms of Abnormal Conditions of Blood Pressure

i. Blurry or double vision.
ii. Lightheadedness/Fainting.
iii. Fatigue.
iv. Headache.
v. Heart palpitations.
vi Nosebleeds.
vii. Shortness of breath.
viii. Nausea and/or vomiting.

5.2.2 Prevention to Blood Pressure

By living a healthy lifestyle, you can help keep your blood pressure in a healthy range. Preventing high blood pressure, which is also called hypertension, can lower your risk for heart disease and stroke. Practice the following healthy living habits:

i. Maintaining a healthy weight. Being overweight can make you two to six times more likely to develop high blood pressure than if you are at your desirable weight. Even small amounts of weight loss can make a big difference in helping to prevent and treat high blood pressure.

ii. **Getting regular exercise:** People who are physically active have a lower risk of getting high blood pressure -- 20% to 50% lower -- than people who are not active. You don't have to be a marathon runner to benefit from physical activity. Even light activities, if done daily, can help lower your risk.

iii. **Reducing salt intake:** Often, when people with high blood pressure cut back on salt, their blood pressure falls. Cutting back on salt also prevents blood pressure from rising.

iv. **Avoid chewing tobaco smoking and using alcohol :** Chewing tobaco smoking and drinking too much alcohol can raise your blood pressure.

v. **Reduce stress:** Stress can make blood pressure go up, and over time may contribute to the cause of high blood pressure. There are many steps you can take to reduce your stress.

Control Measures to Blood Pressure

1. **Check** your blood pressure regularly.
2. **Take** your blood pressure medicine as directed. If you are having trouble, aske your doctor what can be done to make it easier.
3. **Eat** a healthy diet that is high in fruits and vegetables and low in sodium saturated facts, trans fat, and cholesterol.
4. **Achieve** and maintain a healthy body weight.
5. **Participate** in 30 minutes of moderate physical activeity on most days of the week.
6. **Quit** smoking - and if you don't smoke, don't multiplies the risks of high blood pressure.
7. **Avoid** second- hand smoke.
8. **Manage** stress through activities you find relaxing.
9. **Limit** the amount of alcohol you drink (no more than one drink each day for women and two for men).

10. **Support** a family member or close friend with high blood pressure by reparing healthy meals, taking walks and managing stress together.

5.2.3 Introduction to Blood Sugar (Diabetes)

Diabetes is a disease that occurs when your blood glucose, also called blood sugar, is too high. Blood sugar, or glucose, is the main sugar found in blood. The body gets glucose from the food we eat. This sugar is an important source of energy and provides nutrients to the body's organs, muscles and nervous system. The absorption, storage and production of glucose is regulated constantly by complex processes involving the small intestine, liver and pancreas.

Glucose enters the bloodstream after a person has eaten carbohydrates. The endocrine system helps keep the bloodstream's glucose levels in check using the pancreas. This organ produces the hormone insulin, releasing it after a person consumes protein or carbohydrates. The insulin sends excess glucose in the liver as glycogen. The pancreas also produces a hormone called glucagon, which does the opposite of insulin, raising blood sugar levels when needed. the two hormones work together to keep glucose balanced.

Over time, having too much glucose in your blood can cause serious problems. Even if you don't have diabetes, sometimes you may have problems with blood sugar that is too low or too high. Keeping a regular schedule of eating, activity, and taking any medicines you need can help.

If you do have diabetes, it is very important to keep your blood sugar numbers in your target range. You may need to check your blood sugar several times each day. Your health care provider will also do a blood test called an A1C. It checks your average blood sugar level over the past three months. If your blood sugar is too high, you may need to take medicines and/or follow a special diet.

5.2.4 Symptoms of Blood Sugar (Diabetes)

i. **Frequent urination :** When your blood sugar is high, your kidneys expel the excess blood sugar, causing you to urinate more frequently. One of the early warning signs of diabetes is frequent urination that is urgent enough to wake you up to go to the bathroom during sleep.

ii. **Increased thirst :** While your kidneys are working overtime and you're urinating more frequently, valuable fluids will be pulled from your tissues. Frequent urination will make you feel constantly thirsty.

iii. **Fatigue :** When your blood sugar is high, your body works hard to get rid of the excess sugar. Not only does this process take a toll on your body, but it also alters the way that your body uses glucose for energy. Excessively high blood sugar, or hyperglycemia, has fatiguing effects among other symptoms. Additionally, the dehydration that accompanies more frequent urination is a common cause of fatigue in diabetics.

iv. **Blurred vision :** High blood sugar can cause damage to the small blood vessels of the eye, resulting in a swollen lens that can cause blurred vision. As blood sugar levels rise and lower, your vision may return to normal or worsen, respectively.

v. **Increased hunger :** When you have high blood sugar, your body is actively looking to get rid of it. Because your body expels so much of the glucose you're getting from your food, you may have increased feelings of hunger.

vi. **Unexplained weight loss :** With the discharge of excess glucose, you're losing your largest energy source, and when your body is unable to use glucose for energy, it starts burning fat and muscle, causing weight loss. Unexplained weight loss is considered to be significant at 10 lbs or 5% of overall body weight.

vii. **Slow healing cuts and wounds :** Similar to damaged eye tissue causing blurred vision, damaged blood vessels cause weakened blood circulation. Because of this, it's harder for blood to reach the affected area, and minor cuts or wounds can take weeks or months to heal. This slow healing makes unhealed cuts and wounds prone to infection, increasing the risk of amputation.

viii. **Tingling or numbness in the hands or feet :** High blood sugar can have a significant impact on nerves. This damage can start with feelings of tingling or numbness and can escalate to pain or neuropathy over time.

ix. **Skin discoloration :** Insulin resistance can cause your skin to develop dark patches (acanthosis nigricans) that are typically found in the folds of the neck, underarm area, or groin. This darkened skin can appear raised and velvety in texture.

x. **Yeast infections:** The excess sugar in your blood and urine creates an ideal environment for yeast. Yeast can feed off the extra sugar in genital areas, as well as the mouth or armpits. Maintaining blood sugar can help reduce the likelihood of getting yeast infections.

5.2.5 Prevention to Blood Sugar (Diabetes)

i. **Monitor blood sugar levels closely :** High blood sugar levels often do not cause symptoms until they run well over 200 mg/dL. As such, it is essential for a person with diabetes to monitor their blood sugar several times a day. Doing so will mean that blood sugar levels never get that high.

A person with diabetes can use a home glucose monitor to check blood sugar levels. Recommendations for how frequently to check glucose levels during the day will vary from person to person. A doctor can make the best recommendations regarding blood sugar monitoring to a person with diabetes.

ii. **Reduce carbohydrate intake :** Researchers have carried out studies showing that eating a low-carbohydrate, high-protein diet reduces blood sugar levels.The body breaks down carbohydrates into sugar that the body uses as energy. Some carbs are necessary in the diet. However, for people with diabetes, eating too many carbohydrates can cause blood sugar to spike too high.Reducing the amounts of carbohydrates a person eats reduces the amount a person’s blood sugar spikes.

iii. **Increase dietary fiber intake:** Eating plenty of soluble fiber, including whole grains such as brown rice, may help.Fiber plays a significant role in blood sugar management by slowing down the rate that carbohydrates break down, and the rate that the body absorbs the resulting sugars. The two types of fiber are soluble and insoluble fiber. Of the two types, soluble fiber is the most helpful in controlling blood sugar. Soluble fiber foods are vegetables, legumes, whole grains, fruit, etc.

iv. **Maintain a healthy weight :** Losing weight helps control blood sugar levels. Being overweight is linked to increased incidents of diabetes and greater occurrences of insulin resistance. Eating a healthful diet full of fruits and vegetables and getting enough exercise can help a person lose weight or maintain their currently healthy weight.

v. **Exercise regularly :** Exercise has many benefits for people with diabetes, including weight loss and increased insulin sensitivity. Exercise also helps to lower blood sugar levels by encouraging the body’s muscles to use sugar for energy.

vi. **Manage stress :** Stress has a significant impact on blood sugar levels. The body gives off stress hormones when under tension, and these hormones raise blood sugar levels. The managing stress through meditation and exercise can also help to lower blood sugar levels.

vii. **Get enough sleep :** Sleep helps a person reduce the amount of sugar in their blood. Getting adequate sleep each night is an excellent way to help keep blood sugar levels at a normal level.

5.2.6 Introduction to Uric Acid

Uric acid is a natural waste product which is produced after the digestion of food molecules containing purines from the digestive system. Purines are found in high levels in some foods such as meat products, dried beans, beer, etc. Usually, kidneys are involved in filtering the uric acid and excreting out through urine. If the intake of the purine is more, our body cannot excrete out and gets built up in our blood cells. A high uric acid level is known as hyperuricemia. Kidney disease, Diabetes mellitus, hypothyroidism, psoriasis, arthritis, gout and few cancers are certain health disorders caused by the high uric acid levels in our blood cells.

Uric acid is the ultimate catabolite of purine metabolism in humans and higher primates. It is a weak organic acid that under physiologic conditions exists mainly as a monosodium salt. Uric acid levels are influenced by age and sex. Prior to puberty, the average serum uric acid is 3.6 mg/dl for males and females. Following puberty, values rise to adult levels with women typically 1 mg/dl less than men. This lower level in women apparently reflects estrogen-related enhancement of renal urate clearance and disappears at the menopause. Many additional factors, including exercise, hypothyroudism, obesity, genetics disorders, renal insufficiency, diet, drugs, and state of hydration, may result in transient fluctuations of uric acid levels.

5.2.7 Symptoms of High Uric Acid

i. It's characterized by sudden, severe attacks of pain, swelling, redness and tenderness in one or more joints, most often in the big toe. An attack of gout can occur suddenly, often waking you up in the middle of the night with the sensation that your big toe is on fire.
ii. Severe pain in your joints.
iii. Muscle and joint stiffness.
iv. difficulty moving affected joints.
v. redness and swelling.
vi. misshapen joints.
vii. Fatigue.
viii. Dry Skin.
ix. Constipation.
x. Kidney Disorders.
xi. Muscle Weakness.
xii. Aches and Tenderness of Muscles.

5.2.8 Prevention to Uric Acid

The most important measure to manage blood uric acid levels is dietary control. Limiting intake of foods that are rich in purines such as red meat, tuna, organ meat etc. will help maintain normal uric acid levels. As the body breaks down fructose, leading to purine production, limiting the intake of foods & drinks containing fructose syrup can help reduce uric acid levels as well.

Also, being overweight or obese increases the risk of having high blood uric acid, so weight loss may be effective in managing uric acid in certain individuals.

For more information on causes, symptoms & treatment of high uric acid levels, get in touch with us. There are many natural ways which can be used to lower the level of uric acids in our blood cells. These include:

- Reduce weight. Obesity is one of the causes of increased uric acid levels.

- Consume low-fat dairy products.
- Avoid drinking alcohol frequently.
- Drink a lot of water, juices and tea.
- Keep a check on purine-rich food
- Reduce the intake of the sugar in your diet and lot more.

Control Measures to High Uric Acid

Natural Ways to Lower Uric Acid

- Avoid alcohol and sugary drinks.
- Avoid rugs tha raise uric acid level.
- Eat more low-purine foods. (Most nuts, whole-grains, low-fat dairy)
- Maintain a nealthy body weight.
- Add vitamin C to diet. Drink lemon-water twice a day. Include amla in diet.
- Soak 1 Tbsp, fenugreek seed in half cup water overnight a drink that water in the morning and chew the soaked seeds.
- Eat cherries, have Haldi-milk at night, drink plenty of water.
- Limit purine-rich food (excess refined sugar, beverages, high-fat dairy)
- Add coriander-leaves or coriander-powder (spice in diet.
- Reduce stress and o light yoga/exercise.

Goat (Inflamatory Arthritis)

Fig. 5.7

Activities 5.5

Collect various posters, brochures, and other materials from the nearby health institutions and present them in the classroom to give information about blood pressure, blood sugar, and uric acid and increase public awareness. Note the effects of their decrease or increase in the blood point by point. Also, discuss prevention and control measures with your classmates and show the results to the teacher.

5.3 Introduction to Heart Attacks

A heart attack is also known as a myocardial infarction. It occurs when the part of the heart muscle could not get enough blood supply. Coronary artery disease is the major cause of heart attack. Chest pain is the most common warning sign of a heart attack. But there can be other symptoms, too, like lightheadedness, nausea, and shortness of breath. Symptoms can be severe or mild, and are often different from one person to the next. Some people may not even notice any warning signs of a heart attack.

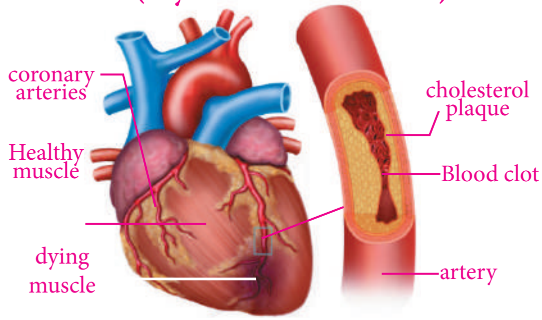
A heart attack happens when blood flow to the heart is blocked or cut off. If there's not sufficient oxygen-rich blood flowing to the heart, it can cause damage to the affected area. As a result, the heart muscle begins to die. When your heart isn't getting the blood and oxygen it needs to function properly, it can put you at a higher risk of heart failure and other serious complications. A heart attack is a life threatening medical emergency. The sooner you can get medical treatment that restores normal blood flow to your heart, the better your chance of a successful outcome.

Heart attack symptoms vary widely between individuals and present differently in men and women. Symptoms can come on quickly and intensely, or they might develop gradually over days or even weeks. Here are a few of the most common warning signs of a heart attack:

- Discomfort in the jaw, neck, back or chest
- Shortness of breath
- Cold sweat
- Lightheadedness or nausea

5.3.1 The Causes of Heart Attacks

The leading cause of heart attacks is coronary heart disease. This is where plaque builds up in the arteries that supply blood to the heart. The general buildup of plaque in the arteries is also known as atherosclerosis. There are two main types of heart attack.



Type I heart attacks are where plaque on the inner wall of the artery ruptures and releases cholesterol and other substances into the bloodstream. This can then form a blood clot and block the artery. **In type II** heart attacks the heart does not receive as much oxygen-rich blood as it needs, but there is not a complete blockage of an artery.

Other causes of heart attacks include–torn blood vessels, blood vessel spasms, drug misuse, hypoxia, lack of oxygen in the blood .

Coronary artery disease (CAD), which is plaque buildup in the arteries, is the most common cause of heart attacks. CAD can lead to partial or complete arterial blockage, depending on the severity of the rupture. Other factors or conditions can also cause a myocardial infarction, like a coronary artery spasm or a COVID-19 infection.

The following risk factors increase your chances of a heart attack:

- Age
- High blood pressure
- High cholesterol
- Obesity
- Diabetes
- Genetics
- Stress

5.3.2 Prevention to Heart Attacks

Preventive care is essential when you're at risk of a heart attack. Even if you've had a previous myocardial infarction, you can reduce the risk of a subsequent attack. Eat a healthy diet, avoid smoking and exercise regularly to improve your heart health. If you have an underlying condition like diabetes or another heart disease, make sure you monitor your health closely and take your medications.

i. **Don't smoke or use tobacco :** One of the best things you can do for your heart is to stop smoking or using smokeless tobacco. Even if you're not a smoker, be sure to avoid secondhand smoke.Chemicals in tobacco can damage the heart and blood vessels. Cigarette smoke reduces the oxygen in the blood, which increases blood pressure and heart rate because the heart has to work harder to supply enough oxygen to the body and brain.

ii. **Get moving: Aim for at least 30 to 60 minutes of activity daily :** Regular, daily physical activity can lower the risk of heart disease. Physical activity helps control your weight. It also reduces the chances of developing other conditions that may put a strain on the heart, such as high blood pressure, high cholesterol and type 2 diabetes.

iii. **Eat a heart-healthy diet :** A healthy diet can help protect the heart, improve blood pressure and cholesterol, and reduce the risk of type 2 diabetes. A heart-healthy eating plan includes: vegetables and fruits, beans or other legumes, lean meats and fish, low-fat or fat-free dairy foods, Whole grains, healthy fats, such as olive oil etc. Limit intake of the salt, sugar, processed carbohydrates, alcohol and saturated fat (found in red meat and full-fat dairy products) and trans fat (found in fried fast food, chips, baked goods).

iv. **Maintain a healthy weight :** Being overweight — especially around the middle of the body — increases the risk of heart disease. Excess weight can lead to conditions that increase the chances of developing heart disease — including high blood pressure, high cholesterol and type 2 diabetes.

v. **Get good quality sleep :** People who don't get enough sleep have a higher risk of obesity, high blood pressure, heart attack, diabetes and depression. Most adults need at least seven hours of sleep each night. Make sleep a priority in your life. Set a sleep schedule and stick to it by going to bed and waking up at the same times each day. Keep your bedroom dark and quiet, so it's easier to sleep.

vi. **Manage stress :** Some people cope with stress in unhealthy ways — such as overeating, drinking or smoking. Finding alternative ways to manage stress — such as physical activity, relaxation exercises or meditation — can help improve your health.

vii. **Get regular health screenings :** High blood pressure and high cholesterol can damage the heart and blood vessels. But without testing for them, you probably won't know whether you have these conditions. Regular screening can tell you what your numbers are and whether you need to take action.

5.3.3 The treatment of heart attacks

Each minute after a heart attack, more heart tissue is damaged or dies. Urgent treatment is needed to fix blood flow and restore oxygen levels. Oxygen is given immediately. Specific heart attack treatment depends on whether there's a partial or complete blockage of blood flow. Medications to treat a heart attack might include aspririn, Clot busters (thrombolytics or fibrinolytics) etc. Aspirin reduces blood clotting. It helps keep blood moving through a narrowed artery. Similarly, Clot busters (thrombolytics or fibrinolytics) drugs help break up any blood clots that are blocking blood flow to the heart. The earlier a thrombolytic drug is given after a heart attack, the less the heart is damaged and the greater the chance of survival.

Angiography is most important for treatment of heart attack. It used to check the health of your blood vessels and how blood flows through them. It can help to diagnose or investigate several problems affecting blood vessels, including: atherosclerosis – narrowing of the arteries, which could mean you're at risk of having a stroke or heart attack.

Angiography and angioplasty are two different medical procedures that are related to the blood vessels. While angiography is used to investigate or examine your blood vessels for a potential heart condition, angioplasty involves widening the narrowed arteries to treat the condition.

Surgical and other procedures

If you've had a heart attack, a surgery or procedure may be done to open a blocked artery. Surgeries and procedures to treat a heart attack include:

Coronary angioplasty and stenting : This procedure is done to open clogged heart arteries. It may also be called percutaneous coronary intervention (PCI). If you've had a heart attack, this procedure is often done during a procedure to find blockages (cardiac catheterization).

During angioplasty, a heart doctor (cardiologist) guides a thin, flexible tube (catheter) to the narrowed part of the heart artery. A tiny balloon is inflated to help widen the blocked artery and improve blood flow. A small wire mesh tube (stent) may be placed in the artery during angioplasty. The stent helps keep the artery open. It lowers the risk of the artery narrowing again. Some stents are coated with a medication that helps keep the arteries open.

Coronary artery bypass surgery (CABG). This is open-heart surgery. A surgeon takes a healthy blood vessel from another part of the body to create a new path for blood in the heart. The blood then goes around the blocked or narrowed coronary artery. CABG may be done as an emergency surgery at the time of a heart attack. Sometimes it's done a few days later, after the heart has recovered a bit.

Cardiac rehabilitation : Cardiac rehabilitation is a personalized exercise and education program that teaches ways to improve heart health after heart surgery. It focuses on exercise, a heart-healthy diet, stress management and a gradual return to usual activities. Most hospitals offer cardiac rehabilitation starting in the hospital. The program typically continues for a few weeks or months after you return home.

People who attend cardiac rehab after a heart attack generally live longer and are less likely to have another heart attack or complications from the heart attack.

Activities 5.6

Prepare a short report on angiography and bypass surgery using various media and sources and present it to the classroom.

Project Work

i. A model of the human circulatory system should be prepared and presented in the classroom by sticking thick threads of different colors on half a meter of thick black plastic or cardboard paper with glue. It is easier to draw the lines of a model by looking at the figure in your book .

ii. Go on a site visit to a nearby health center or hospital with the teacher. There, with the help of health workers, they identify the blood group of the students and prepare a report and present it in the classroom.

Exercise

A. Choose the correct one and put the tick mark(√)

i. The circulatory system is a network _____________
   - a. that carries blood throughout the body.
   - b. can be damaged by disease or injury.
   - c. helps regulate body temperature and carries substances that protect the body from disease.
   - d. transports chemical substances called hormones.

ii. The normal diastolic blood pressure in a normal healthy adult human is
   - a. 80 mm Hg b. 60 mm Hg c. 90 mm Hg d. 110 mm Hg

iii. _____________ is a blood disorder where the haemoglobin is defective
   - a. Heterochromia b. Alopecia c. Haemolysis d. Sickle cell anaemia

iv. _____________ carries deoxygenated blood to the lungs from the right ventricle.
   - a. Pulmonary artery b. Pulmonary vein c. Aorta d. None of the above

v. Snake venom usually enters the body through an open wound and enters the bloodstream through the ______________

a. Veins b. Lymphatic system c. Arteries d. None of the above

vi. ______________ forms clots when blood vessels get damaged.

a. Platelets b. Cellulose c. Haemoglobin d. None of the above

vii. This amongst the following is a wrong match

Option	Name of the Heart disorder	Corresponding symptom
a	Heart failure	Insufficient blood supply to the body
b	Angina pectoris	Acute chest pain
c	Cardiac arrest	Lumen narrows
d	Heart attack	Insufficient blood supply to cardiac muscles

viii. The tricuspid valve is present between

a. Ventricle and pulmonary artery b. Ventricle and aorta

c. left auricle and left ventricle d. right auricle and right ventricle

ix. Which blood vessel has valve ?

a. Capillary b. Artery c. Vein d. Venuole

x. Which part of blood helps in clotting of blood ?

a. WBC b. RBC c. Plasma d. Plalelet

xi. Which part of heart recieves pure blood from lungs ?

a. Right auricle b. Right ventricle c. Left auricle d. Left ventricle

xii. What is the normal blood pressure of adult ?

a. 100/70mm of Hg b. 120/80mm of Hg

c. 130/90mm of Hg d. 150/100mm of Hg

xiii. How many chambers are there in human heart ?

a. 2 b. 3 c. 4 d. 5

xiv. Which disease is caused due to large number of WBC in blood ?

a. Leukemia b. Leucopenia d. Anemia d. Pneumonia

xv. Symtoms of high blood pressure

a. Muscle and joint stiffness. b. Frequent urination

c. Shortness of breath d. less amount of oxygen inside the body

xvi. Symtoms of blood sugar(diabetes)

a. Muscle and joint stiffness. b. Frequent urination

c. Shortness of breath d. less amount of oxygen inside the body

xvii. Symtoms of uric acid -

a. Muscle and joint stiffness. b. Frequent urination

c. Shortness of breath d. less amount of oxygen inside the body

xviii. Which not not coorect for treatment of heart attacks

a. Cardiac rehabilitation

b. Coronary angioplasty and stenting

c. Clinical purification of blood by dialysis

d. Coronary artery bypass surgery (CABG)

B. Differentiate between these pairs :

i. Plasma and blood cell
ii. RBC and WBC
iii. Arteries and veins
iv. Blood pressure and blood sugar
v. Auricles and ventricles
vi. Tricuspid valve and bicuspid valve
vii. Pulmonary arteries and pulmonary veins
viii. Uric acid and Heart Attack
x. Angiography and angioplasty
xi. Blood groups and blood types
xi. Anaemia and leukopenia
ix. Coronary angioplasty and Coronary artery bypass surgery

C. Answer the following questions :

i. What is circulatory system ?
ii. What are the 5 main functions of the circulatory system?
iii. What is blood ? Write down any three functions of blood?
iv. What is pulmonary circulation? Explain.
v. Define systemic circulation.
vi. Elaborate on coronary circulation and its significance.
vii. Briefly explain the structure of the human heart.
viii. Name the chambers of the heart.
ix. Explain the three layers of the heart wall.
x. Explain the three major blood vessels of the human body.
xi. What is the function of the heart valves? Provide examples of various valves.
xii. Describe the human circulatory system.
xiii. Describe the human heart's structure and function.
xiv. Describe the blood vessel's structure and function.
xv. With pictures, describe the blood circulation in the human body.
xvi. Write down the introductions of blood groups and emphasize the significance of their identification.
xvii. What is blood pressure? Write down the abnormal conditions, prevention and control measures.
xviii. What is blood sugar ? Write down the abnormal conditions, prevention and control measures.

D. Give reasons to these statements.

i. RBCs are red in colours.
ii. WBCs are colourless .
iii. Platelets help in clotting of blood.
iv. Blood transports the nutrients absorbed in intestines to all parts of the body .
v. Pulse is caused by the arteries .
vi. The wall of the left ventricle is thicker than the wall of the right ventricle .
vii. Arteries are deep seated but veins are superficial .
viii. Colour of the blood in the pulmonary artery is purpule.
ix. A person suffering from anaemia feels weakness even after a short walk.
x. Donated blood is treated with sodium citrate .
xi. The people of Himalayan regions have red cheeks.
xii. Cigarette smoke reduces the oxygen in the blood, which increases blood pressure and heart rate

E. Critical Thinking

i. A person with anemia has too few red blood cells. The most common symptom is a lack of energy. Why would anemia cause this symptom?

ii. One function of the circulatory system is to help maintain a uniform body temperature. Explain how the constant circulation of blood through the body can accomplish this.

F. Complete the table:

i. In the table below briefly write the description and the function of given blood components

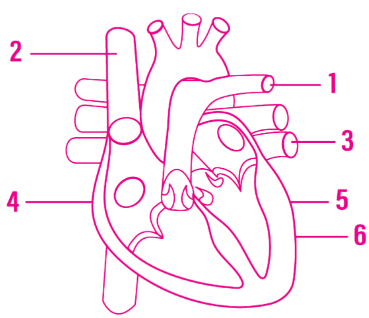
Component	Description	Function
Plasma		
Erythrocytes		
Leukocytes		
Platelets		

ii. In the table below briefly describe the function of basic heart part.

Part	Function
Pericardium	
Septum	
Atrium	
Ventricle	

G. Diagramatic Questions

i. Given alongside is a diagram of the human heart showing its internal structures. Label the parts marked 1-6 and answer the following questions.



a. Which types of blood is carried by the blood vessel marked 2?

b. Name the main artery which takes the blood from the heart to different parts of the body?

c. Which chamber of the heart receives deoxygenated blood from the body?

d. Which chamber of the heart receives oxygenated blood from the lungs?

ii. Study the diagram given below and then answer the questions that follow:

a. Name the cells of the pancreas that produce (1) glucagon (2) insulin.

b. State the main function of (1) glucagon and (2) insulin.

c. Why is the pancreas referred to as an exo-endocrine gland ?

d. Why is insulin not given orally but is injected into the body ?

e. What is the technical term for the cells of the pancreas that produce endocrine hormones ?

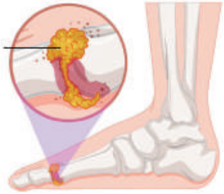
f. Where in the body is the pancreas located ?

iii. What is the picture below related to? What is the instrument used to measure blood pressure? What is the difference between normal and high blood pressure? In which unit is it measured?

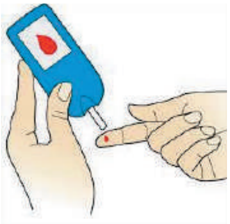
iv. Complete the following.

a. What happened to the person in the accompanying picture? How can the patient be helped in this situation? A heart attack is a silent killer. Justify it.

b. Below is the situation after the increase in uric acid. Write about the symptoms, causes, prevention, and treatment of high uric acid. Write about the measures you can take to increase public awareness about this.

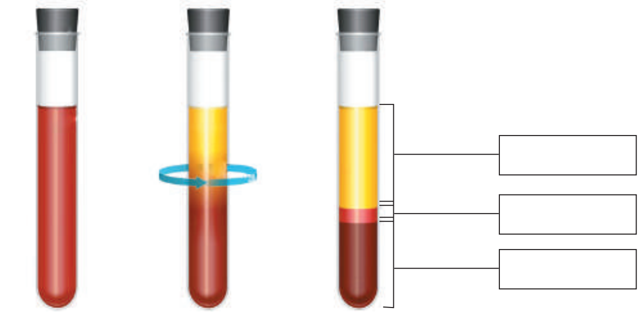


c. The picture below shows the pre-meal (fasting) sugar test reading. What is the state of the reading, according to your understanding? Write about the symptoms, causes, prevention, and treatment of high diabetes. Write about the measures you can take to increase public awareness about this.



iii. Label the major components of the blood on the diagram below.

Platelets and white blood cells	Red blood cells	Plasma



Whole blood sample

Sample placed in centrifuge

Blood sample that has been centrifuged

Chapter 6

Nature and Environment

Total Estimated pariods (Th. 5+ Pr. 2=7)

Student's Learning Outcomes

After studying this unit, the students will be able to :

- explain the concept, causes, and effects of climate change.
- find and adopt measures to reduce climate change.
- prepare a list of various endangered species found in Nepal and suggest conservation measures.
- prepare a list of medicinal herbs of traditional use by enquiry

Rachel Louise Carson (May 27, 1907 – April 14, 1964) was an American marine biologist, writer, and conservationist whose influential book Silent Spring (1962) and other writings are credited with advancing the global environmental movement.

Carson began her career as an aquatic biologist in the U.S. Bureau of Fisheries, and became a full-time nature writer in the 1950s. Late in the 1950s, Carson turned her attention to conservation, especially some problems she believed were caused by synthetic pesticides. The result was the book Silent Spring (1962), which brought environmental concerns to an unprecedented share of the American people.

Introduction

'Nature' and 'environment' are not used in a consistent way. These terms are generally anything but unambiguous. 'Nature', as the older of the two, has a conceptual history that stretches back to classical antiquity and that is very contradictory and confused, not just at first sight. In its original meaning (*natura* in Latin, *physis* in Greek), it was connected with growth and fertility. Crucially, humans as organisms are part of nature and are existentially dependent on it, they can only live with and in nature. To emphasize this fundamental ecological fact is not to lose sight of the varied and changing ideas and constructions of nature that come into being in the minds of people. Rather both belong indivisibly together.

The situation is not much different with the considerably newer concept of 'environment'. The word 'Environment' is derived from the French word 'Environ" which means 'surrounding.' Jakob Johann von Uexküll, the Baltic German biologist and zoologist, is considered one of the originators of the modern scientific concept of environment. According to him, all living beings have their own environments, which are based on their respective subjective activities and perceptions. Environment is a relational concept to the extent that it refers directly to the natural, but also the social space surrounding the living being and forms a unified whole with the latter – specific instances of which can be investigated. It is not just historians who frequently use nature and the environment synonymously. Reference is often made to the 'natural environment' of humans, to distinguish it from their social and cultural surroundings.

And hence, an Environment is everything that is around us, which includes both living and nonliving things such as soil, water, animals and plants, which adapt themselves to their surroundings. It is nature's gift that helps in nourishing life on Earth. A natural environment is a type of an environment where human impact or interaction has been extremely limited. A natural environment encompasses all living and non-living things occurring naturally, meaning in this case not artificial. The term is most often applied to the Earth or some parts of Earth

Environment plays an important role in healthy living and the existence of life on planet earth. Earth is a home for different living species and we all are dependent on the environment for food, air, water, and other needs. Therefore, it is important for every individual to save and protect our environment.

There are different types of human activities which are directly attributed to the environmental disasters, which include- acid rain, acidification of oceans, change in the climate, deforestation, depletion of an ozone layer, disposal of hazardous wastes, global warming, overpopulation, pollution, etc.

6.1 Concept of Climate change

To understand climate change, we first need to understand the difference between weather and climate. Weather refers to the actual atmospheric conditions that are being experienced now. It also includes changes that are forecast over the next few days, for example, in temperature and rainfall. Climate refers to the kind of weather that's typically expected in a region. This includes describing the range of conditions that are possible.

Fig. 6.1 Alaska's Muir glacier in August 1941 and August 2004. Significant changes occurred in the 63 years between these two photos.

Climate change is a long-term shift in the average weather conditions of a region, such as its typical temperature, rainfall, and windiness. Climate change means that the range of conditions expected in many regions will change over the coming decades. This means that there will also be changes in extreme conditions.

The climate varies naturally from year to year and decade to decade. This is caused by natural processes linking the atmosphere, ocean and land, as well as variations in heat output from the sun. In addition to changes in climate that are caused by natural climate variability, climate change can be caused by human activity. The kind of climate change we are experiencing now is being caused primarily by these human factors.

Table 1, Nepal's Climatic Zones

Region	Elevation	Climatic Zone	Average Annual Precipitation	Average Annual Temperature
High Himal	Above 5,000 m	Tundra and arctic climate	150-200 mm	<3-10^0 C
High Mountains	3,000-5,000 m	Alpine and sublpine		

Middle Mountains	1,000-3,000 m	Cool to warm temperatures	275-2,300 mm	10-20^0 C
Siwalik	500-1,000 m	Sub-tropical	1,100-3,000 mm	20-25^0 C
Tarai (Low-laying plains)	below 500 m	Tropical		

Global climate change refers to the average long-term changes over the entire Earth. These include warming temperatures and changes in precipitation, as well as the effects of Earth's warming, such as:

- Rising sea levels
- Shrinking mountain glaciers
- Ice melting at a faster rate than usual in Greenland, Antarctica and the Arctic
- Changes in flower and plant blooming times.

Earth's climate has constantly been changing — even long before humans came into the picture. However, scientists have observed unusual changes recently. For example, Earth's average temperature has been increasing much more quickly than they would expect over the past 150 years. Some parts of Earth are warming faster than others. But on average, global air temperatures near Earth's surface have gone up about 2 degrees Fahrenheit in the past 100 years. In fact, the past five years have been the warmest five years in centuries.

Many people, including scientists, are concerned about this warming. As Earth's climate continues to warm, the intensity and amount of rainfall during storms such as hurricanes is expected to increase. Droughts and heat waves are also expected to become more intense as the climate warms. When the whole Earth's temperature changes by one or two degrees, that change can have big impacts on the health of Earth's plants and animals, too.

Nepal is highly vulnerable to climate change impacts, and recent studies by the Asian Development Bank suggest Nepal faces losing 2.2% of annual GDP due to climate change by 2050. Millions of Nepalese are estimated to be at risk from the impacts of climate change including reductions in agricultural production, food insecurity, strained water resources, loss of forests and biodiversity, as well as damaged infrastructure. The problems of today, such as drought, forest fires, and flooding, will only be magnified by climate change. In Nepal, changes in monsoon patterns will greatly exacerbate the situation of unacceptable presence of poverty and inequalities of opportunities in the country. While many Nepalese people are coping autonomously to current stresses, the state must design and implement effective strategies to adapt to climate change impact to achieve economic and social progress. Adapting to long and short term climate-related problems need creative engagement among government, market actors and the civic movement.

6.1.1 Causes of Climate change

There are lots of factors that contribute to Earth's climate. However, scientists agree that Earth has been getting warmer in the past 50 to 100 years due to human activities. Certain gases in Earth's atmosphere block heat from escaping. This is called the greenhouse effect. These gases keep Earth warm like the glass in a greenhouse keeps plants warm.

Human activities — such as burning fuel to power factories, cars and buses — are changing the natural greenhouse. These changes cause the atmosphere to trap more heat than it used to, leading to a warmer Earth.The sun’s energy warms the Earth and the warmed Earth releases heat to the atmosphere. Certain gases in the atmosphere trap this heat and act like the glass of a greenhouse. Such gases are called greenhouse gases. The main greenhouse gases are water vapour, carbon dioxide and methane. Greenhouse gases absorb heat and radiate some of it back to the Earth, raising surface temperatures. This process is often called the greenhouse effect.

The greenhouse effect is a natural process, but it is being intensified by human activities that increase greenhouse gas levels in the atmosphere, especially carbon dioxide. Increasing greenhouse gas levels in the atmosphere makes it more effective at trapping heat, resulting in overall warming of the earth. Burning fossil fuels (coal, oil, gas) and some industrial processes are the main sources of carbon dioxide.

It is the main cause of human-induced climate change.It stays in the atmosphere for a very long time. Other greenhouse gases, such as nitrous oxide, stay in the atmosphere for a long time. Other substances only produce short-term effects. Not all substances produce warming. Some, like certain aerosols, can produce cooling.These substances are referred to as climate forcers because they force or push the climate towards being warmer or cooler. They do this by affecting the flow of energy coming into and leaving the earth’s climate system.

The earth's climate is naturally variable on all time scales. However, its long-term state and average temperature are regulated by the balance between incoming and outgoing energy, which determines the Earth's energy balance. Any factor that causes a sustained change to the amount of incoming energy or the amount of outgoing energy can lead to climate change. Different factors operate on different time scales, and not all of those factors that have been responsible for changes in earth's climate in the distant past are relevant to contemporary climate change. Factors that cause climate change can be divided into two categories - those related to natural processes and those related to human activity.

A. Natural causes

i. Solar variability
ii. Volcanic activity
iii. Tectonic activity
iv. Orbital (Milankovich) variations
v. Green House Gases
vi. Feedback

The Earth's climate can be affected by natural factors that are external to the climate system, such as changes in solar variability, volcanic activity, tectonic activity, orbital variation and feedback .

Climate is influenced by a multitude of factors that operate at timescales ranging from hours to hundreds of millions of years. Many of the causes of climate change are external to the Earth system. Others are part of the Earth system but external to the atmosphere. Still others involve interactions between the atmosphere and other components of the Earth system and are collectively described as feedbacks within the Earth system. Feedbacks are among the most recently discovered and challenging causal factors to study. Nevertheless, these factors are increasingly recognized as playing fundamental roles in climate change.

i. **Solar variability :** The luminosity, or brightness, of the Sun has been increasing steadily since its formation. This phenomenon is important to Earth’s climate, because the Sun provides the energy to drive atmospheric circulation and constitutes the input for Earth’s heat budget. The resulting imbalance between incoming solar radiation and outgoing thermal radiation will likely cause the Earth to heat up over the next century, accelerating the melting of polar ice caps, causing sea levels to rise and increasing the probability of more violent global weather patterns.

There are two major causes of solar variability: one is solar evolution, driven by conditions in the Sun's core; the other is the magnetic field of the Sun, or rather the field located in the solar convection zone (i.e. in the outer part of the solar interior) and in the Sun's atmosphere. Solar variability refers to the changes in the levels of solar radiation as well as in the number and size of sunspots with 11- year cyclic variation. So, it is likely to affect climate on time scales of minutes to millions of years. It is often believed that only slow variations can affect the climate.

ii. **Volcanic activity :** Volcanic activity can influence climate in a number of ways at different timescales. Individual volcanic eruptions can release large quantities of sulfur dioxide and other aerosols into the stratosphere, reducing atmospheric transparency and thus the amount of solar radiation reaching Earth's surface and troposphere. Volcanoes and related phenomena, such as ocean rifting and subduction, release carbon dioxide into both the oceans and the atmosphere.Variations in carbon dioxide release by volcanoes and ocean rifts over millions of years can alter the chemistry of the atmosphere. Such changeability in carbon dioxide concentrations probably accounts for much of the climatic variation that has taken place during the Phanerozoic Eon.

iii. **Tectonic activity:** Tectonic movements of Earth's crust have had profound effects on climate at timescales of millions to tens of millions of years. These movements have changed the shape, size, position, and elevation of the continental masses as well as the bathymetry of the oceans. Topographic and bathymetric changes in turn have had strong effects on the circulation of both the atmosphere and the oceans.

Tectonic activity influences atmospheric chemistry, particularly carbon dioxide concentrations. Carbon dioxide is emitted from volcanoes and vents in rift zones and subduction zones. Variations in the rate of spreading in rift zones and the degree of volcanic activity near plate margins have influenced atmospheric carbon dioxide concentrations throughout Earth's history. Even the chemical weathering of rock constitutes an important sink for carbon dioxide. (A carbon sink is any process that removes carbon dioxide from the atmosphere by the chemical conversion of CO2 to organic or inorganic carbon compounds.) Carbonic acid, formed from carbon dioxide and water, is a reactant in dissolution of silicates and other minerals. Weathering rates are related to the mass, elevation, and exposure of bedrock. Tectonic uplift can increase all these factors and thus lead to increased weathering and carbon dioxide absorption. For example, the chemical weathering of the rising Tibetan Plateau may have played an important role in depleting the atmosphere of carbon dioxide during a global cooling period in the late Cenozoic Era.

iv. **Orbital (Milankovich) variations :** The orbital geometry of Earth is affected in predictable ways by the gravitational influences of other planets in the solar system. Three primary features of Earth's orbit are affected, each in a cyclic, or regularly recurring, manner. First, the shape of Earth's orbit around the Sun, varies from nearly circular to elliptical (eccentric), with periodicities of 100,000 and 413,000 years. Second, the tilt of Earth's axis with respect to the Sun, which is primarily responsible for Earth's seasonal climates, varies between 22.1° and 24.5° from the plane of Earth's rotation around the Sun. This variation occurs on a cycle of 41,000 years. In general, the greater the tilt, the greater the solar radiation received by hemispheres in summer and the less received in winter. The third cyclic change to Earth's orbital geometry results from two combined phenomena: (1) Earth's axis of rotation wobbles, changing the direction of the axis with respect to the Sun, and (2) the orientation of Earth's orbital ellipse rotates slowly. These two processes create a 26,000-year cycle, called precession of the equinoxes, in which the position of Earth at the equinoxes and solstices changes. Today Earth is closest to the Sun (perihelion) near the December solstice, whereas 9,000 years ago perihelion occurred near the June solstice.

These orbital variations cause changes in the latitudinal and seasonal distribution of solar radiation, which in turn drive a number of climate Change. Orbital variations play major roles in pacing glacial-interglacial and monsoonal patterns. Their influences have been identified in climatic changes over much of the Phanerozoic. For example, cyclothems—which are interbedded marine, fluvial, and coal beds characteristic of the Pennsylvanian Subperiod (323.2 million to 298.9 million years ago)—appear to represent Milankovitch-driven changes in mean sea level.

v. **Greenhouse gases :** Greenhouse gases are gas molecules that have the property of absorbing infrared radiation (net heat energy) emitted from Earth's surface and reradiating it back to Earth's surface, thus contributing to the phenomenon known as the greenhouse effect. Carbon dioxide, methane, and water vapour are the most important greenhouse gases, and they have a profound effect on the energy budget of the Earth system despite making up only a fraction of all atmospheric gases. Concentrations of greenhouse gases have varied substantially during Earth's history, and these variations have driven substantial climate changes at a wide range of timescales. In general, greenhouse gas concentrations have been particularly high during warm periods and low during cold phases. A number of processes influence greenhouse gas concentrations. Some, such as tectonic activities, operate at timescales of millions of years, whereas others, such as vegetation, soil, wetland, and ocean sources and sinks, operate at timescales of hundreds to thousands of years. Human activities—especially fossil-fuel combustion since the Industrial Revolution—are responsible for steady increases in atmospheric concentrations of various greenhouse gases, especially carbon dioxide, methane, ozone, and chlorofluorocarbons (CFCs).

v. **Feedback :** Perhaps the most intensively discussed and researched topic in climate variability is the role of interactions and feedbacks among the various components of the Earth system. The feedbacks involve different components that operate at different rates and timescales. Ice sheets, sea ice, terrestrial vegetation, ocean temperatures, weathering rates, ocean circulation, and greenhouse gas concentrations are all influenced either directly or indirectly by the atmosphere; however, they also all feed back into the atmosphere, thereby influencing it in important ways. For example, different forms and densities of vegetation on the land surface influence the albedo, or reflectivity, of Earth's surface, thus affecting the overall radiation budget at local to regional scales. At the same time, the transfer of water molecules from soil to the atmosphere is mediated by vegetation, both directly (from transpiration through plant stomata) and indirectly (from shading and temperature influences on direct evaporation from soil). This regulation of latent heat flux by vegetation can influence climate at local to global scales. As a result, changes in vegetation, which are partially controlled by climate, can in turn influence the climate system. Vegetation also influences greenhouse gas concentrations; living plants constitute an important sink for atmospheric carbon dioxide, whereas they act as sources of carbon dioxide when they are burned by wildfires or undergo decomposition. These and other feedbacks among the various components of the Earth system are critical for both understanding past climate changes and predicting future ones.

B. Human causes

i. Generating power
ii. Manufacturing goods
iii Cutting down. forests
iv. Using transportation
v. Producing food.
vi. Powering buildings
vii. Consuming too much

Climate change can also be caused by human activities, such as the burning of fossil fuels and the conversion of land for forestry and agriculture. Since the beginning of the Industrial Revolution, these human influences on the climate system have increased substantially. In addition to other environmental impacts, these activities change the land surface and emit various substances to the atmosphere. These in turn can influence both the amount of incoming energy and the amount of outgoing energy and can have both warming and cooling effects on the climate. The dominant product of fossil fuel combustion is carbon dioxide, a greenhouse gas. The overall effect of human activities since the Industrial Revolution has been a warming effect, driven primarily by emissions of carbon dioxide and enhanced by emissions of other greenhouse gases.

The build-up of greenhouse gases in the atmosphere has led to an enhancement of the natural greenhouse effect. It is this human-induced enhancement of the greenhouse effect that is of concern because ongoing emissions of greenhouse gases have the potential to warm the planet to levels that have never been experienced in the history of human civilization. Such climate change could have far-reaching and/or unpredictable environmental, social, and economic consequences.

i. **Generating power :** Generating electricity and heat by burning fossil fuels such as coal, oil and natural gas causes a large chunk of global emissions. Most electricity is still produced from fossil fuels; only about a quarter comes from wind, solar and other renewable sources.

ii. **Manufacturing goods :** Manufacturing and industry produce emissions, mostly from burning fossil fuels to produce energy for making things like cement, iron, steel, electronics, plastics, clothes and other goods. Mining and other industrial processes also release gases.

iii **Cutting down. forests:** Cutting down forests to create farms or pastures, or for other reasons, causes emissions, since trees, when they are cut, release the carbon they have been storing. Since forests absorb carbon dioxide, destroying them also limits nature's ability to keep emissions out of the atmosphere.

iv. **Using transportation:** Most cars, lorries, ships and planes run on fossil fuels. That makes transportation a major contributor of greenhouse gases, especially carbon-dioxide emissions. Road vehicles account for the largest part, but emissions from ships and planes continue to grow.

v. **Producing food :** Producing food requires energy to run farm equipment or fishing boats, usually with fossil fuels. Growing crops can also cause emissions, like when using fertilisers and manure. Cattle produce methane, a powerful greenhouse gas. And emissions also come from packaging and distributing food.

vi. **Powering buildings :** Globally, residential and commercial buildings consume over half of all electricity. As they continue to draw on coal, oil and natural gas for heating and cooling, they emit significant quantities of greenhouse gas emissions.

vii. **Consuming too much :** Your home and use of power, how you move around, what you eat and how much you throw away all contribute to greenhouse gas emissions. So does the consumption of goods such as clothing, electronics and plastics.

In Nepal, about half of greenhouse gas emissions come from the agriculture sector, followed by energy, land-use change and forestry, industrial processes, and waste.

6.1.2 Effect of Climate change

An increase in soil erosion, landslides, flash floods, and droughts has been reported in recent years across the country, with increased intensity and impact on the lives and livelihoods of the Nepalese. Nepal suffers high economic costs due to current climate variability and extremes: the estimated direct cost of these impacts is equivalent to 1.5–2% of current GDP/year and is much higher in extreme years, rising to 5% or more. This is high by international levels. Some major effects of climate change are given below :

i. Damage to your home

Due to climate change, global warming will increase the frequency or intensity of heavy rain events, and coastal flooding due to hurricane storm surge is also worsening because of sea level rise and increased precipitation. Floods, the most common and deadly natural disasters in the Nepal., will likely be exacerbated and intensified by river level rise and extreme weather. Heavy precipitation is projected to increase throughout the century to potentially three times the historical average. Flood may damage the shelter of the people and farming field , too.

More expensive home insurance : As insurance companies pay out huge amounts to homeowners whose houses have been damaged by climate change impacts, many are raising premiums to offset their costs. In high-risk areas, premiums and deductibles may rise, coverage may be more limited, and insurance could ultimately become unaffordable or unavailable for some, especially in climate-vulnerable areas.

Outdoor work could become unbearable : With continued global warming, heat waves are expected to increase in frequency, duration and intensity. Due to climate change, heat waves that occur in sequence, one after the other—will also increase, making recovery from heat waves more difficult. People who work outdoors, such as construction workers, miners, firefighters and agricultural workers, will be most affected by increasing temperatures. One study suggested that outdoor workers should begin their shifts earlier in the day, but if global warming continues at the current pace, by 2100, they would have to start working four to six hours before dawn.

Higher electric bills and more blackouts : As temperatures rise, people will need to stay cool for health and comfort reasons. The increased demand for electricity, especially during peak periods, can also over-tax the electrical grid, triggering brownouts or blackouts. Extreme weather, such as heat waves or snowstorms, can cause power outages too.

Rising taxes : Municipalities are recognizing the need to make their communities more resilient in the face of climate change impacts. Although measures such as building seawalls or hardening infrastructure are hugely expensive. Paying for mitigation and adaptation measures, however, will likely have to be funded through higher property taxes or 'resilience fees'.

More allergies and other health risks : Warmer temperatures cause the pollen season to be longer and worsen air quality, both of which can result in more allergy and asthma attacks.

Ground-level ozone, a major component of smog, which increases when temperatures warm, can also cause coughing, chest tightness or pain, decrease lung function and worsen asthma and other chronic lung diseases. In addition, after floods or storms, damp buildings may foster mold growth, which has been linked to allergies and other lung diseases. With rising temperatures, more people will suffer heat cramps, heat exhaustion, hyperthermia (high body temperature) and heat stroke as days that are unusually hot for the season hamper the body's ability to regulate its temperature. Prolonged exposure to heat can exacerbate cardiovascular, respiratory and kidney diseases, diabetes, and increase the chance for strokes.

Food will be more expensive and variety may suffer : In the last 20 years, food prices have risen about 2.6 percent each year, and the goverment body expects that food prices will continue to rise. While there are several reasons for higher food prices, climate change is a major factor. Extreme weather affects livestock and crops, and droughts can have impacts on the stability and price of food. As temperatures warm and precipitation increases, more pathogens will thrive and affect plant health; in addition, more food will spoil. And because food is a globally traded commodity today, climate events in one region can raise prices and cause shortages across the globe.

Water quality could suffer : Intense storms and heavy precipitation can result in the contamination of water resources. In cities, runoff picks up pollutants from the streets, and can overflow sewage systems, allowing untreated sewage to enter drinking water supplies. In rural areas, runoff transports animal waste, pesticides and chemical fertilizer, and can enter drinking or recreational waters. Polluted drinking water can cause diarrhea, Legionnaires' disease, and cholera; it can also cause eye, ear and skin infections. In some low-lying coastal areas, sea level rise could enable saltwater to enter groundwater drinking water supplies. And in areas suffering from drought, contaminants become more concentrated as water supplies decrease. In addition, algal blooms thrive in warm temperatures and can contaminate drinking water.

Outdoor exercise and recreational sports will become more difficult : Reduced snowfall and early snowmelt in the spring will have an impact on skiing, snowmobiling and other winter sports. Less water in lakes and rivers could also affect boating and fishing during summer. Hotter temperatures, especially in Madhesh will make summer activities like running, biking, and fishing less comfortable and potentially dangerous to your health.

Disruptions in travel : As temperatures rise, it may get too hot for some planes to fly. Hotter air is less dense, so planes get less lift under their wings and engines produce less power. Airlines may be forced to bump passengers or leave luggage behind to lighten their loads. Flights can be disrupted due to flooding because many airports are located on low-lying land. Recreational travel could be upended as climate change impacts many popular destinations.

6.2 Adopt measures to reduce Climate change

Climate change adaptation means altering our behavior, systems, and—in some cases—ways of life to protect our families, our economies, and the environment in which we live from the impacts of climate change. The more we reduce emissions right now, the easier it will be to adapt to the changes we can no longer avoid.

Climate change is fundamentally a development issue. It threatens to exacerbate poverty and hurt economic growth. At the same time, how countries grow and the investments they make to meet the energy, food and water needs of an expanding population can fuel climate change, raising risks worldwide, or contribute to solutions

When human activities create greenhouse gases, Earth warms. This matters because oceans, land, air, plants, animals and energy from the Sun all have an effect on one another. The combined effects of all these things give us our **global climate**. In other words, Earth's climate functions like one big, connected system. Thinking about things as systems means looking for how every part relates to others.

Some adoptation measures

Reducing carbon emissions : This one seems obvious but the paper stresses that it "should remain the focus of climate-change policy." That means improving energy efficiency, conserving usage, and adopting alternative fuel sources in transportation.

Sequestering carbon : Plants trap and store atmospheric carbon, and they could do more of that, if only we'd let them. Some study suggests promoting forest regrowth and managing agricultural land.

Carbon capture and storage : Millions of tons are carbon are being turned into liquid underground, and scientists suggests that "this method has the potential to store billions of tons'. (Only problem: it's really expensive.)

Ocean fertilization : Adding iron to our ocean would promote algae growth. More algae means more underwater plants to consume the carbon. But this is risky: it also could deprive other marine life of oxygen. Plus, the carbon is only trapped if the algae die and sink to the ocean floor.

Managing solar radiation : Adding water droplets to the atmosphere increases cloud cover and reduces sunlight that shines onto the earth. Another option: adding solar reflectors in outer space. It's less clear how these intervention themselves will affect the climate.

Nepal may adopt following measures to reduce Climat change effect

i. Development of adaptive technologies, varieties and breeds.
ii. Development of efficient irrigation and water management systems . Promotion of climate-resilient agricultural practices . Improvement of grain and food storage and distribution systems.
iii. Climate information services, including early warning systems and sectoral information systems
iv. Promotion of financial services and insurance. Development and strengthening of farmers' networks and institutions. Establish objectives for the future forest under climate change.

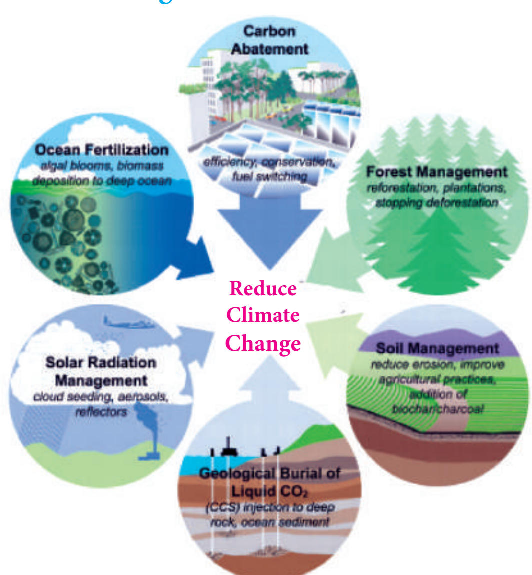


Fig. 6.2

v. Increase awareness and education within the forestry community about adaptation to climate change. Determine the vulnerability of forest ecosystems, forest communities and society. Develop present and future cost-effective adaptive actions .
vi. Manage to reduce the impact when it occurs, speed recovery and reduce vulnerability to further climate change. Identify and appraise adaptation options, develop strategies for implementing adaptation options and Integrate adaptation options into policies and plans.
vii. Building infrastructure to protect major assets such as roads, hydropower installations and water and irrigation systems . Building and enhancing flood and landslide management systems, including watershed and catchment management to address flash floods.
viii. Capacity building for professionals, government institutions and other stakeholders to support adaptation-related activities .Improvement of physical systems and infrastructure to withstand climate risks .
ix. Strengthening of services and institutions to manage climate-related health risks. Promoting research and development on climate change and health .Establishment, management and application of databases to track climate change impacts and adaptation in the health sector.

Activities 6.1

i. Write an essay on the causes, effects, and mitigation of climate change.
ii. Organize a painting exhibition about the effects of climate change.
iii. Make a list on chart paper by observing the activities around you or searching the internet for ways to mitigate climate change.
iv Prepare a power point presentation on climate change with the help of various newspapers, journals, articles, and the internet and present it to the class.

Project Work

The students of the class are divided into groups according to their needs and collect photos and descriptions of the effects of climate change using newspapers and the Internet, then prepare posters. Display the poster in class and discuss the effects of climate change on the environment and human life. After the discussion, prepare a report as a group. After presenting the report in the classroom, keep it as a reference in the school library.

6.3 Various endangered species found in Nepal

Firstly, climate plays a vital role in the life and activities of living beings. Climate affects not only the territory but the life and activities of living beings as well. Let's take an example, some plants grow in a particular place because of the habitat temperature and land.Some types of animals are only found in that place which is suitable for them. Keeping the people and plants aside, few species of animals are left on this planet. Because of some drastic change in climate, there are some animals, birds species are going to enlist as endangered animals. Because of heavy smuggling, Nepal has been facing the extreme problem of endangered animals.

Due to the increase in population, the people cleared the forest and make homes and rooms for their families. Today less than 30% of the total land of Nepal is covered with forest. Furthermore, the practice of livelihood farming has put great pressure on forest lands and wild animals.These, attended by the increasing problems of smuggling have meant that several species of animals have become endangered in Nepal.

Endangered Plants In Nepal

The creation of nature is thoughtful and meaningful. It is important to maintain the balance between plant and animal kingdom. But because of various reasons, the plant resources were destroyed in last few decades, and many species were rendered threatened or extinct. This is the global problem. In Nepal, a major portion of its area is covered with hills and mountains, occupying the central portion of Himalaya. This is the reason for the country being the richest depository of diversity in plant wealth life. In this regard, the altitudinal range, temperature, rainfall and soil have also important role. The medicinal plants are forest based natural resources and have important contributions in Napalese health care. About 90% of the population in Nepal depends upon local healers and Ayurvedic medical treatment, as they are less expensive and easily available. Besides, these medicinal plants are export commodities and sources of national income. Talisaptra, Khayar, Simal, Mirke Lahara, Sugandhakokila, Yarshagumba, Unyu, Thakal, Panch Aunle, Satisal, Bhyakur, Okhar, Jhyau, Banyasar, Chanp, Banchanp, Jatamsai, Kutti, Sungabha,Gunsi, Laghupatra, Bijayagantha, Sarpagandha, Sal, and Bhotechanp are among the endangered plant species found in Nepal.

Introduction to some endangered plants in Nepal

i. Spikenard (Jatamasi)

Fig. 6.3

Jatamasi is a small plant and is rare in Nepal. It has strong smell and is also called sugandhawal. It is available in the high hills of Nepal at the altitude of 3000 to 5000 meters. The plant is straight and its root looks like a net of hair. Its flowers are of pink-white colour. Its roots are used to prepare scented oil which is used in Ayurvedic medicine for the treatment of cholera, epilepsy and heart diseases. Its dust is used to make sweet incense. Its export is prohibited. Serpentina was used as medical purpose, and it is used by indigenous peoples for frost, cough, fever, and pain. The applications of these plants are described in Ayurveda and Unani for medicine or medical purposes.

ii. Golden Michelia (Champa)

Fig. 6.4

It is one of the rare trees in Nepal. Its stem is smooth and ash in colour. It is found in the Mid-hill and at the ltitude from 600 to 1500 meters in the Terai region. The flower of the golden michelia is light yellow and olden. The tree is about 30 meters high. Its wood is used to make furniture. Oil can be extracted from its lower which is remedy for eye diseases and rheumatism. The fruit and flower are very invigorating. The bark is used as medicine.

iii. Serpentina (Sarpagandha)

Fig. 6.5

It is found at the altitude of 1,200 meters in some parts of the madhesh/ terai and hill region of Nepal. It is found in the forest of Sal. It has dry and white stems with long and broad leaves. It bears flowers in summer. The flowers are in bunches and are of white and red colour.

Its root is very useful as it helps to prepare medicines for the treatment of blood-pressure, pain, insomnia, diarrhea, dysentery, worm, etc.

iv. Himalayan yew (Lauth Salla)

Fig. 6.6

It is found in Nepal at the altitude from 1,700 to 3,400 meters, especially in the central and western region of the country. Its leaf is tin like a comb. It is about 8 meters high. Its leaf is used to make medicine for epilepsy, stomach disease, headache, nerve, respiration, diarrhea, blood-pressure, etc. Its leaf is also used to make taxol and medicine for cancer.

v. Panch aule

Fig. 6.7

Panch aule is a small plant with a palm-like root. It has pink colour flowers. It is found at the altitude of 2,300 to 3,600 meters. Its root is used as a medicine because it gives strength. That is why, people illegally collect it either for medicine or for sale.

vi. Himalayan golden raspberry

Fig. 6.8

The Himalayan raspberry has different names, like Rubus ellipticus and Aiselu. It is 4.5 meters, or about 14 3/4 feet in length, and has a gold Himalayan raspberries are trifoliate, elliptic, or obovate, with long bristles and teeth. It is sweet in taste but not widely harvested domestically.

Some of the endangered animals in Nepal.

Tigers

Tigers are in the topmost lists of endangered species of Nepal. Because the bones of these animals are used in Chinese and Japanese traditional medicine, which leads people to kill and smuggling of them.The rising demand for the tiger related goods mostly the bone and skins are its cause. The smugglers have established a clever route by which the tiger's surface in the form of medicines and balms in the Chinese market. But these accesses are only the tip of the aloof person and the smuggling continues.

Fig. 6.9

The regal Bengal tiger is one of Nepal's true wildlife superstars. They once roamed the entire lowland Madhesh/Terai, but once malaria was eradicated from the area in the mid-1950s and people moved in from the foothills to cultivate the land, their numbers dropped dramatically.

Most live in Chitwan National Park, although there are smaller populations in Bardia National Park, Shuklaphanta Wildlife Reserve and Banke National Park. This has been achieved by managing their habitat and educating villagers on how to co-exist with the tigers. Successfully saving the tiger, however, is inextricably tied to the fate of its favourite prey, swamp deer. It is also regarded as a vulnerable species because of habitat destruction.

Snow Leopard

Fig. 6.10

Snow Leopard is an apex predator of the Himalayan ecosystem and is found only in the mountains of central and Southern Asia. The current estimated population of Snow Leopard in the world, ranging from 4000-6000 with Nepal housing an estimated 350-500 Snow Leopards. In Nepal, Snow Leopards are mostly found in Mustang, Mugu, Dolpa and Humla districts. They are characterized by its smoky grey fur coat covered by dark gray spots. They have short forelimbs and long hind limbs that provide agility in steep and rugged terrains. Also, their long tail aids in balancing on cliffs. The snow leopard weighs about 35-55 kg and grows up to 1.8 – 2.3m. The snow leopards pelts, bones and other body parts are in high demand for oriental medicines and are poached.

Musk deer

Fig. 6.11

Musk deer is also on the lists of endangered animals in Nepal. And the reason behind the smuggling of Musk Deer is because of their Musk. Musk is a powdery substance in which male musk deer hide from a gland in the abdomen. This powder is a highly valued item for perfumes and medicines. Chinese believe that it has seductive properties and uses the mask as folk medicine.

Himalayan Black Bear

Fig. 6.12

Himalayan black beer is also on the list of endangered animals in Nepal. And the reason behind its smuggling is its gall bladder. Because the gall bladder provides the ingredients of one of the fanciest oriental medicines.

One Horned Rhinoceros (Eksinge Gainda)

Fig. 6.13

It is on the list of endangered animals of Nepal. One Horned Rhinoceros are hunted and smuggled because of the special importance of its horn, foot nail and skin. Its horn is sold at a higher price in the black market. The skin is a perfect bulletproof and of the high price.

The greater one-horned rhinoceros is an incredible beast, weighing in at two-and-a-half metric tonnes, and second only in size to the elephant.

This magnificent beast is known for its characteristic one hour and skin resembling the armour plating. Weighing up to 2-2.5 metric tons, One-horned Rhino is a gray giant, second only to an elephant in size. A typical lifespan of rhino is about 40-50 years. Rhinos inhabit the alluvial flood-plain vegetation of subtropical climate, lowland grassland, swamps where water and green grass are available throughout the year. So, the Terai region or the southern part of Nepal is best for rhino habitat. Chitwan National Park houses about 600 rhinos of 2000 rhinos of the wild. Other national parks like **Bardia National Park** and **Shuklaphanta National Park** are also playing an important role in increasing the number of rhinos.

Asiatic Elephant

Fig. 6.14

Asiatic elephant is found in the forest of Terai/Madhesh region and many national parks and wildlife reserve. The elephant is a rarely protected animal in Nepal.As we all know it is the largest land mammal of about the height of 3.5 meters. Elephants are hunted and smuggled for their teeth. The teeth are called tusk and it is of very high cost in the black market. Due to the greed of money, people smuggle it due to which their number is decreasing day by day.

It is believed that there are between 100 to 170 wild elephants in Nepal, spread across four areas in the Terai. The Nepalese government has established five protected reserves and an elephant breeding facility at Khorsor, but their situation remains critical.Conflict between elephants and humans remains the greatest threat to their survival. Fields and human settlements have taken over much of the areas they roamed. And for farmers, the damage wrought by elephants is the most destructive of all wild animals.

While the protected reserves have gone some way to helping, elephants are migratory animals, so reducing conflict between humans and elephants remains key. These animals are thought to be very intelligent and have excellent memory power. Like humans, they are very social and have a long lifespan of about 60-70 years. A fully matured elephant can weight about 5000 kg.

Red Panda (Habre)

Fig. 6.15

Red Panda is found at the height of 3,500 meters in the forest of bamboo, cane, and oaks. As it lives in the cold climate it is found in the Langtang National Park, Sagarmatha National Park, and Makalu-Barun National Park. Mostly it is hunted for its beautiful skin with soft and fine hair. Its total number is reducing day by day.

Red Panda has a characteristic reddish-brown, thick fur and has a raccoon-like appearance. 80% of their diet is contributed by the bamboo leaves and shoots. However, they also feed on fruits, berries and other seasonal fruits found in the forest. It is estimated that there are about 10,000 Red Pandas left in the world and among them, about 1000 are found in the forest of Nepal. Records of Red panda appearance are found in Rara, Shey- Phoksundo, Langtang, Sagarmatha, and Makalu Barun National Park and many other protected areas like Annapurna, Manaslu, Gaurishankar, and Kanchanjunga Conservation Areas.

An increase in the human population has led to habitat degradation of the Red Panda. Deforestation for agricultural land and settlement has pushed the Red Pandas outside the protected area. Red Panda is mainly poached for their beautiful fur and meat. The demand for fur is very high and is sold in very expensive amounts in the black market. Nepal is the home for many of the endangered species. However, for the past few decades, it has become the main trading route for smuggling the endangered species to China. The government officers and the local people in conjunction should together and help to save these vulnerable species.

Gharial

Fig. 6.16

Although it remains one of the most endangered crocodile species in the world, the story of the narrow-snouted gharial is a rare, positive conservation story in Nepal. Heavily hunted, hampered by river pollution and their eggs collected for medical purposes, it's no wonder the gharial once came very close to extinction. Now, thanks to a government breeding programme in Chitwan National Park, their numbers have increased to a few hundred.

Gharials are at their most vulnerable at the beginning of their lives, as an egg or a hatchling. As part of the programme, newly laid eggs are collected from nest sites and brought to the breeding centre at Kasar, where the young are raised and then released back into the wild.

Pangolin

Pangolins are the only mammal in the world completely covered in scales and, sadly, the most trafficked. Known as salak in Nepal, their keratin scales are highly-prized in Chinese medicine, making them a poaching target. And poaching is the very thing driving them quickly towards extinction. Nepal is home to two species of pangolin.

Fig. 6.17

Pangolins, the world's most smuggled mammal. More than 20 percent of all illegal wildlife trade comprises the pangolin. They are mainly found in the primary and secondary subtropical forests throughout Nepal from Terai to the mid-hills region. They prefer to live in open lands, agricultural lands and near the human settlement. Pangolins are nocturnal animals i.e active during the night and live in holes during the day. Pangolins are insectivorous and their diets mainly consist of ants and termites supplemented by insect larvae.

Some other endangered species are dolphins, swamp deer, four-horned antelope, black buck, assamese monkey,grey wolf, brown bear, spotted linsang, striped hyaena, leopard cat, clouded Leopard, lynx, gaur bison, wild yak, wild water buffalo, tibetan antelope, great tibetan sheep, hispid hare, pigmy hog, etc .

S.N.	Common Name	Nepali Name	Scientific name
1.	Red panda	Habre	Ailurus filgens
2.	Snow Leopard	Hiu Chituwa	Panthera uncia
3.	Bengal Tiger	Pate Bagh	Panthera Tigris Tigris
4.	One horned Rhinoceros	Gaida	Rhinoceros Unicomis
5.	Himalyan Musk Deer	Kasturi Mriga	Moschus Chrys-gaster leucogaster
6.	Dolphin	Sons	Delphinus Delphis
7.	Swamp Deer	Barashigae	Rucervus duvaucelii
8.	Asiatic Elephant	Jangali Hatti	Elephas Maximus
9.	Four horned Antelope	Chauka	Tetracerus quadricomis
10	Black Buck	Krishna Shar	Antilope cervicapra
11.	Indian Pangolin	Salak	Manis Pentadactyla
12	Chinese Pangolin	Salak	Manis pentadactyla
13.	Assamese Monkey	Asami Rato Badar	Macaca Assamensis
14.	Grey Wolf	Bwaso	Canis lupus
15.	Brown Bear	Himali Rato Bhallu	Ursus Arctos
16.	Spotted Linsang	Lingsan	Prionodon Particular Hodgson
17.	Striped Hyaena	Hudar	Hyaena hyaena
18.	Leopard Cat	Chari Bagh	Prionailurus bengalensis
19.	Clouded Leopard	Bwaso CHituwa	Neofelis nebulosa
20.	Lynx	Lings	Felis tynx
21.	Gaur Bison	Gauri Gai	Bos Gaurus
22.	WIld Yak	Jangali Chauri	Bos grunniens and Bos mutus

23.	Wild Water Buffalo	Arna	Bubalus arnee (B. buballs)
24.	Tibetan Antelope	Chiru	Pantholops hodgsonii
25.	Great Tibetan Sheep	Nayan	Tibetan argali sheep
26.	Hispid Hare	Sespod Kharayo	Caprolagus hispidus

List of endangered Birds in Nepal

Many species of birds are endangered and are in urgent need of conservation. Although most of the important species are protected by law from shooting and disturbance, many are still declining, mainly through loss of their habitats, important habitats such as wetlands are constantly under threat from major developments. Woodland and scrubland clearance, pesticide poisoning, oil pollution in river or lakes, illegal trapping, and poisoning all account for the losses of birds, so it is important for birdwatchers to keep a constant watch out for threats to the survival of our birds. Here is the name list of endangered birds in Nepal.

S.N.	Common Name	Nepali Name	Scientific name
1.	Great Horabill	Thulo Dhanesh	Buceros bicornis
2.	Impeyan Pheasant	Danphe	Lophophorus impedance
3.	Bengal Florican	Khar Mugur	Houbaropsis bengalensis
4.	Black Stork	Kalo Saras	Ciconia nigra
5.	White Stork	Seto Saras	Ciconia ciconia
6.	Crimson-horned Pheasant	Munal	Tragopan satyra
7.	Cheer Pheasant	Chir	Catreus wallichii
8.	Lesser Florican	Mujur	Sypheotides indica
9.	Saurus Crane	Saras	Grus antigone Antogone

There are a total of 3 reptiles endangered in Nepal. Here is the name list of endangered Reptiles in Nepal.

S.N.	Common Name	Nepali Name	Scientific name
1.	Gharial	Gharial Gohi	Gavialis gangeticus
2.	Golden Monitor Lizard	Sungohoro	Varanus albigularis
3.	Asiatic Rock Python	Ajingar	Python molurus

6.3.1 Conservation measures to endangered species

Preserving plants and animals is important not only because many of species are beautiful, or can provide economic benefits for us in the future. But because they already provide us with many valuable services.These organisms clean air, regulate our weather and water conditions, provide control over agricultural pests and diseases. And also offer an extensive genetic library from which we can derive many useful things.

The hunting and smuggling of the animals are making them listed in the endangered animal lists. Some of them are killed for their skin, some for their trunk, some for their bones which are of the very high cost.

If these animals are completely disappearing from the earth then there will be a huge effect on the ecosystem. The loss of habitats due to the change of ecosystem and Negative effect on the natural environment are also the factors affecting the lives of animals or birds for that matter.

So the following measures should be endorsed to preserve rare animals and to maintain the ecosystem.

Conservation of Ecosystem

The animals or birds can survive in their natural habitat. The habitats for birds and animals are provided by the natural ecosystem. If we want to conserve the rare birds and animals we must conserve the ecosystem first. We must conserve the forest, water resources, etc which help to conserve the ecosystem.

Restriction in hunting

People hunt for their satisfaction and some for illegal trade. Every valuable part of those animals is taken by the hunters for illegal trade. Such activities decrease the number of birds and animals. So hunting should be strictly prohibited and strict legal actions should be taken against the offender.

Awareness Programs

At the national and local level, the awareness program should be conducted. Because the awareness program can help to give knowledge about the importance of birds, animals, and other living beings. So that the endangered animals are safe.

Public Participation in the conservation program

If we want to conserve the endangered animals than the conservation program should be conducted. But the conservation program will only be effective if there is the participation of local people. The local people should be made responsible for the conservation of birds and animals around them.

Reduction of effects of Human activities

Well, every nation needs development but that does not mean doing unnecessary things in name of development. Well, every development activity like the construction of road, industry, building, dam, etc bring changes in the environment. The development activities produce waste products. Sewage and harmful chemical etc. Those things can hugely affect the environment and that deplete the rare birds, animals, and other living beings too. That's why the adverse should be controlled in the time of conducting development activities.

Conservation measures to endangered species in Nepal

Many ways we can do together to help preserve endangered animals. The government itself has established several conservation or breeding centers to keep animals from extinction.

Not only the government, some people who are members of foundations or institutions that love the environment and animals also take the initiative to conserve animals. Some of them have succeeded in caring for and protecting endangered animals whose existence is threatened by poaching.

Various protection and preservation programs are carried out by institutions caring for endangered animals. It is not enough for the institutions to take the initiative to save animals, but it is also up to us that we carry out some activities that help save endangered animals such as:

i. Identification of rare and endangered species
ii. Careful Before Buying a Product
iii. Don't Buy Products Made from Endangered Animals
iv. Providing Education and Outreach
v. Supporting Environmental Conservation Efforts

vi. Buy local food ingredients
vii. Not Supporting Animal Torture Activities
viii. Save Electricity Usage
ix. Visit the National Park, Wildlife Sanctuary
x. Making Captive Breeding
xi. Making a Prohibition Board
xii. Report on People Hunting for Endangered Animals
xiii. Development of rules and norms of human behavior in nature
xiv. Creation of various environmental programs
xv. Rallies, actions in defense of rare animals
xvi. Organization of volunteer movements to protect wildlife

We can take the assistance of technology to save endangered animals.Technological progress must inevitably clash with respect for nature and animals. It is up to man to choose whether to use technology to safeguard the planet or destroy it irreparably. We are very close to the sixth mass extinction, it will not be caused by a meteorite or an ice age but by the human being. Until today, despite the constant warnings of science, man continues his path towards self-destruction, bringing with him many animal species. It is still possible to reverse the negative trend and preserve the species not yet extinct thanks to modern technological systems.

i. 3D printers can save rhinos

The extinction of rhinos is due almost exclusively to poaching. These poor animals are slaughtered and killed for their horns. On the black market, rhino horns are in great demand especially in eastern countries where traditionally they are attributed to medical properties. To defeat this phenomenon, a Seattle biotechnology company, Pembient, uses 3D printers to produce synthetic rhino horns. By using keratin combined with rhino DNA, you can have homemade horns without killing any rhino. Synthetic horns are sold at a much lower price than those coming from poaching with the hope that the latter will no longer find a market.

ii. The use of drones

Drones are used both to monitor the movement of animals and thus prevent them from heading towards inhabited or heavily trafficked areas and to identify and capture poachers.

iii. Artificial insemination

To avoid the definitive extinction of animals, scientists have thought of collecting eggs from the two specimens and inseminating them with frozen spermatozoa of male specimens and will then be implanted in female specimens. Researchers are studying other reproductive techniques to be applied to the animal world to avoid the extinction of other species.

iv. Biobanks and cloning

The other system to be able to preserve the genetic heritage of animals is to create biobanks that preserve the tissues and DNA of animals at risk. The genes preserved in this way could be used for cloning, in particular, they could reinsert already extinct species. Or even modify the DNA of those still alive to make them more suitable for the climatic conditions dictated by global warming.

Activities 6.2

i. Prepare a list with pictures of various endangered animals and plants found in Nepal and present it in the classroom. Discuss and write a summary of all of these protection measures. Write those conclusions on a piece of cardboard and paste them in the classroom.

ii. Prepare a list of various herbs found in Nepal and present it in class in a table format with information about their history, location, farming, and utility.

6.4 Identify the importance of herbs traditionally used.

More than 500 species of medicinal plants used in traditional medicine grow in forests and surrounding areas. About 50 species are commercially exploited from the natural resources. The forest, which is the natural habitat of medicinal drugs, is being depleted each year. Till two decades ago, one-third of the total land of the country was covered with forests and this green forest was its pride and wealth. But because of the disturbances of natural habitat of these plants only about 20% of forest remains . It may owing to illegal cutting of plants for timber, fuel wood, unauthorized settlement, deliberate setting of fire by cattle grazer inquest of fresh patches of grazing land. These medicinal plants are also destroyed for commercial exploration and collection of entire plants, roots rhizomes barks, tubers, corms, seeds, flowers and fruits. The plant species are also destroyed indirectly because of various other human activities viz. over grazing of domestic animals in the forest. The natural calamities like uplifting or sinking of land, flooding, glaciations, droughts, landslides and fire have significant contribution to lead the drug plants in endangered and threatened stage. Diseases insect attacks absence of pollination and inadequate reproductive mechanism are also some additional factors, which cause harm to plants. Talisaptra, khayar, simal, mirke lahara, sugandhakokila, unyu, thakal, satisal, bhyakur, okhar, jhyau, banyasar, chanp, banchanp, jatamsai, kutti, sungabha etc., arebthe importance of herbs traditionally used.

6.4.1 Some important herbs are in use

i. Tulsi


Fig. 6.18

The predominant cause of global morbidity and mortality is lifestyle-related chronic diseases, many of which can be addressed through Ayurveda with its focus on healthy lifestyle practices and regular consumption of adaptogenic herbs. Of all the herbs used within Ayurveda, tulsi is preeminent, and scientific research is now confirming its beneficial effects. There is mounting evidence that tulsi can address physical, chemical, metabolic and psychological stress through a unique combination of pharmacological actions. Tulsi has been found to protect organs and tissues against chemical stress from industrial pollutants and heavy metals, and physical stress from prolonged physical exertion, ischemia, physical restraint and exposure to cold and excessive noise. Tulsi has also been shown to counter metabolic stress through normalization of blood glucose, blood pressure and lipid levels, and psychological stress through positive effects on memory and cognitive function and through its anxiolytic and anti-depressant properties. Tulsi's broad-spectrum antimicrobial activity, which includes activity against a range of human and animal pathogens, suggests it can be used as a hand sanitizer, mouthwash and water purifier as well as in animal rearing, wound healing, the preservation of food stuffs and herbal raw materials and traveler's health. Cultivation of tulsi plants has both spiritual and practical significance that connects the grower to the creative powers of nature, and organic cultivation offers solutions for food security, rural poverty, hunger, environmental degradation and climate change. The use of tulsi in daily rituals is a testament to Ayurvedic wisdom and provides an example of ancient knowledge offering solutions to modern problems.

ii. Ghiukumari

The botanical name of Aloe vera is **Aloe barbadensis miller**. It is said to contain various nutrient substances and vitamins that have curative properties. According to the findings, aloe vera could have some effectiveness in treating malaria, wounds, abdominal problems, skin diseases, allergic reactions and some other diseases.

Fig. 6.19

It grows up to 80 to 100 cm in length. It helps to stabilize blood sugar level, hence is good for diabetes. It is helpful to cure burns and other skin disorders. It give relief from wounds and ulcers. It prevents growth of acne and moisturizes the skin. It helps to treat fungus, insect bites, herpes, vaginal infections and allergic reactions. Its juice is a tonic in conditions like jaundice, amenorrhea and piles. It is antiseptic, helps to kill many of viruses and bacteria. It helps to alkalize the body, balances acid production and treats constipation. It also controls the levels of cholesterol and oxidative stress.

iii. Bojo

Fig. 6.20

Acorus calamus L. is an indigenous herb in Nepal. It belongs to family Acoraceae and grows in wetland with scented rhizomes. It is also known as Sweet flag in English and commonly as Bojo in Nepal. The present investigation reveals the chemical compositions and antioxidant activity of rhizome essential oil of A. calamus. The essential oil of rhizomes of Acorus calamus L. from Kaski district, Nepal was extracted by hydrodistillation method and volatile constituents were analyzed using Gas chromatography-Mass spectrometry technique.

It is a perennial herb, semi aquatic, marshy plant with a creeping and much branched, aromatic rhizome. The rhizome is cylindrical about 19-25 mm in diameter and 10 cm long. It is light brown outside, white and spongy inside. The leaves are thick, erect and sword shape, when bruised emits strong scent. Sweet flag produces small yellow flowers on a spike. Plants rarely flower or set seed.

Sweet flag is mainly used in medicine. The oil is used to cure gastritis. In the form of infusion it is carminative and possesses emetic and anti-spasmodic properties. It is used in perfumery industry. It also has insecticidal properties. The water-ethanolic extract of sweet flag exhibit anti-oxidant property.

iv. Gurjo

Fig. 6.21

Tinospora cordifolia is a herbaceous vine of the family Menispermaceae indigenous to tropical regions of the Indian subcontinent. It has been used in Ayurveda to treat various disorders, but there is no clinical evidence for the effectiveness of such treatment. Health benefits of gurjo are not limited to boosting immunity only. This herb is packed with chemical constituents like alkaloids, terpenoids, lignans, steroids, and others which has got anti-oxidants, antimicrobial, antibacterial, antifungal, anti-diabetic and antistress properties, hypolipidaemic effect, anticancer, and anti-HIV potential, antiosteoporotic effects, antitoxic effects, wound healing, anticomplementary activity, and immunomodulating activity. It is also extensively used for the treatment of diabetes, high blood pressure, fever, jaundice, skin diseases, and respiratory problems.

v. Ghortapre

Fig. 6.22

Ghortapre is a clonal, biennial weed. It is tasteless, odorless and is most commonly found in or near water bodies and in swampy soils. Its leaves are fan-shaped and the flowers can be white, purple, or pink with small oval fruits. The whole part of this weed is used as medicine. Ghortapre are mostly found in tropical and subtropical countries. Its wide range of uses includes blood purification, blood pressure control, memory enhancement, and longevity. Ghortapre is used in Ayurveda for cell regeneration and brain cell development. It has also been used to treat emotional disturbances such as depression and anxiety, which are the root causes of physical problems. Antifungal, antiinflammatory, neuroprotective, antioxidant, wound healing, anti-depressant, antidiabetic, cognitive development, and liver protection.

vi. Titepati

Fig. 6.23

Titepati is the main plant found in most places in Nepal. Titepati is usually performed in Pooja or Shraddha. This plant is also used as a sottar for animals. Some animals consider it delicious and eat it. It is also very durable. This herb, easily found in the forest or in the fields, has proved to be very useful for health. Because of its properties, it is considered the king of medicine. It is called mugwort or black sage in English, and its scientific name is Artemisia vulgaris.

Artemisia vulgaris, the common mugwort, is a species of flowering plant in the daisy family Asteraceae. It is one of several species in the genus Artemisia commonly known as mugwort, although Artemisia vulgaris is the species most often called mugwort.

Mugwort (Artemisia vulgaris L.) is a plant related to ragweed that's used to flavor food and as an herbal medicine. It is thought to boost energy, calm nerves, support digestion, relieve itching and pain, and promote regular periods, among other things.

vii. Asuro

Fig. 6.24

Justicia adhatoda commonly known in English as Malabar nut, adulsa, adhatoda, vasa, vasaka, is native to Asia. Asuro is often used as a fence around our villages . Like other common flowers, Asuro flowers have both male and female reproductive organs in the same flower. The part of this plant that is especially used is the leaf. It is bitter. Since this plant is green throughout the year, its leaves can be collected all the time. However, collecting its leaves during flowering is more effective. Its leaves are boiled and consumed for colds, coughs, asthma, rheumatism, fever, bleeding from the nose and mouth, tuberculosis, and bronchitis. Asure breath is used for patients.

viii. Neem

Fig. 6.25

Neem, (Azadirachta indica), also called nim or margosa, fast-growing tree of the mahogany family (Meliaceae), valued as a medicinal plant, as a source of organic pesticides, and for its timber.

Neem trees can reach 15–30 metres (49–98 feet) in height and have attractive rounded crowns and thick furrowed bark. The compound leaves have toothed leaflets and are typically evergreen but do drop during periods of extreme drought. The small fragrant white flowers are bisexual or staminate (male) and are borne in clusters in the axils of the leaves. The fruit is a smooth yellow-green drupe and has a sweet-flavoured pulp.

According to Maharishi Ayurveda, the Neem leaf is especially useful in balancing Vata disorders. It removes ama and other toxins from the body, purifies the blood, and neutralizes damaging free radicals. It is nourishing to the hair (keshya). Neem leaf is also revered for its antibacterial and antiviral properties.

ix. Yarsagumba


Fig. 6.26

Yarsagumba is a unique caterpillar-fungus fusion that occurs when parasitic mushroom spores (Ophiocordyceps sinensis) infect and mummify a ghost moth larva living in the soil. A spindly fungus later sprouts from the dead caterpillar host's head. Cordyceps is found in the snow-clad pastures in the altitude of 3,000 to 4,200 meters from sea level. It is a kind of fungi of length of 5 to 8 cm. it grows in the body of caterpillar. It is a kind of vegetation which falls under fungi group. It is used in Ayurvedic for the treatment of heart disease and brain disease. It is also used as an invigorating medicine for our body when we take it with milk and honey. Due to its expensiveness, it is smuggled.

Project Work

Prepare a list of herbs in traditional use found at a local level. Make a chart of their importance and conservation measures and paste it in the classroom.

Exercise

A. Choose the correct one and put the tick mark(√)

i. ____________ plays an important role in healthy living and the existence of life on planet earth.
   a. Nature   b. Climate   c. Environment   d. Pollution

ii. Which is not a environment disaster-
   a. change in the climate   b. global warming
   c. pollution   d. forestation

iii. ____________ is a long-term shift in the average weather conditions of a region, such as its typical temperature, rainfall, and windiness.
   a. Nature   b. Environment
   c. change   d. Natural catastrophe

iv. which is not an effect of climate change-
   a. Rising sea levels
   b. Mountain glaciers are shrinking.
   c. Ice is melting at a faster rate than usual in Greenland, Antarctica, and the Arctic.
   d. don't change the temperature

v. Droughts and ____________ are also expected to become more intense as the climate warms.
   a. social progess b. market boom c. economic growth d. heat waves

vi. Which is not a natural causes of climate change -
   a. Solar variability b. Volcanic activity
   c. Generating power d. Feedback

vii. Which is not a human causes of climate change -
   a. Cutting down forests b. Volcanic activity
   c. Generating power d. Powering buildings

viii. Damage to your home is related to-
   a. Rising taxes
   b. Damage to your home
   c. Food will be more expensive and variety may suffer
   d. Outdoor work could become unbearable

ix. Because of heavy smuggling, Nepal has been facing the extreme problem of.____________
   a. climate change b. land destroy
   c. natural resources d. endangered animals

x. Endangered plants in Nepal-
   a. Sal, Sissoo, Asna, Karma b. Paddy, Maize, Mustard, Pea
   c. Mango, Apple, Leechi, Orange d. Talisaptra, Khayar, Simal, Mirke Lahara

xi. Which is not correct for endangered animals
   a. Habre, bagh, Hiu Chituwa, and Gainda
   b. Kasturi Mriga, sons,barahsingae, and Chauka
   c. Cow, buffalo, sheep, and goat
   d. Jangali chauri, salak, arna, and gauri gai

xii. Which is not correct for endangered birds -
   a. Kag, kalo kauwa,and koili
   b. Thulo dhanesh, khar mayur, and kalo stork
   c. Seto stork,munal, and chir
   d. Sars, danphe,and mayur

xiii. Which is not important herb –
   a. Tulsi b. Bojo c. Neem d. Gulab

B. Match the meanings to the words. Use a dictionary to help you.

i. the ice in the Arctic and Antarctic	drought
ii. cutting down a forest	power stations
iii. harmful chemicals in the air or water	climate change
iv. coal, oil and gas	the ice caps
v. carbon dioxide	rainforests
vi. when there is no rain for a long time	CO_2
vii. the tropical forests	pollution
viii. tropical storms	greenhouse gases
ix. gases that trap the sun's heat	deforestation
x. these produce electricity	hurricanes
xi. the Earth is getting hotter	fossil fuels

C. Complete the table

Species	Nepali Name	Uses (any thee)	conservation method or measures for them (any three)
Spikenard			
Azadirachta indica			
Ophiocordyceps sinensis			
Malabar nut			
Tinospora cordifolia			

D. Differentiate between these pairs.

i. Nature and Environment
ii. Natural envionment and Natural disaster
iii. Greenhouse gases and greenhouse effect
iv. Climate and climate change
v. Endangered palnts and endangeed animal
vi. Natural causes and human cuases of climate change
vii. Traditional measues and technology measures for endangaered species.

E. Explain the following:

i. Nepal is highly vulnerable to climate change impacts.
ii. The climate varies naturally from year to year and decade to decade.
iii. Tigers are in the topmost lists of endangered species of Nepal.
iv. Acorus calamus L. is an indigenous herb in Nepal
v. Cordyceps is found in the snow-clad pastures.

F. Answer the following questions :

i. What is climate change ?
ii. Write down the any five environment disaster .
iii. Write down the concept of climate change .
iv. What is the most important cause of climate change?
v. What are climate forcers?
vi. What can be done about climate change?
vii. Does climate change have natural causes?
viii. Write down the effect of climate change .
ix. How does climate change affect us?
x. How do higher electricity bills and more blackouts owing to climate change .
xi. What are the causes and effects of climate change?
xii. Which causes are natural and which are caused by humans?
xiii. What are the endangered plants ? Write down the names of any five endangered plants ?
xiv. What are the endangered animals ? Write down the names of any five endangered animals?
xv. are the plants ? Write down the names of any five endangered plants ?
xvi. Conservation measures for endangered species are important. Make a list of five conservation xvii.measures for them.
xviii. are the conservation measures for endangered species in Nepal? Write down any five of them.
xix. Identify the importance of herbs traditionally used.

xx. What are the important herbs traditionally used in Nepal . Write down the names of any five of them, along with an explanation and application.

G. Diagrammatic Questions :

i. Look at the picture and complete the following table.


Pictures name	Climate Change's Role	Measures to reduce climate change due to this	Effects

iii. Drag and drop the words to match them with the corresponding picture.

Match the

Burning of fossil fuels	Diminished water sources	Smog related diseases
Increasing smog levels	Green house effefct	Rising sea levels
Melling glaciers/ice sheets	Growing crops	Drought
Storms	Flooding	

iv. Identify the adjoining figure. Write about how important these plants are. Make a list of similar plants around you. Write down the uses of the most commonly used herbs in your home.

Chapter 7

Force and Motions

Total Estimated pariods (Th. 7+ Pr. 3=10)

Student's Learning Outcomes

After studying this unit, the students will be able to :

- state Newton's laws of gravitation and solve related simple mathematical problems
- define gravity due to acceleration and express the relationship between gravity due to acceleration and the distance from the earth's surface to its center
- introduce gravity and calculate the weight of an object
- clarify the concept of free fall,
- describe the effect of air resistance on a falling object and explore its application in everyday life.

André-Jacques Garnerin, (born Jan. 31, 1769, Paris, France—died Aug. 18, 1823, Paris), French aeronaut, the first person to use a parachute regularly and successfully. He perfected the parachute and made jumps from greater altitudes than had been possible before. As a young man Garnerin studied physics. In 1793 he became an inspector in the French army, where he encouraged the use of balloons for military purposes, but he was captured during hostilities with England and was imprisoned for two years.

Introduction

We know, the ripen fruit falls towards the earth. A stone thrown upward falls back to the ground. Satellites go around the planets and planets go around the sun in their own orbits. These are some surprising and interesting facts in our daily life. The unseen force causes all these events. This is due to the gravity and gravitational force.

7.1 Gravitation

Before 16th century, it was believed that heavenly bodies like sun, moon, planets and satellites used to revolve around the earth. This earth centered module of the solar system was called geocentric model. In 16th century, Nicholas Copernicus put forward another model called heliocentric model about the solar system. In this model sun is considered as the centre of the solar system and other heavenly bodies such as planets and satellites revolve around the sun.

Later In 1687 AD, Sir Isaac Newton discovered the existence of a force between any two masses. For example, two buildings in our surrounding, a desk and a bench, a man and a house and so on exert force on each other. This force between two masses is called gravitational force. The gravitational force is always attractive. That is each body attracts other body towards it. This force exists universally among all bodies in the universe. Earth revolves around the sun because gravitational force between sun and earth provides necessary centripetal force. Similarly, moon revolves around the earth.

Hence, the mutual force of attraction between any two bodies in the universe is called gravitational force.

Newton's Universal Law of Gravitation

It states that "gravitational force between two bodies is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres."

Suppose, two bodies having masses m_1 and m_2 are at the distance of 'd' from each other and 'F' be the force of attraction between them. According to Newton's Universal law of gravitation,

Force (F) is directly proportional to the products of their masses

i.e. $F \alpha\ m_1 \times m_2$........................ i.. (when d is constant)

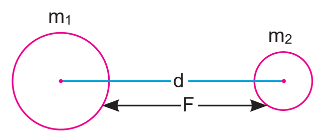


Fig. 7.1

Again,

Force (F) is inversely proportional to square of the distance between their centres

i.e. $F \alpha \frac{1}{d^2}$ .... ii.. (when m_1 and m_2 are constant)

Combining equation i. and ii., we get

$$F \alpha \frac{m_1 m_2}{d^2} \qquad \text{or,} \quad F = \frac{G m_1 m_2}{d^2}$$

Where 'G' is constant of proportionality known as universal gravitational constant.

Universal gravitational constant (G)

If $m_1 = 1$ kg, $m_2 = 1$ kg

and d = 1m

then,

Gravitational force between them is,

$$F = \frac{G m_1 m_2}{d^2}$$

$$\text{or, } F = \frac{G.m_1 m_2}{d^2}$$

$$\text{or, } \quad F = G. \frac{1 \times 1}{1^2}$$

$$\text{or, } F = G \times 1 \qquad \therefore F = G$$

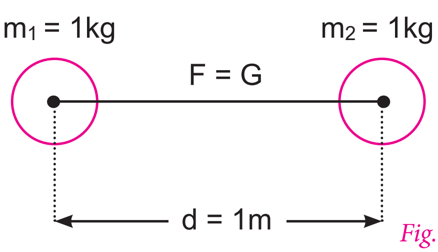


Fig. 7.2

Hence, universal gravitational constant 'G' can be defined as the force of gravitation produced between two bodies of unit mass (having masses 1kg each) and separated by 1m from their centers.

It is found that the value of 'G' is same throughout the universe. The value of 'G' does not depend on the nature of the mutually attracting bodies (terrestrial or celestial) nature of masses, tempreture, pressure and the properties of the medium (rarer or denser) in which the bodies are placed. Its value is 6.67×10^{-11} Nm^2 kg^{-2}. It was firstly calculated by Henry Cavendish. The value of 'G' is constant every where in the universe so, it is called universal gravitational constant.

Unit of 'G'

We have, $F = \dfrac{Gm_1m_2}{d^2}$ or, $G = \dfrac{F \times d^2}{m_1 \times m_2}$

In the SI system, the unit of 'F' is newton (N), distance in meter (m) and mass is kg. Then the unit of 'G' is :

$$G = \frac{\text{Newton} \times (\text{meter})^2}{\text{kg} \times \text{kg}} = \frac{Nm^2}{kg^2}$$

Therefore, the SI unit of 'G' is $Nm^2\ kg^{-2}$

Related Numerical Problems

1. Two stones of masses 25kg and 50kg are separated by distance 25m apart on the surface of the earth. What is the gravitational force between these stones. ($G = 6.67\times10^{-11}Nm^2kg^{-2}$)

Solution:

Given,

Mass one stone (m_1)	= 25kg
Mass of another stone (m_2)	= 50kg
Distance between them (d)	= 25m
Gravitational constant (G)	$= 6.67\times10^{-11}Nm^2kg^{-2}$
Gravitational force between them (F)	=?

We have, $F = \dfrac{Gm_1m_2}{d^2}$

or, $F = \dfrac{6.67 \times 10^{-11}\ Nm^2\ kg^{-2} \times 25kg \times 50kg}{(25m)^2}$

$\therefore$ $F = 1.334\times10^{-10}$ N

Thus, the gravitational force between these two stones is 1.334×10^{-10} N

2. The mass and radius of earth are 6×1024kg and 6400km respectively. What will be the gravitational force between earth and a man of mass 80kg sitting on the surface of the earth?

Solution:

Given,

Mass of the earth (M)	$= 6\times10^{24}$ kg
Mass of man(m)	= 80kg
Gravitational constant (G)	$= 6.67\times10^{-11}Nm^2kg^{-2}$
Radius of the earth (R)	$= 6400km = 6400\times1000\ m = 6.4\times10^6 m$

We have,

$$F = G\frac{Mm}{R^2}$$

or, $F = \dfrac{6.67 \times 10^{-11}\ Nm^2\ kg^{-2} \times 6 \times 10^{24}\ kg \times 80kg}{(6.4 \times 10^6 m)^2}$ or, $F = 781.64N$

Thus, the gravitational force between earth and the man is 781.64 N

Properties of Universal Gravitational Constant (G)

a. The value of 'G' is independent of the medium in which the masses are placed
b. The value of 'G' is independent of the nature of masses.
c. The value of 'G' is not affected by temperature and pressure.
d. The value of 'G' is independent of the direction of the gravitational forces

Consequences of Gravitational Force

a. Gravitational force is responsible for holding the atmosphere above the earth surface.
b. Gravitational force is responsible for the existence of solar system and revolution of planets around the sun.
c. Gravitational force keeps things firmly on the ground.
d. Gravitational force is responsible for the formation of tides in the sea and oceans.
e. Flow of river water is due the gravitational force.
f. Falling of fruits from trees is due to gravitational force.

Factors affecting gravitational force

The gravitational force (F) is mainly affected by two factors :

a. mass of two bodies : when the product of mass of the bodies increases, the gravitational force also increases
b. distance between their centers: when the distance between their centers increases, the gravitational force decreases

For example: What happens to the force of gravitation when

i. Mass of a body is made double keeping distance constant?

According to Newton's Universal Law of gravitation

or, $$F = \frac{Gm_1m_2}{d^2} \quad \text{.................. (i)}$$

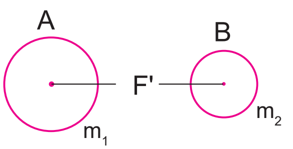


Fig. 7.3

When mass of body 'A' is doubled,

$$F' = \frac{G\,2m_1m_2}{d^2} \quad \text{...................... (ii)}$$

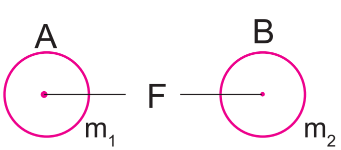


Fig. 7.4

Comparing equations (i) and (ii), we get

$$\frac{F'}{F} = \frac{\dfrac{G\,2m_1m_2}{d^2}}{\dfrac{G\,m_1m_2}{d^2}}$$

$$\frac{F'}{F} = \frac{2Gm_1m_2}{d^2} \times \frac{d^2}{Gm_1m_2}$$

$\therefore \quad F' = 2F$

Hence, the force is increased by two times.

ii. Distance is halved keeping the masses constant?

$$F = \frac{Gm_1m_2}{d^2} \quad \text{.................. i.}$$

When, distance is made half,

$$F' = \frac{Gm_1m_2}{\left(\frac{d}{2}\right)^2} \quad \text{.................. ii.}$$

Comparing equations i. and ii., we get

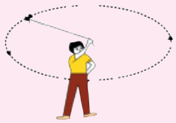
$$\frac{F'}{F} = \frac{\dfrac{Gm_1m_2}{\frac{d^2}{4}}}{\dfrac{Gm_1m_2}{d^2}}$$

$\therefore \quad F' = 4F$

Hence, the force is increased by 4 times.

Activities 7.1

Take a piece of thread. Tie a small stone at one end. Hold the other end of the thread and whirl it round, as shown in figure. Note the motion of the stone. Release the thread. Again, note the direction of motion of stone.



Observation: Stone takes a tangential movement and drops to the bottom after some distance.

Explanation: Stone tied with the string is in a uniform circular motion but the direction of its velocity changes with time. Once we release the thread, the stone moves tangentially. This tangential motion is not permanent and after some distance, it drops to the ground.

Why the stone drop to the ground?

Once the string is released, the gravitation force comes into action. This force attracts the stone with force equal to F = ma (where a is the acceleration due to gravity). The direction of this force is towards the center of the earth. So, now the stone has two motion one is tangential to the string and another is the accelerating motion towards the ground. Together these motions make a parabolic path and the stone finally drops to the ground.

7.2 Gravity

We know that the shape of earth is like an orange. It may be a great surprise to think that how people can stay on the spherical earth. Nepal and America are located just nearly opposite on the surface of earth. A person living in Nepal will have their head directed towards the sky while standing on their feet on the surface. Likewise, a person living in America, just opposite to Nepal, will have their head faced towards the sky too while standing on their feet on the surface. The reason behind this effect is the gravity of the earth. It pulls both of them towards the center of the earth.

If out of the two involved bodies in Newton's law of gravitation, one body is the earth (or planet/ satellite) then the gravitational force is called force of gravity or simply gravity. Thus, **gravity is merely a special case of gravitation in which there is involvement of a heavenly body**. For example, the gravitational force between the earth and a body near or on the surface is called the earth's gravity. Similarly, the attraction of Jupiter and a body near or on its surface is called Jupiter's gravity.

Thus, the force of attraction with which a heavenly body pulls any object towards its centre is called gravity of the earth or simply gravity. The force of gravity on a body is its weight. The factors that affect gravity are mass and radius of the planets and satellites.

On the basis of Newton's universal law of gravitation, the gravity of a planet or a satellite can be calculated.

Activities 7.2

i. Take a stone. Throw it upwards. It reaches a certain height and the nit starts falling down.

Observation: The stone come back to us after reaching some height.

Explanation : When we through a stone upward we work against the law of gravity. Thus it takes some force to throw upward. Higher the force higher is the maximum height of the stone. During this process, the velocity decreases. After some time the velocity is nil. This is the maximum height. Now gravitational force exceeds the up thrust and the stone falls freely.

Fact: We can calculate the height if we know the velocity at which the body is thrown by the following formula.$v^2-u^2 = 2gs$ here $v= 0$, u = initial velocity; $g = -9.8m/s^2$

s= maximum height covered by the stone.

The maximum magnitude of velocity is at the level of hand in both the motion whether upward or downward. And both are the same. For example, if we through a ball with 50km/hr upward. Then the ball will come in hand with the same speed that is 50km/hr.

ii. Take an empty plastic bottle. Close the mouth of the bottle with an airtight stopper. Put it in a bucket filled with water. You see that the bottle floats. Push the bottle into the water. You feel an upward push. Try to push it further down. You will find it difficult to push deeper and deeper. This indicates that water exerts a force on the bottle in an upward direction. The upward force exerted by the water keeps increasing as the bottle is pushed deeper till it is completely immersed.

Now, release the bottle. It bounces back to the surface.

Does the force due to the gravitational attraction of the earth act on this bottle? If so, why does the bottle stay immersed in water after it is released? How can you immerse the bottle in water?

Explanation: Earth attracts water molecules also. As result water molecules also want to go near the core of the earth. When we immerse a water bottle it displaces some water molecules. If the force of the displaced water is lesser than the gravitational attraction force of the bottle, we need not need to apply external force e.g. stone/heavy particles. But, with plastic bottles, it does not happen so. The volume of displaced water is higher than the mass of the bottle. As a result, we need external pressure to immerse the bottle.

As we go deeper into the water, the upward pressure on the bottle increases due to the increase in the pressure of water. As a result, we need more force to submerge the bottle further.

Expression for gravity of a Planet (Earth)

Consider earth to be sphere of mass M and radius R with centre O. let a body of mass m is placed at its surface. Then the gravitational force between the earth and the body is given by

$$F = G\frac{Mm}{R^2} \quad \text{.............(i) (where } d = R)$$

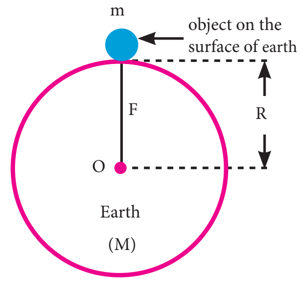


Fig. 7.5

Since, the weight of a body is the measure of the gravity acting on the body.

$$\text{Gravity (F)} = \text{weight (W)} = G\frac{Mm}{R^2}$$

For constant mass 'm'

Gravity $\quad F \propto \dfrac{M}{R^2}$

or, $\quad W \propto \dfrac{M}{R^2}$ ....(ii)

1. Equation ii. shows that the weight (W) of a body on the surface of a heavenly body is directly proportional to the mass (M) of the heavenly body. Greater the mass of the heavenly body, larger is its gravity i.e. greater will be the weight on the heavenly body.

2. The weight (W) of a body on the surface of a heavenly body is inversely proportional to the square of the radius (R) of that body. The weight of the body will be less if the radius of heavenly body is longer.

   It is found that the gravity of the moon is 1/6 of the gravity of the earth. That's why, a person, who can jump 0.5m high on the earth's surface, can jump 3m high on the surface of the moon. Similarly, a person, who can lift a mass of 10kg on the surface of the earth can lift a mass of 60 kg. on the surface of the moon.

   The Jupiter is about 319 times greater than that of the earth. Due to its larger radius (about 11 times) than the earth. The gravity is only about 2.5 times more than the gravity of the earth as $F \propto \dfrac{1}{R^2}$. Also, the weight of the body weighs 2.5 times more on the Jupiter than on the earth. This means, if a person can lift a body of mass 50 kg. on the earth's surface then he/she can lift 20kg. only on the surface of the Jupiter.

Difference between Gravitation and Gravity :

	Gravitation	Gravity
i.	It is universal force.	It is not universal force.
ii.	It occurs between any two bodies in the universe.	If out of two bodies, one of them is heavenly body, the force of attraction between them is gravity.

Effects of Gravity

The following are some of the effects of gravity.

(a) We are able to stand up, run and carry out other activities due to gravity of the earth.

(b) Flowing of rivers, blowing of wind, stability of buildings, bridges etc. possible due to gravity of earth.

(c) The gravity of earth is responsible for holding the atmosphere around its surface.

(d) It makes construction of building and bridges possible.

(e) Tides occur in the ocean due to effect of gravity of the moon.

Related Numerical Problems

1. A boy of mass of 40 kg is standing on the earth surface. The mass and radius of the earth to be 6×10^{24} kg and 6400km respectively. Find the weight of the boy and gravity of the earth.

Solution:

Given,

Mass of the earth (M) $= 6\times10^{24}$ kg

Mass of boy (m) $= 40$kg

Radius of the earth (R) $= 6400\text{km} = 6400\times1000 \text{ m} = 6.4\times10^{6}\text{m}$

Gravitational constant (G) $= 6.67\times10^{-11}\text{Nm}^2\text{kg}^{-2}$

Weight of the boy (W) = $F = \dfrac{GMm}{R^2}$

or, $$F = \frac{6.67\times10^{-11}\text{ Nm}^2\text{ kg}^{-2}\times 6\times10^{24}\text{ kg}\times 40\text{kg}}{(6.4\times10^{6}\text{m})^2}$$

$\therefore$ W = 390.82 N

The weight of the boy at the surface of the earth is 390.82 N

Weight

Weight refers to the gravity force of planets and other bodies in the Universe, and the effect that this has on objects. It is important to remember that weight is not the same as mass - the weight of an object and its mass are directly proportional. This means that for a given gravitational field strength, the greater the mass of the object, the greater its weight.

Weight is a non-contact force because gravity exerts its force through a field. An object does not need to be touching the Earth to have a weight. The weight of an object can be measured using a calibrated spring-balance, often called a Newton meter. Weight is also referred to as 'gravity force'.

gravity force = mass × gravitational field strength (g)

This is when:

- gravity force (weight) is measured in newtons (N)
- mass is measured in kilograms (kg)
- gravitational field strength (g) is measured in newtons per kilogram (N/kg)

The equation can be rearranged to make mass the subject:

$$\text{mass} = \frac{\text{gravity force}}{\text{gravitational field strength}}$$

Example:

Calculate the gravity force (weight) of a skydiver with a mass 70 kg falling towards the Earth?

(Remember that gravitational field strength = 10 N/kg on Earth).

weight = mass × gravitational field strength

weight = 70 × 10

weight = 700 N

All objects with mass have a gravitational field around them. A gravitational field is where a mass experiences a force.

All matter has a gravitational field that attracts other objects. The more mass an object has, the greater its gravitational field will be. For example, the Earth has a greater gravitational field than the Moon because it has a much greater mass than the Moon. The Moon is attracted to the Earth because it is within the Earth's gravitational field.

Gravitational potential energy

When an object is lifted in a gravitational field, energy is transferred to a gravity store. This store is called gravitational potential energy.

gravitational potential energy = mass × height × gravitational field strength (g)

This is when:
- gravitational potential energy is measured in joules (J)
- mass is measured in kilograms (kg)
- height is measured in metres (m)
- gravitational field strength (g) is measured in newtons per kilogram (N/kg)

Example:
Calculate the energy transferred to the gravity store when a woman of mass 60 kg climbs 4 rungs up a ladder. Each rung is 15 cm high.
First calculate the distance climbed in metres:

15 cm is 0.15 m
$0.15 \times 4 = 0.6$ m

Then calculate the gravity store increase (the gravitational potential energy), remembering that g is 10 N/kg on Earth:
gravitational potential energy = mass × height × gravitational field strength (g)
gravitational potential energy = 60 × 0.6 × 10
gravitational potential energy = 360 J

> Calculate the energy transferred to the gravity store when a rocket of mass 4000 kg reaches 10 km up in the atmosphere. Express your answer in megajoules (MJ).

Acceleration due to gravity (g)

When a body is dropped form a height, its velocity keeps on increasing as it comes closer to the earth surface. It gains the acceleration equal to the acceleration due to gravity of the earth. Thus, velocity of a freely falling body increases by 9.8 m/s in each second.

Acceleration due to gravity is defined as the acceleration produced in a freely falling body due to force of the gravity of the earth. Its SI unit is m/s^2. Its average value on the earth surface is 9.8 m/s^2.

The relation between acceleration due to gravity (g) and radius of the earth (R).

Let us consider a body of mass 'm' is on the surface of the earth having mass 'M' and radius 'R'. Then,
According to Newton's Law of gravitation,

$$F = \frac{GMm}{R^2} \quad \text{..................(i)}$$

Similarly, from Newton's Second Law of motion,

$$F = mg \quad \text{..................(ii)}$$

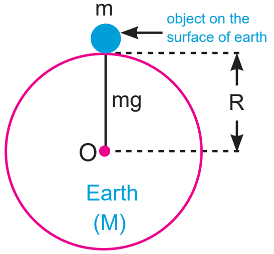


Fig. 7.6

From 0i) and (ii), we get,

$$mg = \frac{GMm}{R^2}$$

$$\text{or,} \quad g = \frac{GM}{R^2}$$

$$\therefore \quad g \propto \frac{1}{R^2} \quad \text{(since G and M are constants)}$$

Hence, the acceleration produced on the surface of the earth (g) is inversely proportional to the square of the radius of the earth.

Variation of acceleration due to gravity (g)

The value of acceleration due to gravity (g) depends on the shape of the earth, height and depth from the surface of the earth.

a. Variation of g due to the shape of the earth:

As we know that our earth is not perfectly spherical in shape. It is flattened at the poles and bulging at the equator as shown in fig. Consequently, the polar radius (R_p) is less than its equatorial radius (R_e).

The value of acceleration due to gravity on the surface of the earth is given by

$$g = \frac{GM}{R^2}$$

$$\therefore g \propto \frac{1}{R^2} \quad \text{(since G and M are constants)}$$

$$\text{i.e.} \quad g_p \propto \frac{1}{R_p^2} \quad \text{and} \quad g_e \propto \frac{1}{R_e^2}$$

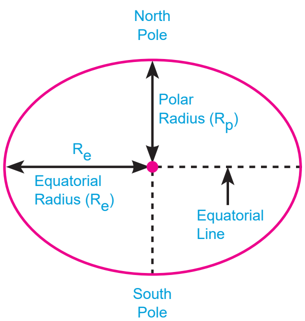


Fig. 7.7

Since, $R_e > R_p$ so $g_p > g_e$

Thus, the value of 'g' is maximum at the poles and minimum at the equator.

At equatorial region, g = $9.78 m/s^2$.
At polar region, g = $9.83 m/s^2$.
On an average, g = $9.80 m/s^2$.

b. Variation of 'g' due to height/altitude from the surface of the earth:

Consider mass of the earth is 'M' and radius 'R' with center 'O'. The value of acceleration due to gravity on the surface of the earth is given by

$$g = \frac{GM}{R^2} \ldots\ldots\ldots\ldots\ldots \text{(i)}$$

If g' is the value of acceleration due to gravity at a height 'h' from the surface of the earth, then

$$g' = \frac{GM}{(R+h)^2} \ldots\ldots\ldots\ldots\ldots \text{(ii)}$$

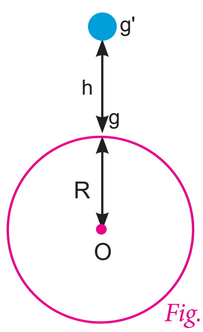


Fig. 7.8

Dividing equation (ii) by (i) we get,

$$\frac{g'}{g} = \frac{\frac{GM}{(R+h)^2}}{\frac{GM}{R^2}}$$

or, $$\frac{g'}{g} = \frac{GM}{(R+h)^2} \times \frac{R^2}{GM}$$

or, $$\frac{g'}{g} = \frac{R^2}{(R+h)^2}$$

$$\therefore g' = g\left(\frac{R}{R+h}\right)^2$$

Also,

Since, R < (R + h) so, g' < g

Therefore, the value of acceleration due to gravity decreases with increase in height from the surface of the earth.

c. Value of 'g' with depth from the earth's surface

If g' is the value of acceleration due to gravity at depth 'x' from the surface of the earth then, it can be shown that

$$g' = \left(1 - \frac{x}{R}\right)g \qquad \text{Since, } \left(1 - \frac{x}{R}\right) < 1 \qquad \text{So, } g' < g.$$

Therefore, the value of acceleration due to gravity decreases with increase in depth from the surface of the earth.

At the earth's centre, x = R

$$g' = \left(1 - \frac{x}{R}\right)g$$

or, g' = 0

So, value of acceleration due to gravity at the centre of the earth is zero.

Acceleration due to gravity on the surface of the moon

Mass of the moon is smaller than the earth. Acceleration due to gravity on the moon is 1/6 times lesser than the earth. That is why, the value of 'g' on the moon is $1.67 m/s^2$.

The constant *g* can also be referred to as the acceleration due to gravity. An object falling towards the surface of a large body would have this acceleration. It is the largest acceleration that the falling object would experience in free fall.

resultant force = mass × acceleration due to gravity

This is when:

- resultant force is measured in newtons (N)
- mass is measured in kilograms (kg)
- acceleration due to gravity is measured in (m/s^2)

Acceleration due to gravity is 9.81 m/s^2 on Earth but it is acceptable to use 10 m/s^2 for calculations.

Activities 7.3

Activity : : Experiment : Acceleration due to Gravity

Aim: Investigating the acceleration of two different objects during free fall.

Apparatus : Tennis ball and a sheet of A4 paper.

Method:

1. Hold the tennis ball and sheet of paper (horizontally) the same distance from the ground. Which on would strike the ground first if both were dropped?
2. Drop both objects and observe. Explain your observations.
3. Now crumple the paper into a ball, more or less the same size as the tennis ball. Drop the paper and tennis ball again and observe. Explain your observations.
4. Why do you thin k the two situations are different?
5. Compare the value for the acceleration due to gravity of the tennis ball to the crumpled piece of paper.
6. Predict what will happen if an iron ball and a tennis ball of the same size are dropped from the same height. What will the values for their acceleration due to gravity be?

Relation between weight, mass and acceleration due to gravity

The terms "mass" and "weight" are used interchangeably in ordinary conversation, but the two words don't mean the same thing. The difference between mass and weight is that mass is the amount of matter in a material, while weight is a measure of how the force of gravity acts upon that mass.

- Mass is the measure of the amount of matter in a body. Mass is denoted using m or M.
- Weight is the measure of the amount of force acting on a mass due to the acceleration due to gravity. Weight usually is denoted by W. Weight is mass multiplied by the acceleration of gravity (g)

The mass of an object can refer to the constant of proportionality between the force that acts on an object and the acceleration of the object. This can be expressed as $F \propto a$ and as $F=ma$, where F is the force applied, m is the mass of the object, and a is the acceleration of the object.

This is how mass is defined in Newton's second law of motion.

The mass of an object is also related to the gravitational force produced by the object. This mass is termed *gravitational mass*.

It is not obvious that objects in general produce gravitational forces, but it is very obvious that Earth produces gravitational forces, as unsupported objects noticeably accelerate toward Earth.

The reason that the gravitational forces produced by Earth are clearly observed, but the gravitational forces produced by other objects are not clearly observed is that the mass of Earth is very great compared to objects such as humans, or even much more massive objects such as large buildings.

The mass of Earth is approximately 5.97×10^{24}kg. Producing a gravitational force sufficiently great to accelerate objects at a rate clearly observable by human senses requires a mass comparable to the enormous mass of Earth.

The mass of Earth produces what is termed a *gravitational field*. A gravitational field is a region within which an object is acted on by a gravitational force.

The mass of any object produces a gravitational field, but for objects on Earth, the forces due to their gravitational fields are sufficiently small that they are approximately zero. When considering objects on Earth, for most examples, it is valid to model Earth as the only object to produce a gravitational field.

The gravitational force on an object in the gravitational field of Earth is called the weight of the object. The weight of an object is related to its mass by the following formula: $W = mg$, where W is the weight of the object, m is the mass of the object, and g is the gravitational field strength at the position of the object.

Weight is a force, so its SI unit is newton.
The SI base unit of mass is the kilogram.

In nonscientific English, the weight of an object is commonly referred to as being measured in kilograms. The correct scientific use of English, however, requires that a number of kilograms refer to a measurement of the mass of an object. The weight of an object is measured in newtons rather than in kilograms.

The formula $W = mg$ can be rearranged to make g the subject, giving $g = W/m$.

We see from this that the SI unit of gravitational field strength is newtons per kilogram (N/kg).

On Earth, the gravitational field strength is approximately 9.8 N/kg.

The weight of an object that is supported by a surface acts on that surface. The following figure shows an object with a weight, W, at rest on a surface.

For the most part, when comparing mass and weight on Earth—without moving—the values for mass and weight are the same. If you change your location with respect to gravity, mass will remain unchanged, but weight will not. For example, your body's mass is a set value, but your weight is different on the Moon compared with on Earth.

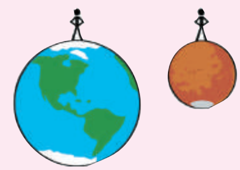
Mass	Weight
Mass is a property of matter. The mass of an object is the same everywhere.	Weight depends on the effect of gravity. Weight increases or decreases with higher or lower gravity.
Mass can never be zero.	Weight can be zero if no gravity acts upon an object, as in space.
Mass does not change according to location.	Weight varies according to location.
Mass is a scalar quantity. It has magnitude.	Weight is a vector quantity. It has magnitude and is directed toward the center of the Earth or other gravity well.
Mass may be measured using an ordinary balance.	Weight is measured using a spring balance.
Mass usually is measured in grams and kilograms.	Weight often is measured in newtons, a unit of force.

While a person's mass doesn't change elsewhere in the solar system, the acceleration due to gravity and weight varies dramatically. The calculation of gravity on other bodies, as on Earth, depends not just on mass but also on how far the "surface" is from the center of gravity. On Earth, for example, your weight is slightly lower on a mountain top than at sea level. The effect becomes even more dramatic for large bodies, such as Jupiter. While the gravity exerted by Jupiter due to its mass is 316 times greater than that of Earth, you wouldn't weigh 316 times more because its "surface" (or the cloud level we call the surface) is so far out from the center.

Other celestial bodies have different values of gravity than Earth does. To get your weight, simply multiply by the appropriate number. For example, a 68 kg- person would weigh 179.52 kg on Jupiter, or 2.64 times their weight on Earth.

Activities 7.4

Calculate the Stick Figure's weight on both earth and the moon.
Mass of stick figure on earth : 100 kg
Acceleration due to gravity on Earth __________
F_N = mass ×gravity
Weight on earth __________
Acceleration due to gravity on moon : 1.62 m/s/s
Mass on MOON __________
Weight on Moon __________



Using your NASA App, Click on a planet and scroll down the left side and look for the surface gravity of the planet. Should be the number with m/s². Use the formula F_N = mass (kg)× gravity (m/s²) to calculate the weight of an 80Kg on three planets.

Planet 1	**Planet 2**	**Planet 3**
Planet __________	Planet __________	Planet __________
Surface Gravity	Surface Gravity __________	Surface Gravity __________
To get weight or Force in Newtons, multiply 80 kg × surface gravity Weight = __________	To get weight or Force in Newtons, multiply 80 kg × surface gravity Weight = __________	To get weight or Force in Newtons, multiply 80 kg × surface gravity Weight = __________

Relation between acceleration due to gravity and radius of the Earth .

Acceleration due to gravity on the surface of the moon

Mass of the moon is smaller than the earth. Acceleration due to gravity on the moon is 1/6 times lesser than the earth. That is why, the value of 'g' on the moon is $1.67 m/s^2$.

Related Numerical Problems

i. A man can lift 100kg of mass on the earth. How much he can lift on the surface of the moon?

Solution,

Mass on earth = 100kg = $100kg \times 9.8 m/s^2$ = 980 N

A man can lift 980 N on earth.

Again on moon surface,

$W = 980N$, $g = 1.67 m/s^2$, $m = ?$

According to formula,

$$W = mg \text{ or } m = \frac{W}{g} = \frac{980N}{1.67 m/s^2} = 586.8kg$$

So, the same man can lift 586.8kg on the surface of the moon.

ii. Calculate the value of acceleration due to gravity on the surface of the moon, if the mass of moon is 7.4×10^{22} kg and the radius of the moon is 1.74×10^6 m also find the weight of a body having mass 80 kg on its surface. ($G = 6.67 \times 10^{-11} Nm^2/kg^2$)

Solution,

Mass of the moon (M) = 7.4×10^{22} kg

Radius of the moon (R) = 1.74×10^6 m

Value of G = $6.67 \times 10^{-11}\ Nm^2 / kg^2$

Acceleration due to gravity (g) = ?

$$g = \frac{GM}{R^2}$$

$$= \frac{6.67 \times 10^{-11} \times 7.4 \times 10^{22}}{(1.74 \times 10^6)^2}$$

$$= \frac{4.9358 \times 10^{12}}{3.0276 \times 10^{12}} = 1.63 m/s^2$$

We know,

Now, mass of the body (m) = 80 kg

Weight of the body (W) = ?

We have,

$W = m \times g = 80 \times 1.63 = 130.4N$

Hence, the weight of the body is 130.4N

iii. How much mass can a person lift in the Jupiter if he can lift 50 kg on the earth surface?

Solution,

On the earth

Mass (M) = 50 kg

Acceleration due to gravity (g) = $9.8 m/s^2$

Weight (W) = ?

We know,

$W = m \times g$

$= 50 \times 9.8 = 490$ N

Hence, he can lift 490 N weight on the earth.

On the Jupiter

Weight (w) = 490 N

Acceleration due to gravity (g) = $25 m/s^2$

Mass (m) = ?

We have,

$w = m \times g$

or, $490 = m \times 25$

or, $\frac{490}{25} = m$

$\therefore m = 19.6$ kg

Hence, the person can lift 19.6 kg on the Jupiter surface.

iv. The radius of the earth is is 6400km, height of the Mt. Everest is 8848m above the sea level. Find the acceleration due to gravity at this height.(value of g = $9.8 m/s^2$). Also find the weight of the man having mass 80kg at the top of Mt. Everest.

Solution:

Given,

Radius of the earth (R) = 6400km = 6400×1000 m = 6.4×10^6m

Gravitational constant (G) = $6.67\times10^{-11} Nm^2kg^{-2}$

Height of the Mt. Everest (h) = 8848m

Acceleration due gravity at sea level (g) = $9.8m/s^2$

The acceleration due to gravity at this height is given by

$$g' = \left(\frac{R}{R+h}\right)^2 g$$

$$g' = \left(\frac{6.4 \times 10^6}{6.4 \times 10^6 + 8848}\right)^2 \times 9.8$$

$g' = 9.77 m/s^2$

Now, weight (W)= mg'

= 9.77×80 = 781.6N

Some Solved Short questions

1. What will be the effect on acceleration due to gravity if radius of the earth is decreased?

   If the radius of the earth decreases keeping its mass constant then the value of acceleration due gravity (g) increases since, $g \propto \frac{1}{R^2}$

2. The probability of getting hurt is more when a man jumps from certain height, why?

   Acceleration is produced on a falling body due to the gravity of the earth. As the body falls, its velocity increases in every second. At the end of fall he gains more velocity and therefore strikes the earth with more velocity. Since the man strikes the earth with more velocity, he experiences more force. So, the probability of getting hurt is more when a man jumps from certain height.

3. A body is dropped from the same height at pole and equator. At which place do the object reaches quickly on the ground?

   We know, $g \propto \frac{1}{R^2}$ and as equatorial radius (R_e) > polar radius (R_p). So acceleration due to gravity at pole (g_p) > the acceleration due to gravity at equator (g_e). Hence, the body falls quickly at pole than at the equator.

4. The value of acceleration due gravity is less at the top of Mt. Everest than at its bottom? Why?

For a place, the value of acceleration due to gravity 'g' is inversely proportional to distance (radius) from the centre of earth. (i.e. $g \propto \frac{1}{R^2}$), the radius of earth for the top of mountain is greater than the bottom. So, the value of g is less at top of Mt. Everest than at the bottom.

5. **Where will the value of acceleration due to gravity be greater at Terai or at the mountain?**
   For a place, the value of acceleration due to gravity 'g' is inversely proportional to distance (radius) from the centre of earth. (i.e. $g \propto \frac{1}{R^2}$), the radius of earth at Terai region is less than at the mountain region. So, the value of acceleration due to gravity is more in Terai than mountain.
6. **Mass of a body remains same everywhere but its weight varies from place to place. Why?**
   The mass of a body depends upon the total number of atoms and average mass of atom present in the body. So, it remains constant. But w = mg i.e. $w \propto g$, the weight of the body depends upon acceleration due to gravity at a place. Since, 'g' differs from place to place so weight of the body also differs from place to place.

Activities 7.5

Activity :: Case Study : Galileo Galilei

In the late sixteenth century, it was generally believed that heavier object would fall faster than lighter objects. The Italian scientist Galileo Galilei thought differently. Galileo hypothesized that two objects would fall at the same rate regardless of their mass. Legend has it that in 1590, Galileo planned out an experiment. He climbed to the top of the Leaning Tower of Pisa and dropped several large objects to test his theory. He wanted to show that two different objects fall at the same rate (as long acceleration of a falling object is independent of the object's mass.

A few decades after Galileo, Sir Isaac Newton would show that acceleration depends upon both force and mass. While there is greater force acting on a larger object, this force is canceled out by the object's greater mass. Thus two objects will fall (actually they are pulled) to the earth at exactly the same rate.

Question : Read the case study above and answer the following questions.

1. Divide into pairs and explain Galileo's experiment to your friend.
2. Write down an aim and a hypothesis for Galileo's experiment.
3. Write down the result and conclusion for Galileo's experiment.

Feather and coin experiment

Sir Isaac Newton dropped a coin and feather into a long, wide and inverted glass tube. He found that the coin fell faster than the feather as in figure (a). Then, he took the air out using vacuum pump and did the same experiment. But at this time, he observed that both coin and feather fell at a time as shown in figure (b).

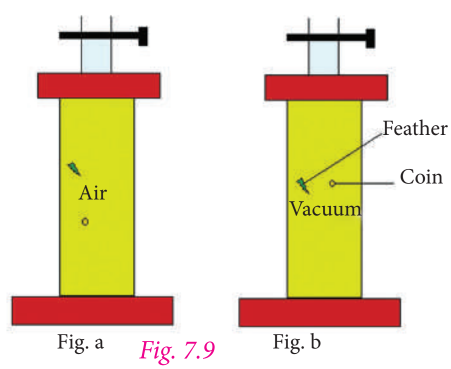


Fig. 7.9

This experiment showed that "acceleration due to gravity of freely falling bodies is same whatever the masses they have." Astronauts of Apollo- 12 also performed the same experiment on the moon surface and found the same result.

Activities 7.6

Take a sheet of paper and stone. Drop them simultaneously form the first floor of building . Observe whether both of them reach the ground simultaneously.

We see that paper reaches the ground little later than the stone . This happens because of air resistance. The air offers resistance offered to the stone.If we do the experiment in a glassjar from which air has been sucked out, the paper and the stone would fall at the same rate .

Observation : The stone reaches fast while paper arrives at the bottom late.

Explanation : We all know that earth attracts all the object with the force proportional to the mass of the object.

$F= GMm/R^2$

(Where G is the universal gravitational constant; M is the mass of the earth; m is mass of the object, and R is the radius of the earth.)

$\Rightarrow ma=GMm/R^2$

$\Rightarrow a=GM/R^2$

Thus we see that all the body falls with the same acceleration. We call this Acceleration due to gravity (g). Its value is $9.8 m/s^2$.

But this does not happen in reality. Other forces come into play in a free fall. For example Friction due to air. Light objects like paper have a higher surface area. They offer higher resistance to the air; while the stone is heavy with a small source area. Stone offer lower friction with the air. As a result, when we fall paper and stone at the same time, stone reaches the ground fast.

A glass from which air is drawn out does not offer any resistance whether it is a stone or a paper or something else. As a result, all the objects fall at the same speed and reach the bottom simultaneously.

Differences between 'g' and 'G' :

S.N.	Acceleration due to gravity (g)	Gravitational constant (G)
i.	It is the acceleration produced on a body due to gravity.	It is the gravitational force between two bodies of unit masses kept 1m far from each other.
ii.	It is vector quantity.	It is a scalar quantity.
iii.	Its SI unit is m/s^2.	Its SI unit Nm^2/kg^2.
iv.	Its value is changeable.	Its value is constant.
	Average value of $g = 9.8 m/s^2$ at the surface of earth.	Its value is $6.67 \times 10^{-11} Nm^2/kg^2$.

7.3 Free fall

When a body falls freely towards the centre of the earth under the influence of its gravitational pull, the motion of that body is free fall. At the time of free fall, the body gains the acceleration equal to acceleration due to gravity (a = g). Due to the absence of air, falling of body in moon surface is free fall. This is equal to the acceleration due to gravity 'g'. On the earth, there is no perfect free fall of any falling body due to air resistance.

Hence, when a body is falling towards the centre of the earth under the influence of gravitational pull of the earth only, the motion of the body is called is free fall. In case of free fall, the body is in weightlessness condition because the body feels no reaction force.

An object is said to be in "free fall" if the only force acting upon it is gravity.

a. A satellite orbiting the Earth is said to be in free fall.
b. The astronauts in a space ship are in free fall. The only force acting on the astronauts is gravity.
c. The planets are in free fall as they orbit the sun.

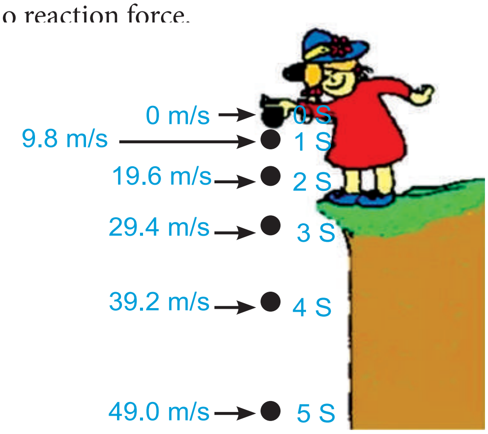


Fig.7.10 velocity of freely falling apple

Weightlessness

When we stand on the ground, our feet give action force towards the ground, as a result the ground exerts reaction on our body and we feel our weight. The sensation of our weight is due to this reaction of the contact surface of the floor on our body. If there is no reaction of the contact surface, we will feel weightless.

Hence, weightlessness is defined as the condition in which the effective weight of a body becomes zero due to the no reaction force of the heavenly bodies or any other contact surface.

The body will in the state of weightlessness in the following condition

a. In a state of free fall of object

When an object is attached to a spring balance suspended from a support, the spring balance shows the weight of the object.

When the spring balance is detached from the support and allowed to fall freely, both spring balance and the object is falling with acceleration equal to acceleration due to gravity(g) and the spring of Spring balance is not extended and the object have no reaction force acting on it throughout fall. So, it is in the state of weightlessness. For example:

- When the lift is falling down with some acceleration, the floor of the lift gives reaction on person's body and he feels weight.
- If the string of lift breaks and the lift comes in the state of free fall. In this case no reaction is given by the floor of the lift and the person inside lift feel weightlessness.

b. Astronaut in a space ship orbiting earth

The gravitational force between the earth and spaceship provides the necessary centripetal force to move the spaceship around the earth. So, the centripetal acceleration (a_c) acting towards the centre of the earth is equal to acceleration due to gravity (g) which means the space ship will be in the state of free fall. Thus, the floor of space ship exerts no reaction on the astronaut sitting in a space ship and he experiences weightlessness.

c. At null points

Null points are the points in outer space where the gravitational force due to heavenly masses cancel out (i.e. it may be between earth and the moon). Hence the effective value of acceleration due to gravity and the weight of a body at null points will be zero.

Solved Short questions

1. Why does the person feel weightlessness in a freely falling lift?

   In case of freely falling lift, both lift and the person in the lift is falling with same acceleration equal to acceleration to gravity (g). In this case no reaction is given by the floor of the lift and the person inside lift feels weightlessness.

2. An astronaut in artificial satellites (spaceship) revolving around the earth feels weightlessness. Explain.

   For space ship to revolve around the earth, the required centripetal force is provided by the gravitational attraction between the earth and the space ship. So, the centripetal acceleration (a_c) acting towards the centre of the earth is equal to acceleration due to gravity (g). This means the space ship will be in the state of free fall. Thus, the floor of space ship exerts no reaction on the astronaut sitting in a space ship and he experiences weightlessness.

3. The parachutists are not hurt when they jump out of an aeroplane, why?

   When the parachutists jump out of an aeroplane, they accelerate under the effect of gravity. As they open parachute, the air resistance slows down the speed of fall. Once the force of air resistance balance the force of the gravity, the parachutists no longer accelerates and falls down with uniform velocity. So, the parachutists are not hurt when they jump out of an aeroplane.

The formula for free fall:

Imagine an object body is falling freely for time t seconds, with final velocity v, from a height h, due to gravity g. It will follow the following equations of motion as:

$h = \frac{1}{2}gt^2$ $\quad v^2 = 2gh$ $\quad v = gt$

Where,

h	Height traveled
v	Final velocity
g	Acceleration due to gravity
t	Time taken

These equations can be derived from the usual equations of motions as given below, by substituting

initial velocity u=0,

distance traveled s=h and

acceleration, a=g.

We can see it as follows:

$s = ut + \frac{1}{2}at^2$ $\quad v^2 = u^2 + 2as$ $\quad v = u + at$

Freefall is the autonomous phenomena of the body with some mass. It only depends on height from the surface and the time period for which the body is flung.

Solved examples:

Example-1: Compute the height of the body if it has a mass of 2 Kg and touches the ground after 5 seconds?

Solution:

Given parameters are:

Time t = 5 sec

We have to compute the height. So, we can apply the first equation as given above.
i.e. $h = ½gt^2$
Substituting the values,

$h = ½gt^2$
$h = ½×9.8×5^2$ $h = 4.9 × 25$ $h = 122.5$ m
∴ height as required will be 122.5 meter.

Free Fall Equations

The state of motion of a freely falling object is defined by three equations of motion. These three equations are used to determine various free fall parameters (such as free fall velocity, time, and distance covered) depending on which variables are known and which are unknown.
To derive the free fall equations, consider an object in free fall. During free fall, the object is acted upon only by the force due to gravity, and thus, its acceleration is equal to the acceleration due to gravity g . While constructing the free fall kinematics equations, g is taken as negative as the acceleration due to gravity acts in the downward direction (or along the negative y-axis). Under this constant downward acceleration, the velocity of the object increases as it falls to the ground.

First Free fall equation

Let the initial velocity of the object u, and the velocity after time t be v, As acceleration (here $-g$ is the change in velocity per unit time, we have

$$-g = \frac{v-u}{t} \Rightarrow -gt = v-u \qquad \Rightarrow v = u - gt$$

This is the first free fall education. It is use to find the velocity after a certain time interval when the initial velocity and time interval are know.

Second free fall equation

The distance d covered in time t of free fall is equal to the product of the average velocity v_{avg} and time t, that is $s = v_{avg} \times t$.
Now, the average velocity $v_{avg} = \frac{v+u}{2}$. so we have

$$s = \frac{v+u}{2} \times t$$

But to express the distance covered in terms of the initial velocity only (and not the velocity after time t), the first free fall equation $v = u - gt$ can be used to substitute v in the above expression. Thus,

$$s = \frac{(u - gt) + u}{2} \times t = \frac{ut}{2} - \frac{gt^2}{2} + \frac{ut}{2}$$

$$\Rightarrow d = ut - ½gt^2$$

This is the second free fall equation. It is used to find the distance covered in a certain time interval when the initial velocity and time interval are known.

Third free fall equation

The third free fall equation is used to find the velocity aftera certain time interval when the initial velocity and the distance covered in that time interval are known. To obtain the equation, the first and second free fall equations are used.

We have the first equation,

$$v= u - gt \Rightarrow t \frac{u-v}{g}$$

using the above expression of t is the second equatiuon, we get

$$s = ut - \frac{1}{2} gt^2 = u \frac{(u-v)}{g} - \frac{1}{2} g \frac{(u-v)^2}{g^2}$$

$$\Rightarrow 2gs = 2 -2uv - u^2 + 2uv - v^2 = u^2 - v^2$$

$$\Rightarrow v^2 = u^2 - 2gs$$

This is the third free fall equation.

Application of Free Fall Equation for Problem Solving

As the object is initially simply dropped, its initial velocity is 0, that is u = 0.

Now, the acceleration of the object is constant and equal to g = 9.8 ms^{-2} throughout the entire free fall motion, but its velocity increases as it covers more distance with increasing time.

Substituting different values for t(= 0s, 1s, 2s, 3s, ...) in the first two equation, the velocity and distance covered after every time interval can be determined.

At t = 0 s,

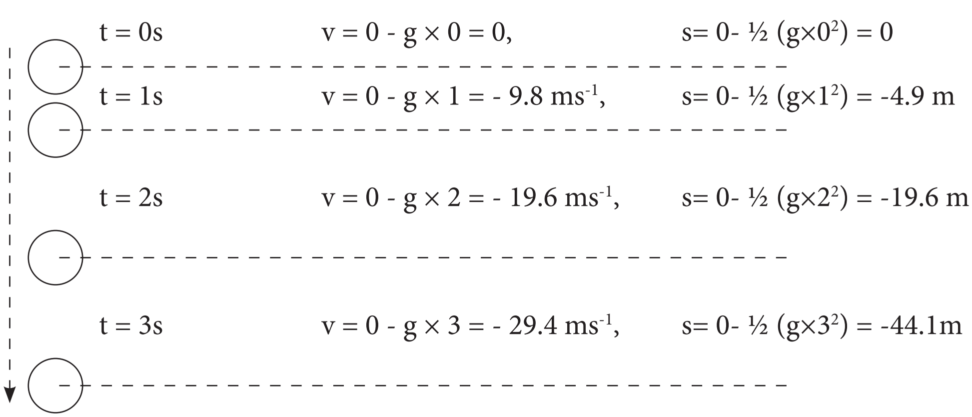
- $v = u - gt = 0 - 9.8 \times 0 = 0$
- $s = ut - \frac{1}{2} gt^2 = 0 - \frac{1}{2} \times 9.8 \times 0^2 = 0.$

At t = 1 s,

- $v = u - gt = 0 - 9.8 \times 1 = 9.8\ ms^{-1}$
- $s = ut - \frac{1}{2} gt^2 = 0 - \frac{1}{2} \times 9.8 \times 1^2 = 4.9$ m.

Similarly, the velocity and distance can be obtained for t=2s, 3s, and so on. This is shown in the figure below .

$g = -\ 9.8\ ms^{-2}$, $u = 0$



The free fall equations can be used to determine the velocity and distance traveled after different time intervals.

Examples

i. A metal coins is thrown straight upwards with an intial velocity of 20m/s . Calculate the distance covered (from the point of projection) and the velocity after 2 s. Take $g=10ms^{-2}$

Solutions:

$u = 20ms^{-1}$ $g=10ms^{-2}$ $t= 2$ s

s=? v=?

We know that ,

$s = ut + 1/2gt^2$

Substituting the values , we will have

$s= 20x2-1/2(10)(2)^2$

$=40-20$

$=20m$

again,

Calculate the velocity,

$v=u+gt$

Substituting the values, we will have

$v =20-10\times2$ $=20-20$ $v= 0\ ms^{-1}$

ii. A book falls from a bookshelf which is at a height of 2.5m from the floor. Determine its velocity just before striking the floor.

Solutions:

Step 1. Write out the given values.

$h = 2.5$ m $g = 9.8\ ms^{-2}$ $v = ?$

Step 1. Calculate the time.

At the initial height the ball is at rest. This implies.

That the initial velocity is zero.

$v^2 = u^2 +2gs$

Bacause $u = 0\ ms^{-1}$, we will have

$v^2 = 2gs$

This implies that

$v = \sqrt{2gs}$

Substitute the values, we will have

$v = \sqrt{2 \times 9.8 \times 2.5}$

$= 7\ ms^{-1}$

A light weight stone is thrown vertically

7.4 Falling object on earth

As an object falls through air, it usually encounters some degree of air resistance. Air resistance is the result of collisions of the object's leading surface with air molecules. The actual amount of air resistance encountered by the object is dependent upon a variety of factors.The two most common factors that have a direct effect upon the amount of air resistance are the speed of the object and the cross-sectional area of the object. Increased speeds result in an increased amount of air resistance. Increased cross-sectional areas result in an increased amount of air resistance.

Activities 7.7

TRUE or FALSE

i. The elephant encounters a smaller force of air resistance than the feather and therefore falls faster.
ii. The elephant has a greater acceleration of gravity than the feather and therefore falls faster.
iii. Both elephant and feather have the same force of gravity, yet the acceleration of gravity is greatest for the elephant.
iv. Both elephant and feather have the same force of gravity, yet the feather experiences a greater air resistance.
v. Each object experiences the same amount of air resistance, yet the elephant experiences the greatest force of gravity.
vi. Each object experiences the same amount of air resistance, yet the feather experiences the greatest force of gravity.
vii. The elephant experiences less air resistance and than the feather and thus reaches a larger terminal velocity.
viii. The feather experiences more air resistance than the elephant and thus reaches a smaller terminal velocity.
ix. The elephant and the feather encounter the same amount of air resistance, yet the elephant has a greater terminal velocity.

If you answered TRUE to any of the above questions, then perhaps you have some confusion about either the concepts of weight, force of gravity, acceleration of gravity, air resistance and terminal velocity. The elephant and the feather are each being pulled downward due to the force of gravity. When initially dropped, this force of gravity is an unbalanced force. Thus, both elephant and feather begin to accelerate (i.e., gain speed). As the elephant and the feather begin to gain speed, they encounter the upward force of air resistance. Air resistance is the result of an object plowing through a layer of air and colliding with air molecules. The more air molecules which an object collides with, the greater the air resistance force. Subsequently, the amount of air resistance is dependent upon the speed of the falling object and the surface area of the falling object. Based on surface area alone, it is safe to assume that (for the same speed) the elephant would encounter more air resistance than the feather.

But why then does the elephant, which encounters more air resistance than the feather, fall faster? After all doesn't air resistance act to slow an object down? Wouldn't the object with greater air resistance fall slower?

Answering these questions demands an understanding of Newton's first and second law and the concept of terminal velocity. According to Newton's laws, an object will accelerate if the forces acting upon it are unbalanced; and further, the amount of acceleration is directly proportional to the amount of net force (unbalanced force) acting upon it. Falling objects initially accelerate (gain speed) because there is no force big enough to balance the downward force of gravity. Yet as an object gains speed, it encounters an increasing amount of upward air resistance force. In fact, objects will continue to accelerate (gain speed) until the air resistance force increases to a large enough value to balance the downward force of gravity. Since the elephant has more mass, it weighs more and experiences a greater downward force of gravity. The elephant will have to accelerate (gain speed) for a longer period of time before there is sufficient upward air resistance to balance the large downward force of gravity.

Once the upward force of air resistance upon an object is large enough to balance the downward force of gravity, the object is said to have reached a terminal velocity. The terminal velocity is the final velocity of the object; the object will continue to fall to the ground with this terminal velocity. In the case of the elephant and the feather, the elephant has a much greater terminal velocity than the feather. As mentioned above, the elephant would have to accelerate for a longer period of time. The elephant requires a greater speed to accumulate sufficient upward air resistance force to balance the downward force of gravity. If we were to depict the relative magnitude of the two forces acting upon the elephant and the feather at various times in their fall, perhaps it would appear as shown below. (NOTE: The magnitude of the force vector is indicated by the relative size of the arrow.)

Observe from the above diagrams that the feather quickly reaches a balance of forces and thus a zero acceleration (i.e., terminal velocity). On the other hand, the elephant never does reach a terminal velocity during its fall; the forces never do become completely balanced and so there is still an acceleration. If given enough time, perhaps the elephant would finally accelerate to high enough speeds to encounter a large enough upward air resistance force in order to achieve a terminal velocity. If it did reach a terminal velocity, then that velocity would be extremely large - much larger than the terminal velocity of the feather.

So in conclusion, the elephant falls faster than the feather because it never reaches a terminal velocity; it continues to accelerate as it falls (accumulating more and more air resistance), approaching a terminal velocity yet never reaching it. On the other hand, the feather quickly reaches a terminal velocity. Not requiring much air resistance before it ceases its acceleration, the feather obtains the state of terminal velocity in an early stage of its fall. The small terminal velocity of the feather means that the remainder of its fall will occur with a small terminal velocity.

But what if there were no air resistance? If air resistance could somehow be eliminated (by conducting the experiment in a vacuum), then which object - the elephant or the feather - would strike the ground first?

The benefits, drawbacks, and applications of air resistance in falling objects

Since air resistance acts in the opposite direction to an object's motion, it slows objects down. Sometimes, air resistance can be useful. For example, parachutes use air resistance to make people fall to the ground slowly. This helps people land safely on the ground.

Other times, air resistance is not useful, and we want to reduce it. For example, when people design airplanes and trains, they want them to travel fast. They do not want too much air resistance to cause them to slow down. By understanding and changing factors that affect air resistance, we can control the amount of air resistance between objects and the air.

The three factors that affect air resistance are-

i. the surface area of the moving object,
ii. the shape of the moving object,
iii. the speed of the moving object

First, we will look at how the surface area of an object impacts the amount of air resistance it faces. Surface area is the space that the surface of an object takes up. It can be measured in square centimetres (cm^2) or square metres (m^2).

Let's compare the surface areas of two parachutes.

Parachute	1 	2 
Surface area	$10\ m^2$	$1\ m^2$

Parachute 1 is bigger and has the largest surface area. Its surface takes up more space. Parachute 2 is smaller and has the smallest surface area. Its surface takes up less space. Let's compare how much air resistance these parachutes experience.

A peroson falls from an airplane with parachute1	A person falls from an airplane with parachute 2
	
The parachute has a larger surace area.	The Parachute has a smaller surface area.
More air pushes against the parachute, so there is more air resistance.	Less air puses against the parachute, so there is less air resistance.
The person falls more slowly.	The person falls more quickly.

Activities 7.8

Identifying How Surface Area Impacts Air Resistance

Sushant is designing parachutes.

i. He says, "The larger the surface area of the parachute, the faster it will fall to the ground."Is he right? Write your opinion.

ii. Fill in the blank to explain why: A larger surface area creates _______ air resistance.

a. more   b. less

Another factor that affects air resistance is the shape of an object. Objects with different shapes experience different amounts of air resistance. Shapes that cause less air resistance are referred to as streamlined shapes. Streamlining is designing the shape of an object to allow fast motion through a fluid, like air or water. The shape and surface area of objects impact the amount of air resistance between them and the air.

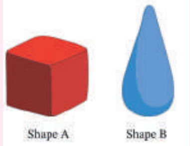
Activities 7.9

Identifying How Streamlining Impacts Air Resistance

A student takes two pieces of modeling clay. She measures how quickly they fall to the ground.

i. Fill in the blank: Shape B will fall than shape A.

a. more quickly   b . more slowly



ii. Why is this the case?

a. Because shape B is more streamlined

b. Because shape A is more streamlined

iii. Write down the features of A and B with advantages and disadvantages

iv. Explain why shape B will fall more quickly.

The third factor that impacts the amount of air resistance is the speed of an object.

Objects that are moving fast experience more air resistance opposing their motion than objects that are moving slowly.

For example, if you run fast, you will feel air pushing against your body. The faster you move, the more air resistance will push against you.

Activities 7.10

Identifying the Relationship between Air Resistance and Speed

The faster an object moves, the more air resistance it has.

Fill in the blank: Air resistance __________ the object.

A. speeds up

B. slows down

C. does not change the speed of

Advantages of air resistance

Air resistance makes flight possible. Imagine sticking your hand outside the car window and feeling the pressure on your hand as you tilt it up and down, like an airplane wing. Without friction, nothing would change as you tilt your hand up or down. Friction results from the compression of the air, and the differential compression from the bottom to the top of a wing. So, without friction, there would be no lift.

With air resistance, acceleration throughout a fall gets less than gravity (g) because air resistance affects the movement of the falling object by slowing it down. Parachutes go up in the air since the area is big enough to create enough resistance to push the parachute up. Flying is a familiar example where air resistance is easily felt.

Air resistance force plays a very important role in the action of a parachute. When a person jumps down while sky diving and opens up his/her parachute, the air resists the jump. Due to this resistance provided by the air, the speed with which the parachute approaches the ground slows down. The gravitational force pulls the parachute in a downward direction, whereas an air resistance force is applied to the parachute in an upward direction. Hence, the air resistance force helps the person to land smoothly on the ground.

The engine, wings, and propellers of an aeroplane are designed in such a way that enough thrust can be generated that helps the plane to overcome the air resistance force. The friction introduced by the air is also responsible to generate turbulence. However, air resistance causes no difficulty in the case of a rocket because a rocket has to exhibit motion in space, which is an environment that does not contain air, and therefore, it is free from air resistance force.

Due to air resistance force , we can fly a kite (or a paper airplane) in the air. We enjoyed this. A kite flies because the lifting force of the wind overcomes both the downward pull of gravity and air resistance to the forward motion of the kite called drag. Three main forces control kite flight: lift, gravity, and drag. When tethered and fixed in a position to gain lift from the wind, a kite maintains a perpetual stall—a poor aerodynamic design for an airplane but essential for a kite flying at a stable and positive angle with respect to the horizon.Flat kites require a tail for drag, which keeps the nose up and creates balance, much like a raft needs a rudder for directional stability.

Many sky-divers, parachute troops, and hang glider pilots have found 'air resistance' useful, else they would have made a hole in the ground. All astronauts/cosmonauts use A lot of air resistance to burn off at least 17,000 miles per hour of orbital speed if they wish to return from space.

Parachutes are used to deploy troops and support into war zones, deliver supplies and cargo, save lives, decelerate aircraft, and more recently, for the sport of skydiving. The simple concept has evolved into a masterful invention that can be steered and manipulated almost like an airplane, just by using lift, drag, and gravity.

Activities 7.11

Build a Better Parachute

Here are instructions for a toy parachute. Your classroom can divide into groups or teams and try altering the materials and design, always using identical objects as the jumper:

1. Cut a circle out of a paper bag, plastic bag, piece of tissue, cotton cloth, silk, etc. Let them decide the size (bigger will be better)
2. Punch holes around the edge of the circle, at least four. Tissue will need some reinforcement first, a piece of tape will work.
3. Tie string to each hole. The pieces should be the same length.
4. Tie the strings together under the parachute and secure the jumper.
5. Test!

Drawbacks of air resistance

Air resistance or friction makes flight difficult at higher speeds. The wing of a high-speed aircraft compresses the air so much that the leading edge will heat up. In some military aircraft, like the SR-71, it heats up so much that it glows red.

Air resistance works to slow the rocket. That is why the rockets on anything going out of the atmosphere must develop enough power to overcome the weight of the rocket, gravity, and air resistance and reach the required speed for leaving the atmosphere. The big disadvantage of air resistance is that it wastes energy. Any form of transport, such as airplanes, trucks and cars would use less fuel and be cheaper if not for air resistance.

Applications of air resistance

Air resistance can be a significant factor in many practical applications. The trajectory of projectiles, the velocity of falling objects, and the design of modern vehicles are just a few instances where air resistance affects the movement of an object.Air resistance force plays a very important role in the action of a parachute. When a person jumps down while sky diving and opens up his/her parachute, the air resists the jump. Due to this resistance provided by the air, the speed with which the parachute approaches the ground slows down.

Activities 7.12

i. Make a hole in the back of a plastic cup about 5 mm in diameter. Close the hole with your finger and fill half of it with water. Take it to a certain height and release the cup. Did the water fall from the hole? Explain the reason for this.

ii. Calculate your weight by measuring your body mass. If a mass measuring scale is not available at school, find out where such a device is available in your area and measure your body mass.

iii. Play Rotapping in your area in Dashain or Tihar. What is the experience of sitting on a ping and going down? Write down your experiences and the reasons for them.

Exercise

A. Choose the correct one and put the tick mark(√)

i. Weight is a measured in-

a. kilogram b. newton e. pound d. joule

ii. Which statement is True ?

a. Gravity only acts through air.

b. Gravity acts towards the ventre of the earth

c. Gravity doesn't act on a flying aeroplane

d. None of the above .

iii. What is the value of 'g' on the moon surface?

a. 1.67 m/s^2 b. 9.8 m/s^2 c. 25 m/s^2 d. 9 .78 m/s^2

ii. What is the value of 'G' ?

a. 6.6 x 10^{-10} Nm^2/kg^2 b. 6.67 x 10^{-11} Nm^2/kg^2

c. 6.67 x 10^{11} Nm^2/kg^2 d. 66.67 x 10^{10} Nm^2/kg^2

iii. What will happen to the gravitational force of attraction between two bodies when the distance between them is made half keeping masses constant?

a. increased by 9 times b. increased by 4 times

c. reduced by $1/4^{th}$ d. reduced by $1/3^{rd}$

iv. What is the relation between weight of a body and acceleration due to gravity ?

a. W = g b. $W \propto 1/g$ c. $W \propto g$ d. W = 2g

v. What will be the weight of a stone having weight 60 N on the earth's surface taken to the moon ?

a. 600 N b. 60 N c. 10 N d. 6 N

vi. What is the weight of a body during free fall ?

a. 100 N b. 20 N c. 10 N d. 0 N

v. How does air resistance affect the speed of a moving object?

a. This depends on the type of the object b. It increases the speed

c. It has no effect on the speed d. It decreases the speed.

B. a. Write T or True if the statement is true; write F or False if the statement is False.

i. Earth's gravity always pulls us toward the center of the Earth. __________

ii. All objects in the Universe have gravity. __________

iii. The larger an object's mass, the more gravity it will have __________

iv. Weight is the same as mass. __________

v. The greater the distance between two objects, the more the gravitational attraction.

b. Fill in the blanks with suitable words.

i. __________ is the force of attraction that pulls objects toward each other because of their masses.

ii. __________ is the amount of matter an object has.

iii. __________ is the force of gravity that is acting on an object.

iv. The SI unit of mass is __________

v. The SI unit of weight is __________

C. Differentiate between these pairs.

i. Mass and weight

ii. Gravity and gravitation

iii. g and G

iv. Free fall and weightlessness

D. Explain the following:

i. Tides rise on the sea.

ii. G is called universal constant.

iii. The value of g is less at the top of mountain than its foot.

iv. A stone and feather fall together on the moon surface when dropped simultaneously.

v. The probability of getting hurt is more when jumped from a significant height.

vi. When coin and feathers are dropped from the roof of a building the coin reaches the ground earlier.

vii. Newtons law of gravitation is called a universal law.

viii. The weight of a body decreases with increases in distance from the earth's surface.

ix. A person does not get injured when he/she falls with a parachute on the earth from the aeroplane.

x. It is difficult to lift a large stone on the surface of the earth but its easy to lift a small one.

E) Answer the following questions :

i. What is gravity ? Give two factors that affect it.

ii. Write any four consequences of the gravitation.

iii. State Newton's Universal Law of Gravitation. Why is this law called universal law?

iv. Prove that $F = \frac{Gm_1m_2}{d^2}$.

v. What is universal law of gravitation? Write the value of gravitational constant with units.

vi. What is acceleration due to gravity ? On what factors does it depend?

vii. What is weightlessness of a body ? Write the conditions at which a body becomes weightless.

viii. What is free fall? What is the weight of a body during free fall?

ix. What is the main conclusion of coin and feather experiment?

x. How does a paratrooper land safely when jumped from an aeroplane?

xi. Where does a body have more weight: at the pole or at the equator of the earth ? Explain.

xii. What will happen to the gravitational force when the distance between the centre of the two bodies is halved?

xiii. In this formula $g = \frac{GM}{R^2}$, What do G,M and R stand for ? Prove that $g \propto \frac{1}{R^2}$.

xiv. What are the circumstances of weight to be zero?

xv. A person is an artificial satellite of the earth feels weightless. Why?

xvi. At what condition gravitation and universal gravitational constant are equal ? Prove it

xvii. State the significance of universal law of gravitation

xviii. The value of gravitational constant G on earth is $6.67\times10-11$ Nm^2/kg^2 . What is its value on the surface of moon?

xix. Two objects of masses m1 and m2 are dropped in vacuum from a height above the surface of earth (m1>m2). Which one will reach the ground first? Justify your answer.

xx. State the name and type of force which is responsible for holding the solar system together.

xxi. Which force is responsible for acceleration of a body in free fall?

xxii. Describe the effect of air resistance on a falling object and explore its application in everyday life.

E. Solve the following numerical problems

i. Calculate the gravitational force between two bodies of masses 50 kg and 80 kg. if the distance between their centers is 20 m. [Ans 6.67×10^{-10} N]

ii. Find the force with which the moon pulls every kilogram of water in Rapti river given that moon is 3×10^5 km away from it and its mass is 7×10^{22} kg. [Ans 51.8N]

iii. If an object at a distance 6.4×10^6 m from the centre of the earth weights 10 N . What will be its weight if it is shifted to 1.28×10^7 m far from the centre of the earth. [Ans . 2.5 N]

iv. The mass of the earth is 6×10^{24} kg and its radius is 6400 km. What is the mass of a man weighing 977 N in a spring balance? [Ans 100kg]

v. The radius of the earth is 6400 km, height of Mt. Everest is 8848 m. If the value of 'g' on the surface of the earth is 9.8 m/s^2, calculate the value of g at the top of Mt. Everest. And also find the weight of man having mass 80 kg at the top of Mt. Everest. [Ans 9.77 m/s^2, 781.6 N]

vi. A stone is dropped freely from 45 m height of the tower. It reaches on the ground in 3 second. Calculate acceleration due to gravity of the stone. [Ans 10m/s^2]

vii. The acceleration due to gravity at the surface of the moon is 1.6 m/s^2. If the radius of the moon is 1.7×10^6m. Calculate the mass of the moon.

viii. The mass of the sun and the earth are 2×10^{30}m and 6×10^{24}kg respectively. If the distance between their centre is 1.5×10^{11}m, find the gravitation force between them.

ix. A man can lift a mass of 200kg on the surface of the earth. What is the amount of mass he can lift on the surface of the moon?

xiii. The mass of the earth is 6×10^{24} kg and its radius is 6400km. What is the mass of the man weighing 977 N in a spring balance.

xiv. A meteor is falling towards the earth due to its gravity. Calculate the acceleration due to gravity of the meteor when it is at the height of 10^4 km from the centre of earth. The mass of earth is 6 x 10^{24} kg. [Ans 4.002m/s^2]

xv. A light weight stone is thrown vertically upwards from the ground and hits the ground after 6 s. Calculate the maximum height reached by the stone during this journey. (Ans.44.1m)

xvi. An object is thrown straight upwards with an An object is thrown straight upwards with an initial velocity of 8 m/s. How long does it take to reach the greatest height? [Ans.0.82 s]

xvii. An apple fruit falls freely from a tree at a An apple fruit falls freely from a tree at a height of 2.4 m. How long does it take to reach the ground? Disregard the air resistance and leave the answer correct to 2 significant figures. [Ans.0.70 s]

xvii. An object falls off from the edge of a blade of An object falls off from the edge of a blade of an off-shore wind turbine. If the tower is 50m, high find the velocity with which the object hits the surface of the water below it. [Ans.31.30m/s]

xviii. An object falls freely from a height through a distance of 5.0 m . Calculate the velocity attained by the object, taking g=10ms^{-2} [Ans. 10ms^{-1}]

xix. A fountain is designed such that water can be A foundation is designed such that water can be projected vertically upwards to a height of 5m. Determine the speed at which the water must be leaving the fountain nozzle . [Ans. 9.8]

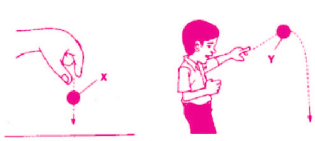
xx. A metallic ring is release from rest from thetop of a cliff 7.2 m high. Find the time it takes the ring to reach the ground. [Ans.1.2s]

xxi. A 500 g parcel is dropped from a height of 60m A 500 g parcel is dropped from a height of from a plane which is moving upwards with a velocity of 5.0 m/s. Determine:
1. the initial velocity of the parcel,
2. the time taken for the parcel to reach the ground? Disregard air resistance and take the value of g to be 10m/s. [Ans. 5,0m/s upward, 4.0 s]

xxii. A child , standing on the floor of balcony of a multi-storey building, throws a ball straight upwards with an initial velocity of 10m/s. If the floor is 25 m high from the ground, find:
1. the maximum height above the ground reached by the ball, and
2. the velocity with which the ball strikes the ground. [Ans. 30.1 m, 24.3 ms^{-1}]

G. Diagrammatic Questions :

i. Choose the correct words to complete the sentences



a. When ball X is released, it will _________ fall down/float in the air)
b. When ball Y is thrown, it _________ (fall down/float in the air)

c. Based on the observations on ball X and Y, all objects are pulled towards ________ (the centre of the moon/the centre of the earth) due to ________ (the gravitational pull on the the sun/the gravitational pull on the earth)

ii. The diagram below shows a face that occurs on Earth.

a. What is force P shown in the diagram above?

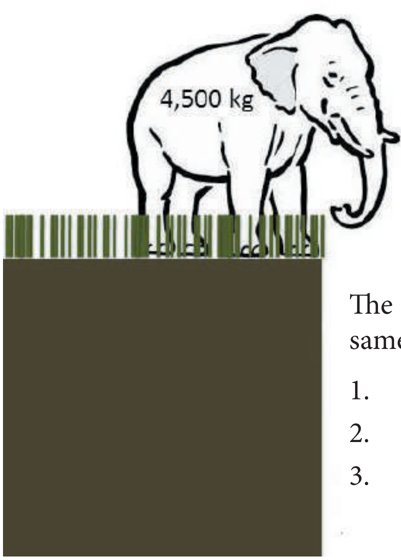
b. Explain the meaning of force mentioned in question (i)

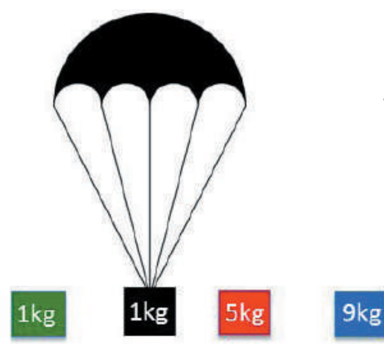
iii. Fill in the chart with the following sentences:

Only noticeable with very large masses	mass x gravity	It's a force	Stronger on the Earth
non-contact force	Measured in Newtons (N)	Measured in Kilograms (Kg)	The amount of matter of an object
The larger it is, the stronger the pull			

Mass	Weight	Gravity

iv. What think...





The four boxes above are dropped from an aeroplane, At the same time and height, an elephat runs off the cliff.

1. Which box (es) will hit the ground first? Explain.
2. Which box (es) will hit the ground last? Explain.
3. The elephant has a greater air resistance than the parachute. So why does the elephant hit the ground before the black box?

Chapter 8

Pressure

Total Estimated pariods (Th. 4+ Pr. 1=5)

Student's Learning Outcomes

After studying this unit, the students will be able to :

- state, and demonstrate Pascal's law in liquids and explore its applications in everyday life
- introduce the upthrust force produced by liquids and gases
- describe and demonstrate Archimedes' principle and explore the application of this principle in everyday life.

Blaise Pascal (1623-1662) was a French philosopher, mathematician, scientist, inventor, and theologian. In mathematics, he was an early pioneer in the fields of game theory and probability theory. In philosophy he was an early pioneer in existentialism. As a writer on theology and religion he was a defender of Christianity. Despite chronic ill health, Pascal made historic contributions to mathematics and to physical science, including both experimental and theoretical work on hydraulics, atmospheric pressure, and the existence and nature of the vacuum.

Introduction

It is painful to walk on gravel road with bare feet as our feet is based on small area of gravel and exerts more pressure on our feet. Likewise, it is easy to chop vegetables with a sharp knife than with blunt one as sharp knife occupies less area on vegetables and exert more pressure. The blood pressure in our body is greater at the feet than at the brain as feet lies at more depth from heart. Similarly, the water tank of a house is located at the highest possible level to have more water pressure in the taps. All these examples illustrate the application of pressure in our daily life. In this unit we will discuss on liquid pressure and other phenomenon related to it.

Thrust

When a body is kept on a surface, it exerts force on that surface. Hence, the total force acting perpendicular on a given surface is called thrust. It is vector quantity. Its SI unit Newton (N) and CGS unit is dyne.

Pressure

The pressure on a body is defined as the thrust acting per unit area of the body. In other words, the pressure on a body can be also defined as the force acting normally on unit area of the body. If a thrust (F) is acting over an area A, then the pressure P exerted is given by

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

It is scalar quantity.

Units of pressure:

SI unit of pressure is Nm^{-2} or pascal (Pa)
CGS unit of pressure is dyne cm^{-2}

Thrust (F)	Pressure (P)
i. The total force acting perpendicular on a given surface is called thrust.	i. Pressure is the thrust acting per unit area of the body.
ii. Its SI unit is newton (N).	ii. Its SI unit is pascal (Pa).
iii. It is vector quantity.	iii. It is scalar quantity.
iv. It is measured by spring balance.	iv. It is measured by barometer.

Liquid Pressure

The pressure exerted by liquid is called liquid pressure.

Let us consider a beaker of cross- sectional area 'A' contains liquid of density 'd' up to height 'h' as shown in the figure.

According to definition of pressure, pressure (P) is force (F) acting per unit area (A). So,

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

or, $$P = \frac{m \times g}{A} \quad [\therefore F = mg]$$

or, $$P = \frac{d \times v \times g}{A}$$

$$(\therefore d = \frac{m}{v} \text{ or, } m = dv)$$

or, $$P = \frac{d \times A \times h \times g}{A} \quad (\because V = A \times h)$$

$$\therefore P = dhg$$

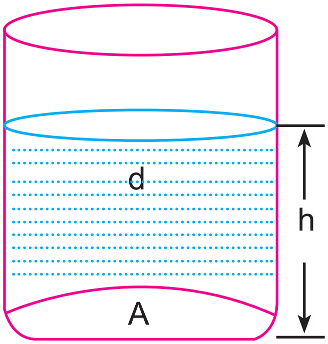


Fig. 8.1

The factors that affect the liquid pressure are density of liquid (d), height of liquid (h), and acceleration due to gravity (g).

The SI unit of pressure is Pascal (Pa) for a given liquid at a given place, the density of the liquid and acceleration due to gravity are constant. Hence pressure exerted by a liquid is directly proportional to the depth of the liquid from the free surface of the liquid. i.e. $p \propto h$.

Related Numerical Problem

1. **Calculate the pressure exerted by water at the bottom of container if the depth of water is 4m.**

Solution:

Height of water level (h) = 4m
Acceleration due to gravity (g) = 9.8 m/s^2
Density of water (d) = 1000 kg/m^2

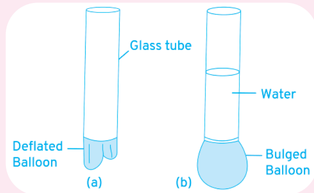
Pressure (p) = ?

We have,

P = hdg = 4 x 1000 x 9.8 = 39200 Pa. Ans

Activities 8.1

Take a balloon and tie it at the lower end of a glass tube and hold vertically as in figure (a). Pour some water in the tube, balloon bulges out as in fig (b) because the water column exerts pressure at its bottom.



Observation: Force on the balloon is equal to the weight of the water column which is called Thrust. Also, pressure exerted by the water P = Thrust/Area of bottom of the tube.

This shows that a liquid exerts pressure at the bottom of the container in which it is kept

8.1 Pascal's law in liquids

Pascal's principle is also called Pascal's law, in fluid (gas or liquid) mechanics, statement that, in a fluid at rest in a closed container, a pressure change in one part is transmitted without loss to every portion of the fluid and to the walls of the container. The principle was first enunciated by the French scientist Blaise Pascal.

Pressure is equal to the force divided by the area on which it acts. According to Pascal's principle, in a hydraulic system a pressure exerted on a piston produces an equal increase in pressure on another piston in the system. If the second piston has an area 10 times that of the first, the force on the second piston is 10 times greater, though the pressure is the same as that on the first piston. This effect is exemplified by the hydraulic press, based on Pascal's principle, which is used in such applications as hydraulic brakes.

Pascal also discovered that the pressure at a point in a fluid at rest is the same in all directions; the pressure would be the same on all planes passing through a specific point. This fact is also known as Pascal's principle, or Pascal's law.

Experimental Verification of Pascal's Law

Consider or spherical vessel fitted with four pistons W, X Y and Z with equal cross - sectional area. 'A' contains liquid if piston 'W' is pushed in with force 'F'. It gives pressure P = F/A. This pressure is transmitted through liquid equally and pushes out other three pistons with equal pressure. This experiment proves that liquid pressure is transmitted equally in all directions.

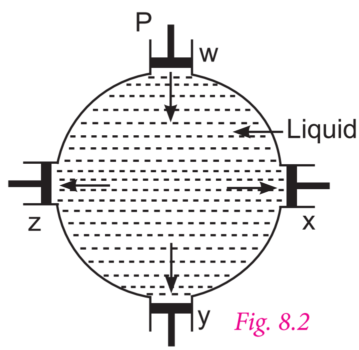


Fig. 8.2

Activities 8.2

Take a plastic bag (or a balloon) and poke small holes (carefully) in that. Fill the plastic bag or balloon with water and seal the big top opening. Slowly press the bag or balloon from the top and watch how water flows through each hole. Water should flow equally from all the pores because the pressure applied from the top is distributed equally to all the holes.

8.1.1 Applications of Pascal's Law in practical life

Above we read that, Pressure applied at any point of a liquid enclosed in a container is transmitted without loss to all other parts of the liquid. Pascal's law finds numerous examples in our daily life such as :

- automobiles
- hydraulic brake system
- hydraulic jack
- hydraulic press
- hydraulic machines.

Applications of pascal's law

The most important applications of Pascal's law are:

i. Hydraulic press.
ii. Hydraulic lift.
iii. Hydraulic brake
iv. Hydraulic jack

Hydraulic press

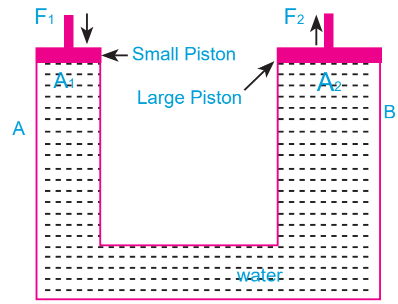


Fig. 8.3 hydraulic press

Hydraulic press is based on Pascal's law. It multiplies force applied and is used to lift heavy loads, automobiles, press cotton, goods and extract of juice of fruits and sugarcanes.

Here, two cylinders A and B are fitted with air tight pistons, one with very small cross sectional area A1 and other with large cross sectional area A2. A horizontal tube connects the two cylinders.

If a small force F1 is applied on small piston, the pressure exerted is given by.

$$P_1 = \frac{F_1}{A_1} \text{ .... i.}$$

This pressure is transmitted unchanged to bigger piston and exerts the pressure P2 it is given by.

$$P_2 = \frac{F_2}{A_2} \text{ .... ii.}$$

According to Pascal's Law,

pressure on small piston (P_1) = pressure on bigger piston (P_2).

$$\text{or,} \quad \frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$\therefore \quad \frac{A_2}{A_1} = \frac{F_2}{F_1}$$

then, $F_2 > F_1$

Hence, a small force can be used to lift heavy loads by using hydraulic machines. So, it is also called a force multipliers.

Related Numerical Problem

1. If pistons A, B and C of the apparatus by given in the diagram are supposed to be frictionless. What is the area of the piston B? What is the force exerted on piston C ?

Solution:

Cross - sectional area of piston A (A_a) = 20 cm² = 0.0020 m²
Force applied on piston A (F_a) = 250 N
Force produced on piston (F_b) = 375 N
Cross - section area of piston C (A_c) = 10 cm² = 0.0010 m²
Cross- sectional area of piston B (A_b) = ?
Force produced on piston C (F_c) = ?

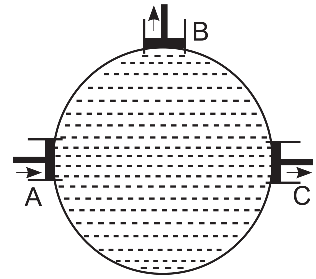


Fig. 8.4

According to formula

$$\frac{F_a}{A_a} = \frac{F_b}{A_b} = \frac{F_c}{A_c}$$

Taking first and second relation,

$$\frac{F_a}{A_a} = \frac{F_b}{A_b} \quad \text{or,} \quad \frac{250}{0.0020} = \frac{375}{A_b}$$

$$= \frac{0.0020 \times 375}{250}$$

$\therefore A_b = 0.003\text{m}^2$

Again taking first and third relations,

$$\frac{F_a}{A_a} = \frac{F_c}{A_c}$$

$$\frac{250}{0.0020} = \frac{F_c}{0.0010}$$

or, $$F_c = \frac{250 \times 0.0010}{0.0020}$$

$\therefore F_c = 125$ N

Hence, the cross- sectional are a of piston B (A_b) is 0.003m² and force produced on piston C (F_c) is 125 N.

Hydraulic lift

It is a machine which works on the principle of Pascal's law. It is used to lift vehicles in automobile servicing centers.

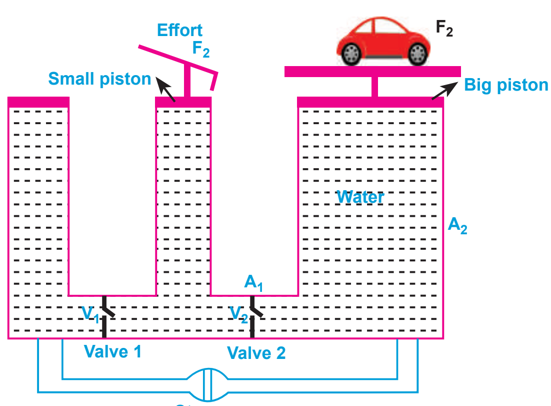


Fig. 8.5 hydraulic lift

Hydraulic lift consists of three metallic cylinders with different diameters. These three cylinders are connected by a pipe and filled with water as shown in figure. There are two valves in connecting pipes V_1 and V_2. The bigger piston has platform on which vehicle is kept to be lifted there is stopper between reservoir and cylinders.

When a small force is applied on small piston by using lever it closes valve V_1 and opens valve V_2. The pressure exerted on small piston is transmitted to bigger piston is magnified. The force is able to lift the vehicle. While opening stopper the vehicle can be brought in the initial level because water maintains its own level.

Hydraulic brake

A hydraulic brake is a braking system that is usually used in four wheels and other heavy automobiles.

Construction : It consists of tube 'T' containing oil called brake oil. One end of this tube is connected to the master cylinder 'C' fitted with a piston that is connected to the brake pedal, the other end of the tube is connected to a slave cylinder 'C' having two pistons connected to the brake shoes. The cylinder C_1 has average diameter than that of C the cylinder also brake oil in them.

Working : When the brake pedal is pressed, the piston in the master cylinder 'C' exerts pressure in the brake oil of the tube 'T'. This pressure is transmitted through the oil to the pistons in the slave cylinder 'C_1'. Being the diameter of 'C_1' larger than that of 'C', the force applied at the brake pedal is magnified. Such a large force in the pistons of C_1 pushes the brake shoes. When the brake shoes are pressed against the ring of a wheel, the brake is jammed on retarding the motion of the automobile.

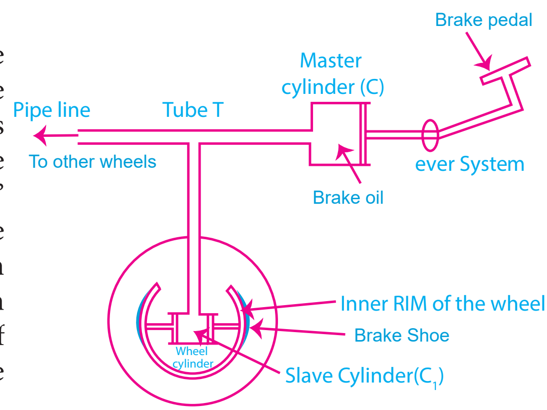


Fig. 8.6 hydraulic brake

Density and relative density of liquid

Density of a substance is defined as the mass per unit volume of that substance.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$\text{i.e.} \quad d = \frac{m}{v}$$

The SI unit of density is kg/m^3 and in CGS system it is measured in g/cm^3.

Relative density of a substance is the ratio of the density of a substance to the density of pure water at $4^\circ C$. It does not have any unit.

$$\text{Relative density} = \frac{\text{Density of the substance}}{\text{Density of water at } 4^\circ C}$$

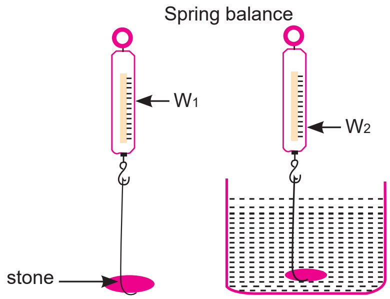
8.2 Upthrust

When a body is wholly or partially immersed in a liquid, the resultant upward force acted on it by the liquid is called upthrust.

When a body is immersed in water it looses some weight than in air. That is due to the upthrust and that decreased weight of object is equal to the upthrust due to liquid. Therefore, Upthrust due to water = wt. of object in air - wt. of object in liquid.

$= W_1 - W_2$

The density of a liquid directly affects the upthrust. As the density of liquid increases the upthrust of the liquid also increases.



Factors of Upthrust

Let us consider a cylinder of height 'h' with uniform cross-sectional area 'A' is in the liquid of density 'd' as shown in the figure. If h_1 and h_2 be the depth of upper and lower surface of cylinder immersed in liquid, then

Thrust on upper surface $(F_1) = P_1 \times A$

$= h_1 dg A$ .... i.

Thrust on lower surface $(F_2) = P_2 \times A$

$= h_2 dgA$ ....ii.

$\therefore$ Resultant thrust on the cylinder

$F_2 - F_1 = h_2 dg A - h_1 dgA$

or, $U = dgA(h_2 - h_1)$

or, $U = dgAh$ $(\because h_2 - h_1 = h)$

$\therefore U = Vdg$ $(\because v = A \times h)$

Hence, the upthrust (U) on a body immersed in a liquid depends on volume of the body v., density of liquid (d) and acceleration due to gravity (g).

$\therefore$ Up thrust (U) = Weight of liquid (w)

or, $U = Mg$

$\therefore U = vdg$ $(\because M = dv)$

$\therefore U = W$

8.3 Archimedes' principle

Archimedes (c.287 - c.212 BC) was a Greek mathematician, philosopher and inventor who wrote important works on geometry, arithmetic and mechanics. He was born in Syracuse on the eastern coast of Sicily and educated in Alexandria in Egypt. He then returned to Syracuse, where he spent most of the rest of his life, devoting his time to research and experimentation in many fields.

In mechanics he defined the principle of the lever and is credited with inventing the compound pulley and the hydraulic screw for raising water from a lower to higher level. He is most famous for discovering the law of hydrostatics, sometimes known as 'Archimedes' principle', stating that a body immersed in fluid loses weight equal to the weight of the amount of fluid it displaces. Archimedes is supposed to have made this discovery when stepping into his bath, causing him to exclaim 'Eureka!'

Archimedes a Greek scientist was the first person who did the experiment to measure the upthrust of a liquid. It states that "when a body is partially or wholly immersed in a liquid, it experiences an upthrust which is equal to the weight of liquid displaced by it." This principle is also applicable in gases.

∴ Upthrust = weight of liquid displaced.

Experimental Verification of Archimedes' Principle

To verify Archimedes' principle

i. Place a beaker under the about of an ureka can over a top pan balance. Fill the can with water till the spout.

ii. Measure the weight of a stone with the help of spring balance and let its weight be W_1.

iii. Gently lower the stone tied on thread into the water of ureka can. Stone displaces water and overflows through spout. The water is collected in a beaker and its weight is noted as W_2.

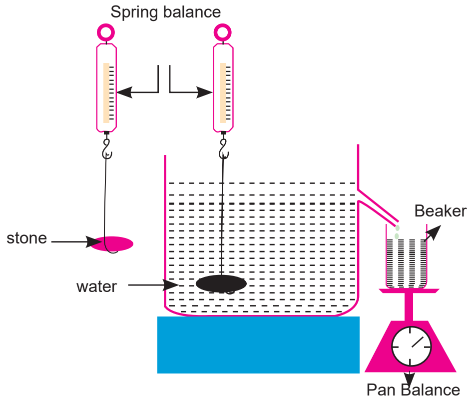


Fig. 8.7 eureka can

Here,

Weight of stone in air = W_1

Weight of stone in water = W_2

∴ Up thrust = W_1 - W_2 ....i.

Weight of beaker = W_3

Weight of beaker with displaced water = W_4

∴ Weight of displace water = W_4 - W_3 ....ii.

After calculation, the value of i. is equal to ii..

This verifies Archimedes' principle.

Law of Floatation

According to law of flotation, 'a body floats on a liquid if it can displace the liquid equal to its weight'.

Weight of the floating body = Weight of liquids displaced, in fact law of floatation is the special case of Archimedes principle.

When a body is allowed to immerse in a liquid, the following two forces act on it.

1. The weight of the body acting vertically downward and,
2. The upthrust on the body acting vertically upward depending on the magnitude of these forces. The following three cases may arise.

Case I

When the weight of the body is greater than the upthrust acting on it, the resultant force will be vertically downward. As a result the body gets sink in the liquid as shown in the figure (a).

In this case, weight of the body (W1)> weight of the liquid displaced (W_2).

or, $m_1g > m_2g$ [$\because w = m \times g$]

or, $m_1 > m_2$

$d_1v_1 > d_2v_2$ [$\because d = \frac{m}{v}$ or $m = d \times v$]

$d_1 > d_2$ [$\because v_1 = v_2$]

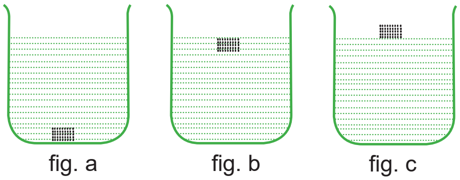


Fig. 8.8

Thus, a body sinks in a liquid only if the density of the body (d_1) is greater than the density of the liquid (d_1) in which the body is kept. Due to it, a piece of iron, being denser than water sinks completely in water.

Case II

When the weight of a body is just equal to the upthrust acting on it, the resultant force acting on it is zero. In this case, the body floats the liquid as shown in the figure (b).

or, $w_1 = w_2$

$\therefore$ or, $m_1 g = m_2 g$

$m_1 = m_2$

$m_1 = m_2$ [$\because w = mg$]

$d_1 v_1 = d_2 v_2$ [$d = \frac{m}{v}$ or $m = d \times v$]

Since, the volume of the body (v_1) is equal to the volume of displaced liquid (v_2) i.e. $v_1 = v_2$ is also equal to d_2

$\therefore d_1 = d_2$

Thus, a body just floats on a liquid when the density of the body (d_1) is equal to the density of the liquid (d_2) in which the body is kept.

Case III

When the weight of the body is less than the upthrust acting on it, the resultant force will be directed vertically upward. As a result, the body comes at rest its some part in air and some part in water as shown in the figure (c). In this case, the weight of the body will be equal to the weight of the liquid displaced by the immersed portion of a body. We have for floating bodies:

$\therefore$ Weight of the body (w_1) = Weight of the liquid displaced (w_2)

or, $m_1 g = m_2 g$, $m_1 = m_2$

or, $d_1 v_1 < d_2 v_2$ [$d = \frac{m}{v}$ or $M = d \times v$]

As the body is immersed partially, the volume of the body > the volume of the liquid displaced i.e. $v_1 > v_2$ and hence we have $d_1 < d_2$

Thus, a body floats keeping some parts of it out when its density (d_1) is less than that of the liquid (d_2).

Frm the above discussion, we conclude that a body sinks in a liquid if the density of a body is greater than that of the liquid. In this case, this weight of the liquid displaced is lesser than the weight of the body. If anyhow the body is given a proper shape so that the weight of the liquid displaced by the body is equal to the weight of the body, the body can be made to float on the liquid. A floating ship is its best example.

The principle of floating is, in fact, a special case of the Archimedes' principle.
The law of flotation states that "weight of a floating body is equal to the weight of the fluid displaced by the body"
or, weight of floating body (w_1) = wt. of the displaced fluid (w_2).

Activities 8.3

1

Take a plastic bottle. You can take a discarded water or soft drink bottle. Fix a cylindrical glass tube, a few cm long near its bottom as shown in Figure You can do so by slightly heating one end of the glass tube and then quickly inserting it near the bottom of the bottle. Make sure that the water does not leak from the joint. If there is any leakage, seal it with molten wax. Cover the mouth of the glass tube with a thin rubber sheet . Now fill the bottle upto half with water. What do you observe? Why does the rubber sheet fixed to the glass tube bulge ? Pour some more water in the bottle. Is there any change in the bulge of the rubber sheet?

2

Take an empty plastic bottle or a cylindrical container. You can take a used tin can or a used plastic bottle. Drill four holes all around near the bottom of the bottle. Make sure that the holes are at the same height from the bottom . Now fill the bottle with water. What do you observe? Do the different streams of water coming out of the holes fall at the same distance from the bottle? What does this indicate?

Verification of Law of Floatation

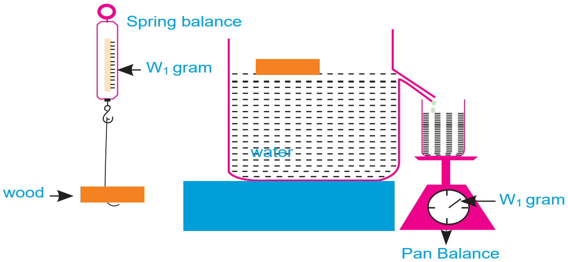


Fig.8.9 verification of law of floatation

Law of floatation can be verified experimentally with the help of a simple experiment.
Place a beaker under spout of eureka can over a top pan balance as shown in the figure. Pour water into eureka can up to spout level. Take a wooden block and weight it and let it be 'W_1'. Then, place the block in the ureka can. It displaces the liquid and overflows and is collected in a beaker. Note the weight of displace water in beaker as W_2.
Now it is found that,
Weight of wooden block = Weight of water displaced

$\therefore \quad W_1 = W_2$

Related Numerical Problems

1. **Find the mass of water displaced by a stone of mass 4 kg, when it is completely immersed in water. (Density of stone is 2 g / cm3)**

Solution :

Mass stone (m_1) = 4 kg
Density of stone (d_1) = 2 g/cm^3 = 2000 kg /m^3
Density of water (d_2) = 1000 kg/m^3
Mass of water displaced (m_2) = ?
Since stone is a sinking body,
Volume of stone (v_1) = Volume of water displaced (v_2)

$$\frac{m_1}{d_1} = \frac{m_2}{d_2}$$

or $\frac{4}{2000} = \frac{m_2}{1000}$

$m_2 = \frac{4 \text{ x } 1000}{2000}$

$\therefore \quad m_2 = 2$ kg

Hence, the mass of water displaced by stone is 2 kg.

2. **An ice cube of volume 0.03 m3 float on water. The density of ice and water are 900kg/m3 and 1000kg/m3 respectively. What fraction of the volume of the ice would be in air ? What would be the height of the ice cube in air if its total height is 0.2m?**

Here,

Volume of ice (v_1) = 0.3m^3 [Density of water (d_2) = 1000 kg/m^3

Density of ice (d_1) = 900kg/m^3

Height of the ice cube (h) = 0.2m

Fraction of ice in air (v_2/v_1) = ?

Height of ice cube above water = ?

We have for floating bodies :

$w_1 = w_2$ [According to law of flotation]

$m_1g = m_2g$ [W = mg]

$d_1v_1 = d_2v_2$ [$d = \frac{m}{v}$ or m = dv]

$\frac{d_1}{d_2} = \frac{v_2}{v_1}$

$\frac{900}{1000} = \frac{v_2}{v_1}$ [$\frac{v_2}{v_1}$ is the fraction inside water]

$\frac{v_2}{v_1} = \frac{9}{10}$

Again, for the fraction of ice in air.

$= 1 - \frac{9}{10} = \frac{10-9}{10} = \frac{1}{10}$

for the height of ice in air = $\frac{1}{10} \times 0.2 = 0.02$m

The fraction of ice cube in air is $\frac{1}{10}$ and 0.02m of the ice in air.

3. **Different weight of a piece of stone on weighing in three different media -air, water and salt solution are shown is the table given:**

Medium	Weight
A	15N
B	18N
C	16N

i. Which one is water and which one is the salt solution out of the three media A, B, & C ? Write with reasons.

ii. If the weight of 1 kg of mass is 10N, find out the mass of the piece of stone.

iii. Find out the mass of water displaced by the piece of stone.

Solution :

i. Since the density of water is higher than the density of air but less than the density of a salt solution. Water exert more up thrust on the body than air but it exerts less upthrust than the salt solution. So the apparent weight of the body is highest in air and least in the salt solution. From the given table, we conclude that C is water and medium A is salt solution.

ii. The weight of the stone in air is 18 N

Hence the mass of the stone (m) = $\frac{W}{g} = \frac{18}{10}$ = 1.8kg

iii. We know that,

Upthrust due to liquid = Weight of the liquid displaced

Loss in weight of the stone in the liquid = weight of the liquid displaced

Weight of the stone in air - weight of the stone in water = weight of the liquid displaced (w_2)

or 18 – 16 = mass of water displaced (m_2) × g

$m_2 = \frac{2}{10}$ = 0.2kg

Therefore, the mass of water displaced = 0.2 kg

4. The densities of some substances are given below. Answer these questions:

Substance	Density
A	18gm/cm^3
B	12gm/cm^3
C	0.9gm/cm^3

i. Which substance will have the least volume if the equal masses of all the three of them are taken? Why ?

ii. Which one will float in water? Write with reasons.

iii. Which substance will have the least mass. If the equal volume of all substance are taken? Why?

Solution :

i. Let 'm' is the mass taken, then

volume v. = $\frac{m}{d}$

Since, $d_A > d_B > d_c$, The volume of the substance $V_A < v_B < v_C$. Therefore, the substance A will have the least volume.

ii. The density of C is 0.9g/cm^3 while the density of water is 1gm/cm^3. Since the density of C is less than of that the water, substance 'C' will float on water.

iii. Consider V is the volume. Now, the mass of the substance (m) = V × d, since $d_A > d_B >$ dc, $M_A > M_B > M_C$. Therefore the substance C will have the least mass.

Activities 8.4

Take two beakers one with pure water and other with salt water. Put fresh egg in both liquids. In which liquid does the egg float and why?

Here, density of salty water is more than that of pure water. So, it has more upthrust and egg floats on it.

8.3.1 Applications of the Archimedes Principle

Archimedes' principle is used in designing of ships and submarines. They are to be made of a specific dimensions so that in spite of the large value of density of steel, the ship would float in water.Lactometers also work on Archimedes' principle as adulteration causes a change of density which can easily be identified using this device. Archimedes' principle provides the principle of working of a hydrometer, which is used to determine the density of fluids using water.

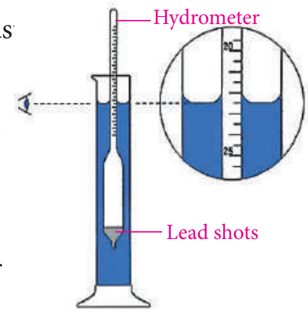


Fig. 8.10

Hydrometer : A Hydrometer is an instrument that is used to meas density of the liquids. It works on Archimedes' principle. It consists of a hollow glass tube with a bulb-shaped wider bottom, sealed from both ends. The wider bottom works as ballast tank, and it is usually filled with the lead, and the liquid whose density is being measured is poured in the narrow tube that has the graduations for the measurement. The hydrometer is placed in the sample liquid, and when it gets stabilized, readings are noted down. The level of hydrometer submerged in the liquid and the water displaced by it are measured to calculate the specific gravity of the liquid. If the hydrometer sinks deep in the sample liquid, it implies that the density of the liquid is less, i.e., the specific gravity of the sample liquid is less.

Lactometer : Lactometer is an instrument that is used to check the purity of the milk. Like hydrometer, it also works according to Archimedes' principle. Lactometers measure the specific gravity or density of the milk, which helps in finding the contents present in milk and determine its purity. Milk is kept undisturbed for a while until the cream deposits on it, and then the lactometer is placed in this milk sample, if the lactometer floats it means that milk is pure, but if the lactometer sinks, it means milk is adulterated or impure.


Fig. 8.11

Floating : Every object displaces the water of weight equal to its own weight. If the weight of the body is greater than the upthrust force acting upon it then the object sinks, whereas if the weight of the body is equal to the upthrust force acting upon it then the body floats on the liquid. Ice and icebergs float on the surface of the water because of the balanced upward buoyant force acting on them. So, the principle of floating is that the upthrust force acting on the body should be equal to the weight of the liquid displaced by the body.

Swimming : Archimedes' principle also comes into play when you are swimming. While we swim, the upward force, also called the buoyant force, acts on us. The swimmer is able to float on the surface of the water as the pressure above the swimmer is greater than the pressure from beneath as the density of the water is greater than that of the air. It is commonly seen that it is easier to swim in saltwater than freshwater because the buoyant force not only depends on the water displaced but also on the density of the fluid. As saltwater has a higher density than freshwater, the buoyant force acting on the body in saltwater will also be higher as compared to freshwater, which is why it is easier for the swimmers to swim in the saltwater.

Ships: Have you ever wondered that why an iron nail sinks in the water but large ships do not? Well, the reason behind that is Archimedes' principle. The iron nail sinks in the water because the weight of the water displaced by the nail is less than its own weight, i.e., the density of the iron nail is more than that of the water. While constructing ships, Archimedes' principle is followed, a large portion of the ships are kept hollow from inside that maintains their density less than the water density, hence the weight of the ship becomes less than the weight of the water displaced by it, and the buoyant force of magnitude equal to the displaced water exerts on the ship, and the ship floats on the surface of the water.

Submarines : Submarines also work on Archimedes' principle. Submarines can be submerged into the water and can also float on the surface of the water by maintaining the densities of the displaced water and submarine. These densities are maintained by the two important components present in the submarine that are the compressed tank and the ballast tank. If we fill the ballast tank with water, it results in a greater density of the submarine than the density of displaced water, hence the submarine dives into the water, whereas if this water is expelled out from the ballast tank with the help of the compressed tank, then the average density of the submarine becomes lesser than the density of the displaced water, and the submarine floats on the water surface.

Hot Air Balloon : Archimedes' principle is also applied to the working of hot air balloons. The balloon rises in the air when the weight of the air surrounding the balloon is greater than its own weight, whereas if the weight of the balloon is greater, it will start descending. When the weight of the surrounding air and hot air balloon is equal, it becomes stationary. The density between the air and the balloon is controlled by varying the amount of hot air in the balloon.

Fish : Archimedes' principle also comes into play to make a fish float in the water. Most of the fishes have a swim bladder, which helps them control the buoyant force acting on them. Fishes filled their swim bladder with air to rise to the water surface as it increases their volume, and more water is replaced by them, hence buoyant force exerted on them also increases. To dive into the water, fishes release the air from the swimbladder, hence their volume decreases, and buoyant force acting upon them also reduces.

Geology : Archimedes' principle finds its applications in geology too. The density of the solids can be measured using this principle. To measure the density of the substance, it is suspended to the spring balance, and when it is immersed in a liquid whose density is known to us, the apparent loss in the mass of the sample substance is noted down, and by using the Archimedes' principle, the density of the substance is then calculated.

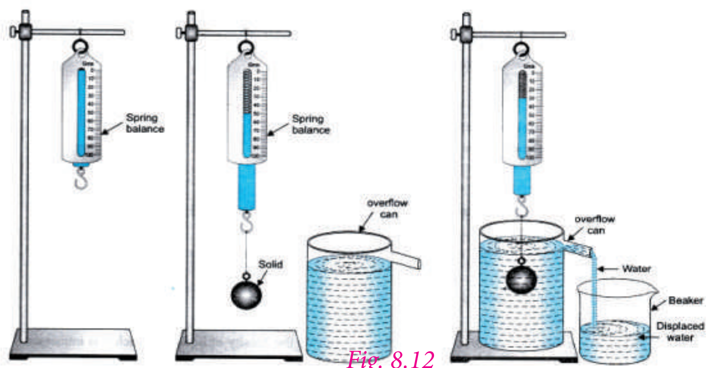
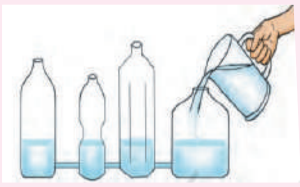


Fig. 8.12

Zero error in spring balance Weight of the solid in air Weight of the solid immersed in water

Activities 8.5

Take 4-5 plastic bottles of different shapes and sizes. Join them together with small pieces of glass or rubber tube as shown in Fig. Keep this arrangement on a level surface. Now pour water in any one of the bottles. Note whether the bottle in which water is poured gets filled first or all the bottles get filled up simultaneously. Note the level of water in all the bottles from time to time. Try to explain your observations.



Project Work

How can we check the purity of gold or other metals used in jewelry using Archimedes' principle? Discuss this topic with classmates, teachers and parents and prepare a report. Also prepare a list of areas where the Archimedes principle is used in daily life.

Exercise

A. Tick the correct answer.

i. What is the unit of pressure?

a. Newton b. Pascal c. m^2 d. Kg/m^2

ii. On which principle does hydraulic press depend on?

a. Law of floatation b. Atmosphere pressure
c. Pascal's Law d. Archimede's principle

iii. Which instrument is used to measure atmospheric pressure?

a. Hydrometer b. Thermometer c. Lactometer d. Barometer

iv. Why is liquid used in hydraulic brake?

a. It is in compressible b. It transmits pressure equally in all directions
c. It does not have fixed shape d. Both a and b

B. Differentiate between these pairs.

i. Density and relative density.
ii. Force and pressure.
iii. Archimedes principle and law of floatation.
iv. Hydrometer and Lectometer.

D. Give reasons to these statements.

i. Iron nail sinks in water while a ship made up of iron floats on it.
ii. It is easier to lift water bucket under water.
iii. Deep sea divers wear diving suit.
iv. A dam has thicker bottom surface than its upper surface.
v. A hole at the bottom of boat is more dangerous than that at the side.
vi. An egg floats on saturated solution of salt water.
vii. Write down any five applications of Pascal's law in daily life.
viii. Explain the upthrust force produced by liquids and gases.
ix. Write down any five applications of Archimedes' principle in daily life.

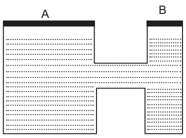
E. Answer the following questions.

i. State Pascal's law. Explain it in brief with example.
ii. State Archimedes' principle. Explain it with a diagram.
iii. What is liquid pressure? On which factors does it depend?
iv. State law of floatation. Explain with example.
v. What is upthrust? What factors affect it?
vi. On which principle is hydraulic jack constructed? Write its use.
vii. Name the instrument based on the following principles.

a. Pascal's Law b. Law of floatation

viii. Prove that

a. $P = hdg$ b. $U = vdg$



ix. In the given figure on which surface (A or B) more pressure is exerted and why?
x. What happens when cold water is poured over a tin can closed with lid containing boiled water?

E. Solve the following numerical problems.

i. If the depth of water in a rectangular tank is 5 m, find the pressure exerted by water at the bottom of the tank. (g= 9.8 m/s^2) [Ans 49000 Pa]

iii. An ice block of dimension 30 cm x 20 cm x 10 cm is placed in water. Calculate the part of ice above the water surface. The densities of water and ice are given 1 g / cm^3 And 0.9 g/ cm^3 respectively. [Ans: 1/10 part]

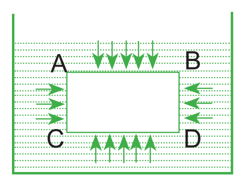
iii. Density of iron is 7600kg/m^3. What will be the mass of iron block with dimensions of 11cm × 15cm × 20cm? [Ans: m = 9.12kg]

iv. A cork has density of 200kg/m^3. What fraction of volume of the cork is submergd when the cork floats in water? Density of water is 1000kg/m3 [Ans: $\frac{1}{5}$ th]

v. An iceberg of 50 × m × 30cm × 20cm floats in water. The density of ice and water are 900kg/ m^3 mass of water displaced and also find out the portion of iceberg that remains above the water surface. [Ans: 27 kg, $\frac{1}{10}$]

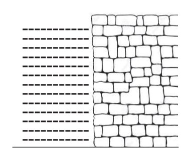
vi. How much water is displaced by brick of 1kg mass. When it is placed in water [density of brick = 2.5gm/cm^3]. [Ans : 0.4kg]

F. Diagrammatic questions



i. In the diagram, a body ABCD is placed in water. Study the diagram and answer the following questions.
 1. On what surface of the body will pressure be the maximum and why?
 2. On what level will up thrust be the maximum and why? Justify your answer.

ii. Answer the following questions on the basis of the diagram given below.

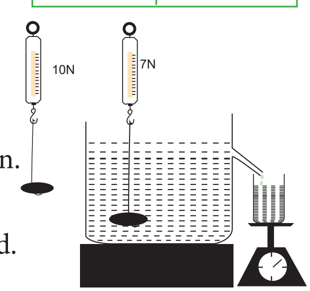


 1. Is there any difference between the upthrust of water at the middle and that at the bottom?
 2. Why is the wall made thick at the bottom?

iii. Densities of some of the substances are given in the table. Answer the following questions on the basis of them.

Substance	Density (g/cm^3)
x	11
y	8
z	0.9

 1. If equal mass of all are taken, which one will have the largest volume?
 2. If all have equal volume, which one will have least mass?
 3. Among the above substances, which one will float on water?



iv. In the diagram the weight of a stone in air and in water are shown. Study the diagram and answer the following questions.
 i. Find upthrust due to water and weight of the liquid displaced.

ii. Write the conclusion of the experiment.
iii. State the principle proved by the conclusion.

v. Different weights of a piece of stone on weighing in three different media air, water and salt solution are given below.

Media	Weight
A	30N
B	20N
C	25N

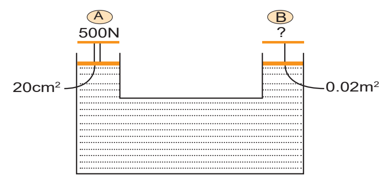
1. Among this three, identify air, water and salt solution?
2. Find out the mass of water displaced by stone.
3. If 1 kg of stone is equal to 10N, calculate the mass of stone in air. [Ans : 0.5kg, 3kg]

vi. Densities of some substances are given in the table answer the following questions on the basis of it.

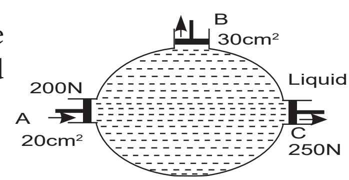
Substance	Density (g/cm^3)
X	11
Y	8
Z	0.9

1. If masses of all are taken equal, which one will have the largest volume?
2. If all have equal volume, which one will have largest mass?
3. Among the above substances which one floats on water?

vii. If the cross - sectional area of piston A and B are $20cm^2$ and $0.02\ m^2$ respectively. What load is necessary on piston B to balance 500 N load placed on piston A ? [Ans ; 5000 N]



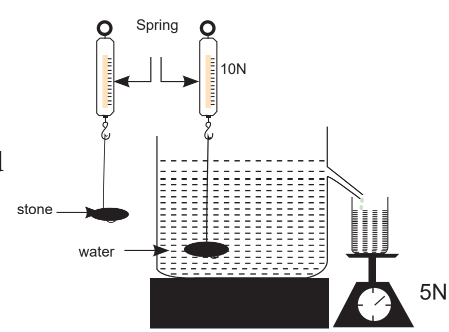
viii. Suppose the pistons A, B and C of the given apparatus are frictionless. What force is exerted on piston B ? Also find the cross - sectional are of piston C.
[Ans : 300 N, 25 cm^2]



v. Study the given diagram and answer the following questions.

a. What is the upthrust acting on stone?
b. What is the mass of stone in air?
c. What is the mass of water displaced?
d. On which principle is the experiment based on?

[Ans 5 N, 1.5 kg, 0.5 kg]



Chapter 9

Heat

Total Estimated pariods (Th. 8+ Pr. 2=10)

Student's Learning Outcomes

After studying this unit, the students will be able to :

- introduce thermal energy, temperature and heat
- explain the effect of heat on the volume of an object based on the motion of molecules and to explore the significance of the anomalous expansion of water in daily life
- introduce the specific heat capacity of matter and to solve related simple mathematical problems
- briefly explain the working principles of simple lab thermometers, digital thermometers, clinical thermometers, and radiation thermometers and to demonstrate by application the method of calibration of simple thermometers

Rudolf Clausius, in full Rudolf Julius Emanuel Clausius, (born January 2, 1822, Köslin, Prussia [Poland]—died August 24, 1888, Bonn, Germany), German mathematical physicist who formulated the second law of thermodynamics and is credited with making thermodynamics a science. Clausius was appointed professor of physics at the Artillery and Engineering School at Berlin in 1850, the same year in which he presented a paper stating the second law of thermodynamics in the well-known form: "Heat cannot of itself pass from a colder to a hotter body." He applied his results to an exhaustive development of the theory of the steam engine, stressing the concept of entropy (dissipation of available energy).

9.1 Introduction

We all have common-sense notions of heat and temperature. Temperature is a measure of 'hotness' of a body. A kettle with boiling water is hotter than a box containing ice. In physics, we need to define the notion of heat, thermal energy, temperature, etc., more carefully.

Thermal Energy

Thermal energy (also called heat energy) is produced when a rise in temperature causes atoms and molecules to move faster and collide with each other.The energy that comes from the temperature of the heated substance is called thermal energy.

Here are some everyday examples of thermal energy that you'll be familiar with:

The molecules and atoms that make up matter are moving all

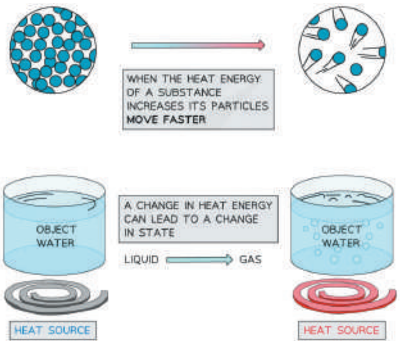


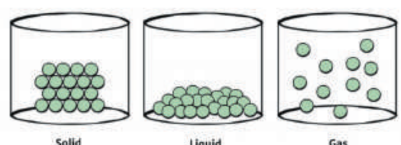
Fig. 9.1

the time. When a substance heats up, the rise in temperature makes these particles move faster and bump into each other. Thermal energy is the energy that comes from the heated up substance. The hotter the substance, the more its particles move, and the higher its thermal energy.

Let's think about that cup of hot chocolate- the hot chocolate has thermal energy from its vibrating particles. When you pour some cold milk into your hot chocolate, some of this energy is transferred from the chocolate to the particles in the milk. So what happens? Your hot chocolate cools down because it lost some of its thermal energy to the milk. The tea has thermal energy from its vibrating particles. When you pour some cold milk into your hot tea, some of this energy is transferred from the tea to the particles in the milk.

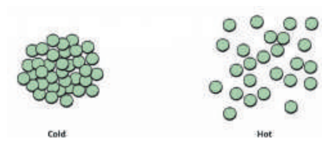
Fig. 9.2

States of Matter



Some matter changes from solid to liquid to gas as its particles heat, vibrate and separate.

Hot and cold Molecules

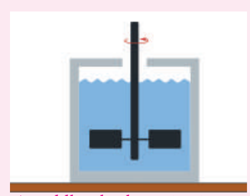


As cold particles heat, they contain more energy and so vibrate and separate.

Fig. 9.3

Activities 9.1

Suppose the paddle wheel depicted in adjoining figure is rotated by an electric motor which is rated at 10 W output power for 30 minutes. How much thermal energy is transferred to the water? (Hints:In this system, all the energy eventually is transferred to thermal energy of the water (assuming the heat capacity of the paddles is negligible). Therefore, we can use the definition of power to find the total thermal energy (E_T)= Power x Time)



A paddle wheel rotating in a water tank

Heat

Heat is a form of energy which gives sensation of warmth. Heat is the total kinetic energy of molecules of a body. Heat is an important source of energy. Heat flows from hotter body to colder body. We use heat for different purposes like cooking heating, running vehicles etc.

Every substance is made up of a large number of molecules. When heat is given to a substance the kinetic energy of the molecules increases and they move with greater velocity. Heat is the sum of kinetic energy of molecules of a body. Heat depends on number of molecules and average kinetic energy of molecules of the body.

The total amount of heat possessed by a body i.e. internal energy depends on :

a. The number of molecules of a body i.e. the mass of the body. It means larger the number of molecules higher is the value of internal energy of a body.
   i.e. amount of heat $\propto$ the mass of the body.
b. Average kinetic energy of the molecules (temperature of the body).

i.e. Amount of heat $\propto$ average kinetic energy of molecules.

$$\text{amount of heat} \propto \text{mass of the body} \times \text{temperature}$$

When a body is heated, the magnitude of the vibration of the molecules of the body increases. This consequently increases kinetic energy of the molecules and hence the internal energy of the body rises. When the body is allowed to cool, the magnitude of the vibration of the molecules begins to decrease and thus its internal decreases that is a hot body has more internal energy than another identical cold body. If two bodies, one hot and another cold, are kept in a thermal contact, the internal energy flows from the hotter body to the colder body. This energy in flow is called heat. The moment it ceases to flow, it can not to flow, it can be called heat. In short, heat is a form of energy that flows from a hot body to a cold when they are placed in a thermal contact. In other words, heat is the total kinetic energy of the molecules contained in a body.

Definition of Heat in terms of kinetic energy

According to molecular theory, matter is composed up of minute particles called molecules. These molecules or atoms are in random motion. The random motion of the atom or molecules is responsible for the kinetic energy of the body. If the kinetic energy of the atoms or molecules in a substance increases, it becomes warmer.

Hence, according to kinetic molecular theory, heat is defined as the total kinetic energy of the molecules contained in a body. For example, 2 litre of water at certain temperature has more heat energy than 100 ml of same water at the same temperature.

Units of Heat Energy

Heat is measured by using calorimeter. Its SI unit is joule (J). In CGS system, it is measured in calorie.

Here, 4. 2 J = 1 calorie

The amount of heat energy required to raise the temperature of 1 g of pure water by 1°C is called one calorie heat.

Sources of Heat

There are different types of sources of heat. The sun is the main source of energy. Burning of fuel like coal, wood, petrol, kerosene etc. produce heat. Electricity has heating effect. Friction also produces heat. So, all of them are sources of heat.

Heat is an important source of energy. We use heat for various purposes in our daily life.

Importance of Heat

1. Heat is used for cooking our food.
2. Heat is used for running different machineries in industries.
3. Heat is also used for running vehicles.
4. Heat causes wind.
5. Heat helps to form clouds from the surface water that helps to rain.
6. It is used to manufacture glass, cement, ceramics etc.

Temperature

The degree of hotness or coldness of a body is called its temperature. Temperature is the effect of heat. It is also defined as average kinetic energy of the molecules contained in a body.

Temperature is the thermal condition of a body which determines how heat transfers from one body to another body in thermal contact. Temperature of a body is measured by using thermometer.

Thermometer is a device which is used to measure the temperature of a body. The liquid used in thermometer is called thermometric liquid. Mercury and alcohol are used in the thermometer as thermometric liquid. A thermometer works on the basis of the principle that "when a body is heated, it expands and contracts on cooling."

Relation between Heat and Temperature

Let's take an example, suppose that we have a bucketful of Lukewarm water and a glowing matchstick which of them is hotter ? Certainly, the glowing matchstick may burn us because it has more average kinetic energy of the molecules (temperature). But when they are left to cool, the matchstick will cool faster because the number of vibrating molecules is less in it. Thus, it has less heat. If the glowing match stick and the bucket of water are kept in thermal contact, what will be the direction of the flow of heat ? It will be either from the matchstick to the bucket or from the bucket to the matchstick ? Discuss to find the possible answer.

Activities 9.2

Explore how hotter things have faster moving particles, while particles in colder things move slower.

Materials : i. 2 clear glasses or jars ii. Food coloring (two colors, ideally) iii. Water iv. Microwave or kettle

Procedures :–i.Fill one glass with cold water, chilled in the refrigerator or freezer.

ii. Fill the other glass with hot water. Heat in the microwave or a kettle, but be careful that it doesn't get too hot!

iii. Place the two glasses side by side.

iv. At the same time, add three drops of one color to the hot glass, and three drops of another color to the cold glass.

v. Do not stir! Watch the color as it moves and is distributed in each glass. What do you see?

You should notice the food coloring in the warm water spreading out faster than the food coloring in the cold water. If you didn't observe this, try making your cold water a little colder and your warm water a little warmer. Also make sure you add the food coloring to each glass at the same time.

Thermal Equilibrium

An important concept related to temperature is thermal equilibrium. Two objects are in thermal equilibrium if they are in close contact that allows either to gain energy from the other, but nevertheless, no net energy is transferred between them. Even when not in contact, they are in thermal equilibrium if, when they are placed in contact, no net energy is transferred between them. If two objects remain in contact for a long time, they typically come to equilibrium. In other words, two objects in thermal equilibrium do not exchange energy.

Experimentally, if object A is in equilibrium with object B, and object B is in equilibrium with object C, then (as you may have already guessed) object A is in equilibrium with object C. That statement of transitivity is called the zeroth law of thermodynamics. (The number "zeroth" was suggested by British physicist Ralph Fowler in the 1930s. The first, second, and third laws of thermodynamics were already named and numbered then. The zeroth law had seldom been stated, but it needs to be discussed before the others, so Fowler gave it a smaller number.) Consider the case where A is a thermometer. The zeroth law tells us that if A reads a certain temperature when in equilibrium with B, and it is then placed in contact with C, it will not exchange energy with C; therefore, its temperature reading will remain the same (Figure). In other words, *if two objects are in thermal equilibrium, they have the same temperature*.

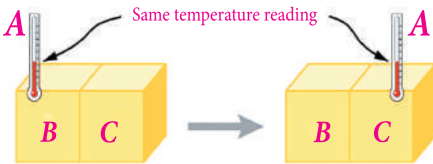


Fig. 9.4

If thermometer *A* is in thermal equilibrium with object *B*, and *B* is in thermal equilibrium with *C*, then *A* is in thermal equilibrium with *C*. Therefore, the reading on *A* stays the same when *A* is moved over to make contact with *C*.

A thermometer measures its own temperature. It is through the concepts of thermal equilibrium and the zeroth law of thermodynamics that we can say that a thermometer measures the temperature of *something else,* and to make sense of the statement that two objects are at the same temperature.

When two (or more) bodies are in contact with each other but no heat flows from one body to another, they are said to be in a state of thermal equilibrium. The movement of heat from a warmer object to a colder one – when two substances at different temperatures are mixed together, heat flows from the warmer body to the cooler body until they reach the same temperature (Zeroth Law of Thermodynamics – Thermal Equilibrium). Part of the heat lost by the warmer body is transferred the cooler body and part is lost to the surrounding object or the air.

Energy Simply stated, energy is the ability to do work or cause change. The energy of motion is called kinetic energy. Particles within matter are in constant motion. The amount of motion of these particles depends on the kinetic energy they possess. Particles with more kinetic energy move faster and farther apart. Particles with less energy move more slowly and stay closer together. The total kinetic energy of all the particles in a sample of matter is called thermal energy. Thermal energy, an extensive property, depends on the number of particles in a substance as well as the amount of energy each particle has. If either the number of particles or the amount of energy in each particle changes, the thermal energy of the sample changes. With identically sized samples, the warmer substance has the greater thermal energy. In Figure , the particles of hot water from the hot spring have more thermal energy than the particles of snow on the surrounding ground.


Fig. 9.5

Not all of the particles in a sample of matter have the same amount of energy. Some have more energy than others. The average kinetic energy of the individual particles is the temperature, an intensive property, of the substance. You can find an average by adding up a group of numbers and dividing the total by the number of items in the group. For example, the average of the numbers 2, 4, 8, and 10 is $(2+4+8+10)/4 = 6$. Temperature is different from thermal energy because thermal energy is a total and temperature is an average.

You know that the iced tea is colder than the hot tea, as shown in Figure . Stated differently, the temperature of iced tea is lower than the temperature of hot tea. You also could say that the average kinetic energy of the particles in the iced tea is less than the average kinetic energy of the particles in the hot tea.

Fig. 9.6

When a warm object is brought near a cooler object, thermal energy will be transferred from the warmer object to the cooler one. The movement of thermal energy from a substance at a higher temperature to one at a lower temperature is called heat. When a substance is heated, it gains thermal energy. Therefore, its particles move faster and its temperature rises. When a substance is cooled, it loses thermal energy, which causes its particles to move more slowly and its temperature to drop.

Activities 9.3

Water Temperature Experiment

Materials :

- Three Glass Jars
- Room Temperature Water
- Food Coloring
- Cold Water
- Hot Water

Instructions

1. Begin by preparing three jars of water. Fill one with cold water, one with room temperature water, and one with hot water.

   Helpful Tip: For cold water, fill the jar and put it in the fridge for an hour or two. For the room temperature water, fill the jar and leave it on the counter for an hour or two. For the hot water, boil the water on the stove or put it in the microwave for a minute or two.

   Before moving to the next step, take a moment to observe the jars. The temperature of water should be the only difference. Do you think the water temperature will impact what happens when the food coloring is added to each jar? Write down your hypothesis (prediction) and then continue the experiment to see if you were correct.
2. Place 2-3 drops of food coloring in each jar.
3. Observe what happens to the food coloring. Does it behave differently in each jar?

You'll notice right away that the food coloring behaves differently in each jar. Do you know why the food coloring slowly mixed with the cold water and quickly mixed with the hot water ?

When observing the food coloring in the water, you will immediately notice that it behaves differently based on the temperature of the water. When placed into water, food coloring will begin to mix with the water. The food coloring will mix the fastest in the hot water because the molecules are moving fast due to their increased thermal energy. These fast-moving molecules are pushing the molecules of food coloring around as they move, causing the food coloring to spread faster. The food coloring in the room temperature water will take longer to mix with the water because the molecules are moving more slowly due to their decreased thermal energy.

Lastly, the food coloring in the cold water will take a long time to mix with the water because the molecules are moving even slower due to a further decrease in thermal energy.

Difference between heat and temperature

Heat	Temperature
Heat is one form of energy. It is the thermal energy.	Temperature is not an energy. It is the thermal state of a physical body (or system).
Heat transfer is a reason behind temperature change.	Temperature variation can be the result of gain or loss of heat.
Heat is exchangeable. It can flow from one body to another.	Temperature is not exchangeable. Only heat can be exchanged.
Total amount of heat present in a particular body cannot be measured. It can be measured only during flow or exchange.	Temperature of a particular body can be measured. Moreover, temperature does not flow
Heat flow between two bodies do not rely on the amount of heat present in the bodies.	It is the temperature that decides whether or not heat flow will occur between two bodies.
Heat is not a fundamental property of matter.	Temperature is a fundamental property of the matter.
Heat is a path function.	Temperature is a point function.
Amount of heat transferred between two bodies can be measured by Calorimeter.	Temperature of a body can be measured by Thermometer.
Unit of measurement of heat is: Joule (J) in SI system or Calorie (Cal) in CGS system.	Unit of measurement of temperature is degree centigrade (°C) or Kelvin (K).
Its dimension is $[M L^2 T^{-2}]$.	Its dimension is $[\theta]$.
Heat is not a fundamental property of matter. It is one derived property, and its unit is also one derived unit.	Temperature is a fundamental property of the matter. Its unit (Kelvin, K) is also a fundamental unit (or base unit).
Heat (similar to work) is not a property of thermodynamic system. It is a flow property. Heat capacities and specific heat capacities are, however, properties of thermodynamic system.	Temperature is one property of thermodynamic system.

Anomalous expansion of water

Liquids expand on heating and contract on cooling at moderate temperatures. But water exhibits an anomalous behavior. It contracts on heating between 0˚C and 4˚C. The volume of the given amount of water decreases as it is cooled from room temperature, until it reach 4˚C . Below 4˚C the volume increases and so the density decreases. This means that the water has a maximum density at 4˚C . This behavior of water is called anomalous expansion of water.

Effect of anomalous expansion of water

In cold countries, the temperature of the atmosphere starts falling well below 0 °C in winter. When the temperature falls, the water on the surface of a pond or a lake, initially above 4 °C, begins to give heat energy to the atmosphere. So, the temperature of the water on the surface decreases, and it contracts.

If the water on the surface contracts, its density increases. Therefore, it sinks to the bottom. This process continues till the temperature of all the water in the pond or lake falls to 4 °C. Now, as the temperature of the water on the surface decreases below 4 °C, it starts expanding instead of contracting, and its density decreases. So the water does not sink, but remains on the surface.

When the temperature of the surrounding falls below 0 °C, the temperature of the water on the surface of the lake or pond also decreases to 0 °C, and it gets converted into ice. As ice is a bad conductor of heat, the ice on the surface does not allow heat to pass from the water to the atmosphere. Thus, the water below the layer of ice remains at 4 °C. As a result, fishes, other aquatic animals, and plants can survive.

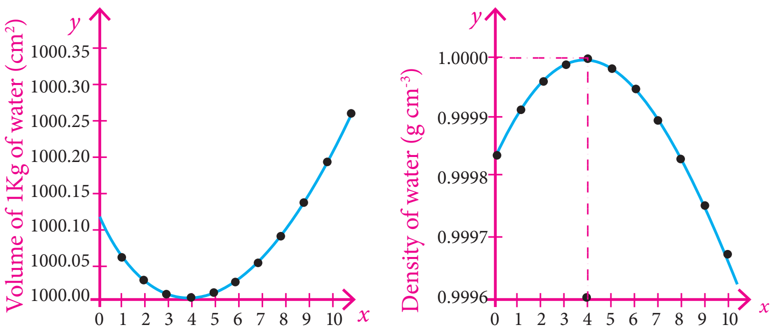


Fig. 9.7

In winter, water pipelines sometimes burst. This is because water starts expanding when its temperature falls below 4 °C. It exerts pressure on the pipe carrying it. The pressure is so huge that the pipe bursts. Sometimes, water enters the long narrow gaps or cracks in rocks.

When the temperature of the surrounding falls below 4 °C, the water starts to expand. As there is no place for the water to expand, it exerts a huge pressure on the rocks, and, as a result, the rocks break. Similarly, when the temperature of the atmosphere falls below 4 °C, the water in plant nerves or capillaries expands. Due to the expansion, the plant nerves or capillaries burst and cause the death of the plant.

The importance of the anomalous expansion of water

i. **Preservation of Aquatic Ecosystem:** Anomalous expansion of water is important for sustaining aquatic life in cold regions or during winter. During cold weather, the top layer of a water body cools first. The temperature of the top layer drops to 4°C. The top layer then becomes denser than other layers descends to the bottom of the water body. This process happens continuously to create a temperature gradient. The bottom most layer remains at 4°C. At this 4°C, aquatic life can thrive. The temperature gradually decreases as the depth decreases. The topmost layer is the coldest. Eventually, the top layer freezes, thereby forming an insulating blanket that prevents further freezing to some extent. This stops the heat from escaping the water body and helps aquatic life to survive. Hence, aquatic life can survive even when the temperature reaches or falls below. If there was no anomalous expansion, the waterworks have frozen altogether.

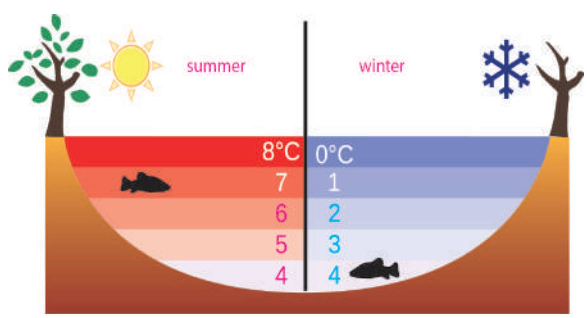


Fig. 9.8

ii. **Cost savings on rock crushing:** Water seeps into the cracks and crevices of rocks. During winter, when the temperature falls below 4°C, the water expands, resulting in hydrostatic pressure on the rock. This produces cracks on the rocks and helps in weathering the rock. We use rock in building physical structures. The huge rocks break down naturally, so the unnecessary expense of breaking them up can be avoided.

iii. **Help for the installation of the pipeline :** Some water pipelines start to leak when the temperature falls below 4°C. This is due to the pressure created by the anomalous expansion of water. In cold countries, water pipes expand due to the anomalous behavior of water, and hence the water exerts a large amount of force on the pipe wall, and it bursts. The anomalous expansion of water theory may be helpful to take precautions prior to installation as the pipeline .

iv. **Precauses for keeping soft drinking bottles in the freezer :** Soft drink bottles are kept in freezers. So, as the temperature drops below 4 degrees Celsius, the drink inside the bottle starts expanding. So, to prevent the molecules from exerting force on the wall and bursting, there is a little space left inside the bottle.

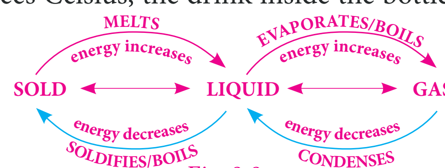


Fig. 9.9

Melting and boiling process of matters

The kinetic theory of matter can be used to explain how solids, liquids and gases are interchangeable as a result of increase or decrease in heat energy. When an object is heated the motion of the particles increases as the particles become more energetic. If it is cooled the motion of the particles decreases as they lose energy.

Melting

In a solid the strong attractions between the particles hold them tightly packed together. Even though they are vibrating this is not enough to disrupt the structure. When a solid is heated the particles gain energy and start to vibrate faster and faster. Initially the structure is gradually weakened which has the effect of expanding the solid. Further heating provides more energy until the particles start to break free of the structure. Although the particles are still loosely connected they are able to move around. At this point the solid is melting to form a liquid. The particles in the liquid are the same as in the solid but they have more energy. To melt a solid energy is required to overcome the attractions between the particles and allow them to pull them apart. The energy is provided when the solid is heated up. The temperature at which something melts is called its "melting point" or melting temperature. At room temperature a material is a solid, liquid or gas depending on its melting temperature. Anything with a melting temperature higher than about 20°C is likely to be a solid under normal conditions. Materials have widely differing melting temperatures e.g. mercury -39°C, ice 0°C, salt 801°C, aluminium 660°C and steel 1535°C. Everyday materials such as ice, butter and wax have different melting temperatures . Ice is probably the melting substance most children are familiar with. It can be problematic when trying to develop an understanding of melting as it does often appear to them to melt without any source of heat. Ice melts at room temperature because the surrounding air is warmer than the ice and at a temperature above the melting temperature. The heat energy required to

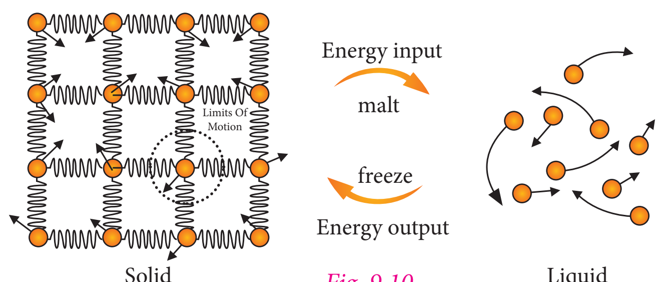


Fig. 9.10

melt the ice comes from the surrounding air which will consequently become a little cooler. Not all solids melt when they are heated. Some may undergo chemical changes as a result of heating. For example paper burns rather than melts.

Boiling

If a liquid is heated the particles are given more energy and move faster and faster expanding the liquid. The most energetic particles at the surface escape from the surface of the liquid as a vapour as it gets warmer. Liquids evaporate faster as they heat up and more particles have enough energy to break away. The particles need energy to overcome the attractions between them. As the liquid gets warmer more particles have sufficient energy to escape from the liquid. Eventually even particles in the middle of the liquid form bubbles of gas in the liquid. At this point the liquid is boiling and turning to gas. The particles in the gas are the same as they were in the liquid they just have more energy. At normal atmospheric pressure all materials have a specific temperature at which boiling occurs. This is called the "boiling point" or boiling temperature. As with the melting point the boiling point of materials vary widely e.g. nitrogen -210°C, alcohol 78°C, aluminium 2467°C. Any material with a boiling temperature below 20°C is likely to be a gas at room temperature. When liquids boil the particles must have sufficient energy to break away from the liquid and to diffuse through the surrounding air particles. As these particles cool down and lose energy they will condense and turn back to liquid. When steam is formed by water boiling at 100°C the particles quickly condense as the surrounding air temperature is likely to be much less that 100°C so the particles cool rapidly. In fact the "steam" coming out of a boiling kettle can only be seen because some of the gas particles have condensed to form small droplets of water. When a gas turns to a liquid (condenses) or a liquid turns to a solid (solidifies) the particles lose energy to the surroundings.

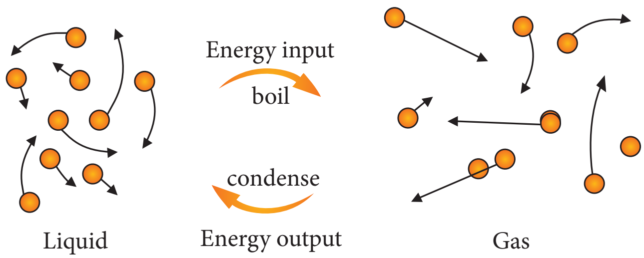


Fig. 9.11

Evaporating

Within a liquid some particles have more energy than other. These "more energetic particles" may have sufficient energy to escape from the surface of the liquid as gas or vapour. This process is called evaporation and the result of evaporation is commonly observed when puddles or clothes dry. Evaporation takes place at room temperature which is often well below the boiling point of the liquid. Evaporation happens from the surface of the liquid. As the temperature increases the rate of evaporation increases. Evaporation is also assisted by windy conditions which help to remove the vapour particles from the liquid so that more escape. Evaporation is a complex idea for children for a number of reasons. The process involves the apparent disappearance of a liquid which makes the process difficult for them to understand. It is not easy to see the water particles in the air. Also, evaporation occurs in a number of quite differing situations - such as from a puddle or bowl of water where the amount of liquid obviously changes, to situations where the liquid is less obvious - such as clothes drying or even those where there is no obvious liquid at all to start with - such as bread drying out. A further complication is that evaporation may be of a solvent from a solution e.g. water evaporating from salt water to leave salt. These situations are quite different yet all involve evaporation. Evaporation may also involve liquids other than water e.g. perfume, petrol, air fresheners. The particle model can be used to explain how it is possible to detect smells some distance away from the source.

9.2 Heat and volume of objects

Three cups of the same size are filled with the same mass of fresh water. One cup is put in a bucket of ice water so the water becomes cold, but does not freeze. One cup is heated so the water becomes hot, but does not boil. One cup is left at room temperature. At the macroscopic level, what someone can see with just their eyes, there appears to be very little difference in the volume of water between the three cups. However, at the molecular level, there is a difference in volume.

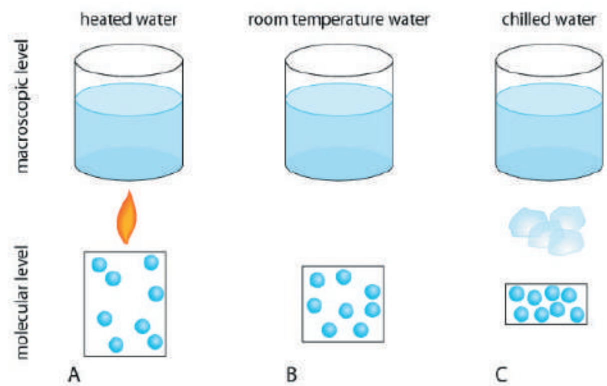


Fig. 9.12

In Figure, the blue circles represent molecules of water. The cup in Fig. A was heated. An increase in temperature caused the water molecules to gain energy and move more rapidly, which resulted in water molecules that are farther apart and an increase in water volume. The cup in Fig. B was kept at room temperature and remained at the same volume. The cup in Fig. C was chilled over ice. A decrease in temperature caused the water molecules to lose energy and slow down, which results in water molecules that are closer together and a decrease in water volume.

When water is heated, it expands, or increases in volume. When water increases in volume, it becomes less dense. As water cools, it contracts and decreases in volume. When water decreases in volume, it becomes more dense. For samples of water that have the same mass, warmer water is less dense and colder water is more dense.

Test this out yourself! Fill up three identical cups of water to the same level. Put one cup in the refrigerator to cool, heat one cup in the microwave, and leave one cup at room temperature. Look carefully to see if you can observe a difference in the volume of water.

Effect of heat on volume

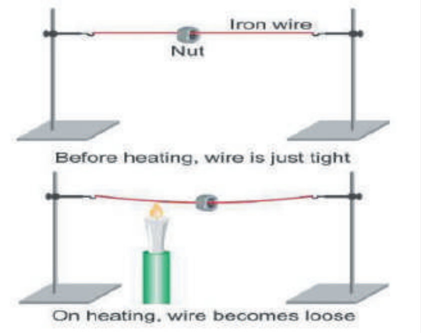
The expansion of a substance on heating is called the thermal expansion of that substance. The increase in length is called linear expansion, the increase in area is called superficial expansion and the increase in volume is called **cubical expansion**. Liquids and gases do not have definite shape, so they only have superficial and cubical expansion. When the substance is heated, the average kinetic energy of the molecules increases and they start moving faster. This increases the mean separation between the molecules, and hence, there is expansion in length, area or **volume** of the substance. On cooling, the average kinetic energy decreases, and hence, the mean separation also decreases. Thus, the substance contracts.

Activities 9.4

Material :

wire, candle, nut, stand

Procedures:



i. Insert the nut into the iron wire and hang it on the stand as shown in the picture.

ii. light a candle and heat the iron wire for a while. What happens when the wire is heated ?

Write your observations, explanations and conclusions based on the definition of thermal energy or heat :–

Observations	Exlanations			Conclusions
	Kinetic energy of a molecule in iron wire	Attraction between the molecules in iron wire	Distance between the molecules in iron wire	
When the iron wire is heated	....	....	....	....
....	....	....	....	....

When the wire is heated by a candle, it becomes loose and the nut dangles. This indicates that the length of the wire increases on heating. When the wire is allowed to cool, it becomes tight again after some time. This indicates that the length of the wire decreases on cooling.

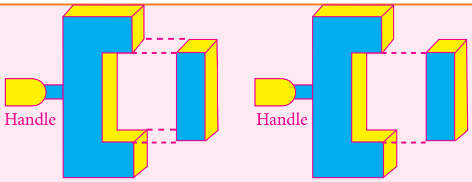
Activities 9.5

Material :

Bar, gauge, bunsen burner, strong tongs

Procedures:

i. Insert the bar into the gauge before heating. ? Observe what will happen.



Before heating the bar (at room temperature)

After heating the bar

ii. After heating, insert the bar in the gauge and look. Observe what will happen.

Write your observations, explanations and conclusions based on the definition of thermal energy or heat :–

Observations	Exlanations			Conclusions
	Kinetic energy of a molecule in iron bar	Attraction between the molecules in iron bar	Distance between the molecules in iron bar	
When the iron wire is heated	....	....	....	....
....	....	....	....	....

When the bar is heated, it expands and does not fit into the gauge. This indicates that the area of the bar has expanded on heating. When the bar is allowed to cool, it fits inside the gauge again. This indicates that the area of the bar contracted on cooling.

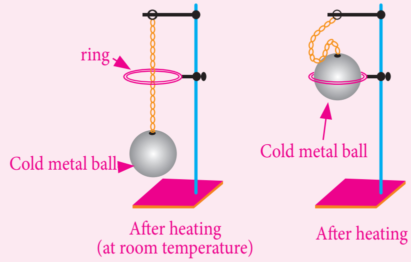
Activities 9.6

Material :

Metal ring, metal ball, bunsen burner, stand

Procedures:

Take a metal ring and metal ball of such size that the ball just passes through the ring. Heat the ball and check whether it passes through the ring. Now let the ball cool down, and check whether it passes through the ring. Observe what will happen .



Write your observations, explanations and conclusions based on the definition of thermal energy or heat

Observations	Exlanations			Conclusions
	Kinetic energy of a molecule in iron ball	Attraction between the molecules in iron ball	Distance between the molecules in iron ball	
When the iron wire is heated	....	....	....	....
....	....	....	....	....

When the wire is heated by a candle, it becomes loose and the nut dangles. This indicates that the length of the wire increases on heating. When the wire is allowed to cool, it becomes tight again after some time. This indicates that the length of the wire decreases on cooling.

A metal ball and ring, each made of the same material, are made in such a way that at the same temperature, the *inside* diameter of the ring is just slightly larger than the diameter of the ball so that the ball will barely pass through. If the ball is heated, it will expand and not be able to be passed through the ring. If the ring and ball are both heated to the same temperature, the ball will pass through once again. The demo deals with the intuitive notion that the 'hole' in the ring will get smaller as the ring is heated.

Pass the ball through the ring while each is at room temperature. The ball may 'stick' slightly as it passes through, but this reinforces the fact that it is a tight fit. Next, place the ball in the flame of the burner and allow it to get very hot. Then try to pass it through the ring. It will not go through.

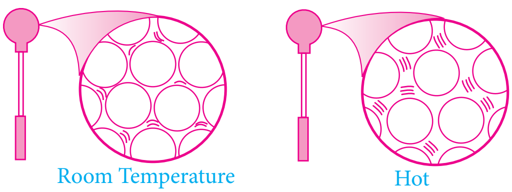


Fig. 9.13

In a solid, the atoms are very attracted to one another. The atoms vibrate but stay in fixed positions because of their strong attractions for one another. Heating a solid increases the motion of the atoms. An increase in the motion of the atoms competes with the attraction between atoms and causes them to move a little further apart. Cooling a solid decreases the motion of the atoms. A decrease in the motion of the atoms allows the attractions between atoms to bring them a little close together.

When thermal energy is added to an object through heat transmission, the average kinetic energy of its molecules increases, i.e. the temperature increases. Molecules collide with each other. The distance between the molecules of an object increases. The volume of the object increases overall. On the contrary, when the thermal energy of an object goes out, the average kinetic energy of the molecules decreases, the temperature decreases and the object shrinks. Thus, the volume of most substances increases with increasing temperature and shrinks as the temperature decreases.

9.3 Specific Heat Capacity

When different substances having equal masses are given equal amount of heat, there will be different rise in temperature. This is because of their different specific heat capacity. On supplying equal amount of heat the rise in temperature will be more in the substance having low specific heat capacity whereas the rise in temperature will be less in the substance having high specific heat capacity.

The substance having high specific heat capacity gets heated slowly and also cools down slowly. The substance having low specific heat capacity gets heated quickly and also cools down quickly.

The specific heat capacity of a body is defined as the amount of heat required to raise the temperature of 1 Kg mass by 1°C (1 K). SI unit of specific heat capacity is J/ Kg°C. Water has highest specific heat capacity among the known substances. Specific heat capacity of water is 4200 J/Kg°C. It means 4200 J heat is required to raise the temperature of 1 Kg mass of water by 1°C. Due to high specific heat capacity water is used for cooling as well as heating purposes.

Specific Heat Capacity of some Substances

S. N	Substance	Specific heat capacity (J/kg °C)
1.	Gold	130
2.	Mercury	140
3.	Brass	380
4.	Copper	390
5.	Iron	470
6.	Sand	800

S. N	Substance	Specific heat capacity (J/kg °C)
7.	Aluminium	900
8.	Petrol	1670
9.	Ice	2100
10.	Kerosene	2200
11.	Alcohol	2400
12.	Water	4200

Some Effects of Specific Heat Capacity

1. Water is used to cool the engines of vehicles. Water has very high specific heat capacity (4200J/kg°C) compared with other liquids. Thus, it can absorb a large amount of heat from the hot engines without any notable rise in the temperature of water. It, thus, prevents the engines from getting excessive hot.
2. The specific heat capacity of water is very high when water is cooled by the same range of temperature. Thus it gives the same amount of heat as it has absorbed. Hence, a large amount of heat may be available by cooling hot water. That's why, water is suitable for heating system.
3. The night in a desert is very cold while the day is very hot. It is because the specific heat capacity of sand is less, so its temperature changes fast. During days, the sand gets heated which results in a very hot day. At night, the sand gets cooled which causes very cold night.
4. Sea breeze occurs at day and land breeze at night. It is because water has maximum specific heat capacity and sand has less specific heat capacity. Due to it at day the sand of land is heated

faster than the water and the air above it becomes less dense by its expansion. Thus the air above the sea being denser blows towards the land and the sea breeze occurs. But at night, the sea water cools slowly but the sand cools faster. Now, the air above the seawater becomes less dense and the air above the land is denser. Thus, the air over the land moves towards the sea and they occur land breeze.

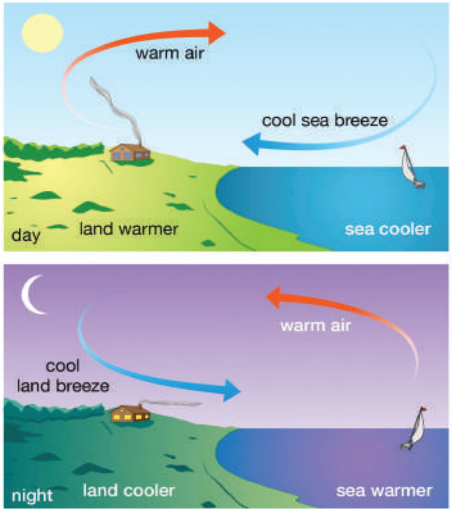


Fig. 9.14

Uses of specific heat in our daily life are given below:

1. Utensils for making tea or coffee, or cooking vegetables or rice, are made of low-specific heat materials. They have a polished bottom. As a result, they heat up faster. For example, copper, aluminum, and so on.
2. High specific heat materials can be used as insulators. Wood, for example, has high specific heat. During the summer, wooden houses will keep the inside cooler. Builders can select appropriate building materials based on location and altitude. This enables the construction of warmer or cooler houses.
3. Utensil handles at home are made of materials with high specific heat. They provide thermal insulation. Specific heat also influences insulating capability and conductivity.
4. Those substances which have very small specific heat capacity, are generally used in cooking the food items because on very small amounts of heat they easily get heated and cooking starts earlier, common examples are pots, kettle, fry pan and many kitchen utensils.
5. Kettle handlers and frying pan handlers are generally made of materials having very high specific heat capacity because even after too much heating their temperature will rise very minutely which prevents us from getting burned while holding such items.
6. Water is used in firefighting because it has a very high specific heat capacity and it can absorb large amounts of heat without increase in noticeable temperature.
7. Water is used to cool the engine of a bus or truck because the specific heat capacity of water is higher.

Heat Equations

When a body is heated it absorbs heat and its temperature rises. But when hot body is cooled, heat and its temperature falls down.

i. Heat lost or gained (Q) by a body is directly proportional to mass of the body (m),

i.e. $Q \propto m$ ....i.

ii. Heat lost or gained (Q) by a body is directly proportional to temperature difference,

i.e. $t_2 - t_1$

$Q \propto t_2 - t_1$ ....ii.

Here, t_2 final temperature of the substance

t_1 initial temperature of the substance

Combining equation i. and ii. we get

$Q \propto m(t_2 - t_1)$

or $Q = ms(t_2 - t_1)$ (where s is the proportionality constant called specific heat capacity of particular substance)

Let, $(t_2 - t_1) = dt$ be the change in temperature.

$\therefore$ Q = msdt

This equation is called heat equation. It states that "heat lost or gained by a body (Q) is equal to the product of mass of body (m), specific heat capacity (s) and change in temperature (dt)".

Solved Numerical Problems

i. **How much heat energy is required to raise the temperature of 500 g of water from 15°C to 60°C? (SHC of water is 4200 J/kg°C)**

Solution,

Mass of water (m) = 500g = $\frac{500}{1000}$ = 0.5 kg

Initial temperature $(t_1) = 15^\circ C$

final temperature $(t_2) = 60^\circ C$

$\therefore$ Difference in temperature (dt) = $t_2 - t_1 = 60 - 15 = 45^\circ C$

Specific heat capacity of water (s) = 4200 J/kg°C

Quantity of heat (Q) = ?

We know,

$Q = m \times s \times dt$

$= 0.5kg \times 4200\ J/kg^\circ C \times 45^\circ C$

= 94500 J

Hence, 94500 J heat energy is required.

ii. Calculate the final temperature of an iron ball having mass 6 kg at 12°C when 15.5 KJ heat energy is supplied to it. (Specific heat capacity of iron is 470J/kg°C

Solution,

Mass of iron (M) = 6 kg

Quantity of heat (Q) = 15.5 KJ

= 15500 J

Specific heat capacity of iron (s) = 470 J/kg °c

Initial temperature $(t_1) = 12^0$ C

Final temperature (t_2) = ?

We have,

Q = msdt

or, $Q = m.s(t_2 - t_1)$

or, $15500 = 6 \times 470 (t_2 - 12)$

or, $15500 = 2820 (t_2 - 12)$

or, $\dfrac{15500}{2820} = (t_2 - 12)$

or, $5.5 + 12 = t_2$

$\therefore \quad t_2 = 17.5^\circ C$

Hence, the final temperature of iron ball is 17.5°C.

9.4 Thermometer

A thermometer is a tool that measures temperature- how hot or cold something is. Thermometers are used to see if you have a fever or tell you how cold it is outside.

Made up of 'thermo' (heat) and 'meter' (measuring device), the meaning of the word thermometer is pretty straightforward. Thermometers measure temperatures in degrees, according to either the Celsius or Fahrenheit system. Meteorologists use thermometers to find out how hot it is or if it's below freezing. Doctors use thermometers to check your body temperature — a very high or low body temperature means you're sick.

Liquid used thermometer

Liquid thermometers were once the most common type in use. They were simple, inexpensive, long-lasting, and able to measure a wide temperature span. The liquid was almost always mercury or coloured alcohol, sealed in a glass tube with a gas like nitrogen or argon making up the rest of the volume of the tube.

Liquid thermometer is a glass capillary tube with a liquid-filled bulb at one end. As the temperature of the liquid in the reservoir increases, it expands and rises into the capillary tube. The level of the liquid in the column corresponds to a specific temperature, which is marked on the outside of the glass. The liquid that is contained within the thermometer may be one of many different substances, but the most common are mercury, toluene (or a similar organic substance), and low-hazard biodegradable liquids.

Everyone is familiar with 'liquid used thermometer' . It is also called 'liquid-in-glass thermometers (LIGTs). The first known thermometers were of the LIGT type. Although they are decidedly 'low tech' devices, LIGTs of extremely high accuracy and precision can be constructed today. The concept behind LIGTs is very straightforward: a liquid in a narrow sealed glass tube expands and contracts with temperature, and temperature is read by a scale alongside the tube. For a number of important reasons, the liquid is typically mercury, although alcohol and other organic liquids can also be used. Several criteria for the liquid must be met to make a good thermometer:

- Remains a liquid over a wide temperature range
- Has a low vapor pressure
- Has a linear expansion vs. temperature response
- Does not wet the glass
- Has a large expansion coefficient for sensitivity

Mercury is superior to organic liquids in all the above criteria except the last. However, mercury freezes at –38.9 °C;

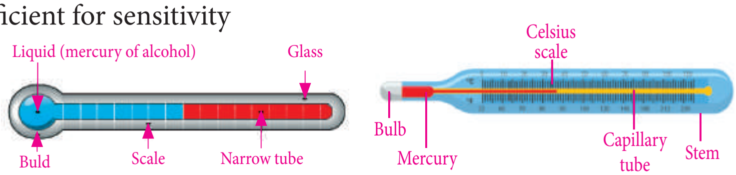


Fig. 9.15

to measure temperatures below this, organic liquids must be used. Unfortunately, mercury is a potent neurotoxin, so a broken mercury thermometer is an environmental hazard.

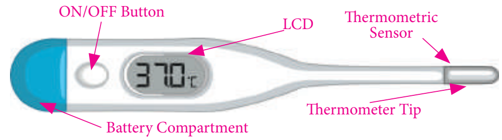


Fig. 9.16

Mercury based thermometer is also called clinical thermometer .It used to measure the human body temperature .The stem of such type of thermometer is calibrated with scales (35^0C to 42^0C or 94^0F to 108^0F.) Alcohol is used in laboratory thermometers.

Alcohol Thermometers	Mercury Thermometers
Alcohol Thermometer is a type of thermometer that uses a bulb filled with alcohol as the temperature sensor.	Mercury thermometer is a type of thermometer that uses a bulb filled with mercury as the temperature sensor.
Liquid inside the bulb can be pure alcohol, toluene, kerosene etc.	Liquid inside the bulb in mercury
Less toxic	Highly toxic
Suitable for mesurement of low temperatures	Suitable for measurement of high temperatures
Used to measure temperatures from -115^0C to 78.5^0C	Used to measure temperatures from -37 to 356^0C
Less durable because alcohol evaporates quickly	Highly durable because Mercury does not evaporate casily
Wall gets wet	Wall does not get wet
Alcohol is dyed since it is colorless	Mercury does not have to be dyed

Digital thermometer

Digital Thermometers are slowly replacing the conventional mercury thermometer due to the ease of taking reading. People often have the misconception that it contains mercury. Digital Thermometers are mercury free. These thermometers contain **thermistor** inside the tip which is used to measure the temperature. They provide quick and highly accurate results over the body temperature range.

These thermometers are easy to read with LCD display on them. They are equipped with beep alarm & memory function and can record a wide range of temperature. Doctor's thermometer which are mostly used can read temperature between 94^oF and 105^oF (35^oC and 42^oC). It is three in one thermometer as it can record oral, auxiliary and rectal temperatures.

Cap is found at the top of the thermometer, since this part is held away from the body. It is of bright colour and made up of smooth, hard plastic. The main function of this cap is to protect the battery from the outer environmental conditions.

The tip is said as the heart of the thermometer. It is the placed closed to the body part to measure the temperature of the body. The tip of the Thermometer contains thermistor to measure temperature. It is a ceramic semiconductor which is bonded in the tip with temperature sensitive epoxy. It is covered with a cap so to prevent it from the outer world. The cap may be made up of metal or stainless steel. Thermistor is responsible for converting the physical temperature into electrical signals.Thermistor is a special kind of semiconductor in which the value of resistance changes with the change in temperature. Due to change in resistance value, the output voltage changes and the temperature change is detected.

Radiation thermometer

Infrared (IR) thermometers are a subset of devices known as 'thermal radiation thermometers'. IR thermometers, also known as pyrometers or radiation thermometers, are non contact thermometers, which measure the temperature of a body based on its emitted thermal radiation.

IR thermometers measure temperature from a distance.

It collects radiant infrared energy emitted from an object. The detector converts the energy signal to a temperature reading. Most IR thermometers respond within 0.5 seconds and have 100 feet (30.5 m) maximum measuring distance, depending on the environmental conditions. The ability of an object to release or absorb energy is called emissivity. IR thermometers are affected by emissivity, which is complicated by shiny surfaces. Most IR units can be adjusted for emissivity by comparing the IR thermometer surface temperature of an object to a reference thermometer temperature reading of the same surface. The IR thermometer can then be adjusted to the reference temperature.

Fig. 9.17

IR thermometers are often used in circumstances when other sorts of thermometers are not practical. If an object is very fragile or dangerous to be near, for example, an IR thermometer is a good way to get a temperature from a safe distance.

Working Principle of Infrared Thermometers

Infrared thermometers work based on black body radiation, according to which any material with a temperature above absolute zero has molecules moving within it. The higher the temperature, the faster the molecules move. The molecules emit infrared radiation as they move, and emit more radiation, including visible light, as they get hotter. This is why a heated metal emits a red or white glow. Infrared thermometers detect and measure this radiation.

Infrared light can be focused, reflected or absorbed like visible light. Infrared thermometers employ a lens to focus infrared light from an object onto a detector known as a thermopile. The function of the thermopile is to absorb infrared radiation and convert it to heat. The thermopile gets hotter as it absorbs more and more infrared energy. The excess heat is converted into electricity, which is transmitted to a detector which determines the temperature of the object.

Calibration of a thermometer

Every thermometer must be calibrated. This can be done by choosing two easily obtainable temperatures called the upper and lower fixed points. After these points are obtained the interval in between can be divided into equal parts or degrees.

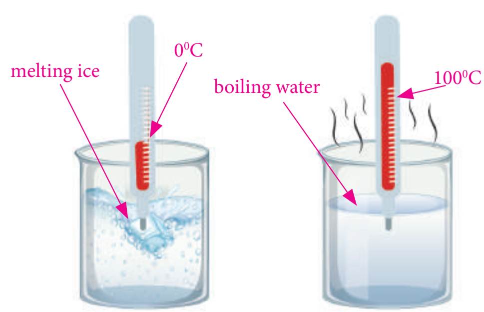


Fig. 9. 18 Two marks are made on the thermometer to indicate the positions of lower fixed point (0^0C) and upper fixed point 100^0C).

We chose the upper and lower fixed points as follows:

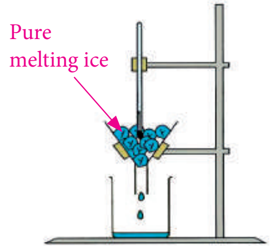
The lower fixed point is the temperature of pure melting ice. The ice must be pure as any impurities lowers the freezing point. The upper fixed point is the temperature of steam from boiling water under standard atmospheric pressure at 760mmHg. The atmospheric pressure is important. At sea level atmospheric pressure is close to 760mmHg. In hilly or high altitude regions the atmospheric pressure is generally lower, and therefore the boiling point of water lower.

Celsius Temperature Scale

This is a commonly used scale in everyday life. According to this scale the lower fixed point or the freezing point of water, is 0°C (said, zero degrees Celsius). The upper fixed point or boiling point at standard Pressure is 100°C. The interval between the two points is therefore 100 degrees.

Determination of the lower fixed point

The thermometer is inserted into pure melting ice as shown. It is important the ice is pure and that it is melting. When the level of the mercury, or alcohol, in the capill tubing stays constant, the level is marked. a oe This mark is 0°C.



9.19 Lower fixed point

Determination of the upper fixed point

The determination of this point is more difficult. If the atmospheric pressure is not exactly 760mmHg made. The bulb of the thermometer is placed in the steam directly above the boiling water. When the mercury level becomes constant the upper fixed point or steam steam temperature is marked. At 760mmHg this point occurs at the temperature of 100°C.

Hence:

Melting point of ice = 0°C.
i Steam temperature = 100°C at 760mm of steam mercury.
After these two fixed points are marked the thermometer is divided into 100 equal intervals
Boiling water between these points.

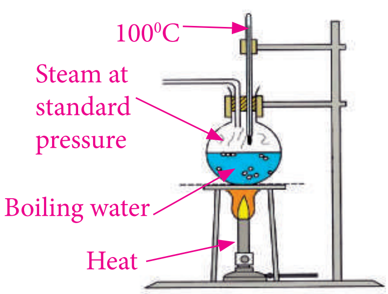
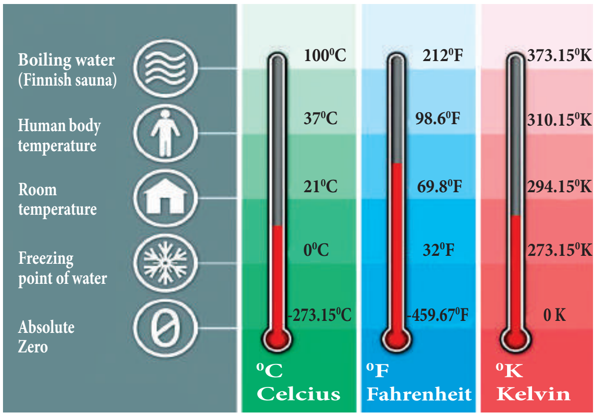


Fig. 9.20

Kelvin Temperature Scale

The temperature scale used in the SI system of units is the Kelvin or absolute scale.
On this scale O°C =273°K. and 100°C = 373°K.
A temperature change of 1°C is the same as a change of 1°K.
On this scale absolute zero gives
O°K = -273°C.
Absolute zero or 0°K is that temperature at which all molecules and atoms have zero kinetic energy - i.e. they have no velocity.

Temperature Scale Table



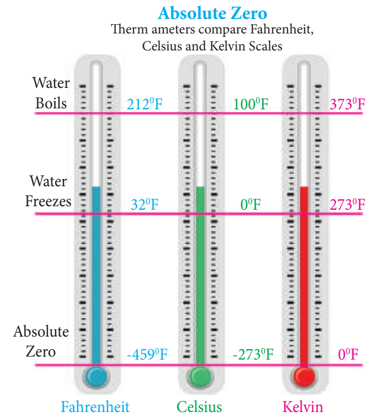


Fig. 9.21

Project Work

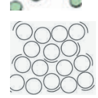
i. Put sand and cooking oil in the same type of pot and heat it on fire. Observe it carefully for some time. Which of these two objects heats up quickly and which slowly? What is the reason for this? Prepare a report.

Exercise

A. Choose the correct one and put the tick mark (√).

i. Thermal energy is also called-
  a. mechanical energy b. heat energy
  c. kinetic energy d. potential energy

ii. Which is not correct for thermal energy-
  a. The warmth from the sun b. A cup of hot chocolate
  c. The heat from heater d. The temperature human body

iii. Which is hot molecules-
  a.  ` b. 
  c.  d. 

iv. The process of changing a substance from solid to liquid state is
  a. Freezing b. Sublimation
  c. Melting d. Evaporation

v. Heat is measured in
  a. Degree b. Joule
  c. Celsius d. Kelvin

vi. The general tendency of cold water remains unchanged until
  a. 1^0C b. 2^0C c. 3^0C d. 4^0C

vii. An abnormal property of water where it expands instead of contracting when the temperature goes from 4 degree C to 0 degree C, and it becomes less dense is known as

a. The anomalous expansion of water
b. The anomalous constraction of water
c. The anomalous constant of water
d. None of above

viii. The density of water gradually increases

a. When heated
b. When kept hot
c. When cooled
d. None of the option

ix. The SI unit of heat is-

a. Kelvin
b. Watt
d. Joule
c. Calorie

x. What equipment is used to measure temperature?

a. Calorimeter
b. Barometer
c. Thermometer
d. None of the these

xi. What is the normal temperature of human body-

a. 37^0C
b. 98.6^0C
c. 100^0C
d. 58^0C

xii. What is the specific heat capacity of water ?

a. 420 J/kg^{0}C
b. 820 J/kg^{0}C
c. 3200 J/kg^{0}C
d. 4200 J/kg^{0}C

xiii. What is the relation between mass and specific heat capacity of a body ?

a. Directly proportional
b. Inversely proportional
c. Equal
d. None of these

B. Complete the following sentences:

i. Heat is a form of ___________ which gives sensation of warmth.
ii. The ___________ of hotness or coldness of a body is called its temperature.
iii. Thermal energy is the energy that comes from the ___________ substance.
iv. Heat lost or gained by a body is ___________ proportional to temperature difference
v. ___________is used to cool the engines of vehicles.
vi. Digital Thermometers are slowly replacing the conventional ___________ thermometer due to the ease of taking reading.
vii. Infrared thermometers work based on ___________ radiation.

C. Differentiate with examples

i. Thermal energy and heat
ii. Heat and temperature
iii. Cold water and hot water
iv. Digital thermometer and radiation thermometer
v. Lower fixed point and upper fixed point of thermometer

D. Explain the following:

i. Fishes survive in ponds even when the atmospheric temperature is below 0°C
ii. A hollow glass sphere which floats with its entire volume submerged in water at 4°C, sinks when water is heated above 4°C.

iii. A glass bottle completely filled with water and tightly closed at room temperature, is likely to burst when kept in the freezer of a refrigerator.
iv. Liquid thermometers were once the most common type in use.
v. When thermal energy is added to an object through heat transmission, the average kinetic energy of its molecules increases.
vi. When water boils in a pot, the pot is hotter than the water.
vii. Spices will stick in oil but not in water.

E. Answer the following questions :

i. What is thermal energy ?
ii. What is heat? Write its S.I. unit.
ii. Two bodies at different temperatures are placed in contact. State the direction in which heat will flow.
iii. Define temperature . Write its S.I. unit.
iv. Why does a piece of ice when touched with hand, appear cool ? Explain.
v. What do you understand by thermal expansion of a substance ?
vi. What do you mean by anomalous expansion of water ? Draw a graph to show the anomalous expansion of water .
vii. State the volume change by heat energy.
viii. What is specific heat capacity ? Write its unit.
ix. What is heat energy ?
x. What is the function of the small bend in a clinical thermometer? Why do we have to shake the thermometer after use?
xi. Write a summary of thermal energy, temperature, and heat.
xii. Explain the effect of heat on the volume of an object based on the motion of molecules
xiii. Write the significance of the anomalous expansion of water in daily life.
xiv. Write a short note on the specific heat capacity of matter .
xv. Explain the working principles of simple lab thermometers, digital thermometers, clinical thermometers, and radiation thermometers .
xvii. What is thermometer calibration? How is its fixed point chosen?
xvi. Write the method of calibration of simple thermometers.
xvii. Explain the structure of digital thermometers with diagram
xviii. Prove that heat eqation of Q=msdt
xix. Write the reason why ice floats on top of water.
xx. What is the reason why the water is colder than the stones or sand on the side of a river, pond, or water-logged field when the sun is shining, but it is exactly the opposite in the evening?

F. Solve the following numericals

i. Calculate the heat energy required to raise the temperature of 4 kg mass of water by 20°C. [Ans. 3. 36 x 10^5 J]
ii. What amount of heat is lost when 5 kg mass of metal ball having specific heat capacity 470 j/kg°C cooled from 30°C to 10°C. [Ans. 47000 J]
iii. A heater of power 1000 W takes 1 minute to raise the temperature of 5 kg mass of a substance from 40˚C to 45^0 C. Calculate the specific heat capacity of the substances. [Ans. 2400 J/kg°C]

iv. A frying pan of 2 kg mass has temperature of 40°C. The specific heat capacity of an alloy of pan is 1200 J/kg°C. What will be its final temperature when 4.8KJ heat energy is supplied to it. [Ans. 42°C]

v. When cold water of mass 15 kg is mixed with hot water of mass 10 kg at 100°C the resultant temperature of mixture is 50°C .What is the temperature of cold water? [Ans. 16.67°C]

vi. Calculate the specific heat capacity of a substance having mass of 1.5 kg. If the heat required is 100 calorie to rise the temperature by 60°C. [Ans. 4.66j/kg°c]

vii. The temperature of 2 kg of water is 10°C and 84000J of heat is supplied in it, what will be its temperature? [Ans. 20°C]

viii. What is meant by specific heat capacity of iron in 470J/kg°C ? In winter seasons the temperature of water is 5°C. If 20kg of water has to be heated to 35°C. Calculate the amount of heat required. [Ans. 2.52×106J]

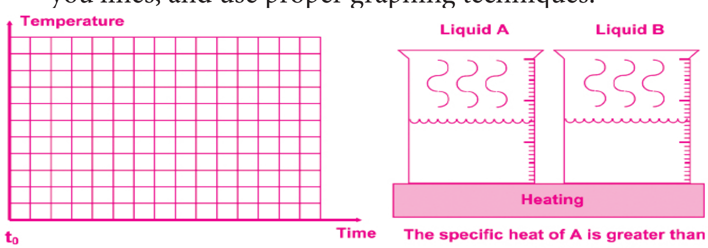
ix. A person heat 20 liters of water at 4°C with 2016KJ heat energy. How much temperature will rise in it? [Ans. 20°C]

x. What is the specific heat capacity of sand if 1.6×10^5 J of heat energy is required to rise the temperature of 10kg sand from 14°C to 34°C ? [Ans. 800J/kg°C]

G. Diagrammatic

i. Sppose we have two separate containcers: One containcer holds Liquid a, and another contaions Liquid B. The mass and inital temperature of the two liquids are the same, but the specific heat of Liquid A is two times that of Liquid B. Each container is placed on a heating plate that delivers the same rate of heating in joules per second to each liquid beginning at initial time t_0.

a. On the gird below, graph the temperature as a function of time for each liquid, A and B. Use a separate line for each liquid, even if they overlap. Make sure to clearly label you lines, and use proper graphing techniques.



The specific heat of A is greater than specific heat of B.

b. Please explain the reasoning that you used in drawing your graph.

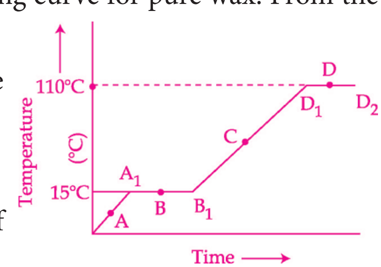
ii. The temperature-time graph given below shows the heating curve for pure wax. From the graph answer the following.

a. What is the physical state of the substance at the points A, B, C and D?

b. What is the melting point of the substance?

c. What is its boiling point?

d. Which portions of the graph indicate that change of state is taking place?



iii. A laboratory thermometer A is kept 7 cm away on the side of the flame while a similar thermometer B is kept 7 cm above the flame of a candle as shown in figure. Which of the thermometers A or B will show a greater rise in temperature? Give reason for your answer

iv. Answer the questions on the basis of the given table.

a. If A, B and C are taken in equal mass and heated by giving equal heat, which one of them gains the maximum temperature and why?

Substances	Specific Heat Capacity
A	2100J/kg°C
B	910J/kg°C
C	138J/kg°C

b. If all of them are liquid, which one of them is suitable for cooling and heating purposes and why?

c. If equal mass of A and B are taken at 80°C and left to cool, which will be cooled faster and why?

d. If all of them are liquid, which is suitable as thermometric liquid?

v. Study the given table and answer the following questions.

a. If the equal mass of X, Y, Z have the same temperature, which one has maximum heat?

Substances	Specific Heat Capacity
X	380J/kg°C
Y	910J/kg°C
Z	470J/kg°C

b. If three pieces of them have equal temperature, which one has the maximum heat mass?

c. What do you mean by specific heat capacity of 'Z' in 470J/kg°C?

d. If the equal mass of the same shape and size of them at 100°C temperature are kept over a wax slab, which of them will melt the wax for the maximum depth?

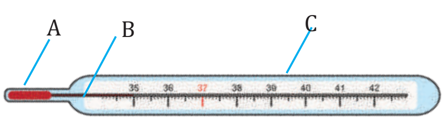
vi. Answer the following questions on the basis of the given diagram.

a. Name the instrument and mention its any one use.

b. Name A, B, and C.

c. Write the functions of A, B and C.

d. How is it different from a digital thermometer?



Chapter 10

Waves

Total Estimated pariods (Th. 11+ Pr. 4=15)

Student's Learning Outcomes

After studying this unit, the students will be able to :

- explain the refraction of waves and demonstrate the laws of refraction,
- introduce the process of total internal reflection of waves and explain the utility of total internal reflection of light and sound
- demonstrate the process of dispersion of light and identify its use in daily life
- define terms related to lenses and to express the Rules of refraction in lenses with ray diagrams
- demonstrate the process by which a lens forms the image of objects at different distances, draw its ray line and describe the characteristics of the image formed.
- define the power of a lens and explain the relationship between the curvature and the power of a lens.
- diagrammatic describes the process of image formation in the human eye
- explain visually the types, causes, and treatment methods of visual impairment
- mention the effects of corneal injury on vision and introduce problems such as macular blindness, cataracts, and color blindness.

Charles Kao, in full Charles Kuen Kao, Pinyin Gao Kun, (born November 4, 1933, Shanghai, China—died September 23, 2018, Hong Kong), physicist who was awarded the Nobel Prize for Physics in 2009 for his discovery of how light can be transmitted through fibre-optic cables. Kao received a bachelor's degree in electrical engineering from the University of London in 1957. That same year, he went to work for Standard Telephones and Cables, a British subsidiary of the American telecommunications company ITT.

Introductions

A wave is the propagation of disturbances from place to place in a regular and organized way. Most familiar are surface waves that travel on water, but sound, light, and the motion of subatomic particles all exhibit wavelike properties. In the simplest waves, the disturbance oscillates periodically at a fixed frequency and wavelength. Mechanical waves, such as sound, require a medium through which to travel, while electromagnetic waves do not require a medium and can be propagated through a vacuum. Light travels in electromagnetic waves. The propagation of a wave through a medium depends on the medium's properties.

Waves can travel immense distances even though the oscillation at one point is very small. For example, a thunderclap can be heard kilometres away, yet the sound carried manifests itself at any point only as minute compressions and rarefactions of the air.

Waves display several basic phenomena. In reflection, a wave encounters an obstacle and is reflected back. In refraction, a wave bends when it enters a medium through which it has a different speed. In diffraction, waves bend when they pass around small obstacles and spread out when they pass through small openings. When two waves meet, they can interfere constructively, creating a wave with a larger amplitude than the original waves, or destructively, creating a wave with a smaller (or even zero) amplitude.

Characteristics of wave

The characteristics of waves are as follows:

i. The particles of the medium traversed by a wave execute relatively small vibrations about their mean positions but the particles are not permanently displaced in the direction of propagation of the wave.

ii. Each successive particle of the medium executes a motion quite similar to its predecessors along/perpendicular to the line of travel of the wave.

iii. During wave motion only transfer of energy takes place but not that of a portion of the medium.

Waves are mainly of three types:

a. mechanical or elastic waves, b. electromagnetic waves and c. matter waves.

a. Mechanical waves

Mechanical waves can be produced or propagated only in a material medium. These waves are governed by Newton's laws of motion. For example, waves on water surface, waves on strings, sound waves etc.

Mechanical waves are of two types:

i. Transverse wave motion

ii. Longitudinal wave motion

i. Transverse wave motion

In transverse waves the particles of the medium vibrate at right angles to the direction in which the wave propagates. Waves on strings, surface water waves and electromagnetic waves are transverse waves. In electromagnetic waves (which include light waves) the disturbance that travels is not a result of vibrations of particles but it is the oscillation of electric and magnetic fields which takes place at right angles to the direction in which the wave travels.

ii. Longitudinal wave motion

In these types of waves, particles of the medium vibrate to and fro about their mean position along the direction of propagation of energy. These are also called pressure waves. Sound waves are longitudinal mechanical waves.

b. Electromagnetic Waves

These are the waves which require no material medium for their production and propagation, i.e., they can pass through vacuum and any other material medium. Common examples of electromagnetic waves are visible light; ultra-violet light; radiowaves, microwaves etc.

c. Matter waves

These waves are associated with moving particles of matter, like electrons, protons, neutrons etc.

Terms related to wave

- **Wavelength**
  The distance travelled by the disturbance during the time of one vibration by a medium particle is called the wavelength (λ). In case of a transverse wave the wavelength may also be defined as the distance between two successive crests or troughs. In case of a longitudinal wave, the wavelength (λ) is equal to distance from centre of one compression (or refraction) to another.
- **Wave Velocity**
  Wave velocity is the time rate of propagation of wave motion in the given medium. It is different from particle velocity. Wave velocity depends upon the nature of medium. Wave velocity v. = frequency (f) x wavelength (λ)
- **Amplitude**
  The amplitude of a wave is the maximum displacement of the particles of the medium from their mean position.
- **Frequency**
  The number of vibrations made by a particle in one second is called Frequency. It is represented by f. Its unit is hertz (Hz) . $f = 1/T$
- **Time Period**
  The time taken by a particle to complete one vibration is called time period. $T = 1/f$, it is expressed in seconds.

Relations between wave velocity, frequency and wavelength in refraction

For a given frequency of light, the wavelength is proportional to the wave velocity : $v = f \times \lambda$

So if a wave slows down, its wavelength will decrease. The effect of this can be shown using wave front diagrams like the one below. The diagram shows that as a wave travels into a denser medium, such as water, it slows down and the wavelength decreases. Although the wave slows down, its frequency remains the same, due to the fact that its wavelength is shorter.

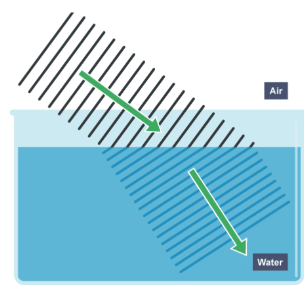


Fig. 10.1

In the above diagram, the right hand side of the incoming wave slows down before the left hand side does. This causes the wave to change direction.

10.1 Refraction of waves

All waves will reflect and refract in the right circumstances. Different materials have different densities. Light waves may change direction at the boundary between two transparent materials. Refraction is the change in direction of a wave at such a boundary.

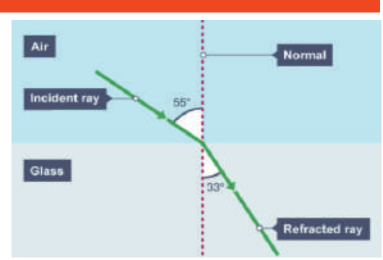


Fig. 10.2

It can cause optical illusions as the light waves appear to come from a different position to their actual source.The density of a material affects the speed that a wave will be transmitted through it. In general, the denser the transparent material, the more slowly light travels through it.

Glass is denser than air, so a light ray passing from air into glass slows down. If the ray meets the boundary at an angle to the normal, it bends towards the normal. The reverse is also true. A light ray speeds up as it passes from glass into air, and bends away from the normal by the same angle.

Refraction can increase or decrease the wave height, as well as the speed and strength of a breaking wave. Refraction is the reason why surface waves are always parallel to the shore.

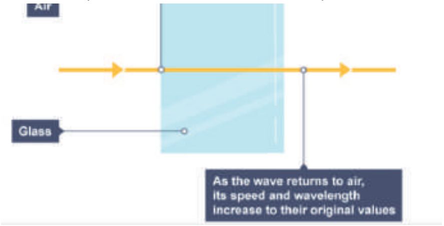


Fig. 10.3

The concept of wave refraction

Refraction of light is one of the most commonly observed phenomena, but other waves like sound waves and water waves also experience refraction. It is the change in direction of a wave passing from one medium to another caused by its change in speed. For example, waves travel faster in deep water than in shallow. If an ocean wave approaches a beach obliquely, the part of the wave farther from the beach will move faster than the part closer in, and so the wave will swing around until it moves in a direction perpendicular to the shoreline. The speed of sound waves is greater in warm air than in cold. At night, air is cooled at the surface of a lake, and any sound that travels upward is refracted down by the higher layers of air that still remain warm. Thus, sounds, such as voices and music, can be heard much farther across water at night than in the daytime.

The electromagnetic waves constituting light are refracted when crossing the boundary from one transparent medium to another because of their change in speed. A straight stick appears bent when partly immersed in water and viewed at an angle to the surface other than 90°. A ray of light of one wavelength, or colour (different wavelengths appear as different colours to the human eye), in passing from air to glass is refracted, or bent, by an amount that depends on its speed in air and glass, the two speeds depending on the wavelength. A ray of sunlight is composed of many wavelengths that in combination appear to be colourless. Upon entering a glass prism, the different refractions of the various wavelengths spread them apart as in a rainbow. The horizon appears flattened due to atmospheric refraction. The density and refractive index of the atmosphere decreases with increasing altitude. So, the rays of sun from the top portion and bottom portion are refracted by different degrees.

The stars twinkle due to atmospheric refraction. The stars' light undergoes several refractions before reaching the earth, refraction regularly changes the refractive index; that's why it twinkles.

Mirage and looming are optical illusions resulting from refraction of light. A swimming pool always looks shallower than it really is because the light coming from the bottom of the pool bends at the surface due to refraction of light. Formation of a rainbow is an example of refraction as the sun rays bend through the raindrops resulting in the rainbow.When white light passes through a prism it is split into its component colours – red, orange, yellow, green, blue and violet due to refraction of light. Refraction has many applications in optics and technology. A few of the prominent applications are : A lens uses refraction to form an image of an object for various purposes, such as magnification. Spectacles worn by people with defective vision use the principle of refraction. Refraction is used in peepholes of house doors, cameras, movie projectors and telescopes.

Activities 10.1

Class 10 students divide into small groups. Each group must have a transparent container, a laser pointer, flashlight, mirror, paper, and a pencil. Keep clean water in the container. Now let the participants in the group show the laser pointer by making different angles in the water of the container. All of you should observe the way the direction of the laser beam changes once it enters the water. Each group should conduct the experiment standing near a wall with their backs to it.

Have one student shine a flashlight into the mirror at different angles. All of you should observe where the light travels on the wall after it hits the mirror. After the groups have finished, review their ray diagrams with them.

Draw a neat and clean figure of reflection and refraction.

- Why did the laser beam look broken when it entered the water?
- Why did the light from the flashlight show up in different areas on the wall after hitting the mirror?

Effects of Refraction in Nature:

i. Our eyes

Our eyes use refraction to interpret light. Light enters the cornea, and then the lens, refracting, at the retina to a precise point. Then, the image is transmitted through the optic nerve to the brain. Because of the refractive properties of tears, teary eyes cause blurred vision.

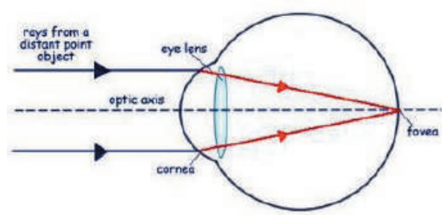


Fig. 10.4

ii. Real World Example - Fish Hunting

This great blue heron finally catches a meal after seeking the waters.

To be a successful hunter, the heron must use the refraction principle to determine where the fish are located before making a strike. The heron can accurately determine where to strike by recognizing that the fish are located at a spot that is different from what its eyes tell it.

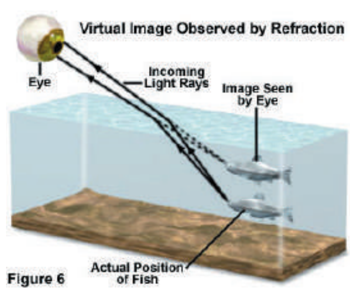


Fig. 10.5

Effects of Refraction in Nature:

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iii. Bending the Sun's Rays Because air is optically slightly denser than a vacuum, when sunlight passes into our atmosphere from the vacuum of space, it bends slightly towards the normal. When the sun is below the horizon and is thus not visible on a direct line, the light path bends slightly, making the sun visible through refraction. observers can see the sun before, or after, it actually sets over the horizon.

iv. **Mirages :** The sun shines on the road in the figure below, and heats up the air just above the road. The difference in density between the hot air over the road and the surrounding air causes the light that passes through the hot air to refract. looking down the road, you see a mirage. what seems to be water on the road is light actually coming from the sky which has been refracted as it passes through the hot air above the road. This phenomenon is common in the desert and on the hot rods.

v. **Rainbow Formation :** Rainbows are caused by refraction and reflection of sunlight off the droplets of water in the air. This can happen after rainstorms or in misty conditions but also close to waterfalls and fountains. As already mentioned, different wavelengths (colors) of light have slightly different refractive indices for a given material which makes them refract at different angles. An observer then sees a rainbow of colors, in order of wavelength.

How the refraction phenomenon occurs?

Refraction is commonly explained in terms of light's wave theory, and is based on the fact that light travels at higher speeds in some media than in others, this is not due to absorption or scattering. rather it is because light itself, as an electromagnetic oscillation, causes other electrically charged particles like electrons to oscillate. The electrons which oscillate emit their own electromagnetic waves that interact with the original light. the resulting "combined" wave has wave packets passing at a slower rate over an observer.

when light enters, exits, or changes the medium it travels in, it slows one side or the other of the wavefront before the other at an angle. This asymmetric slowing of the light causes the angle of its travel to change. Once light has constant properties within the new medium it travels again in a straight line.

Just imagine you are on the beach with your friends. You all decide to swim together, so that as a straight line you link arms and approach the water. You are all slowing down as you start walking into the water, because it's harder to walk through water than through air. Thus imagine approaching the water at an angle relative to the shoreline.

The person at the end meets the water and slows down first, then the next person
In line, then the next person, until all walk through the water. Because one end of the line slowed before the other end, people's line gets crooked, with the people still on the beach at a different angle relative to the edge of the water than the people who have entered the ocean already.

you can say the water bends each individual's path towards a normal line drawn perpendicularly to the shoreline, as the people still on the shore are bent further from the shoreline than those in the water. when it moves from air to water, or from any fast medium to a slow medium, the same thing happens with a light ray: it bends towards normal.

Amount of refraction

Two things depend on The angle at which light bends when it comes in a different medium depends on its velocity change. the larger the velocity change, the greater the refraction angle. for instance, light refracts more when passing from air to diamond, than when passing from air to water. That's because, in diamond, the speed of light is slower than in water.

Another factor is the angle of the incident ray – the amount of refraction will also be more noticeable if the light is entering the substance at a greater angle. Conversely, if the light enters the new substance straight on (at 90 ° to surface), the light will still slow down, but the direction will not change at all.

The laws of refraction

Before studying the laws of refraction, let's learn about some terminology related to them.

Incident ray: The ray of light falling to the surface at point P (above fig.) is called incident ray (AP).

Refracted ray: The ray of light traveling in glass with a change in direction is called refracted ray (PB).

Angle of incidence i.: The angle formed between the incident ray and the normal is called the angle of incidence.

Angle of refraction (r): The angle formed between normal and the angle of refraction is called the angle of refraction.

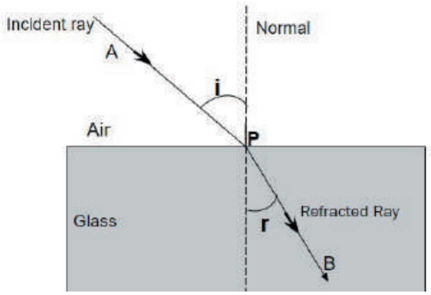


Fig. 10.6

Illustrations on Refraction

Figure 1: Angle of incidence is greater than the angle of refraction (∠i > ∠r). When a ray of light travels from a rarer medium to a denser medium, it bends towards normal. Air rarer medium and glass is denser medium.

Figure 2: Angle of incidence is smaller than the angle of refraction (∠i <∠r). When a ray of light travels from a denser medium(glass) to a rarer medium(air), it bends away from normal.

Figure 3: When a ray of light traveling along with normal shows no deflection. ∠i=∠r=0.

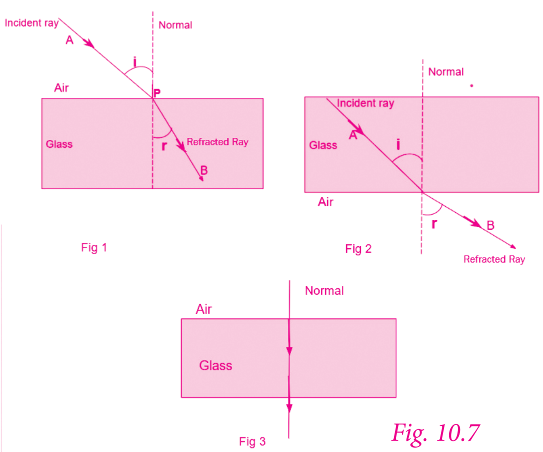


Fig. 10.7

Laws of Refraction

First law : *It states that the incident ray, refracted ray and nor*mal to the interface at the point of incidence all lie in the same plane.

Second law : It states that the ratio of the sine of the angle of incidence and the sine of the angle of refraction is constant. It is given as,

$$\sin i / \sin r = \text{constant}$$

Snell's law: *It states that for the light if given colour and for the given pair of media, the ratio of the sine of the angle of incidence to the sine of the angle of refraction is constant. It gives the degree of refraction and also tells the relation between the ang*le of incidence, the angle of refraction and the refractive index of media.

$$\sin i / \sin r = \mu = \text{constant}$$

where,

- μ is the refractive index of the medium.

Refractive Index

Refractive index (for speed): The ratio of the speed of light in a vacuum to the speed of light in a given medium for the given wavelength is called the 'Refractive index' of that medium. It is denoted by '**μ**'. $\mu = c/v$

where,

- c is the speed of light in a vacuum, and
- v is the speed of light in the medium.

Refractive index (for wavelength): The ratio of the wavelength of light in a vacuum to its wavelength in the given medium is called the 'Refractive index' of that medium. It is denoted by '**μ**'

$$\mu = \lambda_v/\lambda_m$$

where.

- λ_v is the wavelength in a vacuum, and
- λ_m is the wavelength in a medium.

The Refractive index has no units.

Refractive index of medium depends upon:

- Wavelength of light
- Nature of the medium
- Nature of surrounding
- Temperature

No refraction occurs, when

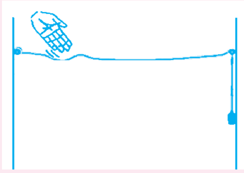
i. light is incident normally on a boundary,
ii. refractive indices of the two media in contact are equal.

10.2 Total internal reflection of waves

A ray of light entered the face of the triangular block at a right angle to the boundary. This ray of light passes across the boundary without refraction since it was incident along the normal . The ray of light then travels in a straight line through the glass until it reaches the second boundary. Now instead of transmitting across this boundary, all of the light seems to reflect off the boundary and transmit out the opposite face of the isosceles triangle. This discrepant event bothers many as they spend several minutes looking for the light to refract through the second boundary. Then finally, to their amazement, they looked through the third face of the block and clearly see the ray. What happened? Why did light not refract through the second face?

Activities 10.2

Propagation of a pulse on a rope



You can easily see the motion of a pulse on a rope. You can also see its reflection from a rigid boundary and measure its velocity of travel. You will need a rope of diameter 1 to 3 cm, two hooks and some weights. You can perform this experiment in your classroom or laboratory.

Take a long rope or thick string of diameter 1 to 3 cm, and tie it to hooks on opposite walls in a hall or laboratory. Let one end pass on a hook and hang some weight (about 1 to 5 kg) to it. The walls may be about 3 to 5 m apart.

Take a stick or a rod and strike the rope hard at a point near one end. This creates a pulse on the rope which now travels on it. You can see it reaching the end and reflecting back from it. You can check the phase relation between the incident pulse and reflected pulse. You can easily watch two or three reflections before the pulse dies out. You can take a stopwatch and find the time for the pulse to travel the distance between the walls, and thus measure its velocity. Compare it with that obtained from the formula :–

$v = \sqrt{\frac{T}{\mu}}$ Hints: μ=Mass/Length=5kg/0.03m = ...kgm^{-1}, Tension(Force) = m.g =5x9.8=...N

(*Note the important point that the speed v depends only on the properties of the medium. T and μ (T is a property of the stretched string arising due to an external force and μ is the mass per unit lenght). It does not depend on wavelength or frequency of the wave itself.)*

This is also what happens with a thin metallic string of a musical instrument. The major difference is that the velocity on a string is fairly high because of low mass per unit length, as compared to that on a thick rope. The low velocity on a rope allows us to watch the motion and make measurements beautifully.

The Discrepant Event - Total Internal Reflection

Total internal reflection takes place when light goes from a slow (high refractive index) medium to a fast (low refractive index) medium. light refracts so much with total internal reflection it actually refracts back into the first medium. This is how fibre-optic cables work: the wire leaves no light. TIR is the phenomenon that makes the water-to - air surface of a fish tank look like a perfectly silver mirror when viewed from below the level of the water.

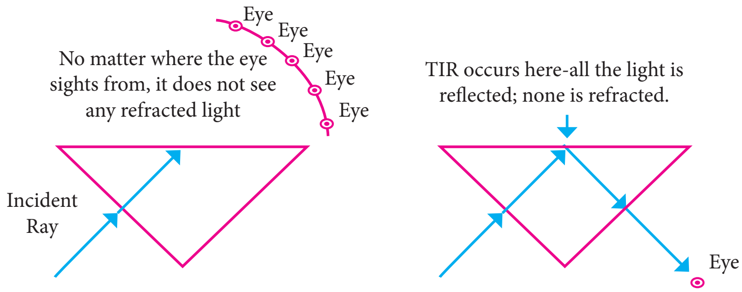


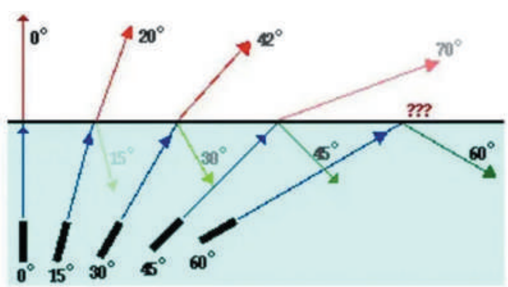
Fig. 10.8

Total internal reflection, or TIR as it is intimately called, is the reflection of the total amount of incident light at the boundary between two media.

To understand total internal reflection, we will begin with a thought experiment. Suppose that a laser beam is submerged in a tank of water (don't do this at home) and pointed upwards towards water-air boundary. Then suppose that the angle at which the beam is directed upwards is slowly altered, beginning with small angles of incidence and proceeding towards larger and larger angles of incidence. What would be observed in such an experiment? If we understand the principles of boundary behavior, we would expect that we would observe both reflection and refraction. And indeed, that is what is observed (mostly). But that's not the only observation that we could make. We would also observe that the intensity of the reflected and refracted rays do not remain constant. At angle of incidence close to 0 degrees, most of the light energy is transmitted across the boundary and very little of it is reflected. As the angle is increased to greater and greater angles, we would begin to observe less refraction and more reflection. That is, as the angle of incidence is increased, the brightness of the refracted ray decreases and the brightness of the reflected ray increases. Finally, we would observe that the angles of the reflection and refraction are not equal. Since the light waves would refract away from the normal , the angle of refraction would be greater than the angle of incidence. And if this were the case, the angle of refraction would also be greater than the angle of reflection (since the angles of reflection and incidence are the same). As the angle of incidence is increased, the angle of refraction would eventually reach a 90-degree angle. These principles are depicted in the diagram below.

As the angle of incidence increases from 0 to greater angles...

The maximum possible angle of refraction is 90-degrees. If you think about it , you recognize that if the angle of refraction were greater than 90 degrees, then the refracted ray would lie on the incident side of the medium - that's just not possible. So in the case of the laser beam in the water, there is some specific value for the angle of incidence that yields an angle of refraction of 90-degrees.



... the refracted ray becomes dimmer (there is less refraction)
... the refracted ray becomes brighter (there is more refraction)
... the angle of refraction approaches 90 degrees until finally a refracted ray can no longer be seen.

Fig. 10.9

TIR is the complete reflection of a ray of light within a medium such as water or glass from the surrounding surfaces back into the medium. The phenomenon occurs if the angle of incidence is greater than a certain limiting angle, called the critical angle. In general, total internal reflection takes place at the boundary between two transparent media when a ray of light in a medium of higher index of refraction approaches the other medium at an angle of incidence greater than the critical angle. For a water-air surface, the critical angle is 48.5°. Because indices of refraction depend on wavelength, the critical angle (and hence the angle of total internal reflection) will vary slightly with wavelength and, therefore, with colour. At all angles less than the critical angle, both refraction and reflection occur in varying proportions.

Glass prisms can be shaped to produce total internal reflection and, as such, are employed in binoculars, periscopes, telescopes, and other optical instruments. Light rays may be conducted over long, twisting paths by multiple total internal reflection in glass or plastic rods or fibres.

Critical Angle

The critical angle is the angle of incidence, for which the angle of refraction is 90°. If light enters a denser medium from a comparatively rarer medium, then the direction of light changes and the light ray bends towards the normal.

One can witness an effect by opening his or her eyes while swimming just below the surface. If the water is still, the surface outside the critical angle appears mirror-like, reflecting objects below. The region above the water cannot be seen except overhead. The hemispherical field of view is compressed into a conical field known as Snell's window, whose angular diameter is twice the critical angle.

The critical angle is denoted by C . It can be calculated by using formula:

$$\text{Sin C} = \frac{1}{\mu}$$

μ = refractive index of a denser medium

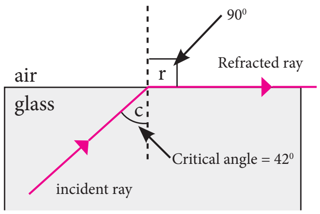


Fig. 10.11

Critical angles for some optical media with respect to air

S.N.	Substance	Critical angle
1	Diamond	24°
2.	Ruby	35°
3.	Glass	42°
4.	Turpentine	43°
5.	Glycerine	43°

S.N.	Substance	Critical angle
6.	Paraffin	44°
7.	Kerosene	46°
8.	Alcohol	48°
9.	Water	49°
10.	Ice	50°

Solved Numerical Problems

1. The speed of light in vacuum is 3 × 108m/s.
Find the speed of light in glycerin [use refractive index of glycerin = 1.47].

Solution,

Given

Speed of light in vacuum (c) = 3×10^8m/s.

refractive index (μ) = 1.47

and speed of light in glycerine v. =?

∵ We know that,

$$\text{R.I.} = \frac{\text{Speed of light in vacuum (c)}}{\text{Speed of light in a medium v.}}$$

or, $1.47 = \frac{3 \times 10^8}{v}$

or, $1.47v = 3 \times 10^8$

or, $v = \frac{3 \times 10^8}{1.47}$

$= 2.04 \times 10^8$ m/s

∴ The speed of light in glycerine is 2.04×10^8m/s.

2. If a ray of light in air strikes a glass slab at an angle of incidence 20°. Calculate the angle of refraction in glass [use R.I. of glass = 1.5].

Solution,

Given,

Angle of incidence i. = 20°

Refractive index (μ) = 1.5

Angle of refraction (r) =?

∴ From snell's law, we have

$$\mu = \frac{\sin i}{\sin r}$$

or, $1.5 = \frac{\sin 20°}{\sin r}$ or $1.5 \sin r = \sin 20°$

or, $\sin r = \frac{\sin 20°}{1.5}$ or, $r = \sin^{-1}\left(\frac{0.3420}{1.5}\right)$

$= 13.18°$

∴ The angle of refraction in glass is 13.18°.

Conditions of total internal reflection

Total internal reflection only takes place when both of the following two conditions are met:

- the light is in the more dense medium and approaching the less dense medium.
- the angle of incidence is greater than the so-called critical angle.

Total internal reflection will not take place unless the incident light is traveling within the more optically dense medium towards the less optically dense medium. TIR will happen for light traveling from water towards air, but it will not happen for light traveling from air towards water. TIR would happen for light traveling from water towards air, but it will not happen for light traveling from water (n=1.333) towards crown glass (n=1.52). TIR occurs because the angle of refraction reaches a 90-degree angle before the angle of incidence reaches a 90-degree angle. The only way for the angle of refraction to be greater than the angle of incidence is for light to bend away from the normal. Since light only bends away from the normal when passing from a more dense medium into a less dense medium, then this would be a necessary condition for total internal reflection.

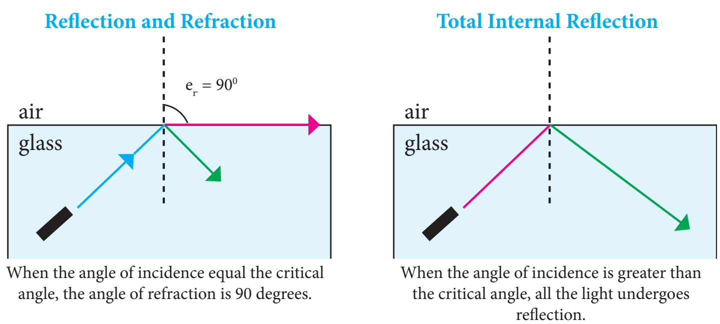


Fig. 10.12

Total internal reflection only occurs with large angles of incidence. How large is large? Larger than the critical angle. As mentioned above, the critical angle for the water-air boundary is 48.6 degrees. So for angles of incidence greater than 48.6-degrees, TIR occurs. But 48.6 degrees is the critical angle only for the water-air boundary. The actual value of the critical angle is dependent upon the two materials on either side of the boundary. For the crown glass-air boundary, the critical angle is 41.1 degrees. For the diamond-air boundary, the critical angle is 24.4 degrees. For the diamond-water boundary, the critical angle is 33.4 degrees. The critical angle is different for different media.

Uses of the total internal reflection of light in daily life

Some examples of total internal reflection in daily life are the formation of a mirage, shining of empty test-tube in water, shining of crack in a glass-vessel, sparkling of a diamond, transmission of light rays in an optical fibre, etc.

Diamond sparkle

The sparkling of a diamond is a classic example of the total internal reflection phenomenon in real life. The light that enters the structure of the diamond is made to strike its surface at an angle greater than the critical angle of reflection, hence the ray of light is not able to escape the structure of the diamond and stays inside for long. This creates a glittery and shining appearance of the diamond.

Fig. 10.13

Mirage

Usually, during the daytime, a water layer appears to be present on the surface of the road or on the sand surface of the deserts, known as a mirage. A mirage is nothing but a type of optical illusion that is generally observed in the deserts or on the surface of hot roads. The formation of mirage is typically based on the total internal reflection of light waves.

Prism

Prisms are one of the most common objects used in our daily life that are capable of displaying the total internal reflection phenomenon in one of the easiest manners. For this purpose, generally, the right-angled isosceles prisms, equilateral prisms, or right-angled prisms are preferred.

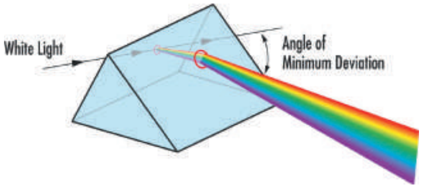


Fig. 10.14

Procedures and uses of light pipes

A light pipe is a rod made of optical acrylic or polycarbonate that transmits light from a light source, typically an LED, on the circuit board to the panel of the device. These light pipes are ideal for carrying the light in a small space, like a status indicator or control panel. It is made up of a bundle of highly transparent and flexible glass fibres called optical fibres . These are devices used to transmit light along any desired path .

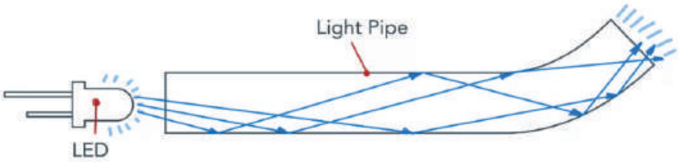


Fig. 10.15

Light pipes (optical fibres) are structures that can be used to transport light between different locations. In general, they can be divided into two major groups: tubes lined with a reflective coating and transparent solids that contain light via total internal reflection.

It consists of a thin fibre glass. When a ray of light enters a fibre, it suffers a series of total internal reflections and finally emerges out from the other end. Since the light energy is not absorbed, intensity of light is not lost.

Optical fibres are used in long distance telephony. Sound energy is convened into electrical energy. Electrical energy is convened into light energy. This light energy is fed to optical fibres and it is transmitted over a long distance through optical fibres. At the receiving end light energy is finally converted to sound energy. Optical fibres are used as endoscopes or fibrescopes. Endoscopes is a device used to examine internal organs of a human body by physicians.

Used in Telecommunication:

Light pipes are used in long distance telephony. Sound energy is convened into electrical energy. Electrical energy is convened into light energy. This light energy is fed to optical fibres and it is transmitted over a long distance through optical fibres. At the receiving end light energy is finally converted to sound energy.

Used in Endoscopes:

Light pipes are used as endoscopes or fibrescopes. The endoscope pipe uses the phenomenon of Total Internal Reflection for imaging of the internal organs of the human body. A narrow tube of glass fibre with plastic coating carries light from one end of the fibre to another into the cavity of the body. The injured part is illuminated by this light. Endoscopes is a device used to examine internal organs of a human body by physicians.

Used in Keyhole surgery:

Laparoscopy is a type of surgical procedure that allows a surgeon to access the inside of the abdomen (tummy) and pelvis without having to make large incisions in the skin. This procedure is also known as keyhole surgery or minimally invasive surgery. The laparoscopy, a technique based on the use of an instrument called a laparoscope—a long, narrow "light pipe" with electrified forceps attached—accomplished all of these goals. With the laparoscope, physicians operated through one or two tiny incisions in a woman's navel; the technology eliminated the need for open abdominal surgery entirely. A laser beam is an intense and narrow beam of monochromatic light (a single wavelength). It can be used for cutting or destroying tissue because of its high energy concentrated on a small area as seen in keyhole surgery. There are many ways of getting illumination to the posterior pole for vitreoretinal surgery, the most commonly used being the fiber optic "light pipe," chandelier lighting, and illuminated instruments.

10.3 Introduction to the Dispersion of Light

A rainbow shining against a gloomy stormy sky is a sight that everyone loves. How does sunshine shining through pure raindrops produce the rainbow of colors observed? A transparent glass prism or a diamond uses the same method to break **white light** into colors. There are about six colors in a rainbow—red, black, yellow, green, blue, and violet; indigo is often identified as well.

Specific wavelengths of light are correlated with certain colors. Depending on the wavelength, we expect to see only one of the six colors as we absorb pure-wavelength light. Our eye's response to a combination of various wavelengths produces the thousands of other colors we can detect in other conditions. White light, in fact, is a combination of all visible wavelengths that are fairly uniform.

Because of the combination of wavelengths, sunlight, which is known bright, tends to be a little yellow, but it does include all visible wavelengths. The colors in rainbows are in the same order as the colors plotted against wavelength. This means the white light in a rainbow is distributed according to wavelength. This scattering of white light is known as **Dispersion**. More precisely, dispersion happens if a mechanism changes the direction of light in a wavelength-dependent way. Dispersion can occur with any form of wave and is often associated with wavelength-dependent processes.

Causes of the Dispersion of Light

- The various degrees of refraction produced by different colors of light cause dispersion. In a vacuum, various colors of light travel at the same speed, but in a refracting medium, they travel at different speeds.
- Violet light travels at a much slower speed than red light. As a result, violet light has the highest refractive index of the medium, while red light has the lowest.
- As a result, violet light has the highest refractive index, while red light has the lowest refractive index (in the visible spectrum). As a consequence, violet-colored light refracts or bends the most, while red-colored light refracts the least.
- The dispersion of white light into its constituent colors as it emerges from a prism is caused by the disparity in the degree of bending of various colors of light.

Examples of Dispersion of Light

Dispersion of white light through a prism: As shown in the figure, when white light falls on the prism a collection of seven colors found to come out from the prism due to the dispersion.

Dispersion due to Oil on Road: Small amounts of oil are usually present on the road surface e.g. lubricating oil from automobiles, which give rise to bands of beautiful colors when it rains.

Formation of Rainbow: A rainbow is considered to be one of the most amazing light displays ever seen on the planet. A rainbow is a multicolored arc formed by light striking water droplets. Rainbows are formed during rain by the absorption, refraction, and dispersion of light in water droplets. All of these phenomena provide a light spectrum in the sky, which is known as a rainbow.

Dispersion in a Diamond: Diamond dispersion is where white light enters a diamond (or any dense object), separates into all the spectral colors of the rainbow, and bounces back to the viewer's eyes in a wonderful display of colored light, also known as diamond fire.

Rainbow Formation

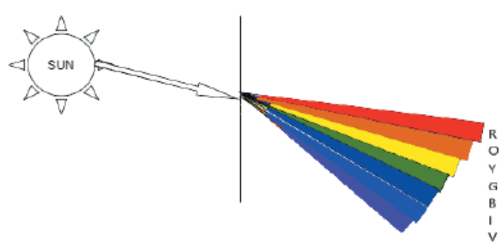


Fig. 10.16

A Rainbow is formed of seven colors (VIBGYOR) Violet, Indigo, Blue, Green, Yellow, Orange, Red. When rain happens the drops of rain falling on the surface works like a prism and when sunlight falls on the drops of water the rays of the sun scatter into different colors and form a rainbow, and sometimes we may also see multiple rainbows. In this concept drops of water, acts likes a prism and create a rainbow. Drops of water are nothing but the spherical ball containing the water and having the refractive index of water (1.333) which makes the white light to dispersed and forming a beam of light of several called rainbow.

Therefore, the necessary conditions for the formation of the rainbow are: the presence of water droplets or raindrops and the position of Sun must be at the back side of the observer of rainbow.

Activities 10.3

Activity to procedure a rainbow in classroom :

i. Take a prism and place it on the table near a vertical white wall.
ii. Take a thin wooden plank, make a small hole in it and fix it vertically on the table.
iii. Place the prism between the wooden plank and wall.
iv. Place a white light source behind the hole of the wooden plank . Switch on the light.
v. Adjust the height of the prism such that the light falls on one of the lateral surfaces.
vi. Observe the changes in the emerged ray of the prism.
vii. Adjust the prism by slightly rotating it till you get an image on the wall.
ix. We observe a band of different colours on the wall.
x. These colours are nearly equal to the colours of the rainbow , i.e. VIBGYOR.

Dispersion of light by a prism

The phenomenon of splitting of visible light into its component colors is called **dispersion**. Dispersion of light is caused by the change of speed of light ray (resulting in angle of deviation) of each wavelength by a different amount.

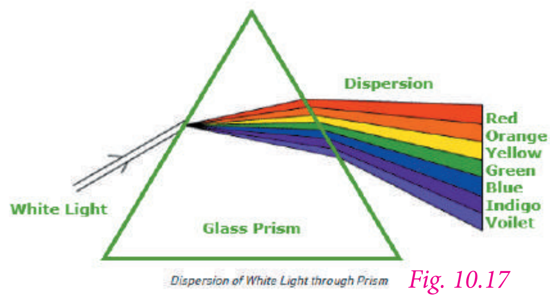


Fig. 10.17

The dispersion of a light wave by a prism is shown in the diagram. As white light is incident on a glass prism, the emergent light appears to be multicolored (violet, indigo, blue, green, yellow, orange and red). The light that bends the least is red, while the light that bends the most is violet. Dispersion is the process of light breaking into its constituent colors. The continuum of light is the pattern of color components in light. When light falls on the surface it dispersed into several colors depending on the wavelength of the color or the frequency, as we know that frequency and wavelength are inversely proportional to each other. Each color has its own wavelength and frequency, so we see different colors for the same white light**.**

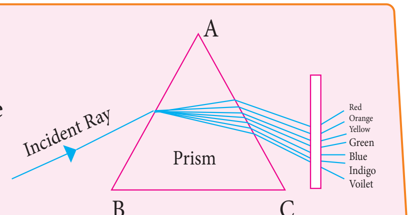
Activities 10.4

Demonstrate the dispersion of light.

Materials needed :

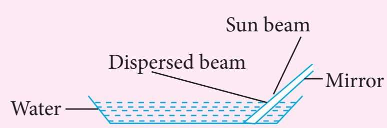
i. A prism ii. A piece of white paper iii. Sunlight iv. A piece of mirror v. A tray.

Procedure :



Part A

i. Hold a glass prism in the beam of sunlight.
ii. Throw the bands of colours coming from opposite side of the prism on the piece of white paper .



Part B

i. Set a tray of water in bright sunlight.
ii. Lean the mirror against the inside edge and adjust it so that a colour band appears on the wall of the room.

Part C

1. Spin a Newton's colour disc with high speed and observe. Observation: Observe the spectrum on the paper.

Inference: A prism disperses a beam of white light into a band of seven different colours of light.

10.4 Introduction to the lens

Light is a form of energy that produces sensation of sight. Sun is the main natural source of light energy. Light is also formed by artificial sources like electric bulb, fluorescent lamp, candle, etc.

Though light itself is invisible, it makes the objects around us visible. Objects can not be seen in the absence of light. When light falls on any objects, it is reflected and reaches to the retina of our eyes. Then it reaches to the brain through optic nerves and sensation of sight of object is produced. Thus, we can see the objects. In some cases, we can not see the objects directly and we use various optical instruments to see them clearly. Lenses are used in these optical instruments. In this lesson, we are going to study about lenses, their types and uses, defects of visions and their remedy.

Lens

Lens is an optical device which is made up of transparent glass bounded by at least one spherical surface . Lens is a useful device which is used in various optical instruments. Human eye also contains a lens. Lens is of two types. Convex lens and concave lens.

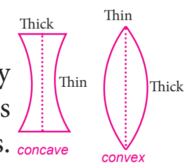


Fig. 10.18

i. Convex Lens

A lens which is thick in the middle and thinner at the edges is called convex lens. When a parallel beam of light falls on convex lens, it converges the beam at a point after refraction. So, convex lens is called converging lens. Convex lens has a real focus.

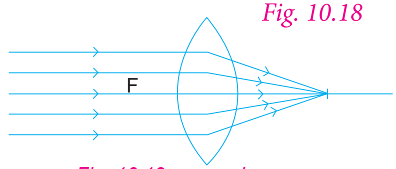


Fig. 10.19 convex lens

ii. Concave Lens

A lens which is thin at the middle and thicker at the edges is called a concave lens. When a parallel beam of light falls on concave lens, it divides the beam from a point after refraction. So, concave lens is also called diverging lens. It has virtual focus.

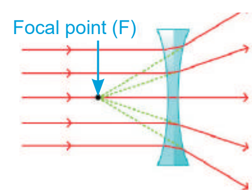


Fig. 10.20

Differences between Convex and Concave Lenses.

Convex Lens	Concave Lens
i. It is thicker at centre than at edges.	i. It is thinner at centre than edges.
ii. It converges parallel beam. So, it is also called converging lens.	ii. It diverges parallel beam. So, it is also called diverging lens.
iii. It has real focus.	iii. It has virtual focus.
iv. It may form both real and virtual images.	iv. It forms only virtual image.

Lens in the Form of Sections of Prism

A convex lens is made up of many prisms. There is thick glass slab in the middle. The base of upper prism faces downward and the base of lower prism faces upward. The parallel rays incident near the centre are bent least and the parallel rays incident at the edges are bent most. The ray of light passing exactly through the centre of the lens is not bent. In a convex lens all the refracted rays are deviated towards the centre and meet at a point called focus (F).

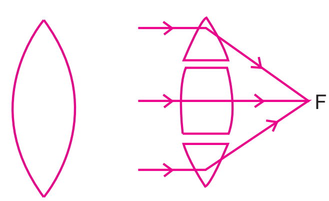


Fig. 10.21 convex lens

Similarly, a concave lens is also made up of many prisms. There is thin glass slab at the middle. The base of upper prism faces, upward and the base of lower prism faces downward. The parallel rays of light passing through the centre are not bent after refraction. As we move towards the edges the incident rays falling on the prism get deviated more than near the centre and appear to come from a points called focus (F).

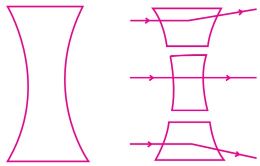


Fig. 10.22 concave lens

Terms related to lenses

Concave

Concave means 'hollowed out or rounded inward' and is easily remembered because these surfaces 'cave' in. A valley is a concave curve. The caves tend to be holes that go in, like valleys or innie belly buttons. If you want to describe a bowl, you might say there is a large blue spot on the center of the concave side.

Convex

Convex means 'curved or rounded outward.' A mountain is a convex curve . You can remember this by thinking that things that vex you tend to stick out.

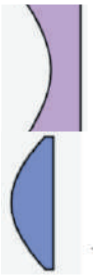


Fig. 10.23

Activities 10.5

i. Take a large shining spoon. Try to view your face in its curved surface. Do you get the image ? Is it smaller or larger ? Move the spoon slowly away from your face .Observe the image. How does it change ? Reverse the spoon and repeat the activity. How does the image look like now ? Compare the characteristics of image on the two surfaces.

ii. Hold a concave mirror in your hand and direct its reflecting surface towards the Sun. Direct the light reflected by the mirror on to a sheet of paper held close to the mirror. Move the sheet of paper back and forth gradually until you find on paper sheet a bright, sharp spot of light. Hold the mirror and the paper in the same position for a few minutes. What do you observe ? Why ?

iii. Take a convex mirror . Hold it in one head.Hold a pencil in the upright position in the other hand. Observe the image of the pencil in the mirror. Is the image erect or inverted? Is it diminished or enlarged? Move a the pencil away from the mirror slowly . Does the image become smaller or larger ? Repeat this activity carefully . State whether the image will move closer to or farther away from the focus as the object is moved away from the mirror?

iv. Place a large shallow bowl on a table and put a coin in it. Move away slowly from bowl. Stop when the coin just disappears from your sight . Ask a friend to pour water gently into the bowl without disturbing the coin. Keep looking for the coin from your position . Does the coin become visible again from your position? How could this happen?

i. Centre of curvature (C)

As shown in the figure centre C_1 and C_2 of spheres whose parts form a lens are called centers of curvature. A lens has two center of curvature.

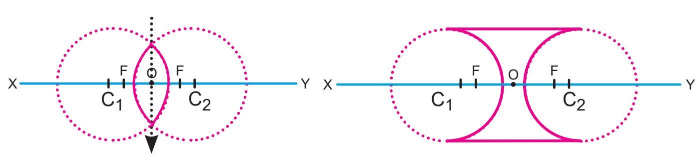


Fig. 10.24

ii. Radius of curvature (R)

The radius of a sphere whose surface forms a part of lens is called radius of curvature. A lens has two radius of curvature.

iii. Principal axis

The straight line joining the two centers of curvature of a lens is called principal axis. In the figures the straight line XY represents principal axis.

iv. Optical centre (O)

The centre point of a lens is called optical centre. It is represented by O. A ray of light passing through this point does not deviate and it goes straight.

v. Principal focus (F)

The point on the principal axis where parallel rays of light converge after refraction through a lens (Convex lens) or appear to diverge from a point on the principle axis (Concave lens) is called principal focus or simply focus. It is denoted by F.

In the figure (a), a parallel beam of light incident on the convex lens, parallel to its principal axis, actually meets at point F on its principal axis after refraction through it. Hence, its principal focus is real.

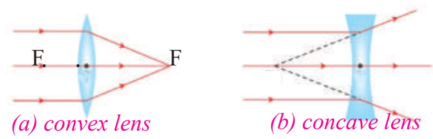


Fig. 10.25

In the figure (b), a parallel beam of light incident on the concave lens, parallel to its principal axis diverges after refraction through it. If this divergent beam is produced back, it meets at point F on its principal axis. Hence, its principal focus is virtual.

Light may pass through either side of a lens, there are two principal focus on either side of the lens as shown in the figure (a) and (b). These two principal focus are at an equal distance from the optical centre of the lens.

vi. Focal Length

The distance between principal focus (F) and optical centre (O) is called focal length. It is denoted by 'f'. Convex lens has positive focal length whereas concave lens has negative focal length.

Image

An image is defined as the collection of focus points of light rays coming from an object.

Real Image

A real image is the collection of focus points actually made by converging/diverging rays.

Virtual Image

A virtual image is the collection of focus points made by extensions of diverging or converging rays.

Rule of refraction in lenses

The following rules of refraction through lens should be followed while constructing ray diagrams.

i. A ray of light parallel to principal axis passes or appears to pass through principal focus after refraction.

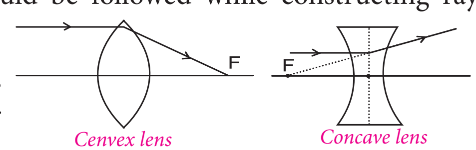


Fig. 10.26

ii. An incident ray passing through optical centre (O) refracts without deviation.

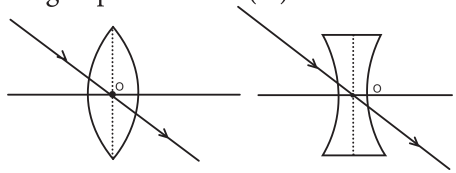


Fig. 10.27

iii. The incident ray passing through principal focus is refracted parallel to the principal axis.

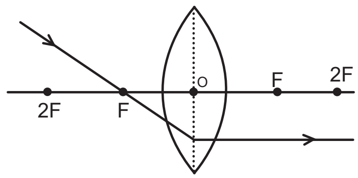


Fig. 10.28

Image Formed by Convex Lens

The size location and nature of images formed by convex lens depend on the position of the objects. They are given below with ray diagrams.

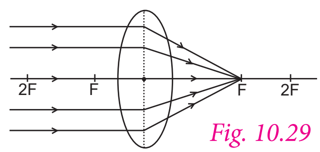


Fig. 10.29

i. Object beyond 2F : When an object is placed beyond the centre of curvature, the real image is formed between the centre of curvature and focus. The image size will not be the same as the object. It will be diminished in size.

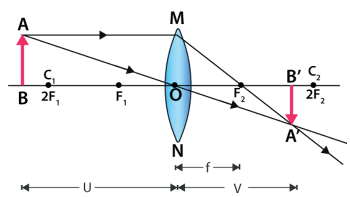


Fig. 10.30

ii. Object at center of Curvature :

When an object is at the centre of curvature, the real image is formed at the other centre of curvature. The size of the image is the same as compared to that of the object.

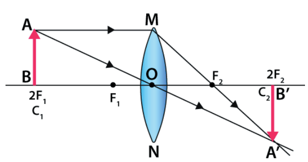


Fig. 10.31

iii. Object between of centre of Curvature (C) and Focus(F) : When an object is placed in between the centre of curvature and focus, the real image is formed behind the centre of curvature. The size of the image is larger than that of the object.

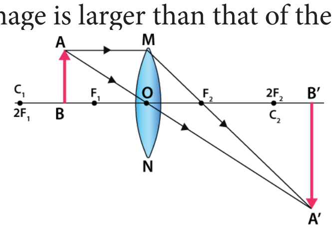


Fig. 10.32

iv. Object in at Focus (F) When an object is placed at the focus, a real image is formed at infinity. The size of the image is much larger than that of the object.

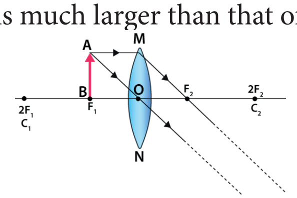


Fig. 10.33

v. **Object between Focus (F) and Optical centre (O) :** When an object is placed in between focus and optical centre, a virtual image is formed. The size of the image is larger than that of the object.

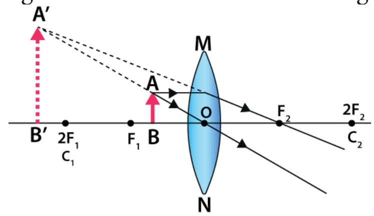


Fig. 10.34

Image Formed by Concave Lens

The image formed by concave lens are always virtual, erect and diminished on the same side as that of the object.

i. When an object is placed at infinity the image is formed at focus (F) which is virtual erect and highly diminished.

ii. When an object is placed between infinity and optical centre the image is formed between focus and optical center on the same side as that of the object. The image is virtual erect and diminished.

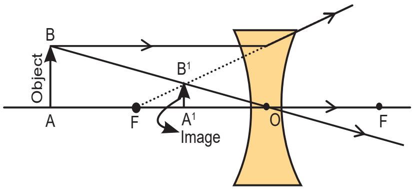


Fig. 10.35

Real Image and Virtual Image

An image that can be obtained on a screen is called a real image. It is formed by the actual intersection of the refracted rays. A convex lens usually forms a real image.

An image which can not be obtained on a screen is called a virtual image. Generally, a concave lens forms a virtual image. It is formed by the apparent intersection of the rays.

Difference between Real Image and Virtual Image

	Real image	Virtual image
i.	It is obtained on the screen.	It is not obtained on the screen.
ii.	It is usually formed on another side or behind the lens.	It is always formed on the same side of the object in the lens.
iii.	It is always inverted.	It is always erect.
iv.	It is formed at the point where the refracted rays meet.	It is formed at the point where the refracted rays appear to meet.

Uses of Lenses

Lenses are useful for various purposes. Some of them are listed below.

- They are used in optical instruments like camera, microscope, telescope etc.
- They are used to correct the defect of vision.
- They are used in the peeping holes of doors.

10.5 The power of the lens

The capacity to converge or diverge the rays of light is called power of lens It is the reciprocal of focal length, expressed in meter.

$$\text{Power} = \frac{1}{\text{Focal length in metre}} \qquad \text{i.e.} \qquad P = \frac{1}{f(m)}$$

The power of convex lens is positive and the power of concave lens is negative. The SI unit of power dioptre (D).

One Dioptre (1 D)

A lens is said to have power one dioptre if its focal length is one meter(1m).

As the focal length is long, the power of lens is less and vice-versa.

Solved Numerical Problems

i. **What is the power of a lens having focal length 25 cm? Also name the type of lens and why?**

Solution:

Focal length of lens. (f) = 25 cm

$$= \frac{25}{100} \text{ m} \qquad = 0.25\text{m}$$

Power of lens (P) = ?

We know,

$$P = \frac{1}{f(m)} \quad \text{or,} \quad P = \frac{1}{0.25} \qquad \therefore \quad P = 4D$$

The given lens is convex lens because its focal length is positive.

ii. **What is the power of convex lens (with sign) of focal length 40cm?**

Solution:

Since, Power = 1 / f

Substituting the given values as,

P = 100/40

= 2.5D

Since it's a convex lens, so power will be positive.

*Thus, the power of convex lens is **+2.5D.***

iii. **Identify the type of lens, and its focal length if its power is 0.2D.**

Solution:

Since the focal length, f = 1 / Power (P)

Therefore, substituting the given values in the above expression as:

f = 1 / (0.2D)

= 5 m

*Since the power is positive, therefore given lens is a **convex lens**.*

The relationship between power of lens and radius of curvature

There is a relation between the focal length of the lens and it's the refractive index, it's known as Lens maker's formula. It includes the radius of curvatures of both surfaces. The lens is a part of the hollow sphere of glass, Radius of curvature of the lens is the radius of that sphere. Each lens has two radii of curvature.

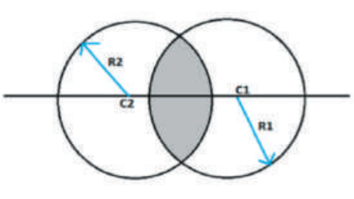


Fig. 10.36

According to the Lens maker's formula:

$1/f = (n-1) \times (1/R_1 - 1/R_2)$

where, n is the Refractive index of the material, f is the focal length of the lens, R_1 is the radius of curvatures of first surface and R_2 is the Radius of curvature of second surface.

Also the power of a lens is given by,

$P = 1 / f$

Now, from both the above equations:

$P = (n-1) \times (1/R_1 - 1/R_2)$

This is the required relation between the power and the refractive index of the lens. This formula can be used to find the power of the lens using the refractive index of the material and radius of curvatures of the lens.

10.6 Human eye

The human eye is a specialized sense organ in humans, capable of receiving visual images which are then carried to the brain. It is also a natural optical instrument. It is like a camera that has a lens and a screen system. It is mainly responsible for vision, differentiation of colour and maintaining the biological clock of the human body. One of the fastest muscles in the human body is orbicularis oculi, which is present in the eye. This muscle is responsible for the closing action of the eyelids – Hence, the expression, 'In the blink of an eye'. We actually see the world upside down, just like how a pinhole camera produces an inverted image. Our brain is wired to process and invert image. An eye exam or a sight test can detect diseases such as blood pressure and diabetes. Colourblindness is more prevalent in males. All babies are born colourblind. Colour vision starts weeks after birth and infants are able to fully perceive colour by 6 months. The Cornea, which is the transparent layer at the front of the eye is the only tissue in the body that does not have blood vessels. Having blood vessels may cloud and block vision.

Parts of the human eye and their functions

The human eyes are the most complicated sense organs in the human body. From the muscles and tissues to nerves and blood vessels, every part of the human eye is responsible for a certain action. Furthermore, contrary to popular belief, the eye is not perfectly spherical; instead, it is two separate segments fused together. It is made up of several muscles and tissues that come together to form a roughly spherical structure.

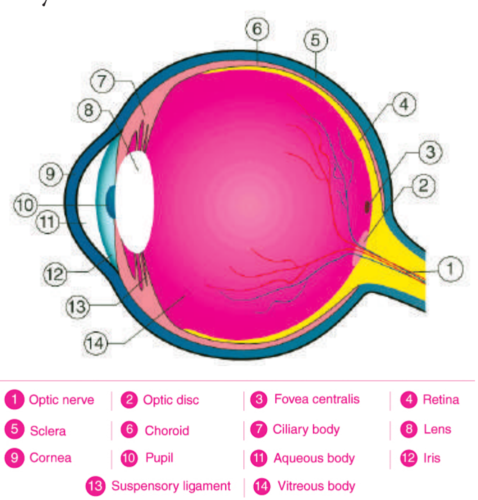


Fig. 10.37

From an anatomical perspective, the human eye can be broadly classified into external structure and internal structure.

The External Structure of an Eye

The parts of the eye that are visible externally include the following:-

Sclera: It is a white visible portion. It is made up of dense connective tissue and protects the inner parts.

Conjunctiva: It lines the sclera and is made up of stratified squamous epithelium. It keeps our eyes moist and clear and provides lubrication by secreting mucus and tears.

Cornea: It is the transparent, anterior or front part of our eye, which covers the pupil and the iris. The main function is to refract the light along with the lens.

Iris: It is the pigmented, coloured portion of the eye, visible externally. The main function of the iris is to control the diameter of the pupil according to the light source.

Pupil: It is the small aperture located in the centre of the Iris. It allows light to enter and focus on the retina.

The Internal Structure of an Eye

The internal components of an eye are:

Lens: It is a transparent, biconvex, lens of an eye. The lens is attached to the ciliary body by ligaments. The lens along with the cornea refracts light so that it focuses on the retina.

Retina: It is the innermost layer of the eye. It is light sensitive and acts as a film of a camera. Three layers of neural cells are present in them, they are ganglion, bipolar and photoreceptor cells. It converts the image into electrical nerve impulses for the visual perception by the brain.

Optic nerve: It is located at the posterior portion of the eyes. The optic nerves carry all the nerve impulses from the retina to the human brain for perception.

Aqueous Humour: It is a watery fluid present between the cornea and the lens. It nourishes the eye and keeps it inflated.

Vitreous Humour: it is a transparent, jelly-like substance present between the lens and the retina. It contains water (99%), collage, proteins, etc. The main function of vitreous humour is to protect the eyes and maintain its spherical shape.

The process of image formation in the human eye

Many parts of the eye shown and described on the page about the anatomy of the eye play important roles in the formation of an image on the retina, which is the back surface of the eye that consists of layers of cells whose function is to transmit to the brain information corresponding to the the image formed on it.

Those parts of the eye that do not take an active part in the formation of the image on the retina have other important functions, such as providing mechanical support to the structures of the eye or supplying the tissues with fluids, nutrients, and so on.

A ray-diagram can be used to show how light passes from a point on a real object (located somewhere in space outside the body) to the corresponding position on the image of the object on the retina at the back of the eye.

The following example is explained below:

i. Representation of an object:

First consider the **object** - which is represented by a simple **red arrow** pointing upwards (left-hand-side of diagram).

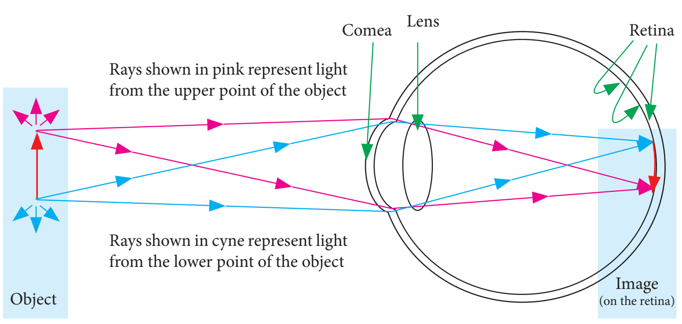


Fig.10.38 Basic ray diagram of imag formation within the human Eye.

Most real objects have complicated shapes, textures, and so on. This arrow is used to represent a very simple object for which just two clearly defined points on the object are traced through the eye to the retina.

ii. Light leaves the object - propagating in all directions:

It is assumed for simplicity that this is a **scattering object**, meaning that after light in the area (which may be called "**ambient light**") reaches the object, it leaves the surface of the object traveling in a wide range of directions.

Light leaving the object in all directions is represented by the small arrows pointing upwards, up-left, up-right (small pink arrows), and downwards, down-left and down-right (small green arrows).

Note that a very similar but slightly simpler case would be to consider a light source instead of a (solid, light scattering) object, and to say that the light source radiated light in all directions. That would result in the same diagram but would be less realistic because most of the light received by the eye is reflected or scattered from solid objects rather than coming directly from a source of illumination e.g. a lamp. In addition, one should never stare directly t bright light sources such as the sun, lasers, and other powerful light sources because doing so can cause permanent eye-damage.

2. Some of the light leaving the object reaches the eye:

Although the object is scattering light in all directions, only a small proportion of the light scattered from it reaches the eye.

The longer strong pink and green lines with the arrows marked along them are called "rays". These represent the direction of travel of light.

The pink rays indicate paths taken by light leaving the top point of the object (that eventually reaches the retina), while the green rays indicate paths taken by light leaving the lower point of the object (that eventually reaches the retina).

Only two rays are shown leaving each point on the object.This simplification is to keep the diagram clear. The two rays drawn in each case are the extreme rays, that is those that only just get through the optical system called the eye. These generally represent a cone of light that propagates all the way through the system from the object to the image.

The idea of this cone of light is represented on the diagram by the area between the pink (upper) rays being shaded pale orange. This shaded area is a reminder that light leaving the top of the object along any ray that could be drawn between the two (extreme) pink rays should reach exactly the same position in the image at the back of the eye. *The same applies to the area between the two green (lower) rays but this is not shaded to avoid over-complicating the diagram.*

3. Light changes direction when it passes from the air into the eye:

When light traveling away from the object, towards the eye, arrives at the eye, the first surface it reaches is the cornea.

The ray-diagram shows the rays changing direction when they pass through the cornea.

This change in direction is due to refraction (i.e. the re-direction of light as it passes from one medium into another, different, medium). For further detail see the page about refraction. Just to describe this ray-diagram it is sufficient to say that several structures in the eye contribute to image formation by re-directing the light passing through them in such a way as to improve the quality of the image formed on the retina. The parts of the eye responsible for most of the refraction of light passing through the eye are the cornea and the lens.

Most of the refraction (bending, or "re-directing" of the light) occurs at the interface between the air outside the eye and the cornea. The lens is important for accommodation, or "focusing", which is also described later.

4. Location of Focused Image:

Ray-diagrams generally consist of many rays representing light paths through a series of optical components.

These typically indicate light:

* **Leaving an object** (often drawn on the left-hand-side of the diagram),
* Passing through a series of **optical elements** (such as the cornea in this example), then eventually
* **Forming an image of the object** (often on the right-hand-side of the diagram).

How is the location of the image found or defined ?

When rays coming from a specific single location on the object (for example, consider the rays coming from the top of the object in this case), pass through the same position as each other in the area in which the image is formed, the point at which they intersect corresponds to the same location (in the image) as the rays left (on the object).

Complicated ray diagrams such as those used to design optical systems (e.g. telescopes) generally include more than two rays from each position on the object. The accuracy with which many rays from the same point on the object pass through the same position in the image space has important implications for focus and the quality of the image.

In this case the two (pink) rays shown coming from the top of the object meet again on the retina, at the back of the eye. The two (green) rays shown coming from the lower point of the object also meet again on the retina, at the back of the eye.

Therefore (in the ray-diagram shown above) the image is formed on the retina.

Recall that the retina is light-sensitive structure containing photosensitive cells (called rods and cones) that convert the light they receive into nerve impulses sent to the brain along the optic nerve: Images formed anywhere other than on the retina are not transmitted effectively to the brain - hence visual impairment(s).

Visual effects of corneal injury

A corneal injury (scratched cornea or scratched eye) is one of the most common eye injuries. A scratched cornea often causes significant discomfort, eye erythema, and photophobia. Corneal injury results from a disruption or loss of cells in the top layer of the cornea, called the corneal epithelium. It can be classified as traumatic, including foreign body-related and contact lens-related, or spontaneous.

Traumatic causes, such as tree branches, makeup brushes, workplace debris, and sports equipment, can all cause corneal injury. Sand and other small particles can cause a corneal abrasion, especially if you rub your eyes. Damaged contact lenses or prolonged use of contact lenses may increase your risk of a scratched cornea.

Corneal injuries are common eye injuries across all age groups. They are particularly common in the workplace.

Eye Donation (Corneal Transplant)

Eye donation involves donating your corneas – not your iris. Sometimes called a keratoplasty, or a corneal graft, a cornea transplant could give someone back the gift of sight. When you register as an organ donor, you can choose to be a tissue donor too. Almost anyone can donate their corneas. The cornea is the clear tissue at the front of your eye that lets in light so you can see. This small and simple part of the eye is hugely important for thousands of cornea transplants a year, often saving the sight of patients for many years.

Your corneas could be invaluable for saving someone's sight. Most people are able to donate their corneas when they die. As with other tissue donations, even people who may be unable to donate their organs can usually become cornea donors. This is because not all of the restrictions that apply to organ donation are applicable to tissue donation. There is no age restriction for donating eyes, skin or bone.

With more donors, we could be changing many more lives. Cornea transplants usually have a very good chance of success. Around 93% of transplants continue to function after one year. By five years, 74% of transplants are still working well and many will continue for many more years after that.

The sooner that donation takes place, the better the transplant outcome. But, your corneas can be donated up to 24 hours after you die. People can need cornea transplants for quite a number of reasons including:

- disease or injury that has made the cornea cloudy or distorted, causing vision loss
- scarring of the cornea after infections such as corneal ulcer
- Keratoconus (thinning of the cornea that causes a cone-like bulge to develop, usually in young people)
- age or inherited conditions that may lead to cloudiness of the cornea in older people
- scarring caused by herpes, the cold sore virus.

A cornea transplant makes a lasting difference to people's lives and is a relatively quick procedure. Depending on which type of corneal transplant people need, and how much of the cornea needs replacing, the transplant can be completed in under an hour.

Tell your friends and family that you want to be a cornea donor – it is very important that they understand and support your organ and tissue donation decision because your family's support is needed for donation to go ahead. Dealing with the death of a loved one is a difficult time to make an important decision quickly.

Introduction to Color Blindness

Colour blindness can be simply defined as trouble in seeing or identifying colours like blue, green and red. There are some rare cases where a person cannot see and identify any colours at all. A person with this syndrome also finds difficulties in differentiating the colours with shades. This syndrome is also called a colour vision problem or colour vision deficiency. The healthy human eye retina contains two light-sensitive cells – rod cells and the cone cells.

The rod cells are for low light and the cone cells are for normal and bright light and responsible for colour vision. Colour blindness is affected when these two light-sensitive cells fail to perform their functions.There are several factors, which causes a colour vision problem in a person. The factors include: Damaged caused to brain or eye or to the nerve cells, genetic disorders, side effects of drugs, and use of tobacco and alcohol.

Symptoms of this eye syndrome include :Rapid eye movement, sensitivity towards the bright light, trouble in seeing colours and the brightness of colours, and the problem in identifying the differences between colours shades.

Currently, there is no treatment for this syndrome. Photographic frames or filters and eyeglasses with contact lenses can be used to a certain extent to improve the dimension between some colours. A properly balanced diet can be followed to improve the symptoms of colour blindness.

Introduction to Cataracts

A cataract is an eye condition in which the lens of the eye becomes cloudy. This causes vision to worsen, making it especially difficult to see fine details clearly. Some people's vision is only slightly affected, whereas others might lose their eyesight very quickly. How it progresses will depend on things like the exact type of cataract.

Cataracts mostly affect people over 50. The risk increases with age: About 20 out of 100 people between the ages of 65 and 74 have a cataract. And more than 50 out of 100 people over the age of 74 are affected.

Cataracts are the main cause of blindness in developing countries. The number of people who go blind from cataracts is considerably lower in industrialized countries due to the availability of effective surgery. Cataract surgery involves removing the cloudy eye lens and replacing it with an artificial lens.

Vision loss due to cataracts is usually very gradual. That is the only symptom: Cataracts aren't painful and don't cause burning or any similar symptoms. People's vision becomes increasingly blurred and cloudy, as if they are looking through fog. Contrasts and colors become less clear as time goes on. Some people become very sensitive to the glare of the sun or other bright lights. Driving becomes more difficult, particularly at night. Poor vision increases the risk of falling and hurting yourself. Spatial vision is affected as well.

Cataracts may have surprising effects too: Sometimes people who wear glasses can suddenly see better without them. This is because the refractive power of their eye changes, affecting their ability to focus on objects at different distances. Improved vision without glasses doesn't last long, though.

Introduction to Night blindness

Night blindness is a type of vision impairment also known as nyctalopia. People with night blindness experience poor vision at night or in dimly lit environments. Although the term 'night blindness' implies that you can't see at night, this isn't the case. You may just have more difficulty seeing or driving in darkness. Some types of night blindness are treatable while other types aren't. See your doctor to determine the underlying cause of your vision impairment. Once you know the cause of the problem, you can take steps to correct your vision.

The sole symptom of night blindness is difficulty seeing in the dark. You're more likely to experience night blindness when your eyes transition from a bright environment to an area of low light, such as when you leave a sunny sidewalk to enter a dimly lit restaurant. You're also likely to experience poor vision when driving due to the intermittent brightness of headlights and streetlights on the road.A few eye conditions can cause night blindness, including:

- nearsightedness, or blurred vision when looking at faraway objects
- cataracts, or clouding of the eye's lens
- retinitis pigmentosa, which occurs when dark pigment collects in your retina and creates tunnel vision
- Usher syndrome, a genetic condition that affects both hearing and vision

Older adults have a greater risk of developing cataracts. They're therefore more likely to have night blindness due to cataracts than children or young adults.

Vitamin A deficiency can also lead to night blindness.Vitamin A, also called retinol, plays a role in transforming nerve impulses into images in the retina. The retina is a light-sensitive area in the back of your eye. Blood testing can measure your vitamin A and glucose levels.

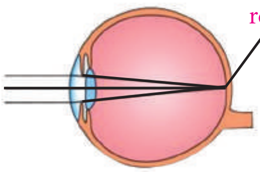
Night blindness caused by nearsightedness, cataracts, or vitamin A deficiency is treatable. Corrective lenses, such as eyeglasses or contacts, can improve nearsighted vision both during the day and at night.

An introduction to defect of vision

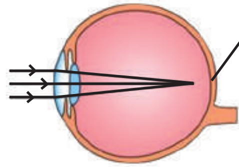
When the lens of eye can not change its focal length according to the distance of an object the eye becomes unable to see the objects clearly placed at any point within the range of vision. This is called defect of vision, when ciliary muscles fail to contract or expand the eye lens properly.

There are two most common defects of vision.

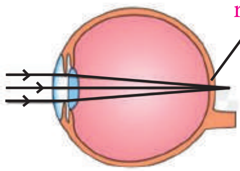
a. shortsightedness (Myopia)
b. longsightedness (Hypermetropia).



Normal Eye
(Light focuses on retina)



Near sighted Eye
(Light focuses in front of retina)



Far sighted Eye
(Light focuses behind of retina)

Fig. 10.39

i. Short - sightedness (Myopia)

It is the defect of eye in which a person can not see the distance object clearly but can see the near by objects distinctly. In this case, the image of distanced object is formed in front of retina as shown.

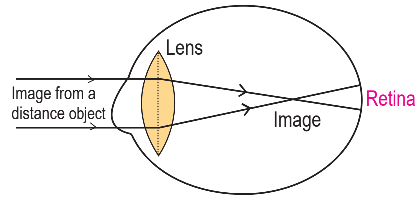


Fig.10.40 short-sightedness of eye

Causes of defect

i. Elongation of the eye balls.
ii. Decreasing of focal length of the eye lens.

Remedy

This defect is corrected by using concave lens of suitable focal length. The concave lenses diverge the light rays, so the image is formed exactly on the retina. Actually, this concave lens forms the virtual image of the distant object at far point as shown figure below.

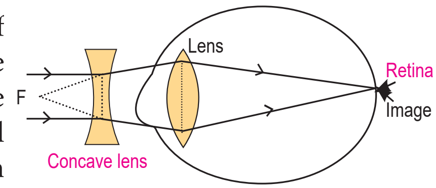


Fig.10.41 remedy of short-sightedness of eye

ii. Long-sightedness (Hypermetropia)

It is the defect of eye in which a person can not see near object but can see distance object clearly. In this case the image of near object is formed behind the retina as shown in the figure.

Causes of defect

i. Shortening of eyeball.
ii. Increasing the focal length of the eye lens.

Remedy

This defect is corrected by using convex lens of suitable focal length. The convex lens converge the light rays, so the image is formed on the retina. Actually, this convex lens forms virtual image of the object at the 25cm at the near point.

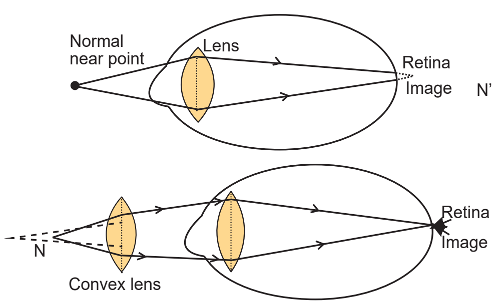


Fig. 10.42 long-sightedness of eye and its remedy

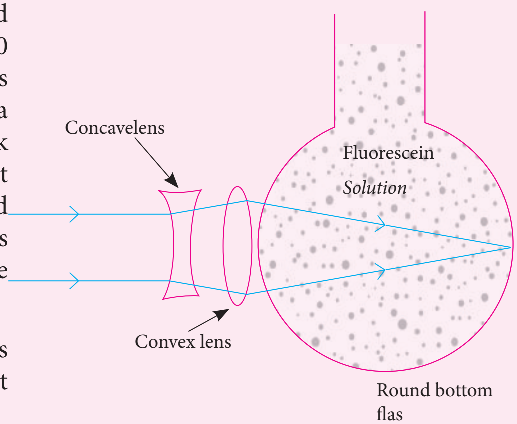
Difference between Myopia and Hypermetropia

S.N.	Short sightendness (Myopia)	Long sightendness (Hypermetropia)
i.	It is the defect of vision in which a person can see near object but can not see distant object.	It is the defect of vision in which a person can see distant object but can not see the near object.
ii.	The focal length of eye lens is always small.	The focal length of the eye lens is always large.
iii.	This defect is removed by using suitable concave lens on spectacles.	This defect is removed by using suitable convex lens on spectacles.
iv.	The image of the nearby object is formed behind the retina.	The image of the distance object is formed in front of the retina.

Activities 10.6

Fill a round bottom flask with clean water and few drops of fluorescein solution (1 g per 100 ml of methylated spirit) until the light beam is clearly visible in the solution. Select and fix a suitable convex lens in round bottom flask with cello-tape to focus the beam of light infront of retina (opposite wall of round bottom flask). Shine a beam of light on the lens and observe what happens to the beam inside the flask.

Put a concave lens infront of the convex lens in flask and pass light through it and see what happens to the beam inside the flask again ?



Causes of vision defects

Vision changes (defects) may be caused by a wide variety of underlying conditions or diseases. Some vision change originate in the eye itself, while others are caused by conditions that affect the brain, central nervous system, or other parts of the body. Although many of the conditions that cause vision changes are not serious and can be easily corrected with eyeglasses or contact lenses, others may be caused by sight-threatening or life-threatening conditions. Contact your health care provider to determine the cause of your vision changes.

Common causes of vision defects

Vision defects may be caused by conditions including:

- Age-related macular degeneration (disorder that causes loss of vision in the macula, the area of the retina responsible for seeing detail in the central vision)
- Cataracts (clouding or loss of transparency in the lens of the eye)
- Corneal edema (swelling and clouding of the normally transparent cornea)
- Diabetic retinopathy, cataracts, and blindness (serious vision complications of diabetes)
- Dry eyes
- Infections of the eye
- Injury to the eye
- Macular edema (fluid accumulating within layers of the retina)
- Migraines
- Myopia (nearsightedness; inability to focus on distant objects)
- Need for corrective lenses, such as eyeglasses or contact lenses, or need for change in eyewear prescription
- Presbyopia (age-related farsightedness; inability to focus on near objects)
- Retinal detachment
- Uveitis and iritis (inflammation of structures of the eye)

Some methods for correcting vision defects

There are many methods to correct vision impairment. Here we will discuss eyeglasses, contact lenses, and laser surgery.

- **Eyeglasses**

  Eyeglasses are the most common form of eyewear used to correct or improve many types of vision problems. They consist of a frame that holds 2 pieces of glass or plastic, which have been ground into lenses to correct refractive errors. Refractive errors can include trouble seeing far away (nearsightedness or myopia) and trouble seeing close up (farsightedness or hyperopia). They can also include blurring due to an irregularly shaped cornea (astigmatism). Eyeglasses work by adding or subtracting focusing power to the eye's cornea and lens.

- **Contact lenses**

  Contact lenses are thin, clear plastic disks you wear in your eye to improve your vision. Contacts float on the tear film that covers your cornea.Like eyeglasses, contact lenses correct vision problems caused by refractive errors. A refractive error is when the eye does not refract (bend or focus) light properly into the eye resulting in a blurred image.

- **Laser Surgery**

  Laser eye surgery is the best known and most commonly performed laser refractive surgery to correct vision problems. Some people call it LASIK surgery, or laser-assisted in situ keratomileusis. During LASIK surgery, a special type of cutting laser is used to precisely change the shape of the dome-shaped clear tissue at the front of your eye (cornea) to improve vision. The surgery can also be costly, depending on where a person lives. Some people's corneas can undergo changes in their shape, leading to vision issues such as astigmatism and myopia. Laser eye surgery is a medical procedure that reshapes this layer. Precisely how laser eye surgery reshapes the cornea depends on the vision condition that the treatment aims to correct. Laser eye surgery can fix vision issues such as nearsightedness and farsightedness. The surgery is quick, and people remain awake throughout the procedure. It is also usually painless—if a person experiences pain, it usually indicates there have been complications.

Project Work

i. Make a small hole at the bottom of a milk can and close it with finger. At a dark room at night fill 3/4 of the cane ii ith clean (filtered) water. Light a torch in the container so that whole light shives down into the water. Remove the finger and let the water pour into sink. Does the stream of water sparkel ? Why does it happened so ? Write a report .

ii. Estimate your own near point distance. Look at some words printed on a page and slowly bring it near. Find till what distance you can read the word without making any strain to your eye. If yoeit short sighted, find your far point. Write a report .

iii. Look at the cross and spot in figure with your right eye closing left eye. Focus your right eye on the dot at the same time you will sec the cross. Slowly bring the book nearer and nearer. When the image of cross falls on blind spot of your eye you cannot see the cross. If you bring the book nearer again you will see the cross. Write a report .

iv. Fill a glass with water and dip a drinking straw keeping its one end about 1 cm above the water level .. Blow the end with another straw, you will sprinkle water in air. Let one of your friends looks sprinkled water keeping the sun behind him. He will see the spectrum. How is it seen ? Write a report .

Exercise

A. Choose the correct one and put the tick mark (√).

i. Mechanical wave is-

a. Elastic wave b. Electromagnetic wave c. Matter wave d. None of these

ii. Transverse wave motion is type of-

a. Longitudinal wave motion, b. Electromagnetic wave

c. Matter wave d. Mechanical wave

iii. Electromagnetic Waves are-

a. Longitudinal wave motion, b. Electromagnetic wave

c. radiowaves d. Mechanical wave

iv. Which is not correct matter wave

a. electrons b. protons c. neutrons d. microwaves

v. The ____________ of a material affects the speed that a wave will be transmitted through it.

a. velocity b. speed c. density d. wavelength

vi. The stars twinkle due to atmospheric.____________

a. refraction b. reflection c. dispersion d. vision

vii. Definition of Total Internal Reflection -

a. the angle of incidence beyond which rays of light passing through a denser medium to the surface of a less dense medium are no longer refracted but totally reflected.

b. it is intimately called, is the reflection of the total amount of incident light at the boundary between two media.

c. the bending of a ray when it passes at an angle from one medium into another in which its speed is different.

d. the separation of white light into colours or of any radiation according to wavelength.

viii. Law of refraction

a. the relation between the wave velocity v., its frequency (F) and the wavelength (λ) in the wave motion.

b. the incident ray, the refracted ray and the normal at the point of incidence, all lie in the same plane.

c. the angle between the incident ray and the normal is equal to the angle between The reflected ray and the normal.

d. a process by which (in the case of solid dispersing in a liquid) agglomerated particles are separated from each other.

ix. A lens is -

a. the reciprocal of the focal length.

b. a process by which (in the case of solid dispersing in a liquid) agglomerated particles are separated from each other.

c. the bending of a ray when it passes at an angle from one medium into another in which its speed is different.

d. a clear curved piece of material (as glass) used to bend the rays of light to form an image.

x. Defects of vision
  a. the two main types of lenses are: Convex Lens (Converging) Concave Lens (Diverging)
  b. three notable categories: transverse waves, longitudinal waves, and surface waves.
  c. there are three typical eye defects and they are myopia or near-sightedness, Hypermetropia or far-sightedness, and Presbyopia.
  d. three types are modal, chromatic, and material.

xi. Effects of corneal injury on vision are
  a. shifting, dryness, and other complications.
  b. modal, chromatic, and material.
  c. bending of light, change in wavelength of light,and splitting of light rays
  d. macular blindness, cataracts, and color blindness.

xii. A lens which is thicker at the center and thin at the edges is called
  a. Convex b. Plano convex c. Concave d. Plano concave

xiii. Where is the image of an object formed when it is placed beyound 2F of convex lens ?
  a. at 2F b. at F c. between F and 2F d. at infinity

xiv. Where should the object be placed in convex lens to obtain erect virtual and magnified image ?
  a. at infinity b. at 2Fc. Beyound 2F d. between F and O

xv. What is the power of a lens having focal length 4 cm ?
  a. 2D b. 25D c. 50D d. 2.5D

xvi. In a human eye amount of light is controlled by
  a. Retina b. Cornea c. Iris d. Sclera

B. Differentiate between these pairs.

i. Waves and Wavelength
ii. Refraction and Total internal reflection
iii. Refraction and Dispersion
iv. Convex lens and Concave lens
v. Eye and Lens
vi. Virtual image and real image
vii. Myopia and hypermetropia
viii. Night blindness and colour blindness
ix. Focal length and Focal point
x. Mechanical wave and Electromagnetic wave
xi. Transverse wave and Longitudinal wave

C. Explain the following:

i. A pencil partly dipped in water seems to be bent.
ii. Mirage occurs only on desert or above the straight pitched road in madhesh region.
iii. Pure diamond flashes brilliantly than glass diamond.
iv. Sunglasses have curved surface but still do not have any power.
v. The sky appears reddish during sun set.
vi. A ray of light is dispersed by prism .
vii. When sunlight is focused on a paper it burns.
viii. Short sighted person uses concave lens in spectacle.
ix. Sound wave is called mechanical wave.
x. Convex lens is called converging lens.
xi. The power of concave lens is negative.
xii. Lens refracts the light .

D. Answer the following questions :

i. What is a wave? How many types of waves ?
ii. Write down the relations between wave velocity, frequency, and wavelength in refraction.
iii. What is the refraction of waves?
iv. Write down the concept of refraction of waves.
v. What are the laws of refraction?
vi. What is Snell's law?
vii. Explain the total internal reflection of waves with a suitable figure . Write the conditions of total internal reflection.
viii. What is the critical angle?
ix. Write down the uses of the total internal reflection of light in daily life.
x. What are light pipes? Write the uses of light pipes.
xi. What is the Dispersion of Light? Write down the causes and uses of it.
xii. How is the rainbow formed?
xiii. How does a prism's light dispersion work?
xiv. What is a lens? How many types of lenses? Describe it briefly .
xv. Write down the rule of refraction in lenses.
xvi. Draw a lebel figure of a human eye.Write briefly about its important parts.
xvii. Write down the process of image formation in the human eye with a sketic diagram.
xviii. Write the relationship between the power of the lens and the radius of curvature .
xix. What are the visual effects of corneal injury? Write down the cause and any two methods of correction.
xx. What is Eye Donation? How and who does this ?
xxi. What is color blindness ?
xxii. What are cataracts and night blindness?
xxiii. Write down some methods for correcting vision defects .
xxiv. What is lens ? Write its types.
xxv. Define power of lens. Name its unit and formula.
xxvi. Draw the ray diagram for a convex lens and also write the size, nature, and position of the image when the object is place.
    a. Beyond 2 F   b. At 2 F   c. Between F and O
xxvii. A lens forms an erect, diminished and virtual image when an object is place between optical centre and principal focus.
    a. Name the types of lens.
    b. Draw ray diagram to show the image formed.
xxviii. What is defect of vision? Write its types.

xxix What is long-sightedness? Write down its causes and remedy with a diagram.

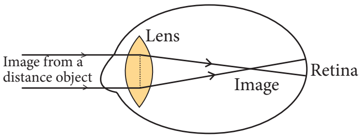
xxx. What is the defect of vision of eye shown in the given figure? How is it corrected? What are its causes.?

xxxi. A student sitting at the back of his class room has difficult in reading the blackboard but he can read his book easily.

a. What is the defect of vision ?

b. What are the causes of this defect?

c. Which lens should be used to correct this defect?



xxxii. Define the following terms:

a. Radius of curvature

b. Principal focus

c. Principal axis

d. Focal length

xxxiii.Sanjay sees distant objects comfortably but he wears spectacles while reading a book.

a. What defect of vision does he have ?

b. What type of spectacles should he use ?

xxxiv.A student sitting on the back bench in a class is not able to see the writing on the white board. What type of defect is he suffering from?

xxxv.Sheetal wears a lens of power + 2D. Answer the following questions.

a. What is the defect of Sheetal's vision called?

b. How is it removed ? Explain with a suitable diagram.

c. Name the lens used.

d. How does she hold a newspaper while reading without using the lens why?

E. Solve the following numerical problems.

i. The power of a lens is + 4D. What is its focal length? Also write its types.(Ans. 25 cm)

ii. Calculate the power of a concave lens having focal length 20 cm. (Ans. 5 D)

iii. An object is placed twice of its focal length. If the focal length of a convex lens is 5 cm. Draw a ray diagram and calculate.

a. Image distance. b. Magnification of the lens.

c. Power of the lens. [Ans. 10 cm, 1,20 cm]

iv. A burning candle is placed at a distance of 12 cm far from a convex lens having focal length of 8 cm. Draw a ray diagram to show the formation of image. Also find out magnification and power of the lens. Write the nature of image too.

v. A convex lens of focal length 10 cm is placed at a distance of 12 cm from a wall. How far from the lens should an object be placed so as to form its real image on the wall?

vi. If an object of 7 cm height is placed at a distance of 12 cm from a convex lens of focal length 8 cm, find the position, nature and height of the image.

F. Write a short note :

i. Refraction of Waves

ii. Laws o f refraction

iii. Total internal reflection

iv. Utility of TIR

v. Dispersion of light

vi. Convex lens

vii. Concave lens

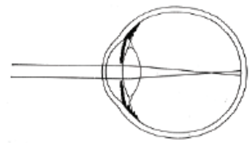
viii. Daily uses of dispersion of light

ix. Rules of refraction

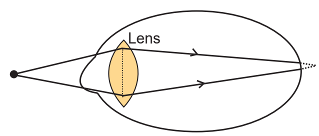
x. Real image

G. Diagrammatic questions.

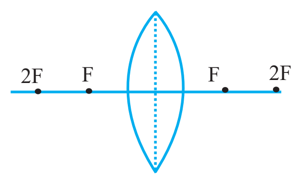
i. What is the defect of vision of the eye in the given figure? What is to be done to correct the defect of vision and why?



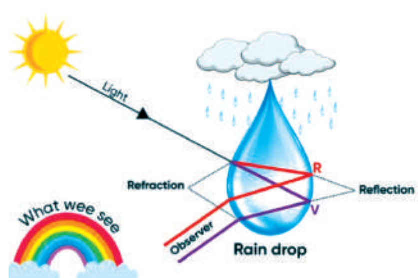
ii. What is the defect of vision in the eyes shown in the given figure? What is to be done to correct this defect of vision and why?



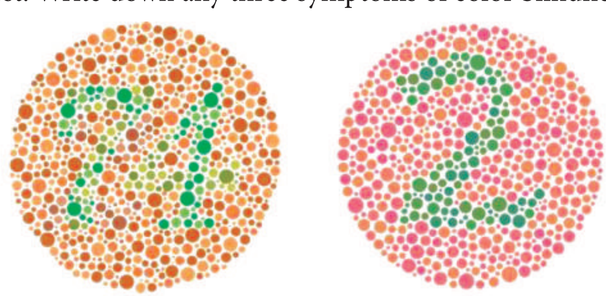
iii. Complete the diagram and write the features of the image formed.



iv. What is the picture below related to? Write about the process in brief.



ii. Certain tests are available to diagnose and measure a patient's color vision deficiency. Doctors can easily diagnose color blindness by using the Ishihara Plate Test. Following is a diagram of this test. Write down any three symptoms of color blindness.



Chapter 11

Electricity and Magnetism

Total Estimated pariods (Th. 10+ Pr. 2=12)

Student's Learning Outcomes

After studying this unit, the students will be able to :

- introduce direct current and alternating current,
- show and draw a diagram of the magnetic field generated by a current-carrying straight wire and solenoid.
- introduce magnetic lines of force and magnetic flux,
- introduce the motor effects and describe their use in daily life
- state Faraday's law of electromagnetic induction and explain the working process of an AC generator/dynamo based on it.
- explain the structure, working process, and importance of the transformer and make simple calculations related to it.

Hans Christian Orsted (born August 14, 1777, Rudkøbing, Denmark—died March 9, 1851, Copenhagen), also spelled Oersted, was a Danish physicist and chemist who discovered that an electric current in a wire can deflect a magnetized compass needle, a phenomenon the importance of which was quickly recognized and which inspired the development of electromagnetic theory.

Orsted became a professor at the University of Copenhagen in 1806 and conducted his first physical research on electric currents and acoustics.

Introductions

Current electricity is possessed due to flow of electrons. It is regarded as the main source of energy in our daily life. In general, electricity is meant by current electricity. It has many common uses in our daily life. It has made our life easier and more comfortable. It is used to operate different types of electrical appliances. We can convert electric energy into other forms of energy like heat, light, sound, magnetic, etc. Electricity influences each and every field of the world. It is renewable source of energy and pollution free source of energy. So, it is very popular source of energy.

In this lesson we study about effects of electricity, electric and magnetic instruments used in our daily life and electric power consumption.

11.1 Direct current (DC) and alternating current (AC)

If the polarity of an electrical source does not change with time, it is called direct current (DC). Battery and dynamo are sources of direct current. Conventional direction of direct current is from the positive terminal of a cell to its negative terminal.

Alternate current (AC) changes its direction at regular intervals. It is usually defined as the current used in power supplies. It flows in one direction during the first half and in the opposite direction in the next half. The frequency of electricity supply in Nepal is 50Hz. It means the polarity of the AC changes 50 times in 1 second. The source of AC is an AC generator.

Fig. 11.1 Cell (source of DC)

Fig. 11.2 AC generator

Difference between Direct Current and Alternating Current

SN.	Direct Current (DC)	Alternating Current (AC)
i.	Polarity of direct current does not change with time.	Alternating current changes its magnitudes continuously and reverses its direction periodically.
ii.	DC voltage cannot be altered by transformers.	AC voltage can be altered by transformers
iii.	It is generated by battery and dynamo.	It is generated by an AC generated.

The average voltage and frequency of the mainline are used in Nepal.

Like most other countries in the South-Asian regions, Nepal too has an average voltage of 230-volts and a frequency of 50-hertz. The home power supply is 230 volts across Nepal. All the local electrical equipment is meant to run on 230 volt, 50 hertz supply. According to "Electricity Rule-2050", 230 volts in A.C. single phase and 400 volts in three phases for general consumers. Electric service at 230/400 volts, three phases, shall be made available to those who require a supply of electricity from four wires, as mentioned in this electric rule. The rule says: The fluctuation in standard volts shall not be greater than 5%, as specified in the Clauses of electricity rules. Similarly, the standard for the frequency is 50 cycles per second (50 hertz). As specified in sub-rule of electricity rule 2050, the fluctuation in the frequency standard shall not exceed 2.5 percent.

11.2 Introduction to the Magnetic Effect of current Electricity

Electricity and magnetism are closely related. A magnetic effect is created when an electric current travels through a copper wire. Hans Christian Oersted was the first to detect the magnetic effects of electric current. The magnetic field is a force that is created by magnetic dipoles and by moving electric charges, and due to the magnetic field, it exerts forces on the nearby moving charges. The magnetic field has both direction and magnitude, and hence it is a vector quantity. The magnetic field shows the strength of a magnet and the direction of the force of the magnet. The strength of the magnet is represented by magnetic field lines from north to south and south to north inside and outside the magnet, respectively.

We use many appliances at home, like mixers, grinders, fans, etc., which draw electricity and convert it to motor movement, i.e., mechanical energy. Also, we know of turbines, windmills, generators, etc., which move a mechanical part to generate electricity. These are possible because when electric current flows through a wire, it produces a magnetic effect around it.

When current flows through a conductor, a magnetic field is developed around it. This effect of current is known as the magnetic effect of current.

Magnetic effects of electric current

Compass needle

A compass needle is a small magnet. Its one end, which points towards north, is called a north pole, and the other end, which points towards south, is called a south pole.

Relation between Electricity and magnetism (Oersted's Experiment)

The first evidence of any connection between Electricity and magnetism was established by Hans Christian Oersted. He accidentally discovered that as he laid a wire carrying an electric current near a magnetic compass needle, it got deflected as if acted upon by a magnet. This observation led to the discovery that when current passes through a conductor, magnetic field is produced around it.

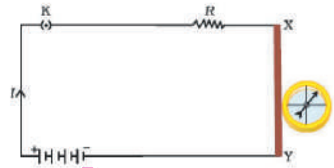


Fig. 11.3

Magnetic field

The space around a magnet or a current carrying conductor, in which the force of attraction or repulsion can be experienced, is called a magnetic field.

Demonstration of magnetic field lines (Iron-filings pattern)

1. Take a bar magnet and placed it on a cardboard.
2. Sprinkle some iron-fillings around the magnet.
3. Tap the cardboard gently.
4. Iron fillings arrange themselves in a pattern as shown in figure.

Conclusion : This pattern demonstrates that under the influence of magnetic field, the fillings align themselves along the magnetic field lines.

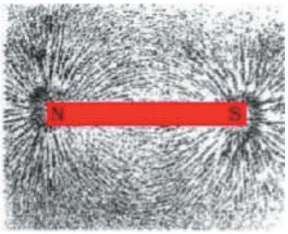


Fig. 11.4

Activities 11.1

Tracing of magnetic field lines of a bar magnet

1. Place a bar magnet on a sheet of paper.
2. Bring the compass near the north pole of the magnet.
3. The needle will deflect such that its south pole points towards North Pole of the bar magnet.
4. Mark the position of two ends of needle.
5. Move the compass so that its south end occupies the position previously occupied by the north end.
6. Again mark the new position of ends of needle .
7. Repeat step 5 and 6 till you reach the south pole of the magnet.
8. Join the points marked to get a smooth curve, which represents a field line.

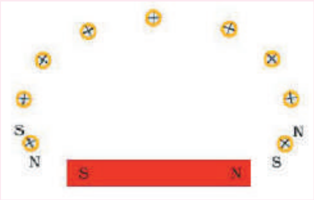


Fig. 11.5

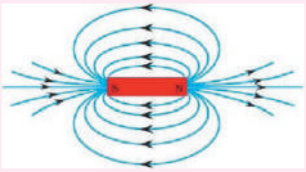


Fig. 11.6

Magnetic field lines

Magnetic field lines are the imaginary lines used to represent a magnetic field. A field line is the path along which a hypothetical free north pole would tend to move. The direction of themagnetic field at a point is given by the direction that a north pole placed at thatpoint would take.

Properties of Magnetic field lines

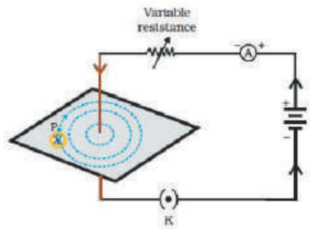


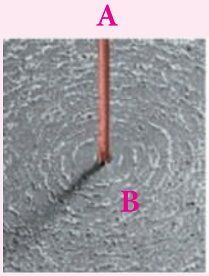
Fig. 11.7

1. Outside the bar magnet, the magnetic field lines originate from the north pole of a magnet and end at its south pole.
2. Inside the bar magnet , field lines move from South Pole of the magnet to the North Pole.
3. Magnetic field lines always form closed curves.
4. The region s, where field li nes are closer, the field i s strong and the regions , where the field lines are farther apart, the field is weak.
5. The direction of the magnetic field is taken to be the direction in which a north pole of the compass needle moves inside it.
6. The magnetic field lines never cut each other. In case, two field lines intersect each other at a point, then it will mean that at the point of intersection, the magnetic needle would point in two different directions, which is not possible.

Activities 11.2

Magnetic field around a current carrying straight conductor

1. Take a straight wire AB and pierced it through a horizontal cardboard such that wire AB is vertical.
2. The ends of the wire AB are connected to a battery.
3. Place some iron fillings on the cardboard.
4. switched the key on.
5. Gently tap the cardboard.
6. The iron fillings arrange themselves in concentric circles around the wire.
7. This shows that magnetic field lines are concentric circles. The circles become larger and larger as we move away from the wire.



Direction of field lines- Right Hand thumb rule

Imagine that you are holding a current carrying wire in your right hand such that the thumb is stretched along the direction of the current, then, the fingers will wrap around the conductor in the direction of the field lines of the magnetic field.

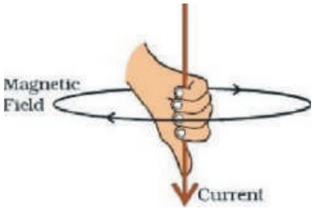


Fig. 11.8

The magnetic field around a current-carrying straight wire and solenoid

In the sketch (a) above, a current is being pushed through a straight wire. Small compasses placed around the wire point in a circle instead of all towards the north pole. This demonstrates the presence of a magnetic field around the wire. If the current is turned off, the compass points return to pointing north.

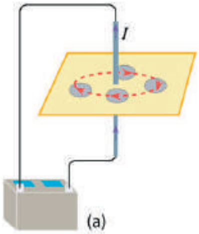


Fig. 11.9

The current moving through a straight wire produces a circular magnetic field around the wire. When using conventional current, the direction of the magnetic field is determined by using the right-hand rule.

Rotational Direction: Current-Carrying Wires

When an electric current passes through a straight wire, it induces a magnetic field. To apply the right hand grip rule, align your thumb with the direction of the conventional current (positive to negative) and your fingers will indicate the direction of the magnetic lines of flux.

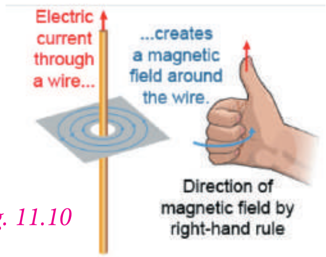


Fig. 11.10

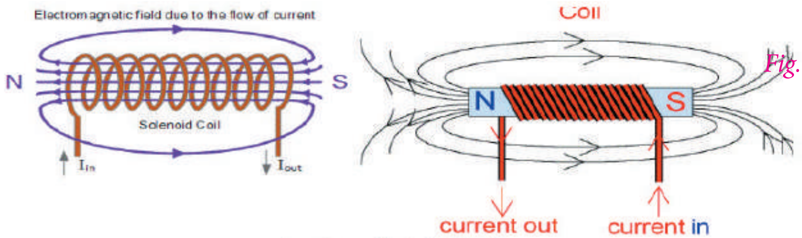


Fig. 11.11

A coil with many circular close turns of insulated copper wire (like a cylinder as shown above) is a solenoid. One end of such a solenoid behaves like the north pole and the other as the south pole.

Therefore, the magnetic field due to current in the solenoid is similar to a bar magnet. The fields always emerge from the North Pole and always merge into the South Pole. The field inside the solenoid is uniform. The strong magnetic field inside the solenoid is so strong that it can be used to magnetize a piece of soft iron when it is placed inside the coil. The magnet formed like this is called an electromagnet.

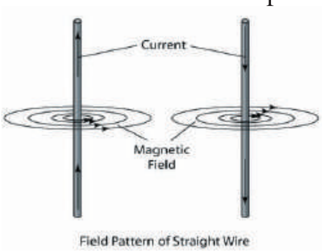


Fig. 11.12

Rotational Direction: Solenoids

When an electric current passes through a solenoid, it creates a magnetic field. To use the right hand grip rule in a solenoid problem, point your fingers in the direction of the conventional current and wrap your fingers as if they were around the solenoid. Your thumb will point in the direction of the magnetic field lines inside the solenoid. Note that the magnetic field lines are in the opposite direction outside the solenoid. They wrap around from the inside to the outside of the solenoid.

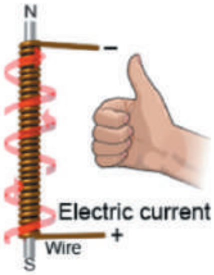


Fig. 11.13

Electromagnet

A temporary magnet made by passing electric current through a coil (solenoid) wrapped around a core of magnetic substance is called electromagnet. Electromagnets are used in many instruments like radio, telephone, electric bell, loud speaker etc.

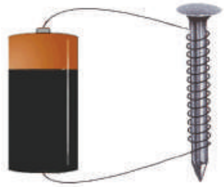


Fig. 11.14 electromagnet

Method to make electromagnet

i. Take a piece of soft iron bar or iron nail.
ii. Wind the insulated copper wire over the iron bar as shown in figure.
iii. Connect the two ends of wire with two terminals of a battery.

The strength of electromagnets can be increased by the following methods.

i. By increasing the number of turns of the wire.
ii. By increasing the magnitude of current.
iii. By inserting soft iron core in the solenoid.

Characteristics of an electromagnet

i. It is a temporary magnet.
ii. Its magnetic strength can be altered.
iii. It doesnot get demagnetized by its storage for long time.
iv. Its poles can be reversed.
v. It can be made very powerful too.

Uses of electromagnet

- Electromagnets are widely used in electrical appliances such as loudspeaker, radio, television and electric bells.
- They are used in industries for lighting and transporting steel plates, scrap iron etc.
- They are also used for removing magnetic particles such as small steel particles from the eyes of a person.
- They are used in separation of magnetic bodies from garbage.

Electric Bell

It is one of the applications of electromagnet. It converts electrical energy into sound energy. Electric bell is used in school, home and office.

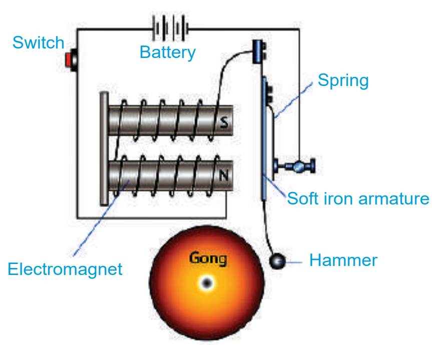
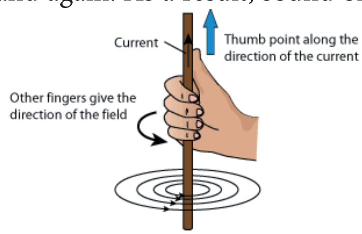


Fig. 11.15 electric bell

It consists of U-shaped soft iron core. This iron core is winded with insulated wire to make it an electromagnet. When the switch is pressed electromagnet attracts iron strip towards itself. This brings the hammer in contact with the bang and sound is produced. Due to displacement of the iron strip from its original position, it loses contact with the screw strip and the circuit of electromagnet breaks. At this time electromagnet loses its magnetism and the iron strip comes back to its original position to complete the circuit again. In this way, entire process is repeated as long as the switch is kept pressed. The hammer strikes the bang again and again. As a result, sound of bell is heard.

Right-Hand Grip Rule

Right Hand Grip Rule states that if we arrange our thumb, forefinger and middle finger of the right-hand perpendicular to each other, then the thumb points towards the direction of the magnetic force, the forefinger points towards the direction of the magnetic field and the middle finger points towards the direction of the current.



Right Hand Grip Rule
Fig. 11.16

In electricity and magnetism, we can know the direction of a charge in a magnetic field through the law of the hand grip rule. To determine the direction, we place the right hand's thumb in the same direction as the electric current passing - from positive to negative. Then, if we bend the remaining fingers of the hand, they indicate the direction of the magnetic field lines.

There is also another version known as the three-finger rule. In this case, the right hand's thumb indicates the speed of the movement of the conductor, the index finger points to the direction of the induction of the magnetic field. Lastly, the bent middle finger represents the return of the induced current.

John Ambrose Fleming was the inventor of this rule to determine the direction of the magnetic field that produces moving charges. For that reason, this rule is also called the fleming right-hand rule.

Right Hand Thum/Grip Rule

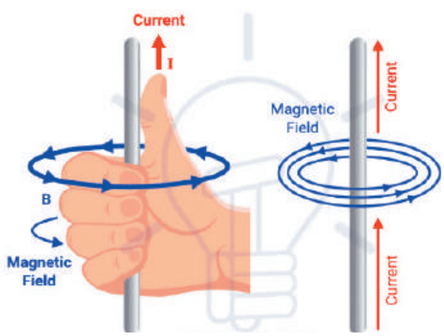


Fig. 11.17

Here is a list of applications of the rule in physics:

i. The angular speed of a rotating object and the rotation speed of any point on that object.
ii. The mechanical moment, the force that causes it, and the location of the point of the force exerted.
iii. A magnetic field, the location of the point where it is determined, and the electric current (or charged particle in the electric flow) that causes it.
iv. A magnetic field in a spiral of wire and an electric current in the wire.
v. The force that a magnetic field exerts on a given object, the object's speed, and the magnetic field itself.
vi. The current induced moving in a magnetic field.

11.3 Magnetic Flux

The number of magnetic field lines passing through a given closed surface is defined as magnetic flux.It measures the total magnetic field that passes through a given surface area. In this case, the area under consideration can be of any size and oriented in any direction with respect to the magnetic field's direction.

Now we know that, magnetic flux is a measurement of the total magnetic field which passes through a given area. It is a useful tool for helping describe the effects of the magnetic force on something occupying a given area. The measurement of magnetic flux is tied to the particular area chosen. We can choose to make the area any size we want and orient it in any way relative to the magnetic field.

If we use the field-line picture of a magnetic field then every field line passing through the given area contributes some magnetic flux. The angle at which the field line intersects the area is also important. A field line passing through at a glancing angle will only contribute a small component of the field to the magnetic flux. When calculating the magnetic flux we include only the component of the magnetic field vector which is normal to our test area.

If we choose a simple flat surface with area A as our test area and there is an angle theta (θ) between the normal to the surface and a magnetic field vector (magnitude B) then the magnetic flux is:

$\Phi = BA\cos\theta$

This is the magnetic flux formula.

Where,

- Φ is the magnetic flux.
- B is the magnetic field
- A is the area
- θ the angle at which the field lines pass through the given surface area

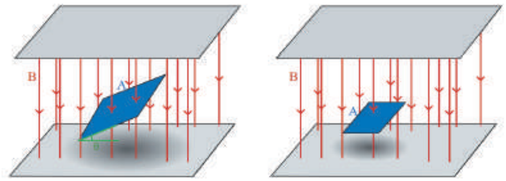


Fig. 11.18 Magnetic Flux through given areas(blue) oriented at an angle (left) and normal (right) the magnetic field.

In the case that the surface is perpendicular to the field then the angle is zero and the magnetic flux is simply BA, Following Figure shows an example of a flat test area at two different angles to a magnetic field and the resulting magnetic flux.

Magnetic Flux Symbol

- Magnetic flux is commonly denoted using the Greek letter Phi or Phi suffix B.
- Magnetic flux symbol: Φ or Φ_B.

Magnetic Flux Unit

Magnetic flux is usually measured with a **flux meter**. The SI and CGS unit of magnetic flux is given below:

- The SI unit of magnetic flux is **Weber (Wb).**
- The fundamental unit is **Volt-seconds.**
- The CGS unit is **Maxwell.**

Understanding Magnetic Flux

Faraday's great insights lay on finding a simple mathematical relation to explain the series of experiments that he conducted on electromagnetic induction. Faraday made numerous contributions to science and is widely known as the greatest experimental scientist of the nineteenth century. Before we start appreciating his work, let us understand the concept of magnetic flux which plays a major part in electromagnetic induction.

In order to calculate the magnetic flux, we consider the field-line image of a magnet or the system of magnets, as shown in the image below. The magnetic flux through a plane of the area given by A that is placed in a uniform magnetic field of magnitude given by B is given as the scalar product of the magnetic field and the area A. Here, the angle at which the field lines pass through the given surface area is also important. If the field lines intersect the area at a glancing angle, that is,

- when the angle between the magnetic field vector and the area vector is nearly equal to 90^0, then the resulting flux is very low.
- When the angle is equal to 0^0, the resulting flux is maximum.

Measurement of Magnetic Flux

The SI unit of magnetic flux is Weber (Wb) or tesla meter squared (Tm^2) named after German physicist Wilhelm Weber. Magnetic flux can be measured with a magnetometer. Suppose a probe of the magnetometer is moved around an area of 0.6 m^2 near a large sheet of magnetic material and indicates a constant reading of 5 mT. Then the magnetic flux through that area is calculated as $(5 \times 10^{-3}\ T) \cdot (0.6\ m^2) = 0.0030$ Wb. In the event of changing magnetic field reading over an area, it would be necessary to find the average reading.

Strong and weak currents

In the renovation process, hydropower transformation is a very important process. But have you ever paid attention to some specific professional knowledge? For example, how much do you know about strong current and weak current?

Fig. 11.18

Strong current and weak current are divided by voltage. Strong current means that the working voltage is above 220V AC, and it is weak current below 220V AC. Lighting fixtures, refrigerators, televisions, and audio equipment (input terminals) in household appliances are all heavy-current electrical equipment.

Strong current category: power supply and distribution projects (10KV/380V/220V) and power projects (above 10KV) are all strong currents.

High-voltage equipment: high-voltage cabinets, high-voltage circuit breakers, transformers, sockets, etc. The working voltage of these devices are all above 220V. The strong current box is also the distribution box. The voltage inside the distribution box is usually 380/220V, which is used for electric power distribution, and various electrical equipment such as lights, fans, and water pumps can be equipped below. The switch box of an ordinary house is a kind of distribution box. The principle of grouping is to use several batteries with similar battery capacity and similar battery voltage in series.

i. Strong electricity and power use are not the same concept. Strong electricity is mostly used for power, such as televisions, air conditioners, elevators and other equipment, but strong electricity is also used to power computers and other equipment. There is also, for example, that the power of an electric car is a 12V battery, which cannot be called a strong current.
ii. The definition of strong and weak electricity cannot be divided by frequency or AC and DC. For example, 800KV DC transmission must be a strong current.
iii. The same cannot be divided by the magnitude of the current. The working current of many high-voltage equipment is very small, but the communication power supply is actually low-voltage and high-current.

In the power system, voltages below 36V are called safe voltages, voltages below 1KV are defined as low voltages, and voltages above 1KV are defined as high voltages. The lines directly supplying power to users are also distribution lines. For example, the user voltage is 380/ 220V can be called a low-voltage power distribution line, and it is also a strong electricity referred to in home decoration (because it is a high voltage used in homes).

Strong current usually means that the AC voltage is above 24V. For example, the voltage of electric lights and sockets in the home is between 110V and 220V. Electrical appliances such as lighting fixtures, electric water heaters, heaters, refrigerators, televisions, air conditioners, and audio equipment in household appliances are all high-power electrical equipment.

The difference between strong current and weak current:

Strong current usually refers to the installation of electrical power in buildings, lighting, sockets, and power distribution rooms. The installation standards of various countries are slightly different. Generally, the installation of 110V or 220 power equipment and pipelines; weak current includes fire fighting, intelligent and other types of work. Generally, the equipment electricity installed is basically low-voltage electricity, including fire fighting, network, broadcasting, building intercom, monitoring security, building automatic control, and so on.

11.4 Motor effect

A wire carrying a current creates a magnetic field. This can interact with another magnetic field, causing a force that pushes the wire at right angles.This is called the motor effect.

The **motor effect** describes how electricity and magnets can work together to create a magnetic force. This magnetic force is the basis of all electric motors, hence the name 'motor effect'.

The basis of the motor effect is the fact that an electric current flowing through a wire produces a magnetic field. Recall that a current-carrying wire has a cylindrical magnetic field around it. If you place the current-carrying wire inside an external magnetic field, the cylindrical magnetic field accompanying the current will interact with the external magnetic field. It is this interaction that produces a force on the wire: it is just like the force between two bar magnets being caused by their magnetic fields interacting with each other.

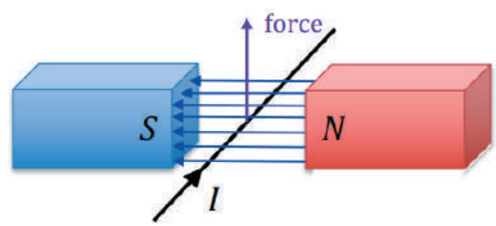


Fig. 11.19

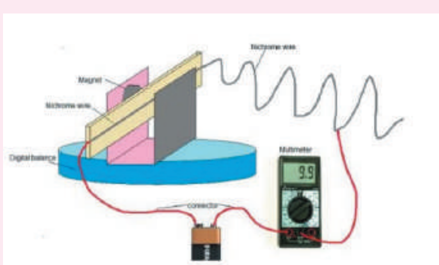
If we pass a current *i.* through a wire that is in a magnetic field(B), it experiences a force(F).

If the wire is at right angles to the magnetic field, the size of the force on a length (L) of wire in the magnetic field is given by :

$$\boxed{F=BIL}$$

Where B=magnetic flux density (in Tesla), I=current(in amperes), and L=length of wire in magnetic field (in metres)

Activities 11.3



Materials : Nichrome wire, multimeter, magnet, connector, Digital balance

Procedure : Set up the apparatus as in the diagram but don’t connect the multimeter to the Nichrome wire until you are ready. Make sure the leads are connected to the correct terminals and set the multi meter to measure up to 10A. Zero the balance using the tare button then test to see if everything is working by touching the multimeter probe to the nichrome wire. The balance reading should go down or up (depending on which pole of the magnet is facing towards the wire. The current through the wire can be varied by moving the connector along the nichrome wire, try this. The force should change. By varying the just the current and measuring the force use a graphical method to determine the flux density of the magnet. You can compare this with the value obtained with a magnetic field sensor.

Examples of motor effect applications in everyday life

Loudspeakers

Loudspeakers and headphones convert electrical signals into sound.They work due to the **motor effect.**They work in the opposite way to microphones.A loudspeaker consists of a **coil of wire** which is wrapped around one pole of a **permanent magnet.**

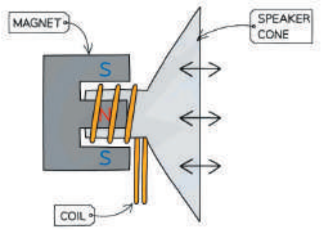


Fig. 11.20 Diagram showing a cross-section of a loudspeaker

An **alternating current** passes through the coil of the loudspeaker. This creates a **changing magnetic field** around the coil.As the current is constantly changing direction, the direction of the magnetic field will be **constantly changing.** The magnetic field produced around the coil **interacts** with the field from the permanent magnet.The interacting magnetic fields will exert a **force** on the coil. The direction of the force at any instant can be determined using **Fleming's left-hand rule.** As the magnetic field is constantly changing direction, the **force** exerted on the coil will **constantly change direction.**This makes the coil **oscillate.** The oscillating coil causes the speaker cone to oscillate. This makes the air oscillate, creating **sound waves.**

Simple Motors

The motor effect can be used to create a simple *d.c* electric motor. The simple d.c. motor consists of a coil of wire (which is free to rotate) positioned in a *uniform magnetic field :*

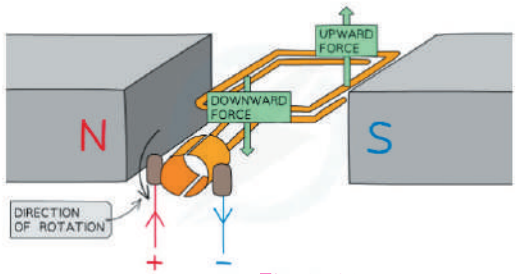


Fig. 11.21

When the current is flowing in the coil at 90° to the direction of the magnetic field:

- o The current creates a magnetic field around the coil.
- o The magnetic field produced around the coil interacts with the field produced by the magnets.
- o This results in a force being exerted on the coil.
- o The direction of the force can be determined using Fleming's left-hand rule.
- o As current will flow in opposite directions on each side of the coil, the force produced from the magnetic field will push one side of the coil up and the other side of the coil down.

This will cause the coil to rotate, and it will continue to rotate until it is in the vertical position. When the coil is in the vertical position there will be a force acting upwards and a force acting downwards. The split ring commutator swaps the contacts of the coil. This reverses the direction in which the current is flowing.Reversing the direction of the current will also reverse the direction in which the forces are acting. As a result, the coil will continue to rotate.The commutator reverses the direction of the current in the coil every **half turn.**This will keep the coil rotating continuously as long as the current is flowing.

Factors Affecting the DC Motor

- The **speed** at which the coil rotates can be increased by:

- o Increasing the **current**
- o Increasing the strength of the **magnetic field**

- The **direction of rotation** of coil in the d.c motor can be changed by:
  - o Reversing the direction of the **current**
  - o Reversing the direction of the magnetic field by reversing the **poles** of the magnet
- The **force** supplied by the motor can be increased by:
  - o Increasing the **current** in the coil
  - o Increasing the strength of the **magnetic field**
  - o Adding **more turns** to the coil

Another most useful application of the motor effect is in the electric motor. An electric motor is a device that converts electrical energy into mechanical energy. It works on the principle of motor effects. Electric motors are used in domestic appliances such as electric fans, washing machines, mixers and grinders, water pumps, vacuum cleaners, electric cars, hair dryers, CD players, etc.

11.5 Electromagnetic induction

Electromagnetic induction was **discovered by Michael Faraday** in 1831, and James Clerk Maxwell mathematically described it as Faraday's law of induction. Electromagnetic induction is a current produced because of voltage production (electromotive force) due to a changing magnetic field. This either happens when a conductor is placed in a moving magnetic field (when using an AC power source) or when a conductor is constantly moving in a stationary magnetic field. As per the setup given below, Michael Faraday arranged a conducting wire attached to a device to measure the voltage across the circuit. When a bar magnet is moved through the coiling, the voltage detector measures the voltage in the circuit.

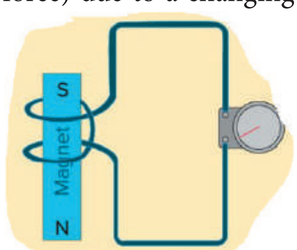


Fig. 11.22

Through his experiment, he discovered that there are certain factors that influence this voltage production. They are:

i. **Number of Coils:** The induced voltage is directly proportional to the number of turns/coils of the wire. Greater the number of turns, greater is voltage produced.

ii. **Changing Magnetic Field:** Changing magnetic field affects the induced voltage. This can be done by either moving the magnetic field around the conductor or moving the conductor in the magnetic field.

Applications of Electromagnetic Induction

Based on his experiments we now have Faraday's law according to which the amount of voltage induced in a coil is proportional to the number of turns of the coil and the rate of changing magnetic field.

- AC generators work on the principle of electromagnetic induction.
- The working of electrical transformers are based on electromagnetic induction.
- The magnetic flow meter is based on electromagnetic induction.

Electromagnetic Induction Formula

Mathematically, the induced voltage can be given by the following relation:

$$\boxed{e = N \times d\Phi / dt}$$

Where,

- e is the induced voltage (in volts)
- N is the number of turns in the coil
- Φ is the magnetic flux – the amount of magnetic field at a surface (in Webbers)
- t is the time (in seconds)

The significance of this discovery is a way of producing electrical energy in a circuit by using magnetic fields and not just batteries. Everyday machines like motors, generators and transformers work on the principle of electromagnetic induction.

Faraday's law

Faraday's law of electromagnetic induction, also known as Faraday's law, is the basic law of electromagnetism which helps us predict how a magnetic field would interact with an electric circuit to produce an electromotive force (EMF). This phenomenon is known as electromagnetic induction.

Faraday performed three main experiments to discover the phenomenon of electromagnetic induction. Faraday's Laws of Electromagnetic Induction consists of two laws. The first law describes the induction of emf in a conductor and the second law quantifies the emf produced in the conductor.

From his experiments, Faraday was able to set up the following laws of electromagnetic induction:

First Law:

Whenever there is a change in the magnetic flux (Φ) linked with a circuit (a coil), an induced e. m. f. is produced in it.

Second Law:

The induced e. m. f. lasts until the change in magnetic flux continues.

Third Law:

The magnitude of the induced e. m. f. is directly proportional to the rate of change of magnetic flux.

Let Φ_1 is the flux initially linked with a coil and Φ_2 is the flux linked with the coil at time t second. Then, the change in magnetic flux linked is given by $\Phi_2 - \Phi_1$.

The rate of change of flux $\Phi_2 - \Phi_1/t$

If E is the e.m.f. induced, then from Faraday's 2nd Law of Electromagnetic induction, we have

$$E \propto (\Phi_2 - \Phi_1/t) \qquad E = -(\Phi_2 - \Phi_1/t)$$

The negative sign in the above equation indicates the apposing nature of the e. m. f.

Activities 11.4

According to Faraday's laws, Kulekhani power station can generate more electricity by doing what? Present your suggestions to the class.

The AC Generator

An alternating current (AC) generator is a device that produces a potential difference. A simple ac generator consists of a coil of wire rotating in a magnetic field. Cars use a type of AC generator called an alternator to keep the battery charged and to run the electrical system while the engine is working.

The alternator

The Diagram shows a simple alternator.

Slip rings maintain constant contact with the same sides of the coil

As one side of the coil moves up through the magnetic field, a potential difference is induced (created) in one direction. As the rotation continues and that side of the coil moves down, the induced potential difference reverses direction. This means that the alternator produces a current that is constantly changing. This is alternating current or AC.

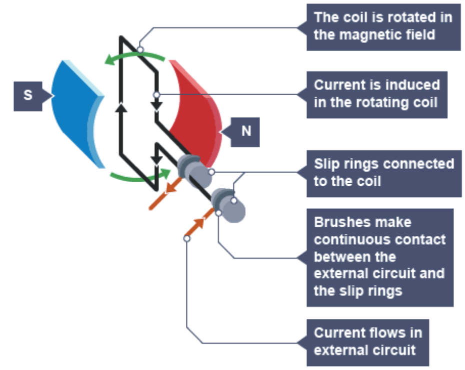


Fig. 11.23

Alternator output on a graph

The output of an alternator can be represented on a potential difference-time graph, with potential difference on the vertical axis and time on the horizontal axis.

The graph shows an alternating sine curve. The maximum potential difference or current can be increased by:

- increasing the rate of rotation
- increasing the strength of the magnetic field
- increasing the number of turns on the coil

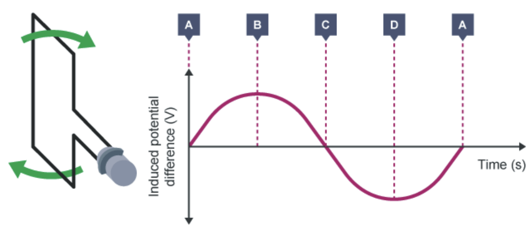


Fig. 1124 The potencial difference-time graph for an alternator

The diagram shows four different positions of the coil in an alternator, and the corresponding potential difference produced.

A - The coil is at 0°. The coil is moving parallel to the direction of the magnetic field, so no potential difference is induced.

B - The coil is at 90°. The coil is moving at 90° to the direction of the magnetic field, so the induced potential difference is at its maximum.

C - The coil is at 180°. The coil is moving parallel to the direction of the magnetic field, so no potential difference is induced.

D - The coil is at 270°. The coil is moving at 90° to the direction of the magnetic field, so the induced potential difference is at its maximum. Here, the induced potential difference is in the **opposite** direction to what it was at B.

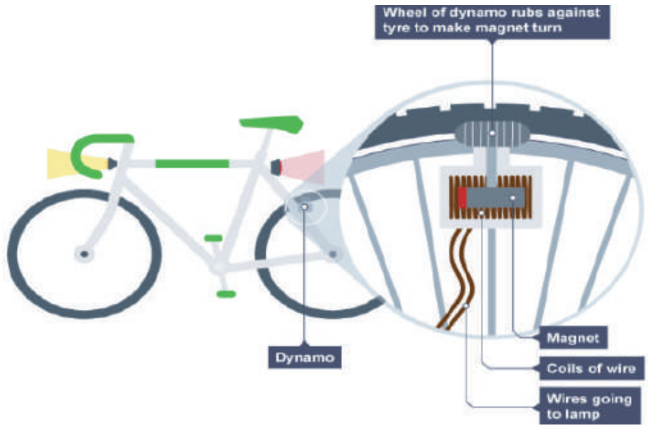
A - The coil is at 360°, ie it is back at its starting point, having done a full rotation. The coil is moving parallel to the direction of the magnetic field, so no potential difference is induced.

Dynamo (The DC generator)

A direct current (DC) generator is another device that produces a potential difference. A simple DC generator consists of a coil of wire rotating in a magnetic field. However, it uses a split ring commutator rather than the two slip rings found in alternating current (AC) generators. Some bike lights use a type of DC generator called a **dynamo** to run the lamps while the wheels are turning.

The dynamo

In a bike dynamo, the magnet r



In a dynamo, a split ring commutator changes the coil connections every half turn. As the induced potential difference is about to change direction, the connections are reversed. This means that the current to the external circuit is always in the same direction.

Dynamo output on a graph

The output of a dynamo can be shown on a potential difference-time graph. The graph shows a curve that stays in the same direction all the time. The shape of the curve can be thought of as a sine curve, with the negative part reflected in the time axis. The maximum potential difference or current can be increased by:

- increasing the rate of rotation
- increasing the strength of the magnetic field
- increasing the number of turns on the coil

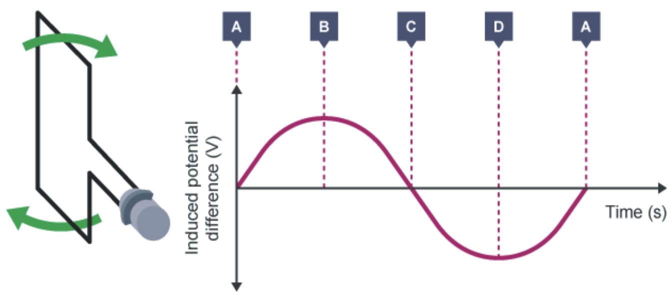


Fig. 11.25 The potencial difference-time graph for a dynamo

The diagram shows four different positions of the coil in a dynamo, and the corresponding potential difference produced.

A - The coil is at 0°. The coil is moving parallel to the direction of the magnetic field, so no potential difference is induced.

B - The coil is at 90°. The coil is moving at 90° to the direction of the magnetic field, so the induced potential difference is at its maximum.

C - The coil is at 180°. The coil is moving parallel to the direction of the magnetic field, so no potential difference is induced.

D - The coil is at 270°. The coil is moving at 90° to the direction of the magnetic field, so the induced potential difference is at its maximum. Here, the induced potential difference is in the **same** direction as at B.

A - The coil is at 360°, ie it is back at its starting point, having done a full rotation. The coil is moving parallel to the direction of the magnetic field, so no potential difference is induced.

Activities 11.5

If possible, find an old bicycle dynamo and open it to identify the parts inside it. The texture of the dynamo given in this text and the texture of the dynamo you open match or not. Prepare a report with facts.

11.6 Major electricity sources

Primary energy sources take many forms, including nuclear energy; fossil energy (like oil, coal, and natural gas); and renewable energy sources like wind, thermal, geothermal, and hydropower. These primary sources are converted to electricity, a secondary energy source, which flows through power lines and other transmission infrastructure to your home and business.

Here, learn about the major sources of electricity: Hydroelectricity, thermal electricity, wind electricity

11.6.1 Hydroelectricity

Hydroelectric energy, also called hydroelectric power or hydroelectricity, is a form of energy that harnesses the power of water in motion—such as water flowing over a waterfall—to generate electricity. People have used this force for millennia. Over two thousand years ago, people in Greece used flowing water to turn the wheel of their mill to ground wheat into flour.

Working process

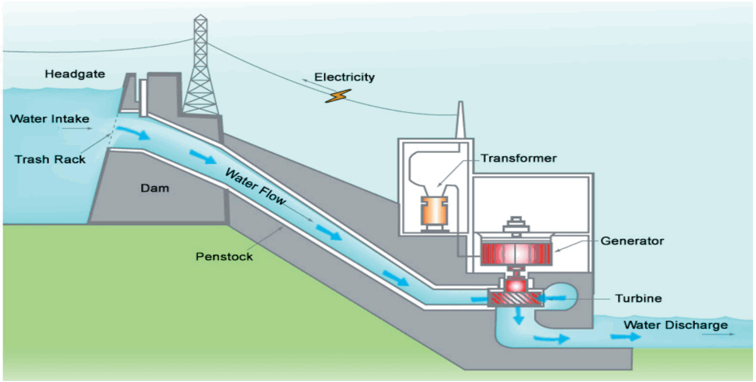


Fig. 11.26

Most hydroelectric power plants have a reservoir of water, a gate or valve to control how much water flows out of the reservoir, and an outlet or place where the water ends up after flowing downward. Water gains potential energy just before it spills over the top of a dam or flows down a hill. The potential energy is converted into kinetic energy as water flows downhill. The water can be used to turn the blades of a turbine to generate electricity, which is distributed to the power plant's customers.

Importance

Hydropower, otherwise known as hydroelectric power, offers a number of advantages to the communities that it serves.

- It is a renewable source of energy. The energy generated through hydropower relies on the water cycle, which is driven by the sun, making it renewable.
- It is fueled by water, making it a clean source of energy.
- It is a domestic source of energy, allowing each state to produce its own energy without being reliant on international fuel sources.
- Hydroelectric power is flexible. Some hydropower facilities can quickly go from zero power to maximum output. Because hydropower plants can generate power and send it to the grid immediately, they provide essential backup power during major electricity outages or disruptions.
- It provides flood control, irrigation support, and clean drinking water.
- It is affordable.

- It is used in simple ways.
- For the country of Nepal , hydroelectricity is the most important source of electricity. The source of energy shares from a conventional source in Nepal is 87% as a significant share of electricity and renewable energy with 56.1% households have access of electricity . Hydropower is the main source of energy in Nepal, nearly 90% installed capacity and 90% generation of electricity.

11.6.2 Thermal electricity

Thermal means : due to heat. Thermal electricity means electricity generated due to heat. Thermal electricity is also known as thermal power . A thermal power station should be needed to generate thermal electricity. A thermal power station is a type of power station in which heat energy is converted to electrical energy. Thermoelectric materials generate power directly from heat by converting temperature differences into electric voltage. These materials must have both high electrical conductivity (σ) and low thermal conductivity (κ) to be good thermoelectric materials. Thermal Power Plants are facilities that produced electrical energy which is a secondary energy source by using the primary energy sources. The electricity generated cause of heat can be of directly or indirectly.

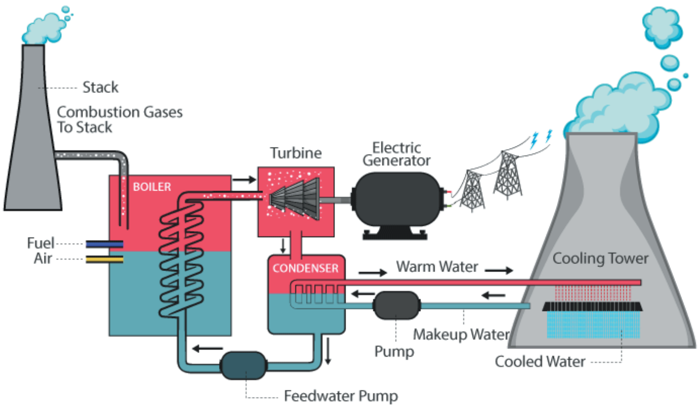


Fig. 11.27 Thermal Power Plant Block Diagram

Working process

Thermoelectric effect (Directly) : The thermoelectric effect is the direct conversion of temperature differences to electric voltage and vice versa. A thermoelectric device creates voltage when there is a different temperature on each side. Thermoelectric generator converts heat Flux into electrial energy through the phenomenon seebeck effect (Thermoelectric effect). These generators are used in power plants and in automobile to generate waste heat energy.

Thermal power station (indirectly): Power station in which heat energy is used to convert water to steam and spins the steam turbine which drives an electrical generator. Heat source can be of any type like coal, petrolium, solar thermal electric etc.

Importance

It is very important because thermal electricity is produced from thermal power staions(TPS). Some of the important ones are mentioned below.

- One of the primary advantages of thermal power is that the generation costs are extremely low. No fuel is needed to generate the electricity, and the minimal energy needed to pump water to the Earth's surface can be taken from the total energy yield.
- Thermal power/electricity is revered by environmental activists because it is completely renewable, does not use fuel to produce power and has virtually no emissions. It also helps reduce global warming and pollution and requires far less land than a coal mine or oil field.

- Thermal power facilities create a number of jobs for local communities. Researchers, scientists and drilling workers are among the specialists needed for safe and effective operations.
- It requires less space as compared to the hydro-electric power station.
- Hung amount of power can be generated by TPS.
- It is a useful source of electricity that the world provides. Not only can thermal energy be employed in conjunction with other renewable energy sources, but it provides backup power, energy storage, and efficient heating and cooling alternatives.

11.6.3 Wind electricity

Wind electricity means getting the electrical energy by converting wind energy into rotating energy of the blades and converting that rotating energy into electrical energy by the generator. Wind energy increases with the cube of the wind speed . Wind electricity is also environmentally friendly . It has no effect on climate change .

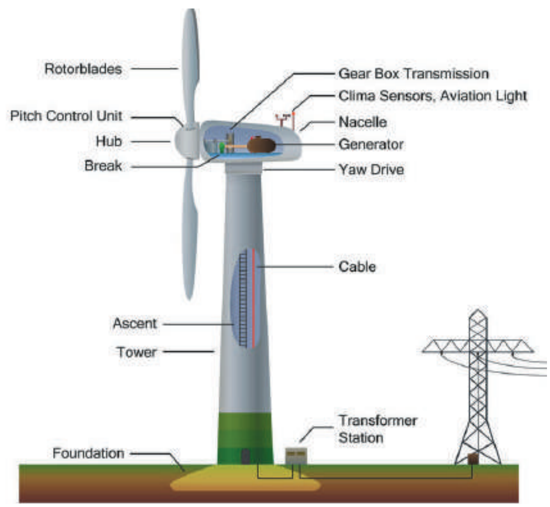


Fig. 11.28

Working process

Wind turbines operate on a simple principle. The energy in the wind turns two or three propeller-like blade around a rotor. The rotor is connected to the main shaft, which spins a generator to create electricity.

Importance

- No CO_2 emission
- Wind is a safe energy source existing everywhere, and there is no need to worry about depletion like fossil fuel
- Simple equipments and easy operation
- Few affection to nature environment

11.7 Transformer

The transformer in the simplest way can be described as a thing that steps up or steps down voltage. In a step-up transformer, the output voltage is increased and in a step-down transformer, the output voltage is decreased. The step-up transformer will decrease the output current and the step-down transformer will increase the output current for keeping the input and the output power of the system equal.

The transformer is basically a voltage control device that is used widely in the distribution and transmission of alternating current power. The idea of a transformer was first discussed by Michael Faraday in the year 1831 and was carried forward by many other prominent scientific scholars. However, the general purpose of using transformers was to maintain a balance between the electricity that was generated at very high voltages and consumption which was done at very low voltages.

A transformer is a device used in the power transmission of electric energy. The transmission current is AC. It is commonly used to increase or decrease the supply voltage without a change in the frequency of AC between circuits. The transformer works on basic principles of electromagnetic induction and mutual induction.

The structure of a transformer

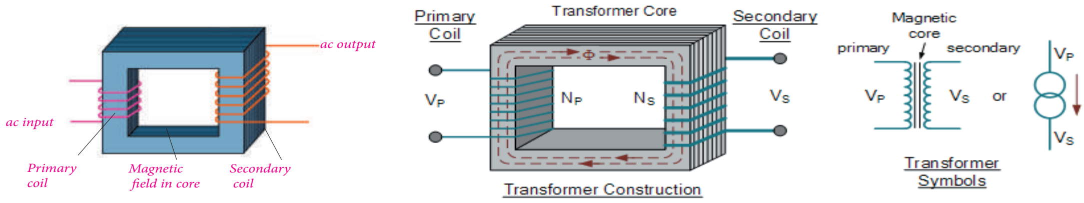


Fig. 11.29

Where:

- Vp - is the Primary Voltage
- Vs - is the Secondary Voltage
- Np - is the Number of Primary Windings
- Ns - is the Number of Secondary Windings
- Φ(Phi) - is the Flux Linkage

A basic transformer is made from two coils of wire; a primary coil from the AC input and a secondary coil leading to the AC output. The coils are not electrically connected. Instead, they are wound around an iron core. This is easily magnetised and can carry magnetic fields from the primary coil to the secondary coil.

A transformer consists of two inductive windings and a laminated steel core. The coils are insulated from each other as well as from the steel core. A transformer may also consist of a container for winding and core assembly (called as tank), suitable bushings to take our the terminals, oil conservator to provide oil in the transformer tank for cooling purposes etc. In all types of transformers, core is constructed by assembling (stacking) laminated sheets of steel, with minimum air-gap between them (to achieve continuous magnetic path). The steel used is having high silicon content and sometimes heat treated, to provide high permeability and low hysteresis loss. Laminated sheets of steel are used to reduce eddy current loss. The sheets are cut in the shape as E,I and L. To avoid high reluctance at joints, laminations are stacked by alternating the sides of joint. That is, if joints of first sheet assembly are at front face, the joints of following assemble are kept at back face.

Working principles of transformer

When a transformer is working:

i. a primary potential difference drives an alternating current through the primary coil.
ii. the primary coil current produces a magnetic field, which changes as the current changes.
iii. the iron core increases the strength of the magnetic field.
iv. the changing magnetic field induces a changing potential difference (voltage) in the secondary coil.
v. the induced potential difference produces an alternating current in the external circuit

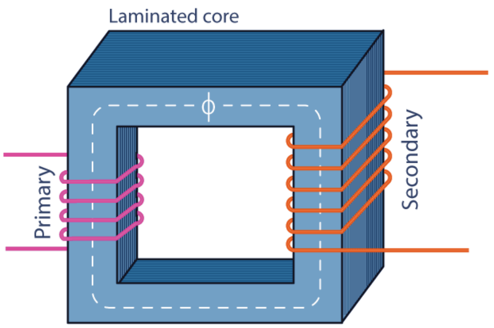


Fig. 11.30

The relationship between wire winding and voltage in a transformer

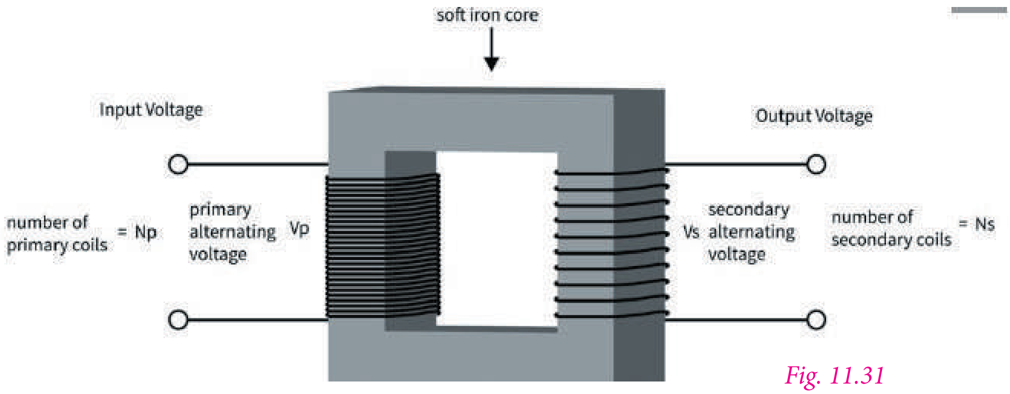


Fig. 11.31

Generally, the primary winding of a transformer is connected to the input voltage supply and converts or transforms the electrical power into a magnetic field. While the job of the secondary winding is to convert this alternating magnetic field into electrical power producing the required output voltage as shown.

Step-up tranformer: Secnodary voltage Vs > Primary Voltage Vp

Step-down tranformer: Secnodary voltage Vs< Primary Voltage Vp

Formula for Calculation Voltage = $\frac{Vp}{Vs} = \frac{Np}{Ns}$

Step-up and Step-down transformers

Transformer is a very useful device, indeed. With it, we can easily multiply or divide voltage and current in AC circuits. Indeed, the transformer has made the long-distance transmission of electric power a practical reality, as AC voltage can be 'stepped up' and current 'stepped down' for reduced wire resistance power losses along power lines connecting generating stations with loads. At either end (both the generator and at the loads), voltage levels are reduced by transformers for safer operation and less expensive equipment.

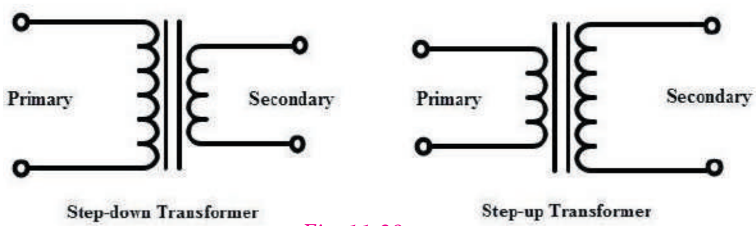


Fig. 11.28

Step-up transformer

A step-up transformer is a type of transformer that converts the low voltage (LV) and high current from the primary side of the transformer to the high voltage (HV) and low current value on the secondary side of the transformer. The reverse of this is known as a step down transformer.

A transformer is a piece of static electrical equipment which transforms electrical energy

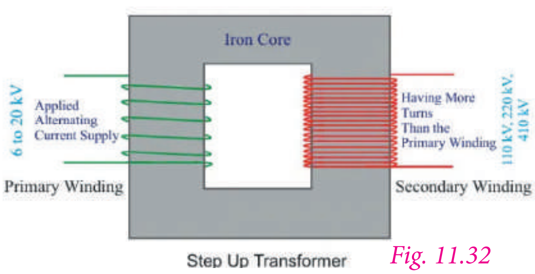


Fig. 11.32

(from primary side windings) to the magnetic energy (in the transformer's magnetic core) and again to the electrical energy (on the secondary transformer side). A step-up transformer has a wide variety of applications in electrical systems and transmission lines.

Step-up Transformer Applications

Here, the application of the step-up transformer has been explained which are as follows:

- Small step-up transformers can be found in electrical and electronic equipment.
- Step-up transformers are also used for electric power motors, X-ray equipment, microwave ovens and other electronic devices.
- Used to step up or increase the generated voltage to a greater voltage level, a vast power step-up transformer is employed as a generating step-up transformer.
- Step-up transformers are utilized in electronic equipment such as inverters and voltage stabilizers for low to high voltage stability.
- Step-up transformers are more commonly employed in power electronic circuits because of their modest weight and dimensions. Also, their application can now be observed in current electronic equipment.

Step-down transformer

A step-down transformer is a type of transformer that converts the high voltage (HV) and low current from the primary side of the transformer to the low voltage (LV) and high current value on the secondary side of the transformer. The reverse of this is known as a step up transformer.

A transformer is a type of static electrical equipment that transforms electrical energy (from primary side windings) to magnetic energy (in transformer magnetic core) and again to the electrical energy (on the secondary transformer side). A step-down transformer has a wide variety of applications in electrical systems and transmission lines.

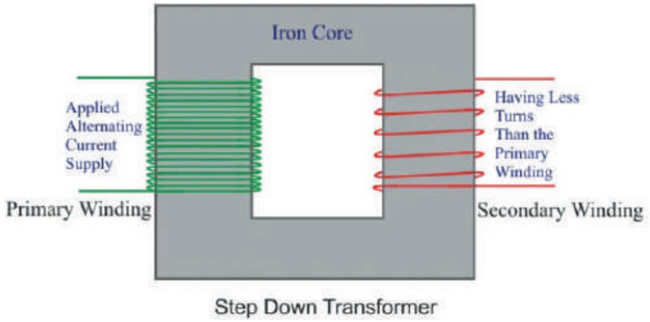


Fig. 11.33

Step Down Transformer Applications

The step-down transformers have a very important function in a power system. They lower the voltage level and adapt it to energy consumers. It is performed in several steps described below:

- A long distance energy transmission system should have a voltage level as high as possible.
- The next voltage level transformation step is adapting the transmission voltage to the distribution level.
- The final voltage transformation step is adapting the voltage to the home voltage level.
- Step down transformers are used in power adaptors and rectifiers to efficiently decrease the voltage. Other applications include:Power transmission lines, welding machines, voltage stabilizers etc.

Calculations :

i. Calculate the number of turns in secondary coil if a transformer is connected to the AC main of 220 V to produce 12 V with the primary coil of 660 turns.

Solution

Primary voltage (Vp) = 220 V

Secondary voltage (Vs) = 12 V

Number of turns in primary coil (Np) =660 turns

Number of turns in secondary coil (Ns) = ?

We know,

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

$$\text{or,} \quad N_s = \frac{V_s \times N_p}{V_p}$$

$$\text{or,} \quad N_s = \frac{12 \times 660}{220}$$

$$\therefore \quad N_s = 36 \text{ turns}$$

Hence, the secondary coil should have 36 turns.

Exercise

A. Choose the correct one and put the tick mark(√).

i. Source of direct current is-
   a. generators b. power plants c. battery d. none of these

ii. Source of alernating current is -
   a. dynamo b. power plants c. battery d. none of these

iii. The average voltage and frequency of the mainline are used in Nepal-
   a. 220V and 100 Hz b. 230 V and 50Hz
   c. 400V and 50Hz d. 230 V and 100Hz

iv. Magnetic effect of current-
   a. When current flows through electrical appliances, they change electricity into heat.
   b. When current flows through electrical appliances, they change electricity into light.
   c. When current flows through a conductor, a magnetic field is developed around it.
   d. When current is passed through a liquid , it undergoes some chemical change.

v. When an electric current passes through a straight wire, it ________ a magnetic field.
   a. produces b. induces c. generates d. creates

vi. Which is not correct for right-hand rule-
   a. The current induced moving in a magnetic field.
   b. A magnetic field in a spiral of wire and an electric current in the wire.
   c. The angular speed of a rotating object and the rotation speed of any point on that object.
   d. A wire carrying a current creates a magnetic field

vii. Which is not correct for motor effect-
   a. vacuum cleaners b. electric cars c. hair dryers d. transformers

viii. The unit of flux density-

a. amperes b. metres c. seconds d. tesla

ix. The phenomenon called electromagnetic induction was first investigated by

a. Newton b. Kepler c. Faraday d. Galileo

x. Fill in the blanks: Electric generator converts electrical energy into____

a. Chemical energy b. Thermal energy

c. Electrical energy d. Solar energy

xi. Factors that affect the voltage generation in Faraday's experiment is

a. Number of Coils b. Changing Magnetic Field

c. Changing Environment d. Option a) and b)

B. Answer the following questions :

i. What is direct current (DC) ? Which sources produce DC ?
ii. What is alternating current (AC) ? Which sources produce alternating current?
iii. What is Magnetic effect of current electricity ?
iv. What is right hand grip rule ?
v. What is magnetic flux?
vi. What is motor effect ?
vii. What is right hand grip rules ?
viii. Draw a diagram of the magnetic field generated by a current-carrying straight wire and a solenoid.
ix. Write briefly about magnetic lines of force and magnetic flux.
x. What are motor effects and how are they used in daily life?
xi. Does Faraday's law of electromagnetic induction apply?
xii. Write down Faraday's law .
xiii. Explain the working process of an AC generator .
xiv. Explain the working process of a dynamo.
xv. What is a transformer ?
xvi. Explain the structure, working process, and importance of the transformer.
xvii. What is the working principle of the transformer?
xviii. What are the main parts of a transformer?
xix. What is a transformer?
xx. What is a step-up transformer?
xxi. What is a step-down transformer?
xxii. Draw a sketch to show the magnetic lines of force due to a current-carrying straight conductor.
xxiii. Name and state the rule to determine the direction of magnetic field around a straight current-carrying conductor.

C. Write a short note.

a.	Direct current	b.	Alternating current	c.	Magnetic effect
d.	Rule of the right-hand grip	e.	Magnetic Flux	f.	Strong current
g.	Weak current	h.	Motor effect	i.	Simple motor
j.	Electromagnetic induction	k.	Faraday's law	l.	AC Generator
m.	DC Generator	n.	Hydroelectricity	o.	Wind electricity
p.	Thermal power	q.	transformer.		

D. Differentiate between these pairs.

i. Dynamo and Generator
ii. Electric motor and Generator
iii. Magnetic flux and Electromagnetic induction
iv. Step-down transformer and Step-down transformer
v. Generator and Transformer
vi. Primary voltage and Secondary voltage.

E. Explain the following:

i. Electricity and magnetism are complementary to each other.
ii. Hydroelectricty is called polution free sources of electricity.
iii. The core of transformer is leminated .
iv. Voltage can not be changed in DC.
v. There is either a convergence or a divergence of magnetic field lines near the ends of a current carrying straight solenoid.
vi. The current carrying solenoid when suspended freely rests along a particular direction.

F. Numericals

i. A transformer has 600 turns of the primary winding and 20 turns of the secondary winding. Determine the secondary voltage if the secondary circuit is open and the primary voltage is 140 V. (Ans. 4.6 V)

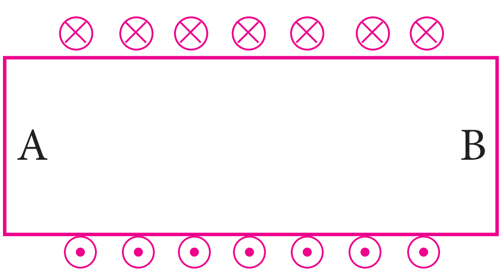
ii. A transformer has 500 turns of the primary winding and 10 turns of the secondary winding. Determine the secondary voltage if the secondary circuit is open and the primary voltage is 120 V. (Ans.2.4 V)

iii. A transformer has a primary coil and a secondary coil with the number of loops are 500 and 5000. Input voltage is 220 V. What is the output voltage? (Ans.2200 V)

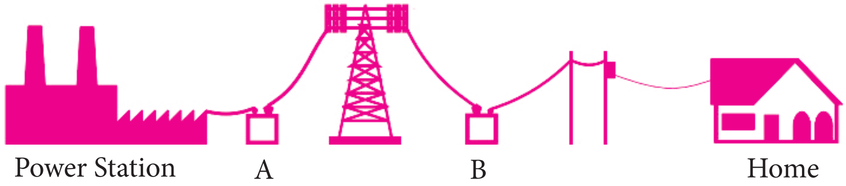
iv. A mains transformer (230 V) has 11,500 turns on its primary coil and 600 turns on its secondary coil. Calculate the potential difference obtained from the secondary coil. (Ans.12V)

G. Diagrammatic Questions :

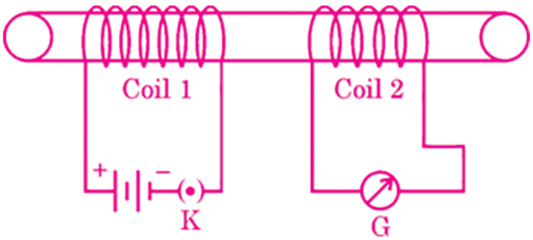
i. Diagram shows the lengthwise section of a current carrying solenoid, ⊗ indicates current entering into the page, ⊙ indicates current emerging out of the page. Decide which end of the solenoid A or B, will behave as north pole. Give reason for your answer. Also draw field lines inside the solenoid.



ii. Write the types of transformers A and B shown in the figure. Write a brief introduction, utility, and examples of both.



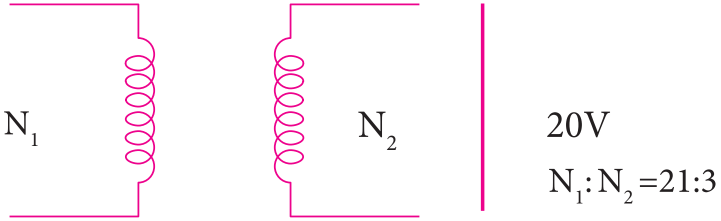
iii. Two coils of insulated copper wire and wound over a non-conducting cylinder as shown. Coil 1 has comparatively large number of turns. State your observations, when



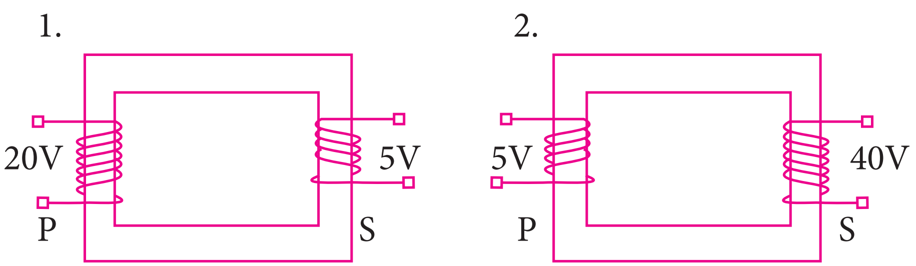
a. Key K is closed
b. Key K is opened

Give reson for each of your observations.

iv. Based on figure below, what is the primary voltage of the transformer.
(Ans. 140 V)

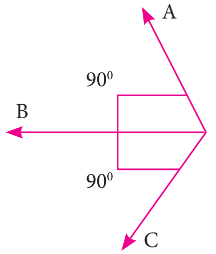


v. Based on the above figure, which of the following statements about the figure above is correct. Give the reason too.

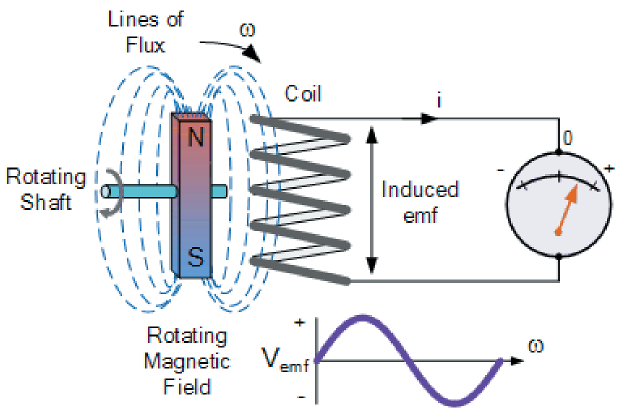


a. Figure 1 is a step-up transformer and figure 2 is a step-down transformer
b. Figure 1 is a step-down transformer and figure 2 is a step-up transformer
c. Figure 1 and 2 are a step-down transformer
d . Figure 1 and 2 are a step-up transformer

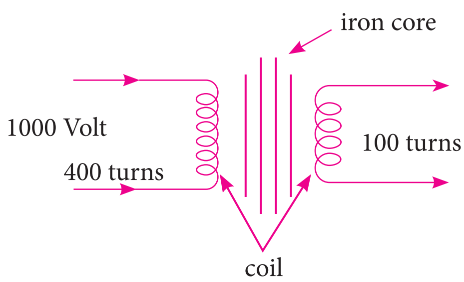
vi. If 'A' indicates the direction of motion of conductor wire in a Fleming's right hand rule, what does 'B' and 'C' indicates ? State the rule .



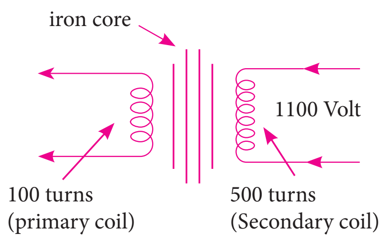
vi. What is trying to show in the following image? What principle is it based on?



vii. What type of transformer is given in the diagram ? Write down with reason. If 1000V line is connected to this transformer , what is its output voltage ?



viii. What type of transformer is given in the diagram ? Calculate the primary voltage of this transformer.



Chapter 12

Universe

Total Estimated pariods (Th. 4+ Pr. 1=10)

Student's Learning Outcomes

After studying this unit, the students will be able to :

- explain the importance of gravity in the universe
- describe the origin of the universe according to the Big Bang theory
- state the results of Hubble's study on the motion of cosmic bodies
- present an argument about possible universe predictions based on the gravitational force laws

Georges Lemaître (born July 17, 1894, Charleroi, Belgium—died June 20, 1966, Leuven), a Belgian astronomer and cosmologist who formulated the modern big-bang theory, which holds that the universe began in a cataclysmic explosion of a small, primeval 'super-atom.' A civil engineer, Lemaître served as an artillery officer in the Belgian Army during World War I. After the war, he entered a seminary and, in 1923, was ordained a priest. In 1927, the year he became professor of astrophysics at the Catholic University of Leuven (Louvain), he proposed his big-bang theory, which explained the recession of the galaxies within the framework of Albert Einstein's theory of general relativity.

Introduction

We know that any object, when released from a height always falls downwards. It means that a force of attraction is exerted on the object in the downward direction. Actually it is the earth that attracts all the objects towards its centre. The force with which the earth attracts all the objects towards its centre is called gravitational force or gravity. According to Universal Law of Gravitation or Newton's Law of Gravitation, 'every particle of matter in the universe attracts every other particle with a force which varies directly as the product of masses of the two particles and inversely as the square of the distance between them'. Newton's law of gravitation holds good for all the bodies of any size and shape in the universe and also it remains invariant under any physical or chemical changes. That's why this law is called Universal.

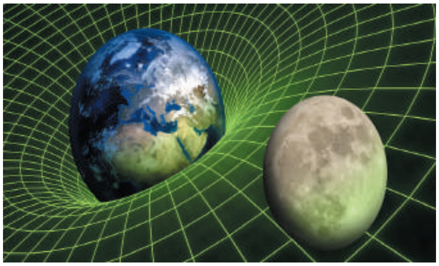


Fig. 12.1

Gravity is the mutual attraction of two bodies in the universe. Since gravity refers to an invisible force pulling matter together, there are many examples of gravity. Every single thing has gravity, including people. Some objects have much more gravity than others. The Earth, for example, has more gravity than people. This is why an object that falls is drawn to the Earth and returns to the Earth instead of being drawn to a person and flying at that person.

Creates Orbit

One of the most noticeable effects of gravity in the solar system is the orbit of the planets. The sun could hold 1.3 million Earths so its mass has a strong gravitational pull. When a planet tries to go past the sun at a high rate of speed, gravity grabs the planet and pulls it towards the sun. Likewise, the planet's gravity is trying to pull the sun towards it but can't because of the vast difference in mass. The planet keeps moving but is always caught up in the push-pull forces caused by the interaction of these gravitational forces. As a result, the planet begins orbiting the sun. The same phenomenon causes the moon to orbit around the Earth except its the Earth's gravitational force not the sun's that keeps it moving around us.

Tidal Heating

Just as the moon orbits the Earth, other planets have moons of their own. The push-pull relationship between the gravitational forces of the planets and their moons causes an effect known as tidal bulges. On Earth, we see these bulges as high and low tides because they occur over oceans. But on planets or moons without water, tidal bulges can occur over land. In some cases, the bulge created by gravity will be pulled back and forth because the orbit varies in its distance from the primary source of gravity. The pulling causes friction and is known as tidal heating. On Io (slightly larger than Earth's moon and the fourth-largest moon in the Solar System), one of Jupiter's moons, the tidal heating has caused volcanic activity. This heating may also be responsible for volcanic activity on Saturn's Enceladus and liquid water underground on Jupiter's Europa.

Creating Stars

Giant molecular clouds made up of gas and dust slowly collapse because of the inward pull of their gravity. When these clouds collapse, they form lots of smaller areas of gas and dust that will eventually collapse as well. When these fragments collapse, they form stars. Because the fragments from the original Giant molecular clouds (GMCs) stay in the same general area, their collapse causes stars to form in clusters.

Formation of Planets

When a star is born, all of the dust and gas not needed in its formation ends up trapped in the orbit of the star. The dust particles have more mass than the gas so they can begin to concentrate in certain areas where they come in contact with other dust grains. These grains are pulled together by their own gravitational forces and kept in orbit by the gravity of the star. As the collection of grains becomes bigger, other forces also begin to act upon it until a planet forms over a very long period of time.

Causes Destruction

Because many things in the solar system are held together thanks to the gravitational pull among its components, strong external gravitational forces could literally pull those components apart thus destroying the object. This happens with moons sometimes. For example, Neptune's Triton is being pulled closer and closer to the planet as it orbits. When the moon gets too close, perhaps in 100 million to 1 billion years, the planet's gravity will pull the moon apart. This effect might also explain the origin of the debris that makes up the rings found around all of the large planets: Jupiter, Saturn, and Uranus.

12.1 The Importance of Gravitational Force in the Universe

Gravity is one of the fundamental forces in the Universe. Although gravity is the weakest of all the forces in the Universe, it is the most important force in the study of astronomy. Originaly defined by Newton, and refined by Einstein, gravity is essentially the natural force of attraction between any two objects. Two factors determine the magnitude of the gravitational force between two objects: i. their masses and ii. the separation distance between them.

The size of the force is proportional to the product of the masses of the two objects. For example, the force doubles in size if either of the masses is increased to twice its mass. On the other hand, the force grows weaker if the two objects are moved farther apart. In fact, it is inversely proportional to the square of the distance between them, so that if the distance is tripled, the force is only one ninth as strong.

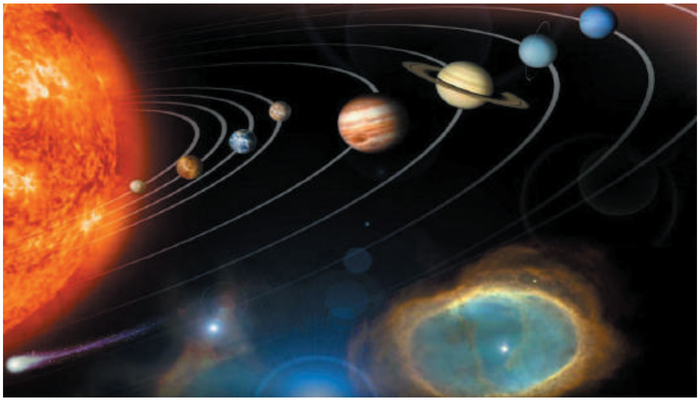


Fig. 12.2

The gravitational force of the sun, acting on the earth, keeps the earth in its orbit, preventing it from traveling away into interstellar space. The gravitational force of the earth, acting on us, holds us to the earth's surface. The gravitational attraction between a person and the earth is proportional the person's mass and inversely proportional to the square of the planet's radius (distance from the person to the center). This number for gravitational attraction is called your weight.

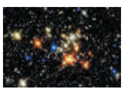
Every planet has mass and so every planet exerts a gravitational force on nearby objects. We say that planets have gravity. However, what we really mean is that there is a gravitational force of attraction between the planet and a person standing on the planet's surface. This force depends on the visitor's mass, the planet's mass, and the planet's radius. Accordingly, people have different weights on different planets.

The gravitational force explains several natural phenomena:

i. Planets revolve around sun due to gravitational force between sun and the planets.
ii. Earth binds all objects on due to this force.
iii. Rainfall, snowfall etc. take place due to gravitational force of earth.
iv. Moon and other artificial satellites revolve around earth due to this force.
v. Tides in ocean is due to gravitational force between moon and water.
vi. The atmosphere is there around earth due to gravitational force of the earth.
vii. Satellites, planets, stars, galaxies, and other objects become stuck in space due to gravitational force.
viii. Gravitational force between earth and sun makes the earth move around the sun.
ix. Gravitational force between moon and earth makes the moon go around the earth.

Activities 12.1

i. Write an essay on the importance of gravitational force in the universe.
ii. Complete the table below using different means.

Images	Name	Introduction	Causes stuck in space
			
		- a large celestial body that revolves around the sun in fixed orbits. - do not have any light of their own but reflect the light of the sun. - do not twinkle like stars because they are much closer to us. - the earth is also an example of this .	
			
			Gravitational Force
	Demo of Gravitational Force		

12.2 The origin of the universe according to the big bang theory

How was our Universe created? How did it come to be the seemingly infinite place we know of today? And what will become of it, ages from now? These are the questions that have been puzzling philosophers and scholars since the beginning the time, and led to some pretty wild and interesting theories. Today, the consensus among scientists, astronomers and cosmologists is that the Universe as we know it was created in a massive explosion that not only created the majority of matter, but the physical laws that govern our ever-expanding cosmos. This is known as The Big Bang Theory.

It is believed that the universe originated around 15 billion years ago in the form of a dense, hot blob of gas expanding rapidly outward. During that period, the universe contained only hydrogen and a small amount of helium. No stars or planets existed at that time. When the universe was some 100 million years ago, only the first stars apparently began to form out of hydrogen. This is also the process of the origin of the Sun about 4.49 billion years ago.

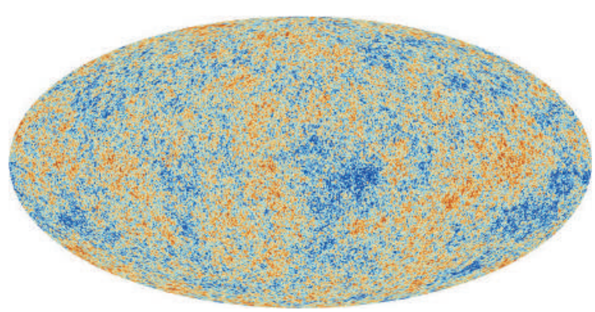


Fig.12.3 : A 2013 map of the background radiation left over from the Big Bang, taken by the ESA's Planck spacecraft, captured the oldest light in the universe. This information helps astronomers determine the age of the universe.

"Big Bang Theory"

Georges Lemaitre (1927) proposed a model for the origin of the universe which became the Big Bang theory. The Big Bang theory explains the origin of the universe, with the key idea that the universe is expanding. In the past, the universe was denser and hotter. All of space was contained in a single point, which is considered the inception of the universe. After the initial expansion, the universe freezes, which allows the creation of subatomic particles, consisting of protons, neutrons, and electrons. The majority of atoms formed were hydrogen, along with helium and traces of lithium. Huge clouds of these primal elements later fused through gravity to form stars and galaxies. The massive elements were synthesized either within stars or during supernovas. Hence, the Big Bang theory does not explain the initial condition of the universe, but instead it describes the general evolution of the universe.

The Big Bang theory is based on Albert Einstein's theory of general relativity. This also takes into consideration the homogeneity and isotropy of space. It was Edwin Hubble (1929) who discovered that the distances to remote galaxies were firmly correlated with their redshifts. According to Hubble, all observable areas of the universe are receding from each other.

Fig. 12.4

Once upon a time, there were two theories for explaining the expansion of the universe: the Big Bang and the Steady State theory. But in 1964, with the discovery of the cosmic microwave background radiation, the Big Bang theory was confirmed.

Time	T in^{0}c	Event
10-43Sec	10^{32}	The cosmos goes through a superfast "inflation," expanding from the size of an atom to that of a grapefruit in a tiny fraction of a second.
10-32Sec	10^{27}	Post-inflation, the universe is a seething, hot soup of electrons, quarks and other particles.
10-6 Sec	10^{13}	A rapidly cooling cosmos permits quarks to clump into protons and neutrons.
3 min	10^{8}	Still too hot to form into atoms, charged electrons and protons prevent light from shining: the universe is a superhot fog.
3 , 0 0 , 0 0 0 years	10,000	Electrons combine with protons and neutrons to form atoms, mostly hydrogen and helium. Light can finally shine.
1 billion years	-200	Gravity makes hydrogen and helium gas coalesce to form the giant clouds that will become galaxies: smaller clumps of gas collapse to form the first stars.
15 billion years	-270	As galaxies cluster together under gravity, the first stars die and spew heavy elements into space: those will eventually turn into new stars and planets.

In 1992, the launching of the Cosmic Background Explorer (COBE) satellite showed that

99.7% of the energy of the universe was released within the first year of its evolution. This confirmed the Big Bang theory, which proposes that the universe originated from a single violent explosion (which gives the name big bang) of a very minute amount of matter of high density and temperature.

The most frequent misunderstanding regarding the Big Bang Theory is that it explains the complete origin of the universe but does not describe the energy, time, and space involved in the creation of the universe. It only explains how the universe emerged from its initial high-temperature state. It would be false to draw parallels to everyday objects when trying to explain the Big Bang Theory, especially where size is concerned. The theory only describes the size of the observable universe and not the universe as a whole.

Accurate derivation requires the use of general relativity, and while treatment using simpler Doppler effect arguments gives nearly identical results for nearby galaxies, interpreting the redshift of more distant galaxies as due to the simplest Doppler redshift treatments can cause confusion.

Activities 12.2

True of False?

- The big bang is an explasion that created the universe.
- It occurred abotu 1263 billion years ago.
- According to scientists, there was just a very big hot point before big bang.
- The big bang created space and energy.
- In 1920, Astronomer Edwing Hubble discovered that the universe is static.
- Some Scientists believe there are many other universe that exist.

12.3 Conclusions of Hubble's Study of the Motion of Cosmic Bodies

In 1929, Hubble published his first paper on the relationship between redshift and distance. He tentatively concluded that there is a linear redshift-distance relationship; that is, if one galaxy is twice as far away as another, its redshift is twice as large. His study is based on 18 galaxies. Two years later, Hubble and Humason presented what astronomers and cosmologists widely judged to be very convincing evidence that the relationship is indeed linear and, hence, that a galaxy's redshift is directly proportional to its distance.

A condition for the Universe to respect the Cosmological Principle is that the speed of galaxies along the line of sight, or equivalently, their redshift, should be proportional to their distance. Hubble tried to test this idea. He had measured the redshift and the distance of all 18 galaxies. His results show roughly a linear relationship between redshift and distance. He concluded that the universe was in homogeneous expansion and gave the first estimate of the coefficient of proportionality 'H' , called the Hubble parameter. This conclusion has been checked several times with increasing precision and is widely accepted today. It can be considered the starting point of experimental cosmology. It is amazing to note that the data used by Hubble was so imprecise that Hubble's conclusion was probably a bit biaised. Anyway, current data leaves no doubt about the proportionality, even if there is still some uncertainty concerning the exact value of H. The Hubble constant is generally parametrized as $H = 100\ h\ km\ s^{-1} Mpc^{-1}$, where h is the dimensionless 'reduced Hubble parameter', currently known to be in the range of $h = 0.71 \pm 0.04$, and Mpc denotes a Mega-parsec, the unity of distance usually employed for cosmology (1 Mpc ' $\simeq$ 3×10^{22}m $\simeq 3 \times 10^{6}$ light-years; the proper definition of a parsec is "the distance to an object with a parallax of one arcsecond"; the parallax being half the angle under which a star appears to move when the earth makes one rotation around the sun). So, for instance, a galaxy located at 10 Mpc goes away at a speed close to 700 km s^{-1}.

"Redshift' is a key concept for astronomers. The term can be understood literally: the wavelength of the light is stretched, so the light is seen as' shifted 'towards the red part of the spectrum.

12.4 Future of the Universe

The future of the Universe will be determined by the struggle between the momentum of its expansion and the pull of gravity.

Our capacity to predict the future of the Universe is limited by how much of it we can observe. The image given below, represents the evolution of the Universe over 13.7 billion years. The Big Bang is depicted at the left of the image followed by a period of exponential growth (inflation). The vertical scale indicates the size of the Universe. For the next several billion years, the expansion of the Universe gradually slowed down due to the effects of gravity on matter. In more recent times, the expansion of the Universe has begun to accelerate again due to the repulsive effects of dark energy.

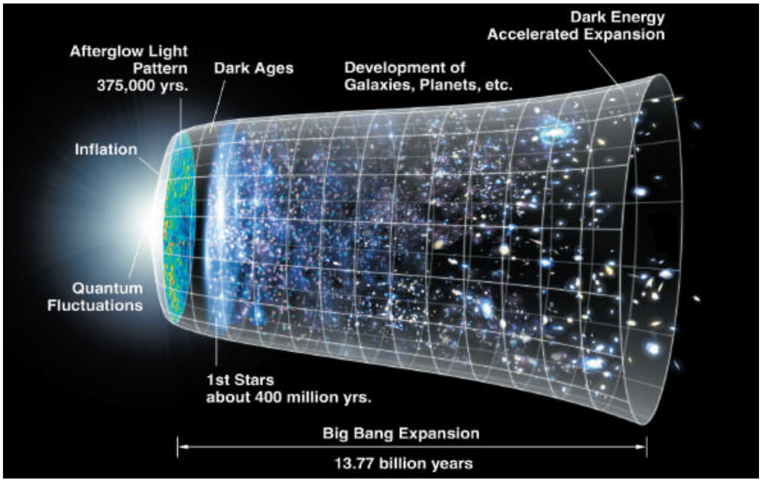


Fig. 12.5

Our predictions about the Universe are based on the assumption that the laws of physics apply consistently to all parts of it. This is called the cosmological principle.

Predicting the future of the Universe Scientific predictions about the future of the Universe are based on the idea that the effect of gravity on matter determines the shape of the Universe, which then determines its future. Critical density is the average density of matter in the Universe at which gravity is just sufficient to halt its expansion, but only after an infinite time. The future of the Universe depends on whether its density is greater than, equal to, or less than the critical density. There are three possible scenarios:

Scenario 1: A closed Universe

If the density of the Universe is greater than critical density, gravity will be strong enough to stop its expansion and eventually reverse it. The geometry of spacetime can be thought of as being shaped like the surface of a sphere. A triangle drawn on the surface of the sphere has an angle sum greater than 180°. Eventually, gravity will cause a closed Universe to collapse back in on itself, ending in the 'Big Crunch'.

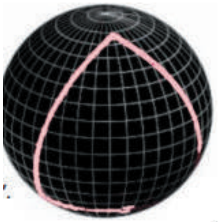


Fig. 12.6

Scenario 2: An open Universe

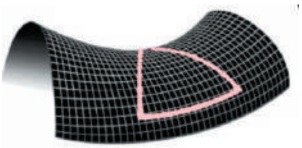


Fig. 12.7

If the density of the Universe is less than critical density, gravity will be too weak to stop its expansion and the Universe will expand forever at an everdecreasing rate. The geometry of spacetime can be thought of as being shaped like the surface of a saddle. A triangle drawn on such a surface has an angle sum less than 180°. As the Universe continues to expand, all the stars and galaxies will eventually exhaust their energy and the Universe will cool down, ending in the 'Big Chill'.

Scenario 3: A flat Universe

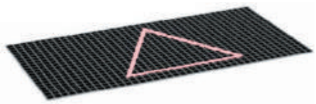


Fig. 12.8

If the density of the Universe is equal to critical density, gravity will be just sufficient to stop its expansion, but only after an infinite time. The geometry of spacetime can be thought of as being flat. In a flat Universe, a triangle has an angle sum of 180°. A flat Universe will expand at an ever-decreasing rate, but at a slower rate than for an open Universe.

What is the most likely future of the Universe?

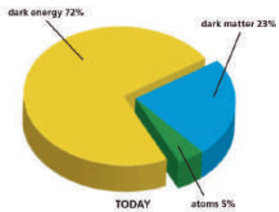


Fig. 12.9

In order to make a reliable prediction about the future of the Universe, cosmologists need to know its average density. To do this, they need to know what it's made of. Until about thirty years ago, astronomers thought that the Universe was composed almost entirely of the 'ordinary' matter that makes up stars, galaxies and us. However, in recent years the evidence suggests there is something else in the Universe that we can't see, perhaps some new kind of matter. Today, cosmologists believe that the Universe contains radiation, baryonic (ordinary) matter, dark matter and dark energy.

radiation	Radiation consists of massless (or nearly massless in the case of neutrinos) particles that travel at the speed of light, such as photons and neutrinos
baryonic matter	This is 'ordinary' matter, such as protons, neutrons and electrons.
dark matter	Astrophysicists have calculated that there isn't enough visible matter in the Universe toexplain how clusters of galaxies hold together, or how spiral galaxies hold together athigh rotational speeds. Dark matter has been hypothesised to explain the 'missing' mass in the Universe. While ithas never been observed directly, dark matter is thought to interact weakly with matter through gravity. However, astrophysicists aren't agreed on what dark matter really is.
dark energy	Observations of distant supernovae indicate that the Universe is expanding at anaccelerating rate. Astrophysicists suggest that this expansion is caused by dark energy, which has a gravitationally repulsive effect on matter. As with dark matter, there is nogeneral agreement on what dark energy really is.

This leads to a fourth possible scenario for the future for the Universe In a Universe that is expanding at an accelerating rate:

- galaxies we now see will recede out of sight, one by one;

- tens of billions of years from now, the Milky Way will be the only galaxy we'll be able to see;
- our Sun will have shrunk to a white dwarf star that will provide little light and heat to Earth;
- stars will slowly burn out and collapse into black holes; and
- the Universe will be a vast, empty, dark and cold place.

Activities 12.3

The end of the universe?

Scientists have given a series of fun names to theories about the universe's end – none of which are thought to occur for hundreds and hundreds of years.

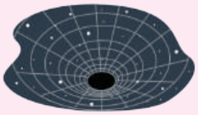
The Big Freeze

As our universe continues to expand. It will continue to cool. Eventually this could potentially lead to the universe becoming too cold to sustain life.

The Big Rip

The expanding universe could cause all matter to be torn apart once the force of the expansion becomes too great.

The Big Crunch



Constant expansion will eventually lead the universe to collapse, ending in a single black hole

The Big Bounce

The theory combines the Big Bang with the Big Crunch. According to it, out universe continues to "bounce" back and forth between a Big Bang and a Big Crunch. After this universe collapses, ending all life, expansion will help bring about a new cycle of life.

Write your answer to the following :

i. It's one million years in the future, and the universe is about to end. What's happening? Why is the universe ending? What will happen to everyone? Be creative and descriptive.

ii. If you knew the universe was going to end soon, what THREE things would you want to do before it all ended, and why? Pretend money is not an issue.

iii. You're in a spaceship traveling toward the edge of the universe. When you finally reach the edge, what is there? Tell a story about your travels to the end of the universe and what you found there.

Project Work

The Big Bang Theory's Model

i. As shown in the picture, make a model of the Big Bang Theory using local and low cost materials and stick it on the wall of the classroom.

ii. Explore open, closed, and flat universes using the internet or any other means. Model them and present them to the class. Prepare a report after extensive discussion among classmates.

iii. Take a balloon and fill it with some air. Then tear the mouth of the balloon with your finger so that the air does not escape, and make dots on the surface of the balloon with different colored markers. Now inflate the balloon and observe the distance between the dots. As the volume of the balloon increases, does the distance between each dot increase, decrease, or remain the same? Make a report with your findings and submit it to the science teacher.

Exercise

A. Choose the correct one and put the tick mark (√) .

i. Which is not correct for gravity
   a. The force that holds the gases in the sun.
   b. The force that causes a ball you throw in the air to come down again.
   c. The force that causes a glass you drop to fall to the floor.
   d. A person with a life vest floating on water.

ii. The Universal Law of Gravitation relates to
   a. Darwin b. Faraday c. Newton d. Einstein

iii. What force is responsible for the earth revolving round the sun ?
   a. Centripetal force b. Centifugal force
   c. Gravitational force d. Upthrust force

iv. What type of force is involved in the formation of tides in the sea ?
   a. Centripetal force b. Centifugal force
   c. Gravitational force d. Upthrust force

v. Which force is responsible for the holding the solar system together ?
   a. Gravitational force b. Centifugal force
   c. Centripetal force d. Upthrust force

vi. Name the scientist who explained the motion of planets on the basis of gravitational force between the sun and the planets .
   a. Kepler b. Newton c. Einstein d. Lemaitre

vii. __________ theory explains the origin of the universe, with the key idea that the universe is expanding.
   a. Kepler b. Hubble c. Lemaitre d. The Big Bang

viii. Eventually, gravity will cause a closed Universe to collapse back in on itself, ending in the. __________
   a. Big Bang b. Big Crunch c. Big Chill d. Big Collapse

ix. Hubble established the relationship between __________ and distance.
   a. velocity b. acceleration c. redshift d. gravity

x. Georges Lemaitre proposed a model for the origin of the universe which became the __________ theory
   a. Big Bang b. Big Crunch c. Big Chill d. Big Collapse

B. Differentiate between these pairs.

i. Gravitation and Atraction`
ii. Closed Universe and Open Universe
iii. Open Universe and Flat Universe
iv. Aastronomers and Cosmologists
v. Big Bangand and Big Crunch
vi. Big Chill and Big Crunch
vii. Gravitatinal Force and Tidal Force
viii. Past and Future of the Universe

C. Explain the following:

i. Satellites, planets, stars, galaxies, and other objects become stuck in space due to gravitational force.
ii. Rainfall, snowfall etc. take place due to gravitational force of earth.

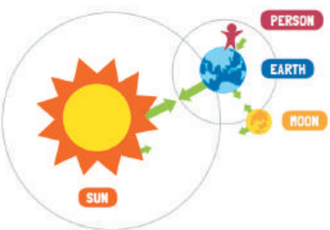
iii. Neptune's Triton is being pulled closer and closer to the planet as it orbits.
iv. The Big Bang theory explains the origin of the universe stars will slowly burn out and collapse into black holes
v. Earth binds all objects on due to gravitational force

D. Answer the following questions :

i. What is gravitational force .
ii. What exactly is the connection between gravitational force and the universe?
iii. Why is gravitational force important to the universe?What happens in a closed universe?
iv. Describe the Big Bang theory .
v. What is an open universe?
vi. What happens if the universe is closed?
vii. What is meant by flat universe?
viii. What are the 3 types of universe?
ix. What is meant by flat universe?
x. Explain the importance of gravity in the universe.
xi. Describe the origin of the universe according to the Big Bang theory.
xii. State the results of Hubble's study on the motion of cosmic bodies.
xiii. Make a case for possible universe predictions based on gravitational force laws.

E. Diagrammatic Questions :

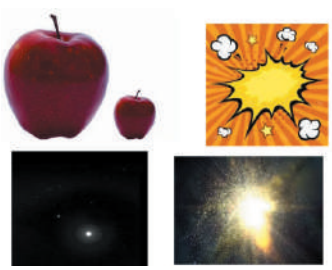
i. Study the picture below and answer the following questions:



a. What is shown in the picture?
b. What is it related to?
c. Write three reasons why it is important.
d. Why don't the sun, earth, and moon come out of their respective orbits?

ii. Find out what specific hypothesis/theory about the origin of the universe is being shown using the four related picture .From the picture, make a conclusion of one paragraph.

iii. Find out what specific hypothesis/theory about the origin of the universe is being shown using the four related picture .From the picture, make a conclusion of one paragraph .



Chapter 13

Information and Communication Technology

Total Estimated pariods (Th. 7+ Pr. 3=10)

Student's Learning Outcomes

After studying this unit, the students will be able to :

- briefly describe the introduction and transmission process of digital signals and give examples of applications
- explore the effects of digital technology on the development of information and communication
- describe and adopt the concepts of netizenship, online reputation, and digital wellbeing
- demonstrate learning through audio and visual media by adopting digital wellbeing

Michael Frederick Hauben (May 1, 1973 – June 27, 2001) was an American Internet theorist and author . He was one of the pioneers who studied the role and impact of the Internet on society. He was a theorist and researcher who focused his online research on social impact especially in the early 1990s; he introduced the term Netizen and he did detailed research which led to his conceptualization of the Netizen in relation to computers, society, democracy, democratization, the decision making process, etc. Michael Hauben established a new scientific field and he used relevant methods studying the activities of citizens of the Net, of different countries, and of the modern world.

13.1 Digital Signal

Analog and digital signals are the types of signals carrying information. The major difference between both signals is that the analog signals have continuous electrical signals, while digital signals have non-continuous electrical signals.

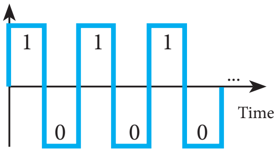
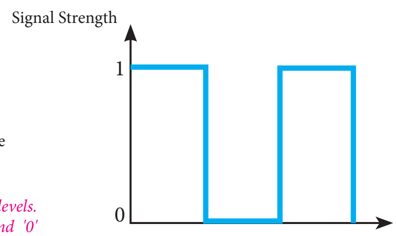


Fig: 13.1 A digital signal with two levels. '1' represented by a positive voltage and '0' represented by a negative voltage



A Signal can have more than two levels

A digital signal encodes data as a sequence of discrete values. It can only have one value from a finite set of possible values at any given time. Many physical quantities can be used to represent information in digital signals, like variable electric current or voltage. It is represented by square waves. Computers, optical drives, and other electronic devices

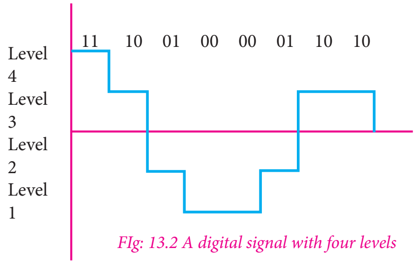


FIg: 13.2 A digital signal with four levels are some examples of digital signal .A digital signal is converted into a binary waveform. It is suited for digital electronics like computers, mobiles, and more.

A digital signal can only take one of two (discrete) states are usually referred to as;

- 1s and 0s
- Highs and lows, or
- Ons and offs

In general, if a signal has L levels then, each level need Log_2L bits Example: Consider a digital Signal with four levels, how many bits are required per level? Answer: Number of bits per level $= Log_2L = Log_24 = 2$ Hence, 2 bits are required per level for a signal with four levels.

Bit

A bit (binary digit) is the smallest unit of data that a computer can process and store. A bit is always in one of two physical states, similar to an on/off light switch. The state is represented by a single binary value, usually a 0 or 1. However, the state might also be represented by yes/no, on/off or true/false. Bits are stored in memory through the use of capacitors that hold electrical charges. The charge determines the state of each bit, which, in turn, determines the bit's value.

Byte

In most computer systems, a byte is a unit of data that is eight binary digits long. A byte is the unit most computers use to represent a character such as a letter, number or typographic symbol. Each byte can hold a string of bits that need to be used in a larger unit for application purposes.

A kilobyte (KB) is 1,024 bytes, not one thousand bytes as might be expected, because computers use binary (base two) math, instead of a decimal (base ten) system.

Computer storage and memory is often measured in megabytes (MB) and gigabytes (GB). A medium-sized novel contains about 1 MB of information. 1 MB is 1,024 kilobytes, or 1,048,576 (1024x1024) bytes, not one million bytes.

Transmission of digital signals

Digital Transmission is a type of signal transmission in which the signals vary discretely with time between two values: one representing the binary number 0 and the other representing 1.

The variable quantity in copper cabling is generally the voltage or electrical potential. Variation in intensity or any other physical quantity is utilised in fiber-optic cabling or wireless communication.

For the transfer of binary information through a communication channel such as a network cable or a telecommunications link, digital signals employ discrete values. A digital signal is transferred one bit at a time on a serial transmission line.

A digital signal periodic or non-periodic, is a composite analog signal with frequencies between zero and infinity. We can transmit a digital signal by using one of two different approaches: baseband transmission or broadband transmission (using modulation).

i. Baseband Transmission

Baseband transmission means sending a digital signal over a channel without changing the digital signal to an analog signal. The following figure shows baseband transmission.

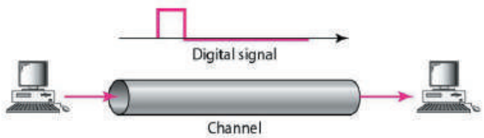


Fig. 13.3

Baseband transmission requires a low-pass channel, a channel with a bandwidth that starts from zero. This is the case if we have a dedicated medium with a bandwidth constituting only one channel. For example, the entire bandwidth of a cable connecting two computers is one single channel. As another example, we may connect several computers to a bus, but not allow more than two stations to communicate at a time.

- The signal is transmitted without making any change to it (ie. Without modulation).
- In baseband transmission, the bandwidth of the signal to be transmitted has to be less than the bandwidth of the channel.
- Ex. Consider a Baseband channel with lower frequency 0Hz and higher frequency 100Hz, hence its bandwidth is 100 (Bandwidth is calculated by getting the difference between the highest and lowest frequency).
- We can easily transmit a signal with frequency below 100Hz, such a channel whose bandwidth is more than the bandwidth of the signal is called Wideband channel.
- Logically a signal with frequency say 120Hz will be blocked resulting in loss of information, such a channel whose bandwidth is less than the bandwidth of the signal is called Narrowband channel

ii. Broadband Transmission (Using Modulation)

Broadband transmission or modulation means changing the digital signal to an analog signal for transmission. Modulation allows us to use a band pass channel-a channel with a bandwidth that does not start from zero. This type of channel is more available than a low-pass channel. The following figure shows a band pass channel.

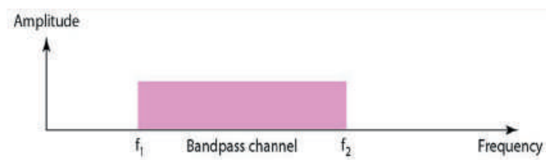


Fig. 13.4

- Given a bandpass channel, a digital signal cannot be transmitted directly through it.
- In broadband transmission we use modulation, i.e we change the signal to analog signal before transmitting it.
- The digital signal is first converted to an analog signal, since we have a bandpass channel we cannot directly send this signal through the available channel. Consider the bandpass channel with lower frequency 50Hz and higher frequency 80Hz, and the signal to be transmitted has frequency 10Hz.
- To pass the analog signal through the bandpass channel, the signal is modulated using a carrier frequency. The analog signal (10Hz) is modulated by a carrier frequency of 50Hz resulting in an signal of frequency 60Hz which can pass through our bandpass channel.
- The signal is demodulated and again converted into an digital signal at the other end as shown in the figure below.

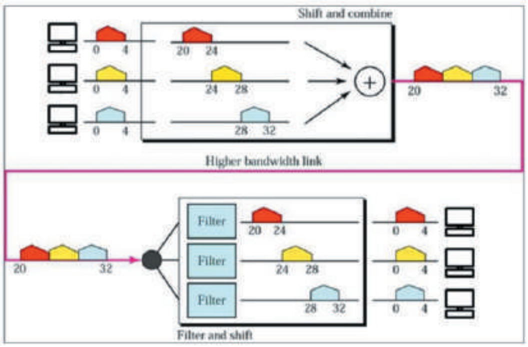


Fig:13.5 Broadband Transmission Involving Modulation & Demodulation

13.2 The Positive and Negative impact of digital technology in everyday life

Digital technologies

Digital technologies are electronic tools, systems, devices, and resources that generate, store, or process data. Well-known examples include social media, online games, multimedia, and mobile phones. It is the branch of scientific or engineering knowledge that deals with the creation and practical use of digital or computerized devices, methods, systems, etc.

Digital Technology Examples

Websites, buying and selling online, smartphones, digital televisions, video streaming, eBooks, digital music, geolocation, blogs, social media, computers, digital printers, self-scan machines,ATMs, digital cameras(digital photo), digital clocks, robotics,drones and guided missiles,mobile banking and finances, dictionary on mobile or tablate , calender, etc.

In today's interrelated world, digital technology is extensively used by our country and it affects our lives everyday. In the current digital age everyday new technology comes as information and communication technology (ICT) riot. These new technologies have been accessible by people in their everyday life and increase their living standards. Now days, many digital (ICT) gadgets are used in our life and they facilitate with mobility thus used anywhere and anytime. These gadgets operate for Information, Speed, and Communication and reduce the physical and mental human work load. By that principles, modern day gadgets truly helped mankind in daily life. ICT has contributed a lot to change our everyday life such as letter to e-mail, market shopping to on-line shopping, classroom learning to e-learning, etc.The effects of ICT as Home and Domestic Activities, Social Networking, Education, Health, Commerce, Banking, and Employment.

Positive Impacts

i. **As Home and Domestic Activities:** We can connect and controls domestic equipments (such as washing machine, refrigerator, cell-phones, laptops etc.). Carry out net banking, online shopping, read newspapers online, watch TV programs, impart education and connects ourselves to our family, friends, or relatives while we are at long distance by using the e-mail, messenger, call-conference, or video-conference.

ii. **As Social Networking:** There are many social networking sites are available like FACEBOOK, TWITTER, and LINKEDIN which allows users to communicate and stay connected with each other across the globe regularly. All these sites have helped to narrow the physical distances between people. Social Networking provides facilities such as faster communication speed, effective sharing of information, paperless environment, etc.

iii. **As Education/E-Learning:** E-Learning is an electronic learning, in which the learner uses a computer to learn a task, skill, or process at that time teacher teaches through the computer online. Students can learn by watching videos, e-books, discussion groups, bulletin boards, blogs and e-learning in a collaborate environment. Students can also ask question to their teacher using emails. Educational institutes uses projector or digi-class to teach students.

iv. **As Health:** When we get sick, we don't like to go outside even to visit the doctors. Today, we had a solution use digital gadgets to contact with our doctor and describe our problems. It is helpful to medical students to learn about disease, medicines, and surgeries. Doctors can demonstrate major surgical operations to medical students by the use of digital technology. Doctors can operate critical patient in guidance of many specialist surgeons through video-conferencing.

v. **As Shopping/Commerce:** Online shopping involves E-commerce. It draws on such technologies as electronic funds transfer, online transaction processing, Inventory management system and automated data collection systems. It makes buying and selling activities easier, more efficient and faster by using computers, internet and shared software. Digital technology helped companies to make more money and spend less on their business.

Fig. 13.5

vi. **As Banking:** Banking helped us to buy things using E-commerce. It carries out electronic transactions through Debit/Credit cards, net banking and Bus/Air/Rail tickets booking at anyplace at anytime with the use our same banking account. We can save our time, access accounts for loan applications, transactions and update our cash flow at any time. Banking is facilitated with virtual money so it introduces an Eco-friendly world.

vii. **As Employment/Jobs:** Digital technology increases the number of employments in our society. People can work as Web developer, IT network administrator, etc who have skills in ICT. It gives new job opportunities for many people to become successful self-employer to work from their home.

viii. **Daily routine Management:** We can store and manage our daily schedule information using digital gadgets. We can also integrate the domestic equipments to use and control together. We can also use net banking, online payments and online trading for purchasing daily needed items. It will save our time to go market and purchase things.

ix. **Social Relationship:** Digital technology provides the facility to make contacts and maintain relationships with people around the world in our daily routine. With the use of Internet and communication channel, we can connect the people via e-mail, social networking websites and cell phones. It saves time and works inexpensive way. There are bulletin boards, discussion groups services are available to communicate with a large number of people at the same time.

x. **Information Sharing:** Now information just right on our fingertips. We can access any information anywhere and anytime. Information, news, views, etc. can be shared by people all around the globe with the use of e-mail, discussion groups on the Internet such as Google Groups, Yahoo! Groups etc. By the sharing of information, it develops global awareness such as cultures, religions, ideologies and lifestyles. These create an environment of openness and increases mutual respect.

Fig. 13.6

xi. **Communication:** We can communicate each other without boundaries. It becomes quicker because we can send an instant message in a fraction of time with the low cost which saves costs and man power for delivery. For that E-mail, teleconferencing, and video-conferencing are available. By the use of video conferencing technique, we can get feel to communicate with someone face to face which is benefit for meeting or communicate together.

xii. **Usage of Free time:** Digital technology can be used to access as an entertainment. We can play games, launch of digital TV, Chatting, watch videos, listen songs, watch or listen to the news, pick up on individual news items, and many more.

xiii. **Children's Education:** New ways of learning are possible through digital technology such as e-learning, distance learning, on-line materials, virtual learning and interactive multi-media. Students can be part of these various learning and teaching from all over the world. For the impossible experiments, we can use simulations and virtual reality. If students and teachers logged at same time at the same pace mad the virtual classroom for e-learning. This is a smart investment four our children's future.

xiv. **Self Employment:** Digital gadgets are help out us to do our jobs easier. We can create our own business shops without the heavy overheads of place, purchase items and sales in market and make the advertising campaigns use of multimedia application. This increased sales and encourages the small businesses. We can use net banking, online payments as the payment option.

xv. **Paperless Environment:** Digital technology mostly uses its gadgets to store and retrieve information instead of paper. Use of digital technology involved less papers, thus it saves the trees and makes our environment healthy.

xvi. **Developing Health Literacy:** With the immediate feedback from doctors, we becomes well sooner. Health literacy deals with the need for people to access and use high quality information about disease and medicines through internet health care services available in digital gadgets.

Negative Impacts

i. **Reduced face-to-face interaction:** Now days, people mostly likes online communication rather than real conversations so people tend to become more individualistic and introvert. Other limitation is that we are not able express our feeling or what we are actually want to say by the use of e-mail or social networking sites. Thus we required face to face communication with them to express our real feeling.

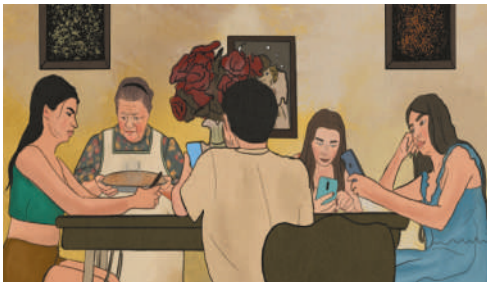


Fig. 13.7

ii. **Social Disconnect:** Although the internet has reduced physical distances between people, but that doesn't means they brought all closer together and emotional distance is increased in some aspects. People always busy with their own virtual world and passing a day. They forget the real world with family and friends and they becoming a formality. Children too are spending more time in virtual world and they adopt wrong thoughts thus rising cyber crimes and extra marital affairs with the use of digital gadgets.

iii. **Reduced physical activity/Health Problems:** Users may accept a more sitting lifestyle by the use of digital gadgets. This can lead to health problems such as headache, fatness, heart disease, diabetes, repetitive strain injury or eyestrain, wrong posture/position, neck pain, physical and mental stress, etc because of continuous use. Children gets stretch by the playing internet games, watching cartoon which may stop them to go outside and they feel afraid to talk with other children. In this kind of lifestyle there is lack of physical exercise, increases our health risk.

iv. **Cost:** Many digital gadgets are expensive. So they are cost effective to purchase and to maintain. Poor students cannot get the benefits of e-learning due to the educational establishments.

v. **Job loss:** Job losses may occur because of manual operations being replaced by automation.

Activities 13.1

Fill in the table below with information about the mobile phones of your family members. After completing the table, identify the member who spends the most time on mobile. Prepare a list of the positive and negative effects of mobile phones on him/her and present it to your parents and classmates.

Family members	Is mobile phone available or not?	The purpose of use	Duration of mobile usage
Father			
Mother			

13.3 Concepts of netizenship, online reputation, and digital wellbeing

Netizenship

The term 'Netizen' is a portmanteau of the English words 'internet' and 'citizen', as in a 'citizen of the net' or 'net citizen'. It describes a person actively involved in online communities or the Internet in general. *Netizens* utilize the Net from their home, workplace, school, library, etc. These people are among those who populate the Net and make it a resource for human beings. These netizens participate to help make the net both an intellectual and a social resource. The concept of Netizen is also commonly referred to by other expressions like: 'Internet Citizen', 'Network Citizen', 'Digital Citizen' or 'Cyber Citizen' which are used interchangeably and synonymously. Netizen has been defined in various ways. Some are as follows:

i. A Netizen refers to a citizen (of the physical space) utilizing or using information technology (IT) as a tool in order to engage in society, politics, and government participation.

ii Netizen is a citizen of the Internet, which is globally connected.

iii. Netizens, or electronic citizens, can be defined as 'those who use the Internet regularly and effectively.'

iv. A Netizen is someone who takes responsibility for and looks after the internet.

According to the above definitions, a Netizen is simply a net citizen, but in the legal sense, because the concept of citizen or citizenship carries both rights and responsibilities, it is preferable to define the term netizen in the same way. In this sense, a Netizen is 'someone who has rights on the internet and accepts responsibility for it.'

The terms of netizenship and netizen (as illustrated in Figure above) were introduced by Michael Frederick Hauben and Ronda Hauben capture the emergence of 'citizens of the Net' ,citizens who carry invigorated rights and obligations and are people who care about Usenet and the bigger Net and work towards building the cooperative and collective nature which benefits the larger world'. Like cyber citizenship, netizenship re-prioritises rights of access and participation while positioning the individual within a 'technological common-wealth'. It is about recognition and legitimisation of a technologically bounded public and communities and, merges civil, political and social rights through new technologies.

Online reputation

Online reputation is the image of a brand or company that is projected on the internet. This is given by the opinions of the users of the brand on the internet, either through reviews in search engines, opinions in forums or publications on social networks, based on their own experiences. Online reputation has a vital importance for the brand,since many times due to poor management of it a business can cease to exist. As a general rule, you can not control what is said about a business on the internet, so it is essential to know how to manage the action plan in the face of a bad review on the internet. Keep in mind that those bad opinions once written are indexed by search engines, so they will appear in the searches that are made on the internet and you have to do everything possible so that they do not affect the image you have of the brand. To prevent a brand from falling victim to a reputation crisis.

The things online that you have liked, shared and commented on, as well as what others have shared about you, may shape what other people think about you; this is your online reputation. Your online reputation could affect how people think about you or even behave towards you.

Sometimes online reputation is the consensus public opinion of an individual or organization based on their online presence and dependent on both their behavior and the subjective thoughts of observers or customers. Online reputation did not always develop so quickly, but with the rapid growth of social media, it's very easy for a company to improve or destroy their online reputation (or have that done to them). Just as individuals and companies have a reputation based on their activity in the real world, a misplaced message, financial scandal, personal disagreement, failure to deliver on promises, or misunderstanding can easily change the way someone is viewed on social media. It can also have a huge financial impact on a business. Online reputation is important to consider and cultivate, especially if careers and finances depend on it. In fact, there's a whole industry that springs up around online reputation management.

Digital wellbeing

Wellbeing is defined as the ability to handle life's stresses, adapt to difficult circumstances, and thrive . Digital wellbeing is the extent to which we can do these things in our digital lives. So digital wellbeing may be defined as having the ability to handle online stress, engage in healthy digital behaviors, and use our technologies in ways that help us thrive.

Digital wellbeing is a term used to describe the impact of technologies and digital services on people's mental, physical, social and emotional health. It is a complex concept that can be viewed from a variety of perspectives and across different contexts and situations:

Individual perspective: personal, learning and work contexts: this involves identifying and understanding the positive benefits and any potential negative aspects of engaging with digital activities and being aware of ways to manage and control these to improve wellbeing.

Societal or organisational perspective: providers of digital systems, services and content have a responsibility for ensuring that these are well managed, supported, accessible and equitable. They also need to empower and build capability in users so that all who engage with them are equipped to do so in a way that supports and/or improves their wellbeing.

We're all at least vaguely familiar with what 'wellbeing' or 'wellness' is - a state of mind in which we judge life positively and feel good, and which comes from being healthy of mind, body, and soul.

Our grasp of this has progressed enormously in recent decades and there's now no shortage of advice for people looking to achieve the peace of mind needed for wellbeing. It encompasses every part of life, from a nutritious diet, regular exercise, and healthy relationships with friends and family, to professional fulfillment, gratifying hobbies, and financial security. Wellbeing even stretches to our relationship with the environment.

There is also a strong psychological component, whereby we regulate our mental health through controlling our emotions and addictions, without overlooking the spiritual or intellectual aspects that give our lives meaning and purpose.

And while this may seem like too many spinning plates for a world overflowing with distractions, temptations, and short-term fixes, it ultimately comes down to developing - and sustaining - healthy day-to-day habits.

Digital wellbeing is a subjective individual experience of optimal balance between the benefits and drawbacks obtained from mobile connectivity. This experiential state is comprised of affective and cognitive appraisals of the integration of digital connectivity into ordinary life. People achieve digital wellbeing when experiencing maximal controlled pleasure and functional support, together with minimal loss of control and functional impairment.

Activities 13.2

Digital wellbeing helps in stress management- discuss with your friends and write down the reasons to confirm this statement. How you implement this in your life and present your ideas to the class.

13.4 Production and Presentation of Audio and Audio-Visual Materials

i. Production of Audio materials

Audio production is the art and science of sound recording, editing, and mixing. It can consist of many different projects like films, music, video games, TV advertisements, corporate videos, podcasts, and more. The main formats that are used for these productions are digital recordings.

Audio production refers to when someone records and edits audio, so audio production includes more than just being a music producer.You can also be an audio producer on TV shows, commercials, films, video games, and podcasts. Any sound you hear in any visual or aural media involves the work of an audio producer.

Materials on which sounds (only) are stored (recorded) and can be reproduced (played back) mechanically, electronically, or both. These materials include audiocassettes, audio cartridges, audio discs, audio reels, talking books, and other sound recordings. An audio media is a form of media communication that uses audio or voice recording as a medium in the delivery of information.

Audio- media are materials or sounds that are transmitted, produced or received through high fidelity waves that are heard through certain equipment. It is the recording, transmission, reception, and reproduction of sound used for communication, information dissemination, and entertainment.

The materials are light and usually portable and easily duplicated or replaced. May refer to analog tape cassettes and digital CDs as well as to computer files containing audio in any number of digital formats.

Types of Audio Materials

Fig. 13.8

i. Magnetic Recordings Cassette Tape

- Invented in the late 30's
- Popularized in the 40's and 50's
- magnetic recording employs the usage of a tape, made of thin plastic that is coated with many things the most important being ferric oxide. This ingredient gives a magnetic recording or a faster to use than any method before it as well as the ability to erase whatever recording had been on the tape.

ii. Digital Recordings (The Compact Disc)

Fig. 13.9

- Invented around the late 70s and early 80s 1.
- Digital recording is done by translating an audio signal into something that could be understood by a computer.
- In the 90s, the compact disc (CD) became the most popular digital recording format.

iii. Digital Audio Files (Mp3)

Fig. 13.10

- By the turn of the millennium, digital audio files that can be stored on computers, using such formats as the MP3, became the norm. It is a patented encoding format for digital audio which uses a form of lossy data compression. It is a common audio format for consumer audio storage.

iv. Phonograph

Fig. 13.11

- A device for the mechanical recording and of sound. In its later forms, it is also called a gramophone.

Applications in Education

- Can be used to improve listening skills
- Enhances learning for verbal information
- An ideal way for teaching foreign language
- Useful tool for those writing/ reading disabilities or non-readers
- Can be used for recording interviews

Productions of Audio Materials

Nowadays, creating audio via audio recording technologies is very easy. Audio equipment is now a portable tool for recording sound and taking notes. The steps in producing audio materials:

i. Planning
ii Understand the Purpose and Brainstorm
iii. Preparation
iii. Presentation
iv. Evaluation

Fig. 13.11

i. **Planing-** Effective planning is the most critical part in the production of educational media. Most people skip right to the shooting step before doing any planning.

ii. **Understand the purpose -** Before anything else, figure out why you need it. Think in terms of the 'final outcome', especially its educational purpose.

Brainstorm: Look at similar resources to gain ideas and inspiration. This is about collecting the ideas you want to produce.

iii. **Preparation -** This step will save you a lot of time. You must prepare the place or the location and also the equipment's.

Things must do in planning know clearly the objectives of the presentation

- Plan well in advance to be organized
- anticipate the problem
- anticipate the size of audience
- think about the quality of material to be used
- appropriateness to the subject
- availability of facilities for its use
- manner in which it is to be used

The audio material must have the :

- clarity of vice
- clear pitch of the audio
- appropriate language
- relevant to the topic
- appropriate length
- unbiased

iv. **Presentation -** Motivate the audience/listeners & stress key points they observe during the presentation.

v. **Evaluations-** End with questions, discussion and other forms of evaluation

Selecting Audio Materials

1. **Locating audio materials** - determine what materials are available locally.
2. **Appraising audio materials** - the "Appraisal Checklist" can be used to guide your selection decisions.

Utilizing Audio Materials

1. Preview the materials
2. Prepare the Materials
3. Prepare the Environment
4. Prepare the Learners
5. Provide the Learning Experiences

Presentation of audio-visual materials

Audiovisual materials, such as videotapes, DVDs, audio tapes, audio CDs and micro forms, can be difficult to identify and access. Audio-visual materials can include videos, audio files (podcasts, MP3s), training material such as guided tutorials and webinars, among others. Audiovisual materials means non print items which, with reasonable care and use, may be expected to last for more than one year.

This format includes any informational or instructional programs presented with slides, video, or digital representations. A presentation must take advantage of the medium. It should not be a substitute for another kind of presentation, such as a demonstration or illustrated talk.

Demonstrations and illustrated talks using alternatives to poster boards, such as PowerPoint, should not enter this category. The length of presentation should be appropriate for its topic and message. A slide presentation, video or computer presentation generally lasts between five and 10 minutes, and should be supplemented with a verbal commentary, synchronized tape recording, or audio track.

Production of audio-visual materials

In the previous topics, we read about how we can produce/prepare audio materials. If video is added to audio materials, they become audio-video materials. Since these materials contain video along with audio, they are widely used. It is used in teaching and learning, group presentations on any topic, etc. We can use it to convey some of the topics we know in our daily life. The same steps as audio production can be used in the production of audio-video materials, only video is added to it. It is important to keep the below mentioned information in mind while creating these materials:–

- Text on a computer screen should be legible from a distance of two meters
- Use bold face type letters
- Design learner friendly interactive multimedia systems
- Use simplified drawings
- Visual should be made to scale
- Use colours and dramatic pictures with humour
- Information given should match the pace of learning
- Use titles and questions liberally
- Make selective use of audio effects

Activities 13.3

Create audio-visual material

i. Record your teacher's lectures in segments of no more than 10 minutes.
ii. A script for the teacher's lecture segments.
iii. Ensure the audio in the video is clear and audible.
iv. Record lectures in an environment free of visual distractions.
v. Use audio and text as another way of creating lecture content.
vi. Give lectures a descriptive title and use a consistent numbering system.
vii. Add a brief welcome video on the home page.

Audio and video recording from a mobile phone or computer

Fig. 13.12

We can create audio and video content using a mobile phone or computer. For audio, just record it. However, both audio and video are mandatory for video. When we record any content from mobile, we must take some caution. You can use the mic to make the video sound clean and clear. The mobile phone should be taken close to the source and recorded. Similarly, if you want to make a nice video, your mobile phone should not be moved too much.

When taking a photo or video, we should always keep the mobile horizontal. This can make the video wider. We can use a mobile or computer for audio or audio-video content. By selecting the topics for audiography or videography, we can make wonderful audio or video by using various apps on mobile devices or computers or the materials given in this textbook.

Smartphone manufacturers usually offer their products with a bundle of pre-set software including a voice recording program. However, sometimes the bundle does not include a voice recording program. What can you do then? You can download either a free or a paid voice recording app from Google Play. There are many such apps, and you can choose the one you like.

As an example, we are using the free version of the popular Smart Voice Recorder app. The app offers the complete functionality necessary for voice recording but, similar to most free versions, contains advertisement slots. This is somewhat inconvenient but it lets you examine the program before buying it. The illustrations will show you such advertisement slots designed as gray rectangles.

Recording an audio file

Open the app Below, you can see the app window after launching it. To start recording, tap the red button or the Start Recording button 1. While you are recording, the big red button will show how much time has passed since you started recording. Above this button you will see the recording level indicator.

While recording, speak close to the microphone by holding the smartphone in front of yourself or pressing it to your ear as you do for a phone conversation. To stop the recording, tap the big red button a second time 2. After the pause, you can continue recording by tapping the red button.

To end the recording, tap the Finish button 3. A new window will open where the audio file can be saved. The default file name is automatically generated. Change the name to something easier to remember 4; this will make it easier for you to work with the audio files when loading them to CMS. Tap the OK button 5.

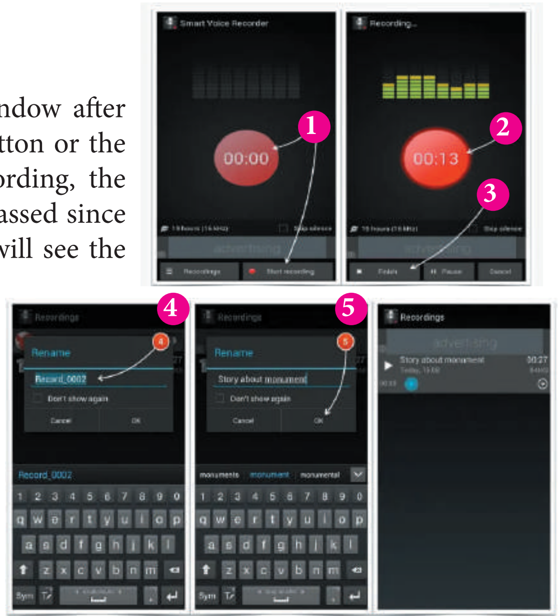


Fig. 13.13

Basic Principle in having an effective presentation

- select an effective presentation format
- place visual elements onscreen
- select appropriate backgrounds
- deliver a memorable, effective presentation
- choose readable typefaces
- choose colors
- choose visual and audio effects

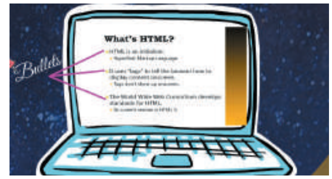
1. Choose your presentation format

You can choose from three basic type of format for a presentation based on powerPoint or Keynote:

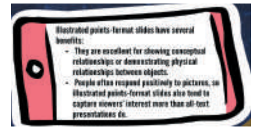
- Bullet points
- Illustrated point
- Speaker's prop

Note: The format you choose should fit your audience and your presentation's subject.

Bullet Point Type : The bullet point format is the default layout that most PowerPoint users and viewers are familiar with. Slides created in this format commonly include a title across the top and a cascading series of bulleted lines of text inside a slide's main text box.



Illustrated Points Type : The illustrated points format is similar, but slides created in this type of presentation focus on pictures, and text appears in a supporting role.



Speaker's Prop : The speaker's prop format is similar to the illustrated point format, but a speaker's prop almost entirely consists of simple pictures that flash onscreen in rapid sequence. Any text that appears in usually very short, uses a large font and only appears for a moment

Note: A speaker's prop is appropriate for abstract subjects (eg. the nature of free will), and if it is done well, it can be fascinating and will engage an audience.

2. Choose a typeface

When you create a presentation, make sure that the fonts you choose are:

- appropriate for the subject and audience
- readable from anywhere in the room
- compatible with the computer you'll be using for the presentation

Fig. 13.14

Note: most readable onscreen font are Tahoma., Georgia, Trebuchet, and Verdana.

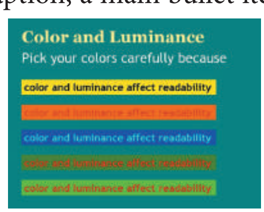
3. Think about your layout

When you place text or picture onscreen, make sure you apply the CRAP design principle.

- Contrast: If things aren't in the same category, make them look very different (e.g., use different fonts for slide headings and main text).
- Repetition: Make visual elements consistent throughout every slide (e.g., use consistent colors, callout shapes, font sizes, picture and text box location, background images).
- Alignment: Place things on the screen with a purpose. Don't just plop images and text in random location (e.g. equalize spaces between multiple pictures, consistently center or left-align text, line up bullets and numbers).
- Proximity: Place related items close to each other (e.g. use a narrow space between a name and job title , a picture and its caption, a main bullet item and its related sub-bullet items).

4. Choose Good Colors

- Contrast.
- Emotional Impact.
- Pick colors with high luminance contest
- Also consider the emotional effect of colors that you choose



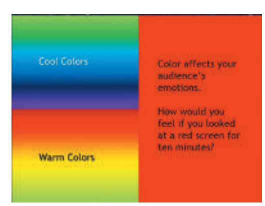


Fig. 13.15

5. Choose Appropriate Backgrounds

- Always make your presentation's background relate to its topic.

Fig. 13.16

Note: PowerPoint and Keynote all allow you to choose from built-in or downloadable background "theme" templates; insert and customize solid colors, gradients, or patterns; or import your own image to use as a background for your presentation

6. Make use of visual and audio effects

Transitions and animations can help you emphasize points, show connections between ideas, or simply capture your audience's attention and prevent their eyes from glazing over.

Fig. 13.17

Visual effect

Sound Effects: Audio cues have the same potential benefits and drawbacks as transitions and animations, but they also have several unique problems of their own:

- Audio clips will sound distorted or tinny unless the computer you are using to present is connected to a good-quality sound system.
- If the audio clip is more than a few seconds long, you'll need to shout to be heard over it.
- It's almost impossible to talk over rock or hip-hop. Your voice just can't compete with the backbeat.

7. Delivery Techniques

Fig. 13.18

You should:

- **Prepare Notes :** Write down key phrases on notecards or, if you will have access to a speaker's computer while you're talking, the program's notes view
- **Practice:** Run through your talk and slideshow before you stand in front of an audience. Start up the presentation, say what you intend to say out loud, advance the presentation to match your speech, and time yourself. If you don't practice, your audience will know.
- **Face Your Audience:** Turn your face toward the audience and make eye contact with them when you speak. If you do, the audience will be able to hear you and they will more likely to believe what you say.

The saved audio files list will open, containing the newly created audio file. The audio file entry contains the date it was created, its length, and size. The entry also contains a way to manage playback. You can listen to the recorded audio file. The audio file has been recorded, now you need to transfer it to the computer.

Transferring an audio file to the computer

Let's discuss two options for transferring an audio file to a computer:

- through cloud storage (Dropbox);
- as an attachment to an e-mail message.

To select an option for sharing the file, tap and hold your finger on the audio file's entry 6 until a new window opens, showing a list of additional actions available for that audio file. Select "Share…" (Share) 7. A window will open, showing the available options for sending the desired file.

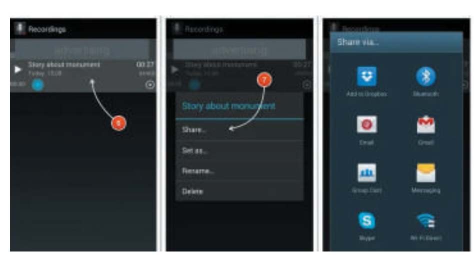


Fig. 13.19

Option for transferring a file by using Dropbox

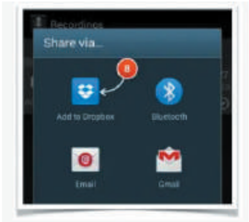


Fig. 13.20

If you see the Dropbox icon on the panel with the available options, that means you already have it installed and can use it to transfer the file to the computer. Tap the Dropbox icon 8.

A window will open, showing the list of Dropbox folders.

Create a new folder where you will place the recorded audio files. To do that, tap the folder icon in the upper right corner 9.

Fig. 13.21

In the newly opened window, enter the new folder's name 10 and tap the Create button. The newly created folder will open. You will see its name in the title.

Tap the Add button 11. The audio file will be placed in that folder. In a little while, it will also appear in an identical Dropbox folder on the computer.

Transferring via a different type of cloud storage is either completely identical to the one described above or it has only minor differences. All types of storage share a common concept – syncing data between the user's various devices. Therefore, it is sufficient to install a program like Dropbox on several devices and specify on each device the folders which need to be synced. After that, any file you place in such a folder will appear on all the devices which you have connected to the cloud storage.

Important : For a successful transfer, both the smartphone and the computer need to be connected to a network. Either to a local network or to the Internet.

Option for transferring the file by e-mail

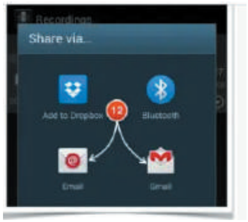


Fig. 13.22

If you do not have Dropbox or another kind of cloud storage installed, you can send the created audio file by e-mail from your smartphone to your computer. To do this, you will need to have an e-mail app on both the smartphone and the computer. Select the e-mail program icon 12.

A new message window will open. The "From" field will show the e-mail address for your user account.

In the "To" field, enter the recipient's e-mail address 13. This can be the same e-mail address if you use the same address on both the computer and the smartphone. Or it can be a different e-mail address. Make sure the message can be opened on the computer and the attached file can be saved.

Fig. 13.23

In the "Subject" field, enter the file name or other text which will help you identify the message 14. Tap the Send button 15.

The audio file is already attached to the message so you need to enter only the recipient's e-mail address and the message subject. Open the message on your computer and save the attached audio file in the prepared file in the computer's file system.

Editing of audio and video content

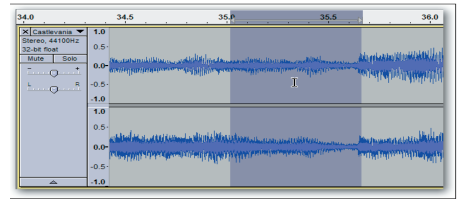


Fig. 13.24

Audio editing is the process of altering recorded sound to create the desired effect. Audio editing is the process of manipulating sound recordings. Video editing is the process of editing segments of motion video production footage, special effects and sound recordings in the post-production process.

Editing of Audio by cutting

Audio editing is considered important in this age of science and technology. So we need to learn some skills used in it. You can edit the audio using the methods given below.

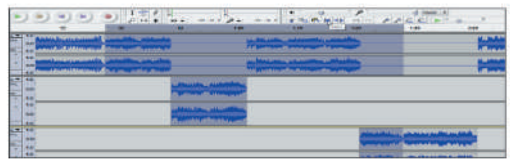


Fig. 13.25

The scrubber in the above screenshot is pointing to a lull in the music, where the audio drops low or fades out. These areas are ideal spots to work with.First, let's make sure the Selection tool is active.

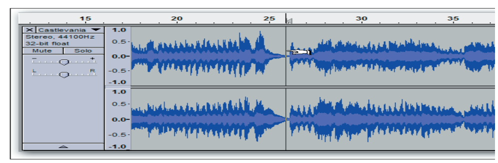


Fig. 13.26

Next, let's make a selection in an area of the track where we want to make an edit. Click and drag your mouse, and you'll see that the background changes to a darker shade of gray.

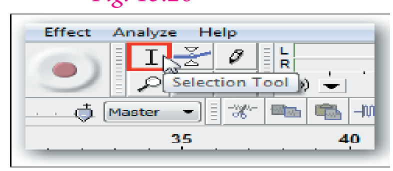


Fig. 13.27

You can hit CTRL+1 to Zoom In, or click on the icon that's a magnifying glass with a plus. This will help us identify more precisely where to end our selection.

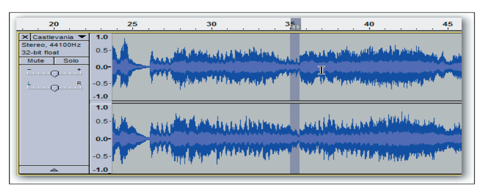


Fig. 13.28

That's much better, isn't it? You can see that on the right side of the selection area, there's a spike in amplitude. That's where want your selection to end, but it's not properly aligned. If you move your mouse close to that area, you'll see the cursor change to a hand that's pointing.

Clicking and dragging while this cursor is shown will allow you to change that particular selection boundary. You can see mine is much better now.

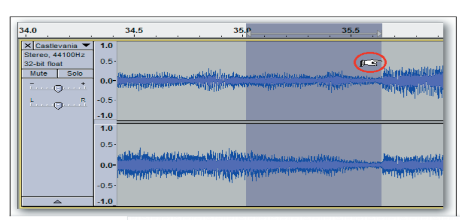


Fig. 13.29

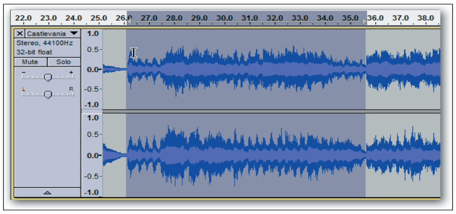


Fig. 13.30

Repeat the same process with the left boundary. You can see selection encompasses a quiet beginning point and a quiet ending point, which makes it sound clean and natural.

You cut this section and move it to another area. You can just click the Cut button or hit CTRL+X.

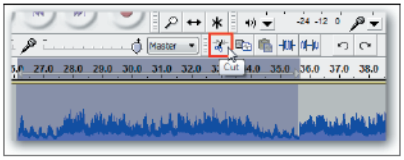


Fig. 13.31

You can see that the rest of the track after your selection got pushed up to where the selection started.

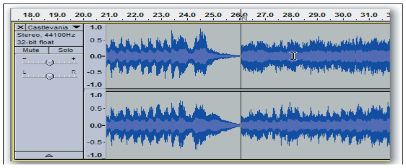


Fig. 13.32

While it's possible to paste that clip in the same track at a different point, it's much easier to make arrangements using multiple tracks. Go to Tracks > Add New > Stereo Track.

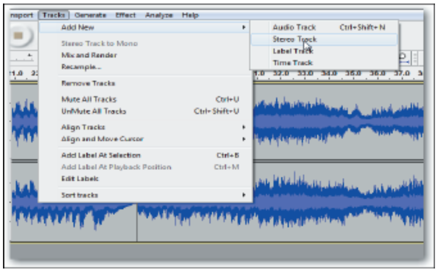


Fig. 13.33

Using different tracks can help keep things straight, so you can think of it like using Layers in an image editor. Sometimes, it's more work to use multiple tracks, and sometimes it's a necessity, but it's process you should familiarize yourself with if you plan to do audio editing.

Two tracks ending up being too tall for good screenshots, so you clicked on the bottom of each track area and dragged up to resize them vertically. This has no effect on the audio, it just makes it easier to see things.

And now, click where you want to paste the clip in the second track and click on the Paste button or hit CTRL+V.

Note that the bottom track has an active selection. The dark background is not in the top track at all, despite being visible in the timeline. Now, change its linear placement, or in other words, move it in time. To do that, we use the Time Shift Tool.

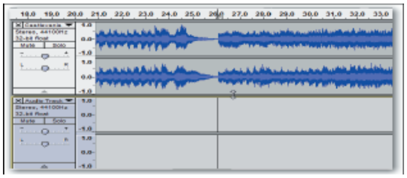


Fig. 13.34

Now you can click and drag anywhere in your selection and the whole thing will slide side-to-side. You can also have it snap to other locations, like the beginning or end.

Alright, when you hit play, however, Audacity will play both tracks over each other. This works well for mixing different tracks, but not here. Let's insert some silence in the first track. Click on the selection tool and highlight the portion of the first track that's directly above the second. You'll see that you can snap to that area.

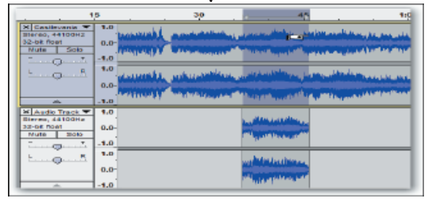


Fig. 13.35

Next, click on the Insert Silence tool, located next to the Undo button.

This converts our selection to silence. Instead of cutting and having the latter part of the track jump forward, this will keep it as-is because the silence acts as a placeholder. Next, cut some of the audio after the pasted clip.

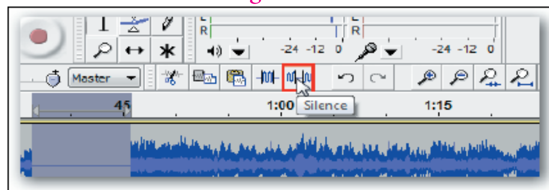


Fig. 13.36

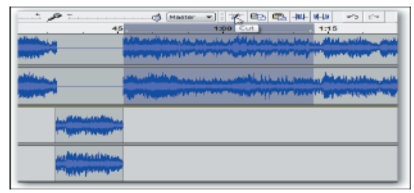


Fig. 13.37

Finally, the portions of the track to align are properly done.

But wait, middle sections of this track, instead of cutting out areas of the track before and after, we can use the trim tool to make this easier. Use the selection tool to highlight what you want to keep.

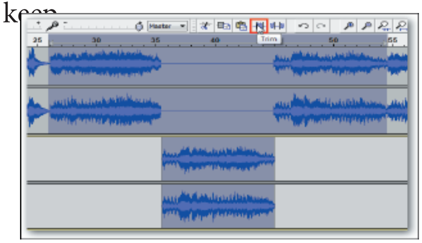


Fig. 13.38

Adjust your start and end points, but be sure to drag your mouse down into the second track while making your selection. Notice how the dark gray background appears on both tracks in the above screenshot. When you're ready, click on the Trim Tool, which is right next to the Paste button.

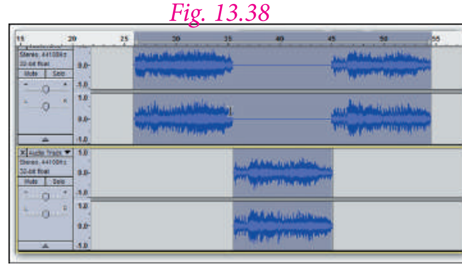


Fig. 13.39

You can see that the Trim Tool acts just like a Crop Tool does in image editors. The Trim Tool leaves the audio where it is, but that's not particularly useful in our case.

If you chose not to follow along, here are a few important points to take away from this procedure:

- Your audio selections can be changed by dragging from as close to the original boundary as possible.
- The Cut Tool removes sections from the timeline, leaving no gap.
- The Insert Silence Tool removes audio but leaves a gap.
- Pasting clips inserts them where ever the scrubber is, i.e. where you clicked last.

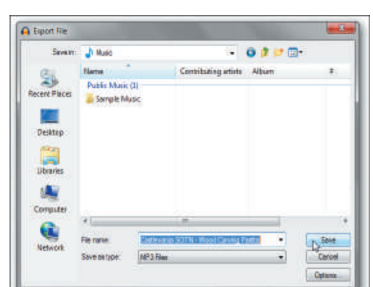


Fig. 13.40

- The Trim Tool acts as a Crop Tool, leaving the audio where it is in the timeline.
- You can add multiple tracks and use them like layers to better arrange your audio piece.

Editing of Audio by joining

We may need to add additional content to some audios. Would you like to join mp3 files of your music and/or other audio files together? This is how it works:

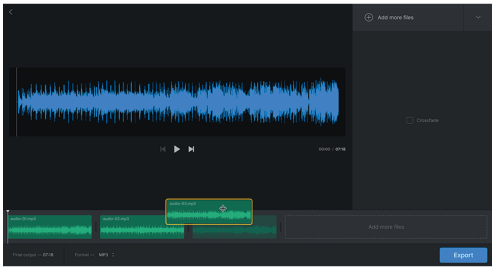


Fig. 13.41

Download the free version of Music Maker, install the program, and start a new project. Open the file manager by clicking on the icon in the toolbar, go to the folder containing your audio files and drag and drop the audio files you want to cut together into the arranger. Drag the first audio file to the beginning of the topmost track and the second one to the track below. Arrange the second audio file so that its beginning is at the end of the first. Play back the audio files by pressing the spacebar. Press it a second time to stop playback. To move the playback marker, click in the timeline. The yellow bar above the timeline will be played. You can freely adjust it using the mouse.

To create a crossfade mixing the two recordings into each other, click on the first audio file and drag the crossfade handle at the right edge of the object slightly inward. This will create a fade-out. Then, click on the following audio file and drag the crossfade handle at the beginning of the object slightly inward. Now, the first audio file will fade out smoothly, while the one behind it simultaneously fades in.This will create a crossfade, like in a DJ's mix, which can now be adjusted more precisely by moving the audio files and changing the length of the crossfades until everything fits perfectly.

To remove an undesired passage, place the playback marker where this passage begins and press the T key. This places a cut at that point and creates two, separate objects. Trim the end of the section too and then delete the cut middle passage from the track by pressing the Del key. Adjust the cuts as necessary by dragging their edges inward or outward.

You can trim any other remaining audio in the passage this way, or restore sections that were accidentally deleted. Close the gap created by the cuts you've made by moving both audio objects together on the track. To finish, export your project as a WAV file or OGG file in the "File" menu. Here, you can specify whether only the current playback range or all the objects included should be exported. The exported audio file will sound exactly the same as the project when played back in Music Maker.

Editing of Audio-Vedio by cutting

In fact, App allows you to edit both imported and recorded audio/videos. Right after the capture phase, the software takes you to the editor where you can edit what you've recorded.

As you can see, the **Timeline** pane has four range-editing commands that only can be used when a range is defined first. If you haven't selected a range, these buttons are disabled and you cannot click them.

Range

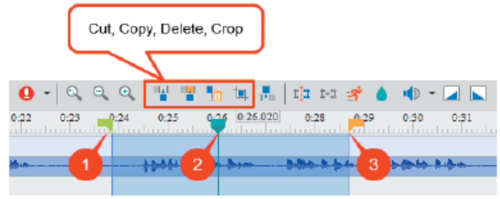


Fig. 13.42

- **Start Marker (1):** The green marker representing the starting point of the selected range.
- **Playhead (2):** The blue line indicating the timestamp that you are currently selecting.
- **End Marker (3):** The orange marker indicating the ending point of the selected range.

The Start Marker and the End Marker help to define a range. Just click to place the Playhead at any position in the **Timeline** pane. Then, you can select a range by either dragging the Start Marker or the End Marker. When you drag a marker, the Playhead will stick with it. The selected range is highlighted in light blue color to help you easily recognize it. To clear the selection, double-click the Playhead anywhere on the time axis.

Note:

- These basic audio and video editing tools act differently depending on whether or not you select an object. If you select an object, the tools affect that object only. If not, they affect the slide and all objects falling into the range (the entire slice of the range).
- To get a better view of the timeline, zoom in or out by holding down CTRL while scrolling the mouse wheel up or down, respectively.

Cut

In general, even when you work carefully, mistakes happen now and then when you record the screen. A big mistake may require you to start over and re-record everything. Meanwhile, a tiny mistake only needs an "undo" then you can continue recording as if it never ever happened. In that case, just cut the mistake out from the video/audio and you're done.

Perform some very simple steps and you can cut and remove unwanted fragments from the video/audio. Here's how:

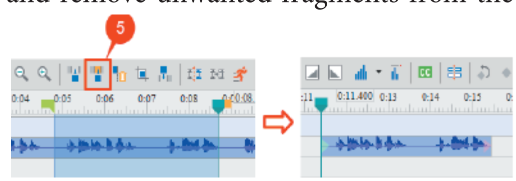


Fig. 13.43

Step 1: Select a video/audio that contains unwanted fragments. After that, make a range by dragging the end marker. Have in mind that the selected range is limited by two markers.

Step 2: Click **Cut Range (4)** or press **CTRL+SHIFT+X** to remove the range. Then, a red stripe appears to show where the two remaining parts of the video/audio are joined together.

Step 3: Optionally, paste the cut content into the same or another slide. To do that, move the Playhead to the desired position and press **CTRL+V**.

Delete

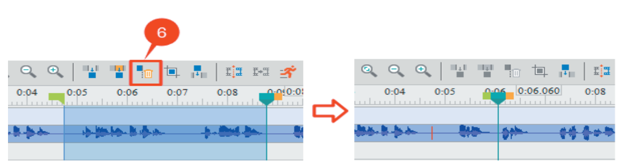


Fig. 13.44

Let's say removing mistakes is a basic task when you edit videos. So, use the **Delete Range** button to remove any unwanted audio and video parts. This is one of the basic audio and video editing tools that ActivePresenter offers you.

To get it done, select a range then click **Delete Range (6)** or press **Ctrl+Delete**.

Note: The **Delete Range** button works just like the **Cut Range** button, except for one difference. While the former is used to delete the content inside the range, the latter "cuts" the content from the range and places it on the clipboard, then you can paste it where you want. In short, **Delete Range** stands for removing while **Cut Range** stands for reallocating.

Crop

Often you record extra footage at the beginning and end of a recording. When you edit videos/audio, you want to trim out these fragments, that is to take off either end of the video/audio. As a result, ActivePresenter offers you a basic tool to solve this issue.

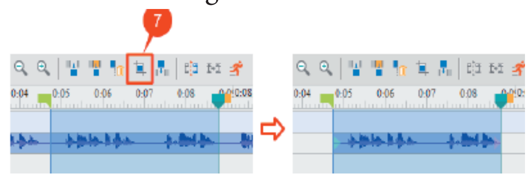


Fig. 13.45

Now, let's use the **Crop to Range** button to remove everything outside the range. Do as follows:

Step 1: Select a video/audio that you want to trim out extra content.

Step 2: Make a range. Bear in mind to keep the main content in the range.

Step 3: Click **Crop to Range** (7) or press **SHIFT+DELETE**. That way, only the part of the selected video/audio that lies inside the range is retained.

As mentioned above, the tools also work when you select no objects at all. In that case, they affect all the objects falling into the range. For example, if you click **Crop to Range** while selecting no objects, you retain only the slide content inside the range and delete all the rest.

Editing of Audio-Vedio by Joining

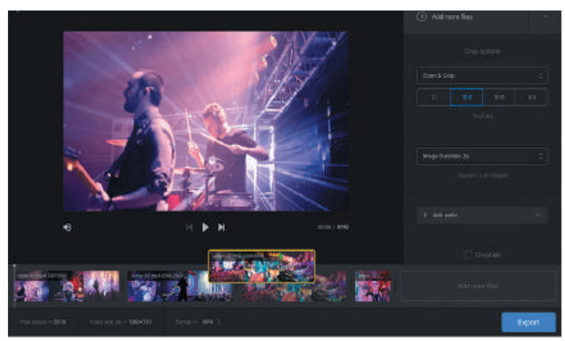


Fig. 13.46

STEP 1

Upload files

Choose the videos and photos you would like to merge. Several files can be chosen simultaneously or they can be added one by one after the first file is uploaded.

STEP 2

Join videos and other files

Rearrange them using drag-and-drop until they're the desired order. For images, you can set duration. Then add audio, change its length and volume. At last, choose the aspect ratio and click the "Export" button. Take a look at the guide to learn more.

STEP 3

Download the merged video

Once your files have been merged, watch the preview. If you want to change something, click on "Back to edit", otherwise click on the "Download" button to save the video.

If you have several videos and images that you want to stitch together, then our video joiner is perfect for you! It also allows setting the desired aspect ratio and output format, add an audio track.

Using our predefined settings, you can quickly create an ideal video for YouTube, Facebook, Instagram or Instagram Story.

Project Work

i. Arrange a debate program between classmates who believe that the use of digital technology has had a positive impact on society and those who believe that it has had a negative impact on society. Write the results of the debate on cardboard paper and paste them in the classroom.

ii. Write an essay on netizenship, online reputation, and digital wellbeing.

Exercise

A. Choose the correct one and put the tick mark (√).

i. Analog and ____________ signals are the types of signals carrying information.
   a. media b. electronic c. digital d. moblie

ii. Digital signals -
   a. continuous electrical singnals.
   b. non-continuous electrical signals.
   c. many physical quantities can't be used to represent information.
   d. represented by verticle waves.

iii. ____________is the smallest unit of data that a computer can process and store.
   a. Digital singal b. Bit c. Byte d. Waveform

iv. ____________ is the unit most computers use to represent a character such as a letter, number or typographic symbol.
   a. Digital singal b. Bit c. Byte d. Waveform

v. Baseband Transmission signal is transmitted-
   a. using modulation b. without modulation
   c. with modulation d. none of these.

vi. Broadband Transmission signal is transmitted-
   a. using modulation b. without modulation
   c. with modulation d. none of these

vii. Digital ____________are electronic tools, systems, devices, and resources that generate, store, or process data.
   a. signals b. baseband c. technologies d. broadband

viii. Which is not digital technologies
   a. social media b. online games c. multimedia d. tractor

ix. Positive impact of digital technologies-
   a. social disconnet b. reduced physical activity
   c. reduced face-to-face interaction d. e-Learning

x. Negative impact of digital technologies-
   a. online shopping, b. reduced physical activity
   c. paperless environment d. e-Learning

xi. Which is not related to Netizen-
   a. Internet Citizen b. Network Citizen c. Digital Citizen d. Radio Citizen

xii. Online reputation is
   a. the image of a brand or company that is projected on the internet.
   b. the extent to which we can do these things in our digital lives.
   c. the process of altering recorded sound to create the desired effect.

d. helpful to medical students to learn about disease, medicines, and surgeries.

xiii. Wellbeing is defined as

a. the image of a brand or company that is projected on the internet.
b. the extent to which we can do these things in our digital lives.
c. the process of altering recorded sound to create the desired effect.
d. helpful to medical students to learn about disease, medicines, and surgeries.

B. Differentiate between these pairs.

i. Information and Communication
ii. Baseband Transmission and Broadband Transmission
iii. Digital signals and Digital technologies
iv. Negative and Positive impact of Digital technologies
v. Online learning and Online reputation
vi. Audio and Audio-video
vii. Citizenship and Netizenship
viii. Social media and Digital media
ix. Digital wellbeing and Digital reputation

C. Explain the following:

i. A binary digit is the smallest unit of data .
ii. We can store and manage our daily schedule information using digital gadgets.
iii. Online shopping involves E-commerce.
iv. Online reputation has a vital importance for the brand.
v. Digital technology reduced face-to-face interaction.
vi. Digital technology reduced physical activity and health problems

D. Answer the following questions :

i. What are some examples of digital signals?
ii. What is a digital signal? Explain the characteristics of an Digital signal.
iii. Define the terms bit and byte .
iv. Is Internet a digital technology?
v. What is the purpose of digital technology?
vi. What are three digital technologies?
vii. How is digital signal transmitted? Write concisely.
viii. Write an essay on the use of digital technology in daily life.
ix. Describe in detail the positive and negative effects of digital technology in daily life.
x. What is netizenship? Write about your concept of it.
xi. What is an online reputation? Write about your concept of it.
xii. What is digital wellbeing ? Write your strong feelings about the concept.
xiii. How has the concept of netizenship, online reputation, and digital wellbeing developed in the age of digital technology? Write your arguments point by point.
xv. What is audio and audio-visual content? Write in brief about the creation and presentation of these materials.
xvi. How can audio and audio-video recording be done from a mobile phone or computer? Write concisely.
xvii. Write down the importance of cutting and joining in the editing of audio and audio-visual material. How can this be done? Write concisely.

xviii.Complete the table below to demonstrate how technology can have a positive impact on our lives. Remember, positive impact means to support or make easier.

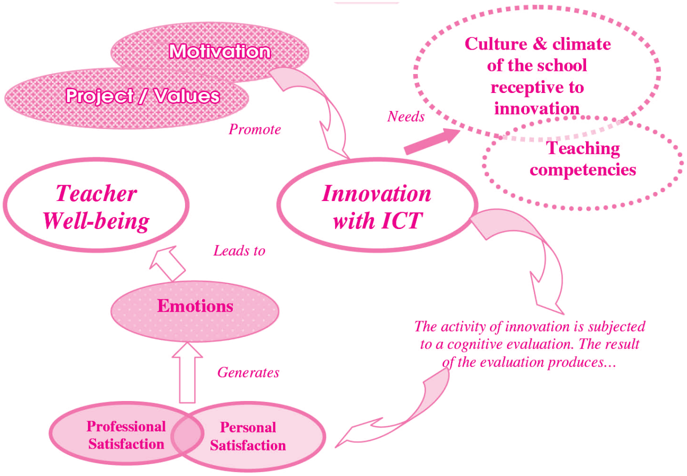
Impact of Technology	Technological Device	Example
Example: Saving lives	a GPS system on a boat	The electronic GPS can show the position of a boat that is starting to sink.
Saving lives		
Connecting people in a positive way		
Helping people		
Reconnecting friendships		
Bridging distance		
Changing how things are done (Positive)		
Helping to solve crime		

E. Diagrammatic Questions

i. Sushant is preparing a poster on 'How to be a Good Netizen' . Select the written words in given box and help sushant to complete the poster below -

Communication **Protection** **Honesty** **Think**

ii. A model relating teacher well-being to innovative digital technology applications is given below . With the help of this model, you can try to make your own digital wellbeing.



Chapter 14

Classification of Element

Total Estimated pariods (Th. 7+ Pr. 2=9)

Student's Learning Outcomes

After studying this unit, the students will be able to :

- demonstrate an understanding of modern periodic law,
- arrange the electron configuration of elements up to atomic number 20 on a subshell basis
- explain the place of metals, non-metals, and semi-metals in the modern periodic table.
- analyze the differences in atomic size, electro-positivity, electro-negativity, valence, and reactivity of certain group and period elements.

Henry Moseley, in full Henry Gwyn Jeffreys Moseley, (born November 23, 1887, Weymouth, Dorset, England—died August 10, 1915, Gallipoli, Turkey), English physicist who experimentally demonstrated that the major properties of an element are determined by the atomic number, not by the atomic weight, and firmly established the relationship between atomic number and the charge of the atomic nucleus. His first researches were concerned with radioactivity and beta radiation in radium. He then turned to the study of the X-ray spectra of the elements.

Introduction

There are 118 elements known till the date. Out of them, 92 elements are natural and the rest are artificially synthesized in the laboratory. The individual study of elements is very difficult. To make the study easier, faster and clearer, the chemists realized the necessity of grouping of elements. Elements are similar or dissimilar to each other. So, chemists have grouped the elements on the basis of their similarities and dissimilarities. The method of arranging similar elements in one group and separating them from dissimilar elements is called classification of elements. The classification of elements helps the study of the elements and their compounds systematic and easier. There were many chemists, who made attempts to classify the known elements. Among them, Antony Lavoisier became the first person to classify the known elements as metal and non-metal. Since then, many chemists contributed in the history of classification of elements. Finally, they became able to classify elements into different groups according to their similarities and dissimilarities in a table or chart.

Periodic table is a tabular arrangement of elements in such a way that the elements having similar properties are grouped together in the same vertical column and dissimilar elements are separated from each other.

In a periodic table, there are vertical columns called groups and horizontal rows periods.

Importance of classification of elements (periodic table)

- The classification helps to study elements in scientific, systematic and better way. It help to know the fundamental properties of the elements.
- It helps to predict the relationship between the different elements. It helps to explain the reactivity of the elements.
- It helps to predict the relationship between the different element .
- It helps to explain the reactivity of the elements.

The modern periodic table of elements is based on Mendeleev's observations. The only difference is that, instead of being organized by atomic mass, the modern table is arranged by atomic number (Z). In 1913, Henry Moseley discovered that an element's atomic number is a more fundamental property than its atomic mass.The atomic *number helps in arranging the elements according to their electronic configuration as it is indirectly equal to the number of electrons of a neutral atom.* The atomic number of an element is equal to the number of protons in an atom of the element since the number of protons is equal to the number of electrons in a neutral atom. Thus, atomic number of an element (Z) = number of protons present = number of electrons present in a neutral atom.

Why is atomic number a better classification system than atomic mass?

This is because (1) the atomic number increases by one unit (not fractional) when we move from one element to the next. This pattern does not follow that of atomic mass. (2) An element's atomic number is fixed and only refers to that particular element. No two elements can have the same atomic number.

14.1 Modern Periodic Table

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Periodic table is a tabular arrangement of elements in such a way that the elements having similar properties are grouped together in the same vertical column and dissimilar elements are separated from each other.

In a periodic table, there are vertical columns called groups and horizontal rows called periods.

Activities 14.1

Make a list of the elements that are used in our daily life (e.g., oxygen, carbon, sodium, aluminum, etc.) and classify them as metals and non-metals. Do all metals and non-metals have the same properties? Discuss in the classroom and write a summary.

Importance of classification of elements (periodic table)

a. The classification helps to study elements in scientific, systematic and better way.
b. It help to know the fundamental properties of the elements.
c. It helps to predict the relationship between the different elements.
d. It helps to explain the reactivity of the elements.

Mendeleev's Periodic Table

By 1869 AD, only 63 elements were discovered. Many scientist tried to classify the elements; however, their attempts were not sucessful. There was not relevant basis of classification. It was Dmitri Mendeleev, a Russian chemist in 1869 who sucessfully classified elements on certain basis. He studied the physical and chemical properties of known elements and propounded his periodic law.

Modern periodic table (long form of periodic table):

The tabular arrangement of elements made by classifying them on the basis of atomic numbers is called modern periodic table. The modern periodic table was prepared by Bohr. It is also known as long form of periodic table. In modern periodic table, the elements are arranged in the order of increasing atomic numbers in horizontal rows called periods. We place under each element all other elements having the same number of valence electrons show similar properties, therefore, all the elements in a particular group of the periodic table have similar properties.

The modern periodic law is based on the atomic numbers of elements. According to modern periodic law: the physical and chemical properties of elements are the periodic functions of their atomic numbers.

Characteristics of modern periodic table:

a. In modern periodic table elements are arranged in order of increasing atomic numbers.
b. There are nine groups numbered by the Roman number from I to VIII and Zero (0). Except 0 and VIII groups, the group from I to VII are divided into sub-group A and B. These are numbered as IA, IIA,………VIA, VIIA,IB, IIB,………VIB and VIIB. Group 0 has no sub group but group VIII has three vertical columns. In this way, there are altogether 18 columns which are also called 18 groups in modern periodic table and now they are numbered 1 to 18.
c. There are seven periods in modern periodic table and they are numbered as 1, 2, 3, .. ,7.
d. In this periodic table the position of an element is related to the electronic configuration of its atom.
e. It explains the similarities and variations in the properties of the elements in terms of electronic configuration and brings about clearly the trends in chemical properties across the long periods.

f. The inert gases (He, Ne, Ar, Kr, Xn and Rn) having completely filled electron shells have been placed at the end of each period under zero group.

g. The greatest advantage of this periodic table is that this be divided into four block elements namely s, p, d, and f block elements.

h. It provides a clear position of different types of elements like active metals, transition metals, non-metals, metalloids, inert gases, lanthanide and actinide.

i. Due to the separation of the two sub-groups, dissimilar elements (e.g alkali metals and coinage metals) don't fall together.

j. The lanthanide and actinide have been given a separate place at the bottom of the periodic table due to their analogous chemical behaviour.

k. This arrangement of the elements is easy to remember and to reproduce.

In briefly, the modern periodic table is developed after the periodic law and the periodic table given by Mendeleev. In the latter part of the 18th century, Mendeleev made his periodic table. Scientists did not know about the internal structure of the atom back then. The development of various atomic models and advances in quantum theory revealed that the atomic number is the most basic property of a chemical element. This led to the modification of Mendeleev's periodic law, which is today called modern periodic law.

The modern or long form of the periodic table is based on the modern periodic law. The table is the arrangement of elements in increasing order of their atomic numbers. The modern periodic table is the present form of the periodic table. And it consists of 18 vertical columns and 7 horizontal rows.

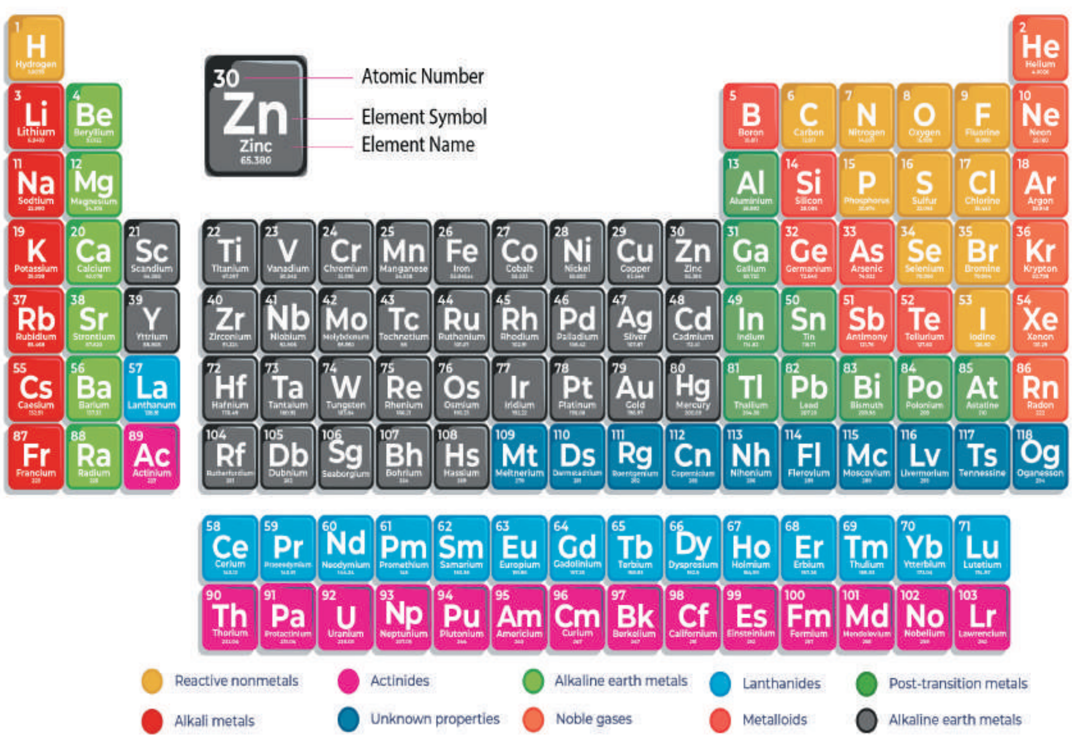


Fig. 14.1

Activities 14.2

i. Prepare a modern periodic table on cardboard paper. In the table, color the groups of elements such as alkali metals, alkaline earth metals, halogens, inert gases, etc., and paste the prepared table on the classroom wall.

ii. Construct a periodic table by placing the elements with atomic numbers 1 to 20 in a table similar to the one given below. Show alkali metals, alkaline metals, halogen elements, and noble gases in different colors.

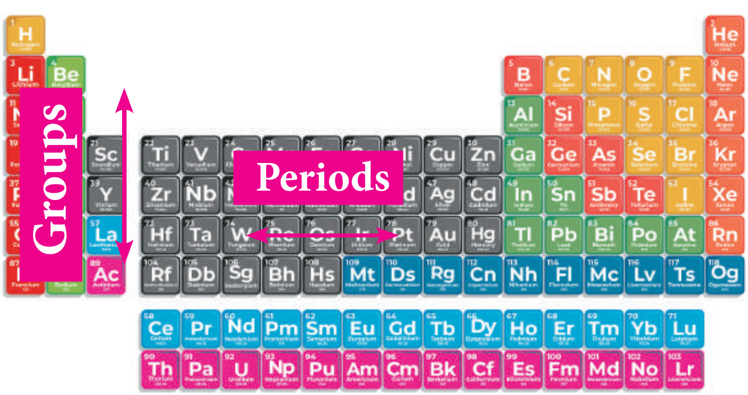
IA	IIA	IIIA	IVA	VA	VIA	VIIA	0

Modern Periodic Rules

The modern periodic law can be stated as: '*The physical and chemical properties of the elements are periodic functions of their atomic numbers*'.

The atomic number is equal to the number of electrons or protons in a neutral atom. After knowing the fundamental unit of elements, scientists now had a clear idea of quantum numbers and the electronic configuration of elements in the periodic table. After knowing the periodic law, chemists noticed that there is an analogy between the 94 naturally occurring chemical elements. This analogy made people curious about the chemistry of these elements. Scientists made various artificial elements. A new periodic table was developed based on the modern periodic law by modifying Mendeleev's periodic table.

Structure, group, and period



- Horizontal row are called periods.
- Elements in the same period have the same number of energy levels.
- Vertical columns are called groups.
- Elements is the same group have similar properties.

Fig. 14.2

The present form of a periodic table that is widely used across the globe is the long form of the periodic table. In this form of a periodic table, the horizontal rows are called periods and the vertical columns are known as the groups.

Groups consist of elements that have similar outer shell electronic configuration in their atoms. Previously the groups were named as IA,…VIIIA, VIII, IB…VIIB and 0. But now they are named as 1, 2, 3…18. In the modern periodic table, periods are the seven horizontal rows.

Principle quantum number ‘n’ decides the period of the element. Principle quantum number (n) is one of the four quantum numbers (n, l, m, and s). It tells us about the principle electron shell. For example, if n= 3, then it indicates the principle shell as 3.

Classification of the elements in the periodic table can be done in four ways on the basis of their electronic configurations:

i. Noble gas elements:

Elements of group 18 of the modern periodic table are considered a noble gas. The electronic configuration of the first element (helium) of this group is $1s^2$. Rest all the elements (neon, argon, krypton, xenon, and radon) have their outer shell electronic configuration is ns^2np^6. As the octet of these elements is complete, hence they are highly stable elements.

Noble Gas Electron Configuration = ns^2 np^6 = an octet, 8 electrons in the valence shell (highest n value). This is a very stable arrangement because it allows the greatest number of electrons to experience the greatest possible effective nuclear charge (Z_{eff}).

ii. Representative elements:

S-block and P-block elements come under the category of representative elements. Elements in groups 1 and 2 are known as the s – block elements (elements with $1s^2$ and $2s^2$ outermost configuration). Group 13-17 are known as the p-block elements (outermost configuration varies from ns^2np^1 to ns^2np^5).

iii. Transition elements:

Elements which belong to group 3 to 12 and have their outer shell electronic configuration as $(n-1)d^{1-10}ns^{1-2}$ are referred to as transition elements. These elements are also known as the d-block elements.

iv. Inner transition elements:

Lanthanides and actinides series which fall at the bottom of the periodic table comes under the category of inner transition elements. In these elements the 4f and 5f orbitals are partially filled, rendering them special properties.

Activities14.3

In the following table , are given six elements A, B, C, D,E and F (here letters are not the usual symbols of the elements) of Modern Periodic Table with the atomic numbers of the elements in parenthesis.

Period	Group	Group
2	A(3)	D(4)
3	B(11)	E(12)
4	C(19)	F(20)

a. What is the electronic configuration of C?
b. State whether F is a metal or a non-metal .
c. State the group of element B.
d. Identify element E (Write the symbol)
f. Are the properties of A, B, and D the same? Give the reason .

The electronic configuration of an atom

The electron configuration of an element describes how electrons are distributed in its atomic orbitals. Electron configurations of atoms follow a standard notation in which all electron-containing atomic subshells (with the number of electrons they hold written in superscript) are placed in a sequence. For example, the electron configuration of sodium is $1s^22s^22p^63s^1$.

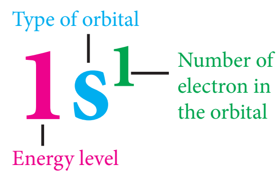


Fig. 14.3

However, the standard notation often yields lengthy electron configurations (especially for elements having a relatively large atomic number). In such cases, an abbreviated or condensed notation may be used instead of the standard notation. In the abbreviated notation, the sequence of completely filled subshells that correspond to the electronic configuration of a noble gas is replaced with the symbol of that noble gas in square brackets. Therefore, the abbreviated electron configuration of sodium is $[Ne]3s^1$ (the electron configuration of neon is $1s^22s^22p^6$, which can be abbreviated to $[He]2s^22p^6$).

Neon	$1s^22s^22p^6$	
Aluminum	$1s^22s^22p^63s^23p^1$	Becomes $[Ne]\ 3s^23p^1$
Argon	$1s^22s^22p^63s^23p^6$	
Calciurn	$1s^22s^22p^63s^23p^64s^2$	Becomes $[Ar]\ 4s^2$

Electron Configurations are useful for:

- Determining the valency of an element.
- Predicting the properties of a group of elements (elements with similar electron configurations tend to exhibit similar properties).
- Interpreting atomic spectra.

This notation for the distribution of electrons in the atomic orbitals of atoms came into practice shortly after the Bohr model of the atom was presented by Ernest Rutherford and Niels Bohr in the year 1913.

Writing Electron Configurations

Shells

The maximum number of electrons that can be accommodated in a shell is based on the principal quantum number (n). It is represented by the formula $2n^2$, where 'n' is the shell number. The shells, values of n, and the total number of electrons that can be accommodated are tabulated below.

Shell and 'n' value	Maximum electrons present in the shell
K shell, n=1	$2x1^2 = 2$
L shell, n=2	$2x2^2 = 8$
M shell, n=3	$2x3^2 = 18$
N shell, n=4	$2x4^2 = 32$

Subshells

- The subshells into which electrons are distributed are based on the azimuthal quantum number (denoted by 'l').

- This quantum number is dependent on the value of the principal quantum number, n. Therefore, when n has a value of 4, four different subshells are possible.
- When n=4. The subshells correspond to l=0, l=1, l=2, and l=3 and are named the s, p, d, and f subshells, respectively.
- The maximum number of electrons that can be accommodated by a subshell is given by the formula 2x(2l + 1).
- Therefore, the s, p, d, and f subshells can accommodate a maximum of 2, 6, 10, and 14 electrons, respectively.

All the possible subshells for values of n up to 4 are tabulated below.

Principle Quantum Number Value	Value of Azimuthal Quantum Number	Resulting Subshell in the Electron Configuration
n=1	l=0	1s
n=2	l=0	2s
	l=1	2p
n=3	l=0	3s
	l=1	3p
	l=2	3d
n=4	l=0	4s
	l=1	4p
	l=2	4d
	l=3	4f

Thus, it can be understood that the 1p, 2d, and 3f orbitals do not exist because the value of the azimuthal quantum number is always less than that of the principal quantum number.

Notation

- The electron configuration of an atom is written with the help of subshell labels.
- These labels contain the shell number (given by the principal quantum number), the subshell name (given by the azimuthal quantum number) and the total number of electrons in the subshell in superscript.
- For example, if two electrons are filled in the 's' subshell of the first shell, the resulting notation is '$1s^2$'.
- With the help of these subshell labels, the electron configuration of magnesium (atomic number 12) can be written as $1s^2\ 2s^2\ 2p^6\ 3s^2$.

Filling of Atomic Orbitals

Aufbau Principle

- This principle is named after the German word 'Aufbeen' which means 'build up'.
- The Aufbau principle dictates that electrons will occupy the orbitals having lower energies before occupying higher energy orbitals.
- The energy of an orbital is calculated by the sum of the principal and the azimuthal quantum numbers.
- According to this principle, electrons are filled in the following order: 1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, 5s, 4d, 5p, 6s, 4f, 5d, 6p, 7s, 5f, 6d, 7p…

The order in which electrons are filled in atomic orbitals as per the Aufbau principle is illustrated below.

The order of increasing energy of the orbitals is then read off by following these arrows, starting at the top of the first line and then proceeding on to the second, third, fourth lines, and so on. This diagram predicts the following order of increasing energy for atomic orbitals.

$1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p < 5s < 4d < 5p < 6s < 4f < 5d < 6p < 7s < 5f < 6d < 7p < 8s$ ...

It is important to note that there exist many exceptions to the Aufbau principle such as chromium and copper. These exceptions can sometimes be explained by the stability provided by half-filled or completely filled subshells.

Electronic Configuration of First 20 Element

The standard notation for the indication of the electronic configuration of atoms is written in a sequence of the label names of each atomic subshell with the number of electrons assigned to that specific subshell written in superscript.

These subshells are made up of atomic orbitals. The four subshell labels that are used are s, p, d, and f. The maximum number of electrons allowed in each of these subshells are 2, 6, 10, and 14 respectively.

For example, the names of the subshells in a sulfur atom would be 1s, 2s, 2p, 3s, and 3p (since sulfur has three electron shells). All of these shells are filled except the 3p shell which has four electrons. Therefore, the electronic configuration of sulfur can be written as $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$.

The electronic configuration of elements can also be written with the help of noble gases. These noble gases have completely filled outermost shells and can be prefixed to the outermost shell of the element whose electronic configuration must be noted.

For example, the electronic configuration of sulfur can be written as [Ne] $3s^2\ 3p^4$, since Neon has an electronic configuration of $1s^2\ 2s^2\ 2p^6$.

Given below is a table describing the electronic configuration of the first 20 elements with atomic numbers.

Atomic Number	Name of the Element	Electronic Configuration	
1	Hydrogen (H)	$1s^1$	$1s^1$
2	Helium (He)	$1s^2$	$1s^2$
3	Lithium (Li)	$1s^2 2s^1$	[He] $2s^1$
4	Beryllium (Be)	$1s^2 2s^2$	[He] $2s^2$
5	Boron (B)	$1s^2 2s^2 2p^1$	[He] $2s^2\ 2p^1$
6	Carbon (C)	$1s^2 2s^2 2p^2$	[He] $2s^2\ 2p^2$
7	Nitrogen (N)	$1s^2 2s^2 2p^3$	[He] $2s^2\ 2p^3$
8	Oxygen (O)	$1s^2 2s^2 2p^4$	[He] $2s^2\ 2p^4$
9	Fluorine (F)	$1s^2 2s^2 2p^5$	[He] $2s^2\ 2p^5$
10	Neon (Ne)	$1s^2 2s^2 2p^6$	[He] $2s^2\ 2p^6$

11	Sodium (Na)	$1s^2 2s^2 2p^6 3s^1$	[Ne] $3s^1$
12	Magnesium (Mg)	$1s^2 2s^2 2p^6 3s^2$	[Ne] $3s^2$
13	Aluminium (Al)	$1s^2 2s^2 2p^6 3s^2 3p^1$	[Ne] $3s^2\ 3p^1$
14	Silicon (Si)	$1s^2 2s^2 2p^6 3s^2 3p^2$	[Ne] $3s^2\ 3p^2$
15	Phosphorus (P)	$1s^2 2s^2 2p^6 3s^2 3p^3$	[Ne] $3s^2\ 3p^3$
16	Sulphur (S)	$1s^2 2s^2 2p^6 3s^2 3p^4$	[Ne] $3s^2\ 3p^4$
17	Chlorine (Cl)	$1s^2 2s^2 2p^6 3s^2 3p^5$	[Ne] $3s^2\ 3p^5$
18	Argon (Ar)	$1s^2 2s^2 2p^6 3s^2 3p^6$	[Ne] $3s^2\ 3p^6$
19	Potassium (K)	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$	[Ar] $4s^1$
20	Calcium (Ca)	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$	[Ar] $4s^2$

s-Block Elements

Those elements which contain s-electrons in their valence shell are called s-block elements. Except for H, all s-Block elements are active metals. They have a (+1 or +2) oxidation state. They form basic oxides. They impart a characteristic colour to the flame. Generally, they form ionic salts with nonmetals. They have low ionization potential. They have very small electron gain enthalpies. They are solids at room temperature (Cs is liquid at about 35 ^oC). Their hydroxides are basic in nature.

p-Block Elements

Those elements which contain p-electrons in their valence shell are called p-block elements . Most p-block elements are non-metals. They have variable oxidation states. p-block elements form acidic oxides. They impart no characteristic colour to the flame. Generally, they form covalent compounds. Halogens form salts with alkali metals. They have high ionization potentials and very large electron gain enthalpies. They are solids, liquids, or gases at room temperature (Br is liquid). The aqueous solutions of their oxides are acidic in nature.

d-Block Elements

Those elements which contain d-electrons in their valence shell are called d-block elements. These elements lie in between the s-block and p-block elements. These elements are called transition elements as they show transitional properties between s and p-block elements. Most of the d-block elements are metals. Most of them exhibit variable oxidation states because of the presence of partly filled d-orbitals. (Except Sc, Zn, Cd, etc.). Many of their compounds are colored. They readily form complexes by acting as Lewis acids. They easily form complexes (coloured). Most of them and their compounds show paramagnetic and ferromagnetic behavior. They act as good catalysts.

f-Block Elements

Those elements which contain f-electrons in their valence shell are called f-block elements. f-block elements are also called inner transition elements. They are lanthanides and actinides.

- **Lanthanides (58Ce–71Lu)**

  All lanthanides closely resemble lanthanum. Lanthanoids are chemically similar to each other. Except for cerium (III and IV) and europium (III and II), the lanthanides occur as trivalent cations in nature. Most lanthanides are widely used in lasers. These elements deflect UV and infrared electromagnetic radiation and are commonly used in the production of sunglass lenses. 8) Lanthanide ionic radii decrease over time, a phenomenon known as lanthanide contraction.

- **Actinides (90Th– 103Lr)**

  All the actinides are radioactive. These are highly electro-positive (showing +3,+4,+5,+6 oxidation states). These metals tarnish in the air. They have a number of isotopes and react with boiling water or dilute acids to give H_2 gas. These directly combine with non-metals.

Similarities between Lanthanides and Actinides:

- Both lanthanides and actinides show +3 oxidation states.
- Both are electropositive and very reactive.
- Both are paramagnetic.

Activities 14.4

i. Play a game of arranging the elements in the periodic table.
Materials: Cards and cardboard paper with the names of the elements
Procedure: Sort the cards with the names of the given elements according to the atomic number as in the periodic table.

ii. Write the electronic configurations of elements with atomic numbers up to 20 on cardboard paper with a marker and present them in the classroom. Also mention the short method using subshell and inert gas signals in the electronic configuration.

Metals, Non–metals, and Metalloids of the Periodic Table

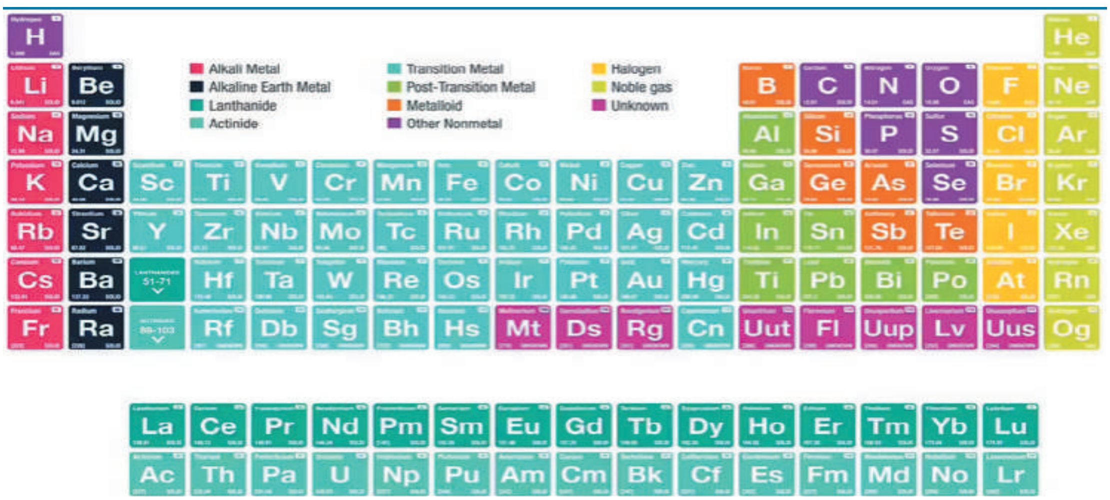


Fig. 14.5

Elements of the periodic table are grouped as metals, metalloids or semimetals, and nonmetals. The metalloids separate the metals and nonmetals on a periodic table. Also, many periodic tables have a stair-step line on the table identifying the element groups. The line begins at boron (B) and extends down to polonium (Po). Elements to the left of the line are considered metals. Elements just to the right of the line exhibit properties of both metals and nonmetals and are termed metalloids or semimetals. Elements to the far right of the periodic table are nonmetals. The exception is hydrogen (H), the first element on the periodic table. At ordinary temperatures and pressures, hydrogen behaves as a nonmetal.

The heavy orange zigzag line running diagonally from the upper left to the lower right through groups in Figure above divides the elements into metals (in blue, below and to the left of the line) and nonmetals (in bronze, above and to the right of the line). Gold-colored lements that lie along the diagonal line exhibit properties intermediat between metals and nonmetals; they are called semimetals.

As previously noted, the periodic table is arranged so that elements with similar chemical behaviors are in the same group. Chemists often make general statements about the properties of the elements in a group using descriptive names with historical origins. For example, the elements of Group 1 are known as the alkali metals, Group 2 are the alkaline earth metals, Group 17 are the halogens, and Group 18 are the noble gases.

Group 1: The Alkali Metals

The alkali metals are lithium, sodium, potassium, rubidium, cesium, and francium. Hydrogen is unique in that it is generally placed in Group 1, but it is not a metal. The compounds of the alkali metals are common in nature and daily life. One example is table

salt (sodium chloride); lithium compounds are used in greases, in batteries, and as drugs to treat patients who exhibit manic-depressive, or bipolar, behavior. Although lithium, rubidium, and cesium are relatively rare in nature, and francium is so unstable and highly radioactive that it exists in only trace amounts, sodium and potassium are the seventh and eighth most abundant elements in Earth's crust, respectively.

Group 2: The Alkaline Earth Metals

The alkaline earth metals are beryllium, magnesium, calcium, strontium, barium, and radium. Beryllium, strontium, and barium are rare, and radium is unstable and highly radioactive. In contrast, calcium and magnesium are the fifth and sixth most abundant elements on Earth, respectively; they are found in huge deposits of limestone and other minerals.

Group 17: The Halogens

The halogens are fluorine, chlorine, bromine, iodine, and astatine. The name halogen is derived from the Greek words for "

salt forming," which reflects that all the halogens react readily with metals to form compounds, such as sodium chloride and calcium chloride (used in some areas as road salt). Compounds that contain the fluoride ion are added to toothpaste and the water supply to prevent dental cavities. Fluorine is also found in Teflon coatings on kitchen utensils. Although chlorofluorocarbon propellants and refrigerants are believed to lead to the depletion of Earth's ozone layer and contain both fluorine and chlorine, the latter is responsible for the adverse effect on the ozone layer. Bromine and iodine are less abundant than chlorine, and astatine is so radioactive that it exists in only negligible amounts in nature.

Group 18: The Noble Gases

The noble gases are helium, neon, argon, krypton, xenon, and radon. Because the noble gases are composed of only single atoms, they are called monatomic.At room temperature and pressure, they are unreactive gases. Because of their lack of reactivity, for many years they were called inert gases or rare gases. However, the first chemical compounds containing the noble gases were prepared in 1962. Although the noble gases are relatively minor constituents of the atmosphere, natural gas contains substantial amounts of helium. Because of its low reactivity, argon is often used as an unreactive (inert) atmosphere for welding and in light bulbs. The red light emitted by neon in a gas discharge tube is used in neon lights.

Activities 14.5

Match the group number with the periodic family

Group number	**Family**
Group no. 1	Noble gases
Group no. 2	Halogens
Group no. 16	Alkalinc Carth Metals
Group no. 17	Alkali metal
Group no. 18	Chalcogen family

The period and atomic size of elements in periodic table

Size of Periods in modern periodic table

The horizontal rows of elements in the periodic table are called periods. In a period elements with gradual change in characters and atomic numbers are placed. The modern periodic table consists of seven horizontal rows called periods. These periods are numbered as 1, 2, 3, 4, 5, 6 and 7. The elements in a period have the same type of valance shell but their chemical properties are quite different because the number of valence electrons is different. On the basis of the numbers of elements present, the seven periods are divided into five different categories.

Period	1	2	3	4	5	6	7
Number of elements	2	8	8	18	18	32	26
Type of periods	Very short period	short period	short period	Long period	Long period	Very Long period	Long and incomplete

Atomic Size of elements in modern periodic table

Across a period from left to right, atomic size decreases as the atomic number increases. This is because more electrons are added to the same shell, and the nuclear charge also increases with the atomic number. As a result, the nucleus attracts the electrons greatly. Due to this, the outermost shell contracts and the atomic size decreases. The atomic size variation of all period 2 elements is shown below.

Elements	Li	Be	B	C	N	O	F
Atomic Size (nm)	0.125	0.09	0.08	0.077	0.075	0.075	0.072

Atomic size is determined by the atomic radius of an atom. An atomic radius is the distance between the center of the nucleus of an atom and its outermost shell.

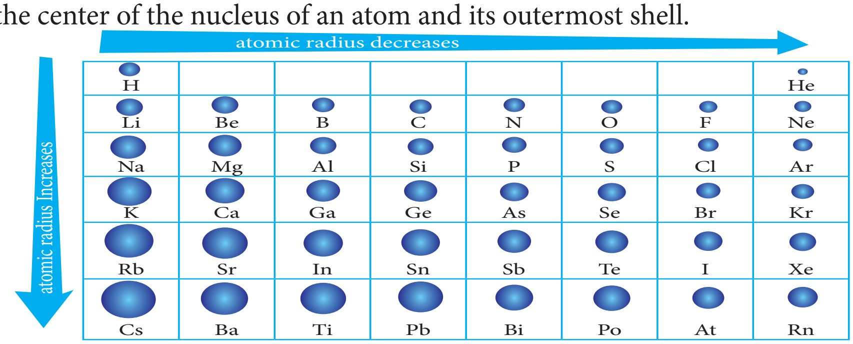


Fig. 14.6 Atomioc Radius Trends in the Periodic Table

Moving down a group or across a column or row in the modern periodic table, we can observe a lot of trends in the properties (physical and chemical) of elements in basic chemistry. For example: When we move down a group of non-metals, the reactivity of the elements decreases while it increases with moving down the group in case of representative metals.

When two atoms are combined, then we can estimate their atomic size by checking the distance between the atoms. The other method by which we can measure the atomic size of a non-metallic element is by forming a single covalent bond between two atoms and checking the distance between the two atoms. The radius found by this method is known as the *covalent radii* of the element. In the case of metal, it is termed as a *metallic radius***.** It is defined as half of the total distance between the nuclei of two adjoining metal ions joined by a metallic bond.

Periodic Property	Across the Period	Down the Group
Atomic Radius	Decreases	Increases
Ionization Energy	Increases	Decreases
Electron Affinity	Increases	Decreases
Electronegativity	Increases	Decreases
Valency	First increases then decreases	Constant
Nonmetallic Character	Increases	Decreases
Metallic Character	Decreases	Increases

The Atomic radius of an atom is measured by X-ray or other spectroscopy methods. The atomic radii of elements vary in the periodic table in a fixed pattern. We can explain this trend by considering the nuclear charge and energy level.

In general, the ***atomic radius decreases as we move from left to right in a period and it increases when we go down a group.*** This is because in periods the valence electrons are in the same outermost shell. The atomic number increases within the same period while moving from left to right which in turn increases the effective nuclear charge. The increase in attractive forces reduces the atomic radius of elements.It was interesting to see how the force of attraction between electrons and protons plays a major role in increasing or decreasing the atomic radius.

Electropositivity and electronegativity

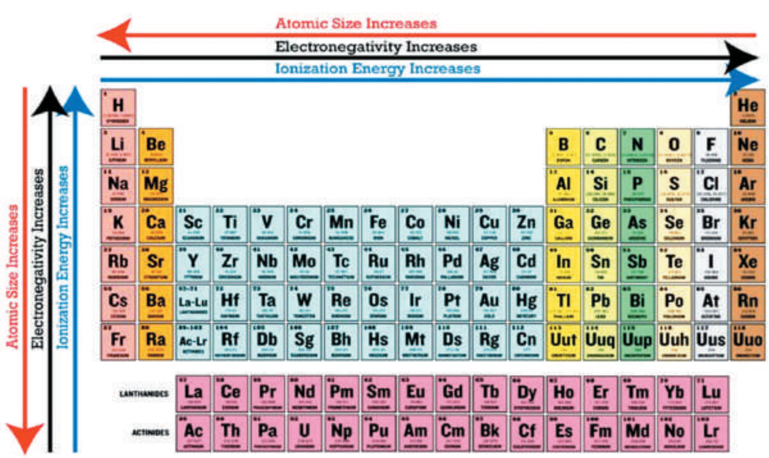


Fig. 14.7

Within a group, elements have the same number of valence electrons but as you go down a group, the number of shells increase. As the number of shells increase. The valence electrons are moved closer away from the nucleus. Thus, it will require less energy (lower ionization energy) to remove an electron from the outermost shell and it will also be more difficult to attract electrons (low electronegativity)

Electropositivity can be defined as the tendency of an atom to donate electrons and form positively charged cations. Electropositivity is primarily exhibited by metallic elements, especially the alkali metals and the alkaline earth metals. It is important to note that electropositivity is the opposite of electronegativity, which is a measure of the tendency of an atom to gain electrons and form negatively charged anions.Therefore, highly electropositive elements have very low electronegativities and highly electronegative elements have very low electropositivity . Eelectronegative elements typically do not have the tendency to lose electrons to form cations and electropositive elements generally do not gain electrons to form anions. Electropositive elements often form ionic salts with electronegative elements. For example, sodium is a highly electropositive element which readily gives up an electron in order to obtain a stable electronic configuration. Chlorine, on the other hand, is a highly electronegative element which readily accepts an electron to achieve a stable octet. Thus, sodium and chlorine can form an ionic bond with each other to yield sodium chloride (an ionic salt with the chemical formula NaCl).

The electropositivity of an element is dependent on several factors such as : the distance between the nucleus and the valence shell, the effective nuclear charge acting on the valence electrons and the ionization energy of the element. Since electronegativity increases across a period, electropositivity decreases across periods. Similarly, since electronegativity decreases down a group, electropositivity increases while traversing down a group. Therefore, the elements at the top-right of the periodic table are the least electropositive and the elements at the bottom-left of the periodic table are the most electropositive.

Since electropositivity is primary a metallic attribute, it is dependent on the metallic character of the element. This is the reason why the alkali metals are regarded as the most electropositive elements (with caesium and francium being the most electropositive elements in the entire periodic table). Since fluorine, oxygen, and chlorine are the most electronegative elements in the periodic table, they are also the least electropositive elements.

The theme mentioned above can also be understood in this way: Electronegativity measures an atom's tendency to attract and form bonds with electrons. This property exists due to the electronic configuration of atoms. Most atoms follow the octet rule (having the valence, or outer, shell comprise of 8 electrons). Because elements on the left side of the periodic table have less than a half-full valence shell, the energy required to gain electrons is significantly higher compared with the energy required to lose electrons. As a result, the elements on the left side of the periodic table generally lose electrons when forming bonds. Conversely, elements on the right side of the periodic table are more energy-efficient in gaining electrons to create a complete valence shell of 8 electrons. The nature of electronegativity is effectively described thus: the more inclined an atom is to gain electrons, the more likely that atom will pull electrons toward itself.

- **From left to right across a period of elements, electronegativity increases.** If the valence shell of an atom is less than half full, it requires less energy to lose an electron than to gain one. Conversely, if the valence shell is more than half full, it is easier to pull an electron into the valence shell than to donate one.
- **From top to bottom down a group, electronegativity decreases.** This is because atomic number increases down a group, and thus there is an increased distance between the valence electrons and nucleus, or a greater atomic radius.

- **Important exceptions of the above rules include the noble** gases, lanthanides, and actinides. The noble gases possess a complete valence shell and do not usually attract electrons. The lanthanides and actinides possess more complicated chemistry that does not generally follow any trends. Therefore, noble gases, lanthanides, and actinides do not have electronegativity values.
- **As for the transition metals, although they have electronegativity values, there is little variance among them across the period and up and down a group.** This is because their metallic properties affect their ability to attract electrons as easily as the other elements.

Electropositive vs Electronegative

	Electropositive	Electronegative
Definition	Electropositive refers to the ability of a chemical element to sose electrons	Electronegative refers to the ability of a chemical element to gain electrons
Function	Ability to repel electrons	Ability to attract electrons
New Species Formation	Forms cations by removing electrons	Forms anions by gaining electrons
Top of the List	The most electropositive element is Francium	The most electronegative element is Fluorine

Valency

All the elements of a period have different valence electrons in their valence cells. The number of valence electrons increases from one to eight on moving from left to right, but the number of shells is the same for all the elements present in the same period. For example, in period 2, the valence electron of lithium (Li) is the same as 1, beryllium (Be) is 2, boron (B) is 3, carbon (C) is 4, and so on. The elements in the same period have different valencies. Across a period from left to right, the valency first increases from 1 to 4, then decreases to 0. This is shown in the elements of the third period.

Third Period	Na	Mg	Al	Si	P	S	Cl	Ar
valency	+1	+2	+3	±4	-3	-2	1	0

The valency of an element is the number of electrons that must be lost or gained by an atom to obtain a stable electron configuration. In simple terms, it is the measure of the combining capacity of an element to form chemical compounds. Electrons found in the outermost shell are generally known as valence electrons; the number of valence electrons determines the valency of an atom.

The theme mentioned above can also be understood in this way: Trend-wise, while moving from left to right across a period, the number of valence electrons of elements increases and varies between 1 to 8. But the valency of elements first **increases** from 1 to 4, and then it **decreases** to zero as we reach the noble gases. However, as we move down in a group, the number of valence electrons does not change. Hence, all the elements of a particular group have the **same valency**. However, this periodic trend is sparsely followed for heavier elements, especially for the f–block and the transition metals. These elements show variable valency as these elements have d-orbital as the penultimate orbital and s-orbital as the outermost orbital. The energies of these (n-1)d & ns orbitals are relatively close.

Reactivity of elements

We have already taken a lot of information from the above topics about the reasons for the reactivity and non-reactivity of elements. The examples of hydrogen, helium, and carbon presented here will help to clarify more. Hydrogen(H) is the first element in the periodic table to have an atomic number of 1. The electronic configuration of H is $1s^1$. As the valence shell of H has only one electron, and thus, hydrogen can lose this electron easily and become H^+. Thus, hydrogen, being electropositive, is highly reactive. Helium (He) is an element of group 8 and period 1, having an atomic number of 2. The electronic configuration of Helium is $1s^2$. As the valence shell of helium is fully filled, it is unreactive. Helium is an inert gas, and inert gases are generally unreactive. Carbon (C) is an element of group 14 and period 2 having an atomic number of 6. The electronic configuration of carbon is (He)$2s^2 2p^2$.As the valence shell of carbon C is not completely filled , it needs four electrons to achieve the noble gas configuration, and thus carbon forms a covalent bond (bond by sharing of electrons). Thus, carbon is a reactive element.

Project Work

i. Decorate the elements in the modern periodic table on cardboard paper. Fill in different colors to separate those elements into metals, non-metals, and semi-metals. In the table you made, fill in the color to show that halogen gas, inert gas, and active metal or non-metal are separated. Present the periodic table in the classroom. Then paste it on the classroom wall.

ii. Create a "Periodic Table" which demonstrates how objects we use everyday, topics we discuss, foods we eat, and more, contain characteristics which allow us to group them using different patterns.

Where to begin:

1. Choose a topic that has characteristics that can be categorized in at least two different ways. Good characteristics to look at may be, but are not limited to:
   dates, colors, cost, company, size, genre or any physical or chemical properties that can divide the subject into various groups and periods. Be creative!!
2. Decide upon and research these particular characteristics. Organize the item vertically and horizontally to show a pattern or relationship. Your periodic table must contain a minimum of 20 elements, arranged in a minimum of 5 groups and 4 periods (or the reverse). Not every space within a group or period needs to be filled. You must have a title for your groups and periods.
3. Each "element" on your periodic table must include:
   - Element Name
   - Chemical Symbol (1 or 2 letters)
   - Atomic Number – arrange the elements first then number them, blank spaces must include a number!
   - Atomic Mass – some numeric characteristic of the element that must increase as you go down and across the table (size, style, cost, etc.)
   - Your choice – picture, state of matter, price, etc.
4. A "Key" is required for the information given for each "element" on the periodic table by drawing a sample square with sample information, and then label what characteristic each piece of information represents.

5. The final copy of you periodic table must be in color and on unlined paper. The size of your periodic table must be between 22" x 14" (half sheet of poster board) and 22" x 28" (full sheet of poster board). Remember that bigger doesn't always necessarily mean better, so choose a size that best fits your table.
6. Title your periodic table at the top of your poster board. Your name and class period can be written on the back.

Hints for Planning:

- Remember that a chemical symbol can be 1or 2 letters, but only the first letter is capitalized.
- Remember that atomic mass can be in decimal or whole number form.
- You may not use the same characteristic for 2 different pieces of information. For example, 2003 can only be used for atomic mass or atomic number, not both.

Suggestions:

- Sketch out each square and manipulate the pieces to help discover patterns (like we did with the periodic people).
- Old catalogs and magazines are helpful for getting topic ideas or information and can be cut out to use as part of the table.
- Some topics ideas include: candy, TV shows, movies, mall stores, music, sports teams, animals, clothes, countries, states, make-up and food.

Exercise

A. Choose the correct one and put the tick mark (√) .

i. Where would you locate the element with electronic configuration2,8 in the mordern Periodic Table ?
   a. Group 8 b. Group 2 c. Group 10 d. Group 18

ii. Which of the following elements does not lose an electron easily ?
   a. Na b. Mg c. F d. Al

iii. Which on of the following does not increase while moving down the group of the periodic table ?
   a. Atomic radius b. Metallic character
   c. Valency d. Number of shells in an element

iv. In the mordern periodic table, elements are mass-
   a. according to decreasing atomic mass.
   b. according toMendeleev's original design.
   c. according to increasing atomic number.
   d. based on when they were discovered.

v. Mendeleev noticed that certain similarities in the chemical properties of elements appeared at regular intervals when the elements were arranged in order of increasing-
   a. density b. reactivity c. atomic number d. atomic mass

vi. The modern periodic law states that-
   a. no two electrons with the same spin can be found in the same place in an atom.
   b. the physical and chemical properties of an element are function of its atomic number.

c. electrons exhibit properties of both particles and waves.
d. the chemical properties of elements can be grouped according to periodicity, but physical properties cannot.

vii. The most distinctive property of the noble gases is that they are-
a. metallic. b. metalloid.
c. radioactive. d. largely unreastive.

viii. Litthium, the first element in Group 1, has an atomic number of 3. The second element in this group has an atomic number of-
a. 4 b. 11 c. 10 d. 18

ix. The person whose work led to a periodic table based on increasing atomic number was-
a. Moseley b. Mendellev c. Rutherford d. Cannizzaro

x. Moseley's work led to the realization that elements with similar properties occured at regular intervals when the elements were arranged in order of increasing
a. atomic mass b. radioactivity c. density c. atomic number

xi. The most useful source of general information about the elements for anyone associated with chemistry is a -
a. calculator b. table of metric equivalents
c. periodic table d. table of isotopes

xii. which two periods have the same number of element?
a. 2 and 4 b. 4 and 5 c. 3 and 4 d. 5 and 6

xiii. In the modern periodic table, elements are ordered according to-
a. decreasing atomic mass b. increasing atomic number
c. Mendeleev's original design d. the date of their discovery

xiv. Calcium, atomic number 20, has the electron configuration [Ar] $4s^2$. In what period is calcium?
a. Period 2 c. Period 8 b. Period 4 d. Period 20

xv. The group of 14 elements in the sixth period that have occupied 4f orbitals is the-
a. actinides. b. transition elements. c. lanthanides. d. metalloids.

xvi. The electron configurations of the noble gases from neon to radon in the periodic table end with filled
a. f-orbitals. b. s-orbitals. c. d-orbitals. d. p-orbitals.

xvii. Which orbitals are characteristic of the lanthanide elements?
a. d-orbitals b. f-orbitals c. s-orbitals d. p-orbitals

xviii. Nitrogen's electron configuration is $1s^2 2s^2 2p^3$. To what group does nitrogen belong?
a. Group 2 b. Group 15 c. Group 7 d. Group 17

xix. Magnesium, atomic number 12, has the electron configuration [Ne] $3s^2$. To what group does magnesium belong?
a. Group 2 b. Group 5 c. Group 3 d. Group 12

xx. The most reactive group of the nonmetals are the
a. lanthanides. b. halogens.
c. transition elements. d. rare earth elements.

xxi. When determining the size of an atom by measuring the distance between identical adjacent nuclei, the radius of an atom is-
a. equal to the distance between nuclei. b. twice the distance between nuclei.
c. onr-fouth the distance between nuclei d. one-half the distance between nuclei.

xxii. Atomic size is determined by measuring the

a. radius of an individual atom.
b. distance between nuclei of adjacent atoms.
c. diameter of an individual atom
d. volume of the electron cloud of adjacent atoms.

B. Match the elements given in column a with their periods given in column B.

Column A	Column B
i. Ca	a. 3rd
ii. O	b. 1st
iii. H	c. 4th
iv. Cl	d. 5th
v. He	e. 2nd

C. Differentiate between these pairs.

a. Mendeleev's periodic table and Modern periodic table
b. Mendeleev's periodic law and Modern periodic law
c. Period and group
d. Metals and Non-metals
e. Short period and Long period
f. The s-block and p-block
g. The p-block and d-block
h. Reactive and Non-reactive elements

D. Explain the following:

i. Lithium (3) and sodium (11) are considered active metals .
ii. Fluorine (9) is more reactive than chlorine(17).
iii. Elements of group 1 are called alkali metals.
iv. 'K'is more reactive than 'Na'.
v. Members of group 7 are called halogens.
vi. Chlorine is placed in p-block in the periodic table.
vii. The group 1 elements are very active.
viii. Transition elements have variable valency
ix. Elements of group 2 called alkaline earth metals.
x. Chemical reactivity of group 7 decreases in moving downward.

E. Answer the following questions :

i. What is periodic table ? What are the advantages of this tables?
ii. Who gave the modern periodic law? What is modern periodic law ?.
iii. Why is the periodic law important?
iv. How do periodic trends relate to periodic law?
v. Is atomic mass a periodic property?
vi. What is relative periodic property?
vii. What is meant by the electronic configuration of an element?
viii. How do you write the configuration of an element?
ix. What is electron configuration? Write the electronic configuration of elements up to atomic number 10 on a subshell basis.
x. What is the electronic configuration of Chlorine 17?
xi. Why are electronic configurations important?
xii. List the electron configurations of the any three noble gases.
xiii. What is the electronic configuration of calcium ?
xiv. What are the characteristics of s, p ,d, f block elements?
xv. Is atomic size and atomic radius the same?

xvi. Identify the similarity in the atoms of pairs of element given below :

a. Na (Atomic number =11) and K (atomic number=19)

b. B (Atomic number =19) and C (Atomic number=6)

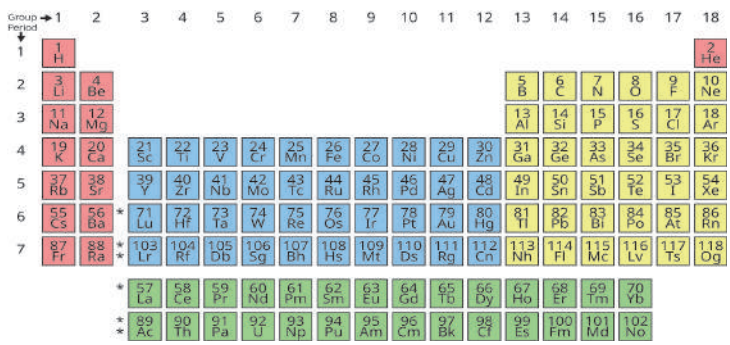
xvii. How will the atomic size in a group and a period in the modern periodic table vary? An atom of some element has electronic configuration [He] $2s^2$ $2p^4$. What is the atomic number, period and group of this element ?

xviii. Explain the place of metals, non-metals, and semi-metals in the modern periodic table.

xix. Analyze the differences in atomic size, electro-positivity, electro-negativity, valence, and reactivity of group and period elements.

F. Diagrammatic Questions :

i. Find Boron, Oxygen, Sodium, Potassium, and Calcium in the periodic table shown in the figure and then classify them according to their location and position . Do you think they'll be metal, nonmetal, or semimetal?



ii. The diagram shows the table of elements. There are over 120 different kinds of elements.

a. What is the name of the table shown above?

b. What name is given to the rows shown in the table?

c. On the diagram above, shade in the column for noble gases.

d. Noble gases are sald to be inert. What does this mean?

e. Name the elements of the symbols listed in the table below.

Element Symbol	Element Name
Mg	
F	

iii. Complete the table below:

Element	Proton Number	Electron arrangements	Number of valence electrons	Group Number	Period Number
Sodium 11 Na 22.990					
Aluminum 13 Al 26.982					

iv. The elements of the second and third periods of the periodic table are given below .

Li	Be	B	C	N	O	F
Na	Mg	Al	Si	P	S	Cl

a. Which atom is bigger,Lithium or Berylium ?Why ?

b. Which one element out of those given above os the most metallic and why?

v. The atomic number of elements A,B,C,D and E are given below :

Element	A	B	C	D	E
Atomic Number	7	10	12	4	19

a. Which two elements are chemically similar?

b. Which element is an inert gas? Why?

vi. Enterpreting the periodic table

Examine the hypothetical periodic table shown below, and in to answer the questions that follow.

K												
										J		
F												
			D			R						

a. Which pair of elements has the same number of valence electrons?

b. Which pair of elements is in the same period?

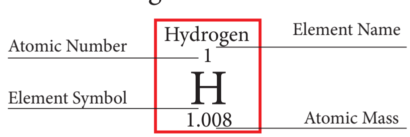
c. Which pair of elements is in the same family?

d. Which element has the smallest atomic number?

e. If the atomic number of Element D is 20, Then what is the atomic number of element R?

vii. Complete the missing information for each of the following elements from a perodic table. You must use the following format:

The periodic table contains the following information for each element.



B	Aluminum	56	Sodium	Co
63.546	53	Tin	W	72.631
93	32.066	Kr	88.906	Gold
Europium	Fe	82	Potassium	107.868

Chapter 15

Chemical Reaction

Total Estimated pariods (Th. 4+ Pr. 2=6)

Student's Learning Outcomes

After studying this unit, the students will be able to :

- explain types of chemical reactions with examples
- demonstrate and explain experimentally the factors that affect the rate of a chemical reaction.

Antoine Lavoisier, in full Antoine-Laurent Lavoisier, (born August 26, 1743, Paris, France—died May 8, 1794, Paris), prominent French chemist and leading figure in the 18th-century chemical revolution who developed an experimentally based theory of the chemical reactivity of oxygen and coauthored the modern system for naming chemical substances. Lavoisier was especially notable, in that his insights confirmed the importance of quantitative measurements of chemical processes.

Introduction

The concept of a chemical reaction dates back about 250 years. It had its origins in early experiments that classified substances as elements and compounds and in theories that explained these processes. Development of the concept of a chemical reaction had a primary role in defining the science of chemistry as it is known today.

Chemical reaction

The combination, decomposition, displacement or neutralization that occurs in atoms and molecules of matter during a chemical change is called a chemical reaction. It is represented by a chemical equation.

The elements or compounds that take part in a chemical reaction are called reactant, whereas the elements or compound that is formed as a result of chemical change are called products.

The reactant molecules are written on the left side of the equation and products are written on the right side of the equation. Both reactants and products are separated by a single headed arrow pointed towards products.

Reactants $\rightarrow$ Products

Word equation

A chemical reaction expressed by writing the full names of reactants and products is called word equation.

Magnesium +Chlorine $\longrightarrow$ Magnesium chloride

Zinc + Hydrochloric acid $\longrightarrow$ Hydrogen + Zinc chloride

Chemical equation

The chemical equation is a symbolic representation of a chemical reaction which involves the molecular or atomic formulas of reactants and products.

$$Mg + Cl_2 \longrightarrow MgCl_2$$

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

15.1 Types of Chemical Reactions

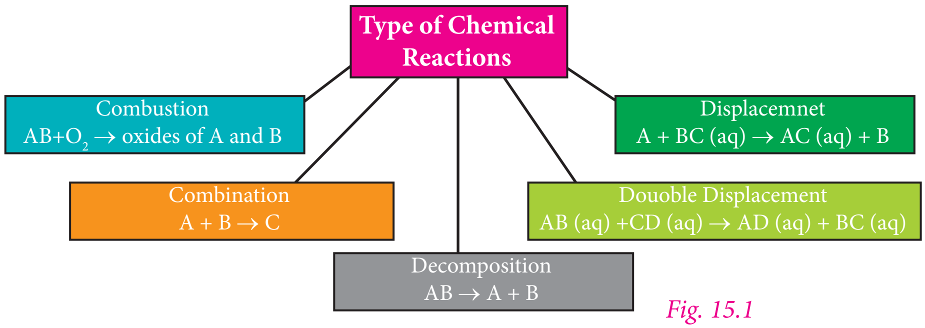


Fig. 15.1

Where A, B, C, and D are sumbolically used for elements or compounds. These are symbolic types of chemical reactions.

There are four types of chemical reaction on the basis of their nature.

1. Combination Reaction

The reaction in which two or more than two substances (reactants) combine to form a new substance (single product) is called combination reaction. It is also known as addition or synthetic reaction. The factors like heat, pressure, light, catalyst etc. can play a important role in it.

$2H_2 + O_2 \longrightarrow 2H_2O$

$N_2 + 3H_2 \longrightarrow 2NH_3$

$2K + Cl_2 \longrightarrow 2KCl$

$C + O_2 \longrightarrow CO_2$

$CaO + H_2O \longrightarrow Ca(OH)_2$

2. Decomposition Reaction

It is just opposite to combination reaction. The chemical reaction in which a substance decomposes into two or more than two new substances is called decomposition or dissociation or analysis reaction. Heat plays important role in it.

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

$2H_2O_2 \xrightarrow{MnO_2} 2H_2O + O_2$

$NH_4OH \longrightarrow NH_3 + H_2O$

$2KClO_3 \xrightarrow{\Delta} 2KCl + 3O_2$

$2AgNO_3 \xrightarrow{\Delta} 2Ag + 2NO_2 + O_2$

Note: Δ is the symbol of heat.

3. Displacement Reaction

The chemical reaction in which atom or group of an atoms are displaced by another atom or group of atoms and form a new compound is called displacement reaction. There are two types of displacement reaction. They are ;

i. Single displacement reaction

The displacement reaction in which one atom or one group of atoms displaced by another atom or group of atoms is called single displacement reaction. For example,

$Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2$ $2KI + Cl_2 \longrightarrow 2KCl + I_2$

$Fe + CuSO_4 \longrightarrow FeSO_4 + Cu$ $Mg + ZnCl_2 \longrightarrow MgCl_2 + Zn$

ii. Double displacement reaction

The displacement reaction in which both reactant molecules are decomposed and exchanged their corresponding ions to form new products is called double displacement reaction. For example,

$AgNO_3 + NaCl \longrightarrow AgCl + NaNO_3$

$CaSO_4 + Na_2CO_3 \longrightarrow CaCO_3 + Na_2SO_4$

$FeCl_2 + 2NaOH \longrightarrow Fe(OH)_2 + 2NaCl$

$CaCl_2 + 2AgNO_3 \longrightarrow Ca(NO_3)_2 + 2AgCl$

4. Acid-base Reaction

The chemical substance in which an acid reacts with base to produce salt and water is called acid-base reaction. This reaction is also called neutralization reaction. For example,

$HCl + NaOH \longrightarrow NaCl + H_2O$ $H_2SO_4 + CaO \longrightarrow CaSO_4 + H_2O$

$KOH + HNO_3 \longrightarrow KNO_3 + H_2O$ $FeO + H_2SO_4 \longrightarrow FeSO_4 + H_2O$

Activities 15.1

Identify the type of chemical reaction and write the name of chemical reactions. An example is shown below.

Cu + Cl2 → CuCl2 **Combination reaction**

i. $CH4(g) + 2O_2 \rightarrow CO_2(g) + 2H_2O\ (g)$ ____________

ii. $SiO_2(s) + CaO(s) \rightarrow CaSiO_3(s)$ ____________

iii. $2AgBr(s) \rightarrow 2Ag(s) + Br_2(g)$ ____________

iv. $2NaOH\ (aq) + HCl\ (aq) \rightarrow 2NaF(aq) + Cl_2(g)$ ____________

v. $NaOH\ (aq) + HCl\ (aq) \rightarrow NaCl(aq) + H_2O\ (l)$ ____________

vi. $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g) + Heat$ ____________

vii. $(NH_4)_2Cr_2O_7 \rightarrow Cr_2O_3\uparrow + N_2\uparrow + 4H_2O\uparrow$ ____________

viii. $Fe + CuS_4 \rightarrow FeSO_4 + Cu$ ____________

ix. $CuSO_4 + H_2S \rightarrow CuS\uparrow + H_2SO_4$ ____________

x. $F^{e2}+ \rightarrow Fe^{3+} + e^-$ ____________

xi. $2AgNO_3 + CaBr_2 \rightarrow 2AgBr + Ca\ (NO_3)_2$ ____________

xii. $CuO + H_2 \rightarrow Cu + H_2O$ ____________

xiii. $Zn + CuSO_4 \rightarrow Cu + ZnSO_4$ ____________

xiv. $Na_2SO_4 + BaCl_2 \rightarrow BaSO\downarrow + 2NaCl$ ____________

xv. $CuSO_4 + 2NaOH \rightarrow Na_2SO_4 + Cu\ (OH)_2$ ____________

xvi. $Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$ ____________

xvii. $2Al + 3Pb\ (NO_3)_2 \rightarrow 2Al\ (NO_3)_3 + 3Pb$ ____________

xviii. $2HgO(s)$ Heat $\rightarrow 2Hg(l) + O_2(g)$ ____________

xix. $2Na(s) + Cl_2(g) \rightarrow 2NaCl\ (s)$ ____________

15.2 Introduction to Chemical Reaction Rates

The rate of reaction or reaction rate is the speed at which reactants are converted into products. When we talk about chemical reactions, it is a given fact that rate at which they occur varies by a great deal. Some chemical reactions are nearly instantaneous, while others usually take some time to reach the final equilibrium.

As per the general definition, the speed with which a reaction takes place is referred to as the rate of a reaction. For example, wood combustion has a high reaction rate since the process is fast and rusting of iron has a low reaction rate as the process is slow.

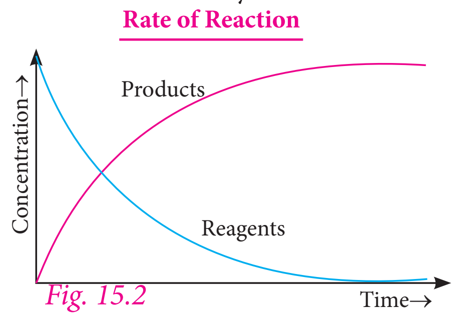


Fig. 15.2

Factors affecting the rate of Reactions

Nature of the reaction

- The rate of reaction highly depends on the type and nature of the reaction. As mentioned earlier, few reactions are naturally faster than others while some reactions are very slow.
- The physical state of reactants, number of reactants, complexity of reaction and other factors highly influence the reaction rate as well.
- The rate of reaction is generally slower in liquids when compared to gases and slower in solids when compared to liquids. Size of the reactant also matters a lot. The smaller the size of reactant, the faster the reaction.

Effect of concentration on reaction rate

- According to the collision theory, the rate of reaction increases with the increase in the concentration of the reactants.
- As per the law of mass action, the chemical reaction rate is directly proportional to the concentration of reactants.
- This implies that the chemical reaction rate increases with the increase in concentration and decreases with the decrease in the concentration of reactants.
- Time plays a major role in changing the concentration of reactants and products. Therefore, even time is a vital factor affecting the reaction rate.

i. Heat Factor

On heating, the reactants gain more energy and start moving more vigorously. This helps to increase the rate of reaction. Temperature usually increases the speed of chemical reaction. For every 10°C rise in temperature, the rate of reaction almost becomes double. Similarly, decrease in temperature makes the chemical reaction slower. For example :

$$2KClO_3 \xrightarrow{\triangle} 2KCl + 3O_2$$

ii. Pressure Factor

Pressure plays an important role in chemical reaction by increasing its speed. Chemical reaction between gases is only possible under high pressure. As the pressure increases, it causes gradual increase in the rate of chemical reaction. Synthesis of ammonia by Haber's process needs high pressure.

$$N_2 + 3H_2 \xrightarrow[\text{Fe/Mo}]{200 - 500\ \text{atm}/\ 500^{\circ}\text{C}} 2NH_3$$

iii. Catalyst Factor

Catalyst is a chemical substance that increases or decreases the rate of chemical reaction but it does not take part in the reaction. Catalyst brings change in the rate of chemical reaction but remains unchanged itself. Catalysts are of two types. They are positive and negative catalyst.

Positive catalyst:

The catalyst that increases the rate of chemical reaction is called positive catalyst. MnO_2 is the example of positive catalyst.

$$2KClO_3 \xrightarrow{MnO_2} 2KCl + 3O_2$$

Negative catalyst:

The catalyst that decreases the rate of chemical reaction is called negative catalyst. For example, Glycerine is the example of negative catalyst.

$$2H_2O_2 \xrightarrow{\text{Glycerine}} 2H_2O + O_2$$

iv. Light Factor

Some chemical reactions take place only in the presence of sun light. Light increases the rate of chemical reaction. For example,

The photosynthesis in green plants takes place in the presence of sun light.

$$6CO_2 + 6H_2O \xrightarrow{\text{Sunlight}} C_6H_{12}O_6 + 6O_2\uparrow$$

$$3O_2 \xrightarrow{\text{UV - rays}} 2O_3$$

v. Surface area Factor

The rate of chemical reaction can be raised by increasing the surface area of solid reactants. It is done by cutting into small piece or grinding into powder. By doing so, more particles of reactants are exposed to each other and the rate of reaction increases.

vi. Solution

Solution also plays an important role in many chemical reactions. When silver nitrate and sodium chloride are brought in contact, they do not react each other. But if they are dissolved in water, they decompose and exchange their ions. Thus, they take part in chemical reaction in the solution form.

$$AgNO_3(aq) + NaCl(aq) \longrightarrow NaNO_3 + AgCl(s)$$

Note: (aq) denotes the solution form that substance.

Activities 15.2

The influence of a catalyst on the rate of a chemical reaction

Materials : Conical flasks, syringe, hydrogen peroxide, and manganese dioxide

Procedure: Take some manganese dioxide in one of the two conical flasks. Then observe the hydrogen peroxide pouring into both the conical flasks with the help of a syringe. Which conical flask produces more gas? After the observation, write a report with conclusions about the role of catalyst.

Activities 15.3

Zinc powder *Zinc granules* *Crushed Marble* *Marble Chips*

The same amount of weak acid is put into each tube in turn. As soon as the acid is put in the tube, start timing on your stop-watch. As soon as the fizzing or bubbles stop, stop the stop-watch and record the time in the table below. Repeat for each tube.

When you have complete this, repeat the procedure with strong acid and record your results.

Weak Acid

Material	Time (s)
Zinck powder	
Zinc Granules	
Crushed Marble	
Marble Chips	

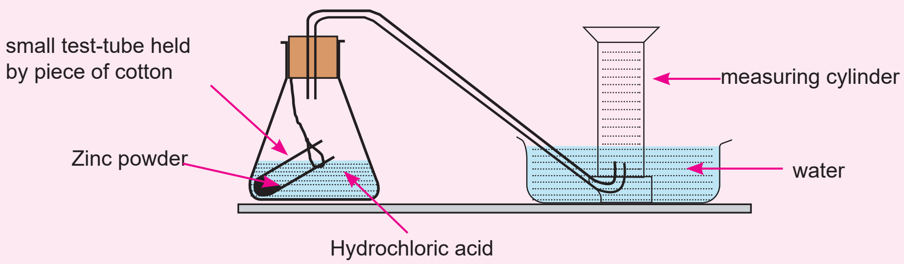
Strong Acid

Material	Time (s)
Zinck powder	
Zinc Granules	
Crushed Marble	
Marble Chips	

How does surface area affect chemical reactions ? Write with a reason

Activities 15.4

A group of students investigated the reaction of zinc and hydrochloric acid using the apparatus below, the zinc was in excess.



After this, the students measured the volume of gas in measuring cylinder at minute intervals. The results are shown below:

Time/mins	0	1	2	3	4	5	6	7
Volume of Gas/cm³	0	13	20	26	30	33	33	33

Plot the result on graph paper and draw the best curve through the points . Write the conclusions now.

Exothermic and Endothermic Reaction

Heat is an important factor that affects chemical reaction. On the basis of production or absorption of heat during chemical reaction, there are two types of chemical reaction. They are :

Exothermic reaction: The reaction that produces heat during chemical change is called exothermic reaction.

$$C + O_2 \longrightarrow CO_2 + Heat$$

$$CaO + H_2O \longrightarrow Ca(OH)_2 + Heat$$
$$C + 2H_2 \longrightarrow CH_4 + Heat$$

Endothermic reaction: The reaction which absorbs heat during chemical reaction is called endothermic reaction.

$$2KClO_3 \xrightarrow{Heat} 2KCl + 3O_2 \qquad CaCO_3 \xrightarrow{Hea\ t} CaO + CO_2$$

Exercise

A. Choose the correct one and put the tick mark (√).

i. Two or more than two substances combine to form a new substance in.
   - a. Combination reaction
   - b. Displacement reaction
   - c. Decomposition reaction
   - d. Neutralization reaction

ii. Which of the following factors is necessary for photosynthesis ?
   - a. Temperature
   - b. Pressure
   - c. Light
   - d. Catalyst

iii. Acid-base reaction is also known as:
   - a. Decomposition reaction
   - b. Combination reaction
   - c. Neutralization reaction
   - d. Synthetic reaction

iv. Which of the following is essential for the combination of nitrogen with hydrogen to form ammonia gas ?
   - a. Sound
   - b. High pressure
   - c. Catalyst (Fe)
   - d. Both b and c

v. Glycerine is an example of :
   - a. Catalyst
   - b. Positive catalyst
   - c. Negative catalyst
   - d. Promoter

B. Give the balanced chemical equations during the following chemical reactions:

i. Phosphorus is burnt in air.
ii. Potassium chlorate is heated.
iii. Calcium reacts with water.
iv. Hydrochloric acid is put in calcium carbonate.
v. Magnesium is burnt in air.

C. Differentiate between these pairs.

i. Combination reaction and decomposition reaction.
ii. Exothermic reaction and endothermic reaction.
iii. Catalyst and promoter.
iv. Physical change and chemical change
v. Positive and negative catalyst.
vi. Single and double displacement reaction.

D. Change the following word equations into balanced formula equations.

i. Copper + Oxygen ⟶ Cupric oxide
ii. Hydrogen + Oxygen ⟶ Water
iii. Zinc + Hydrochloric acid ⟶ Zinc chloride + Hydrogen
iv. Calcium oxide + Water ⟶ Calcium hydroxide
v. Ammonia + Hydrogen chloride ⟶ Ammonium chloride
vi. Calcium bicarbonate ⟶ Lime stone + Water + Carbondioxide

E. Answer the following questions :

i. What is chemical reaction ? Mention the factors that affect it.

ii. What are the types of chemical reaction ? Explain them in brief with examples.

iii. What is acid-base reaction ? Why is it also called neutralization reaction ?

iv. What is the role of pressure in chemical reaction ? Give an example of the chemical reaction in which pressure is used.

v. What do you mean by exothermic reaction ? Give example.

vi. What is the name of the reaction in which two substances exchange ions?

vii. Write the characteristics of a catalyst ?

viii. Write any two methods to increase the rate of reaction

ix. Define reactants and products with example.

x. Balance the following equations also name the type of reactions :

a. $K + O_2 \longrightarrow K_2O$

b. $H_2 + Cl_2 \longrightarrow HCl$

c. $Au + Cl_2 \longrightarrow AuCl_3$

d. $Mg + N_2 \longrightarrow Mg_3N_2$

e. $CaCO_3 \longrightarrow CaO + CO_2$

f. $Fe + CuSO_4 \longrightarrow FeSO_4 + Cu$

g. $HCl + K_2O \longrightarrow KCl + H_2O$

h. $HNO_3 + Ca(OH)_2 \longrightarrow Ca(NO_3)_2 + H_2O$

i. $Cu + O_2 \longrightarrow CuO$

j. $KOH + HCl \longrightarrow KCl + H_2O$

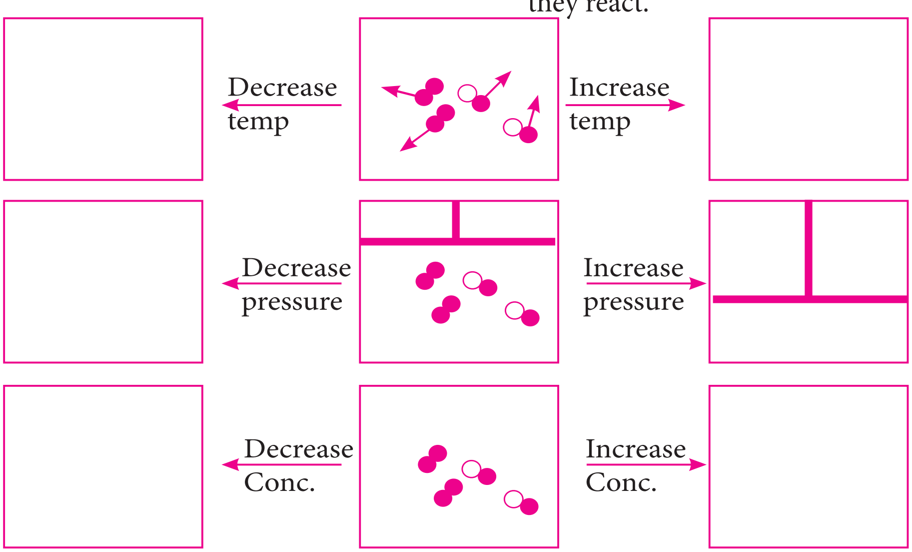
F. Diagrammatic Questions :

i. To draw particle pictures to explain why changing the temperature, presuure and concentration will change the rate of a reactions .


Reactant A


Reactant B

Complete the boxes below to show what would happen to the particles BEFORE they react.



Using your understanding of rates of reaction can you explain the following?

a. Why does increasing the temperature of a reaction increases the rat oe reaction?

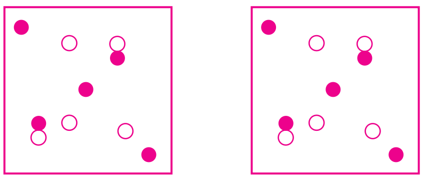
b. Why does adding a catalyst increase the rate of reaction?

c. Why does increasing the concentration of a ceacttant increases the rate of a reaction?

d. Why does hitting your hand on the desk does not result in a reaction, despite particles colliding?

ii. Increased temperature

Complete the particle diagrams by adding arrowd to show particle movement.



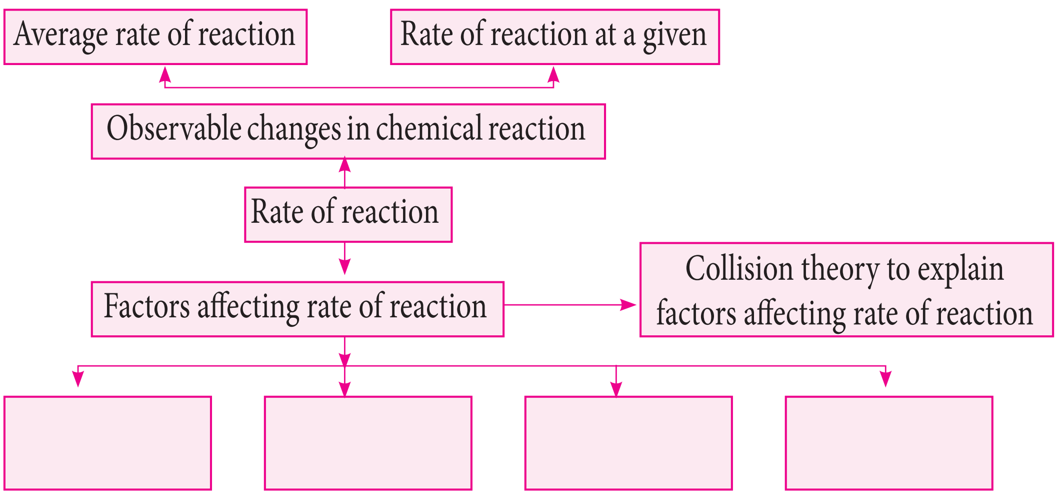
Room temp   High temp

Increasing the temperature produces two effects.

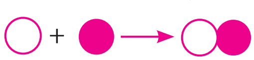
1.

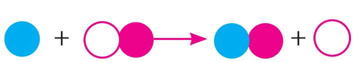
2.

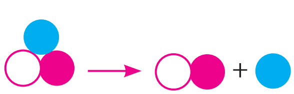
iii. Complete the following concept map

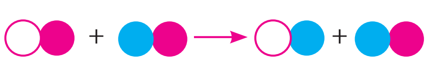


iv. Which typeof chemical reaction is each ? (Here, white circles, black circles, and shadow circles are used for symbolic elements or compounds.)

a.  ____________________

b.  ____________________

c.  ____________________

d.  ____________________

Chapter 16

Gases

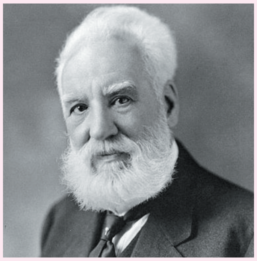
Total Estimated pariods (Th. 6+ Pr. 2=8)

Student's Learning Outcomes

After studying this unit, the students will be able to :

- describe the laboratory method for the preparation of carbon dioxide and ammonia gases .
- describe the properties of CO_2 and NH_3
- describe the uses of carbon dioxide and ammonia gases
- explain acid rain's causes, effects, and mitigation measures.
- explain the causes, effects, and mitigation measures of the greenhouse effect

Robert Angus Smith (15 February 1817 – 12 May 1884) was a Scottish chemist, who investigated numerous environmental issues. He is known for his research on air pollution in 1852, in the course of which he discovered what came to be known as acid rain. He is sometimes referred to as the 'Father of Acid Rain' Born at Pollokshaws, Glasgow, Smith was educated at the University of Glasgow in preparation for ministry in the Church of Scotland but left before graduating. He worked as a personal tutor and, accompanying a family to Gießen in 1839, he stayed on in Germany to study chemistry supervised by Justus von Liebig, earning a PhD in 1841.



Introduction

There are some compounds which are found in the gaseous state in nature. Some of them are carbondioxide, water vapour, carbon monoxide, ammonia, etc. Carbondioxide is heavier than air and the amount of carbondioxide may vary from place to place. It is used to extinguish the fire. Ammonia is lighter than air and highly soluble. In this lesson, we are going to study about the laboratory preparation, properties and uses of carbondioxide and ammonia.

Carbondioxide

Molecular formula - CO_2	Molecular weight - 44 amu

Around 1630, Van Helmont identified a gas given off by burning wood and named the gas as 'wood gas'. Today, we know that gas is carbondioxide. In 1756, Joseph Black proved that carbondioxide occurred in the atmosphere. He named this gas as 'fixed air'. He also indentified carbondioxide in the breath exhaled by humans. In 1783, Antoine Lavoisier named carbondioxide gas as 'oxide of carbon'.

Fig. 16.1

Occurrence of carbondioxide

Carbondioxide occurs in free as well as combined state in nature. It constitutes about 0.03%

of air by volume. It occurs in air by burning of wood, coal, petroleum etc. and respiration of living organisms. It is present in different types of carbonates and bicarbonates of calcium and magnesium in the combined state. Since, this gas is heavier than air, it is found at low levels like deep well, mines, caves etc.

General methods of preparation of carbondioxide gas

a. By burning carbon in excess air

When carbon or carbon containing fuels are burnt in sufficient oxygen, carbondioxide is produced.

$$C + O_2 \xrightarrow{\Delta} CO_2\downarrow$$

b. By burning organic compounds in oxygen

When hydrocarbons like methane, ethane, butane, etc. are burnt in oxygen, carbondioxide is produced.

$CH_4 + 2O_2 \xrightarrow{\Delta} CO_2\downarrow + 2H_2O + \text{Energy}$
Methane

$2C_2H_6 + 7O_2 \longrightarrow 4CO_2\downarrow + 6H_2O + \text{Energy}$

c. By the reacting of acid with metallic carbonates and bicarbonates

When all the carbonates and bicarbonates of metals are treated with dilute hydrochloric acid, carbondioxide is produced.

$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + H_2O + CO_2\downarrow$
Sodium carbonate

$Ca(HCO_3)_2 + 2HCl \longrightarrow CaCl_2 + 2H_2O + 2CO_2\downarrow$
Calcium bicarbonate

Laboratory preparation of carbondioxide gas

In laboratory, carbondioxide gas is prepared by the chemical reaction between calcium carbonate (Limestone) and dilute hydrochloric acid.

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

Apparatus required

Woulfe's bottle, thistle funnel, delivery tube, gas jar and corks.

Chemicals required

Marble chips ($CaCO_3$) and dilute hydrochloric acid (HCl).

Procedures

Put some marble pieces into woulfe's bottle and fit the apparatus air tightly as shown in the figure. Pour dilute hydrochloric acid through thistle funnel into the marble piece. Lower part of thistle funnel should be dipped completely in it.

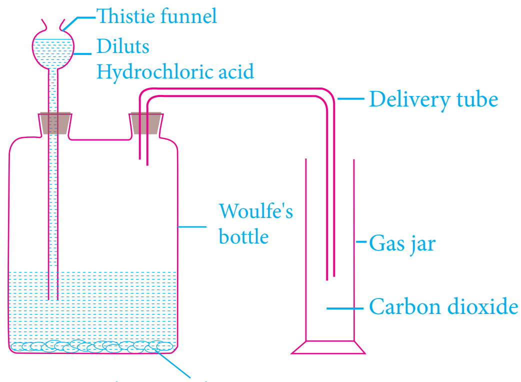


Fig. 16.2 Laboratory preparation of carbondioxide gas

The chemical reaction between marble and dilute hydrochloric acid takes place and produced carbondioxide gas is collected in the gas jar by the upward displacement of air.

Precautions

i. CO_2 should be collected by the upward displacement of air.
ii. The apparatus must be made air tight.
iii. The end of the thistle funnel should be dipped in the acid of the woulfe's bottle.
iv. The end of the delivery tube should not touch the acid inside the woulfe's bottle.

Test for CO_2

The following methods can be used to test CO_2

i. When wet blue litmus paper is inserted into the jar containing carbondioxide gas, it turns into red.
ii. When CO_2 is passed into lime water it turns into milky white due to formation of insoluble calcium carbonate.
$$Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$$
iii. When a burning candle is inserted into the jar containing the gas, it extinguishes. This is because carbondioxide is a non-combustible gas and it does not support burning.
iv. When burning magnesium is inserted into a jar containing carbondioxide, it burns continuously and forms magnesium oxide (white) and carbon (black)

Manufacture of carbondioxide gas

For commercial purpose, carbondioxide gas is manufactured by heating calcium carbonate (marble). While heating limestone with coal at high temperature, it decomposes into carbondioxide and calcium oxide (quick lime).

$$\underset{\text{limestone (marble)}}{CaCO_3} \xrightarrow{\text{Heat}} \underset{\text{(lime)}}{CaO} + CO_2$$

Calcium oxide gives calcium hydroxide, when dissolves in water. Calcium hydroxide is also called lime water.

$$CaO + H_2O \longrightarrow \underset{\text{(lime water)}}{Ca(OH)_2}$$

Properties of carbondioxide gas

a. Physical properties

i. It is colourless, odourless and tasteless gas.
ii. It produces carbonic acid while it dissolves in water.
iii. Since it is acidic in nature, it turns blue litmus paper into red.
iv. It is about 1.5 times heavier than air.
v. It is neither combustible nor supporter of combustion.
vi. When it is cooled to -78°C, it is converted into white solid called dry ice.

b. Chemical properties

i. Carbondioxide reacts with water to give carbonic acid.
$$CO_2 + H_2O \longrightarrow H_2CO_3$$
ii. During photosynthesis, carbondioxide gas reacts with water in plants in the presence of sunlight and chlorophyll to produce glucose.
$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$$

iii. When carbondioxide is heated at 900°C with red hot coke, it produces carbon monoxide gas.

$$CO_2 + C \longrightarrow 2CO$$

iv. Carbondioxide gas turns lime water milky due to formation of insoluble calcium carbonate.

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

On passing the excess amount of carbondioxide, insoluble calcium carbonate changes into soluble calcium bicarbonate and milky colour disappears.

$$CaCO_3 + H_2O + CO_2 \longrightarrow Ca(HCO_3)_2$$

v. CO_2 gas reacts with ammonia under some pressure to produce urea.

$$CO_2 + 2NH_3 \longrightarrow \underset{\text{Urea}}{NH_2\text{–}CO\text{–}NH_2} + H_2O$$

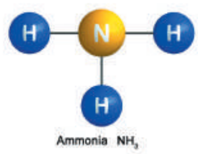
Uses of carbondioxide gas

i. It is used for making aerated drinks like soda water, beer, coca cola etc.
ii. It is used by green plants for photosynthesis.
iii. It is used in fire extinguisher.
iv. It is used in making urea and washing soda.
v. Liquid carbondioxide is used in sugar industries (carbonation).
vi. Solid carbondioxide (dry ice) is used to preserve fruits, fish, meat etc.

When carbondioxide is cooled at -78°C, it changes into a white solid form. The solid form of carbondioxide is called dry ice. When dry ice is taken in a piece of cloth or paper, it does not wet. It is used as a refrigerant for preserving food or cooling agent in the refrigerator.

Ammonia

Molecular formula - NH_3	Molecular weight - 17



Ammonia is compound gas. It is made up of one nitrogen atom and three hydrogen atoms. At first, Lavoisier prepared ammonia gas by heating ammonium chloride and calcium hydroxide.

Occurrence

Ammonia is found in free as well as in combined state in nature. It is present in air, soil and water. It is also present in different ammonium salts like ammonium chloride, ammonium sulphate and ammonium phosphate.

Laboratory preparation of ammonia gas

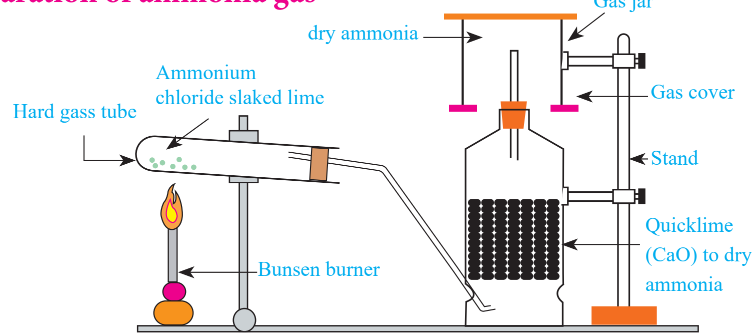


Fig. 16.3 Laboratory preparation of ammonia gas

In laboratory, ammonia gas is prepared by heating a mixture of ammonium chloride (NH_4Cl) and calcium hydroxide [$Ca(OH)_2$] in the ratio of 2:1.

$$Ca(OH)_2 + 2NH_4Cl \longrightarrow CaCl_2 + 2H_2O + 2NH_3 \uparrow$$

Apparatus required

Hard glass test tube, Bunsen burner, stands, delivery tube, gas jar etc.

Chemicals required

Ammonium chloride (NH_4Cl)
Calcium hydroxide [$Ca(OH)_2$]

Procedures

Keep 2:1 mixture of ammonium chloride and calcium hydroxide in a hard glass tube. Fit the all the apparatus as shown in the diagram. Heat the test tube using Bunsen burner. After heating, ammonia gas is produced and collected in the gas jar by downward displacement of air.

In this process, ammonia gas is passed through lime tower. This tower absorbs water vapour and pure and dry ammonia gas is obtained. Ammonia gas is lighter than air. So, it is collected by downward displacement of air. Since, ammonia is highly soluble in water, it can not be collected by downward displacement of water. The hard glass test tube is inclined downward to prevent cracking of test tube by back flow of water.

Precautions

i. The apparatus must be made air tight.
ii. The hard glass tube should be fixed in an inclined position towards its mouth in order to prevent it from cracking.
iii. Heat should be provided uniformly.
iv. The gas Jar should be dried.
v. The product should be passed through a lime tower before its collection in the gas jar.

Test of ammonia

Ammonia can be tested in the following way.

i. A moist red litmus paper when inserted in the jar containing gas turns into blue.
ii. It forms white fume of NH_4Cl when a glass rod dipped in HCl is taken in this gas.
iii. It can be identified by its pungent smell.

General method of preparation of Ammonia

Ammonia can be prepared by the following methods.

a. By heating ammonium salts

When ammonium salts like ammonium carbonate, ammonium sulphate etc, are heated ammonia is produced.

$$(NH_4)_2CO_3 \xrightarrow{\Delta} 2NH_3\uparrow + H_2O + CO_2$$

ammonium carbonate ammonium

$$(NH_4)_2SO_4 \xrightarrow{\Delta} 2NH_3 + H_2SO_4$$

ammonium sulphate ammonium

b. By heating ammonium salts with a strong base

Ammonia is produced in a small scale from ammonium salt which decompose when treated with strong bases like sodium hydroxide or potassium hydroxide.

$$(NH_4)_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O + 2NH_3\uparrow$$

Ammonium sulphate + sodium hydroxide → Sodium sulphate + water + Ammonia

$$NH_4Cl + KOH \xrightarrow{\Delta} KCl + H_2O + NH_3$$

ammonium chloride + potassium hydroxide → Ammonia

Manufacture of Ammonia

On a large scale, ammonia gas is manufactured by the Haber's process. A mixture of nitrogen and hydrogen in the ratio of 1:3 in dry state is passed into a catalytic chamber. The chamber contains finely divided iron (Fe) with small amount of promoter molybdenum (Mo). The mixture with small amount of promoter under a high pressure is heated at 450°C - 500°C. Under this conditions, hydrogen and nitrogen are combined to form ammonia.

$$N_2 + 3H_2 \xrightarrow[Fe/Mo]{500^{\circ}C/250Atm} 2NH_3$$

To yield of ammonia, the following conditions are favoured.

i. Temperature of about 500°C should be maintained.
ii. High pressure of about 200-900 atm should be maintained.
iii. Finely divided iron is used as a catalyst.
iv. Trace of molybdenum are used as a promoter which helps the catalyst to function better.
v. High concentration of reactants should be taken.

Properties of Ammonia

a. Physical properties

i. It is colourless, tasteless gas having pungent smell.
ii. It is highly soluble in water.
iii. It is lighter than air.
iv. It turns moist red litmus paper into blue i.e. basic in nature.
v. It is neither combustible nor supporter of combustion.

b. Chemical properties

i. It dissolves in water to produce ammonium hydroxide.

$$NH_3 + H_2O \longrightarrow NH_4OH$$

ii. It reacts with acids to give salt.

$$NH_3 + HCl \longrightarrow NH_4Cl$$

$$2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2\,SO_4$$

iii. It reacts with carbondioxide at about 1500°C under certain pressure to give urea.

$$2NH_3 + CO_2 \longrightarrow NH_2 - CO - NH_2 + H_2O$$

iv. Ammonia reacts with oxygen to give out nitrogen.

$$4NH_3 + 3O_2 \longrightarrow 2N_2 + 6H_2O$$

v. Ammonium hydroxide (ammonia solution) reacts with acids to give salt and water.

$$NH_4OH + HCl \longrightarrow NH_4Cl + H_2O$$

$$NH_4OH + HNO_3 \longrightarrow NH_4NO_3 + H_2O$$

Uses of Ammonia Gas

i. It is used in manufacture of chemical fertilizers like ammonium nitrate, ammonium phosphate, urea etc.
ii. It is used in refrigerator in liquid state.
iii. It is used to develop blue print in maps.
iv. It is used to make fibre like rayon and nylon.
v. It is used as cleansing agent to remove grease and oil stains.

16.1 Method of preparing to carbon dioxide and ammonia gases in the laboratory

Activities 16.1

Decomposers and CO_2

Materials: 1 package of dry yeast, sugar, water measuring cup, empty plastic pop bottle (clear), 1 large balloon.

Procedure:

i. Dissolve 2 cups of sugar in ½ pop bottle of warm water. (Not boiling!)
ii. Add a teaspoonful of yeast to the liquid and shake vigorously.
NOTE: *Yeast is a fungus that feeds on sugar. Even though the package appears to contain nothing but a dry powder, the powder is really living, onecelled plants that are alive but in a dormant stage. They become active breakdown the sugar in alcohol and release CO_2.*
iii. Fit the balloon over the mouth of the bottle.
iv. You should observe and record what happens.Write the report.

Activities 16.2

Plants and Carbon Dioxide

Materials: 3 test tubes , a drinking straw, boiled water, phenol red indicator (which is red and goes yellow in the presence of carbon dioxide), Aasprig of Elodea, bright light.

Procedure:

i. Pour about 2-3 cm depth of water into each test tube (same depth in each).
ii. Add a few drops of indicator to each.
iii. Breathe out gently through the straw into two of the tubes until the indicator color changes to yellow.
iv. Put the sprig of Elodea into one tube.
v. Place all three in bright light and leave them for about 40 minutes.
vi. Go back and observe what has happened to the three tubes.
vii. Rrecord observations and write a report.

Activities 16.3

PROPERTIES OF CO_2

Materials: Beaker, Measuring spoon, Glass test tube, Baking soda ,Wooden splints, Matches, Vinegar, Cork stopper.

Procedure:

i. Use the background information provided to discuss the science behind greenhouse gases, global warming and how correct levels of both carbon dioxide and oxygen are vital to a healthy planet.

ii. Explain that in this activity you will demonstrate how to produce pure carbon dioxide using baking soda and vinegar.

iii. Place 1 teaspoon of baking soda into a re-sealable bag and ensure the soda falls to the bottom.

iv. Using the beaker, measure and pour 200mm of vinegar into the test tube and seal as quickly as possible with the cork stopper.

v. The vinegar is reacting with the chemicals in the baking soda which makes it produce carbon dioxide.

You move in closer to watch as the mixture in the test tube begins to bubble. Being an endothermic reaction, it should be quite cool to the touch.

vi. Next, light the end of a wooden splint and allow it to burn for a few seconds.

vii. Remove the cork from the test tube and slowly insert the splint; it should extinguish immediately

viii. Record all observations. Write the conclusions.

16.3 Greenhouse

A greenhouse is a house made of glass that can be used to grow plants. The sun's radiations warm the plants and the air inside the greenhouse. The heat trapped inside can't escape out and warms the greenhouse which is essential for the growth of the plants. Same is the case in the earth's atmosphere.

During the day the sun heats up the earth's atmosphere. At night, when the earth cools down the heat is radiated back into the atmosphere. During this process, the heat is absorbed by the greenhouse gases in the earth's atmosphere. This is what makes the surface of the earth warmer, that makes the survival of living beings on the earth possible . However, due to the increased levels of greenhouse gases, the temperature of the earth has increased considerably. This has led to several drastic effects.

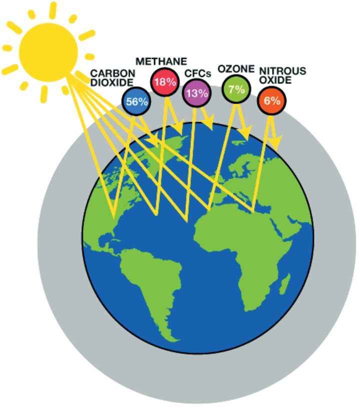


Fig. 16.4 The diagram shows greenhous gases sus as carbon dioxide are the primary cause for the Greenhous Effect

Greenhouse gases are the gases that absorb the infrared radiations and create a greenhouse effect. For eg., carbondioxide, and chlorofluorocarbons.

By trapping heat from the sun, greenhouse gases have kept Earth's climate habitable for humans and millions of other species. But those gases are now out of balance and threaten to change drastically which living things can survive on this planet—and where.

Atmospheric levels of carbon dioxide—the most dangerous and prevalent greenhouse gas—are at the highest levels ever recorded. Greenhouse gas levels are so high primarily because humans have released them into the air by burning fossil fuels. The gases absorb solar energy and keep heat close to Earth's surface, rather than letting it escape into space. That trapping of heat is known as the greenhouse effect.

Causes Greenhouse Effect

The major causes of the greenhouse effect are:

Burning of Fossil Fuels

Fossil fuels are an important part of our lives. They are widely used in transportation and to produce electricity. Burning of fossil fuels releases carbon dioxide. With the increase in population, the utilization of fossil fuels has increased. This has led to an increase in the release of greenhouse gases in the atmosphere.

Deforestation

Plants and trees take in carbon dioxide and release oxygen. Due to the cutting of trees, there is a considerable increase in the greenhouse gases which increases the earth's temperature.

Farming

Nitrous oxide used in fertilizers is one of the contributors to the greenhouse effect in the atmosphere.

Industrial Waste and Landfills

The industries and factories produce harmful gases which are released in the atmosphere. Landfills also release carbon dioxide and methane that adds to the greenhouse gases.

Effects of Greenhouse Effect

The main effects of increased greenhouse gases are:

Global Warming :

It is the phenomenon of a gradual increase in the average temperature of the Earth's atmosphere. The main cause for this environmental issue is the increased volumes of greenhouse gases such as carbon dioxide and methane released by the burning of fossil fuels, emissions from the vehicles, industries and other human activities.

Depletion of Ozone Layer

Ozone Layer protects the earth from harmful ultraviolet rays from the sun. It is found in the upper regions of the stratosphere. The depletion of the ozone layer results in the entry of the harmful UV rays to the earth's surface that might lead to skin cancer and can also change the climate drastically.

The major cause of this phenomenon is the accumulation of natural greenhouse gases including chlorofluorocarbons, carbon dioxide, methane, etc.

Smog and Air Pollution

Smog is formed by the combination of smoke and fog. It can be caused both by natural means and man-made activities. In general, smog is generally formed by the accumulation of more greenhouse gases including nitrogen and sulfur oxides. The major contributors to the formation of smog are automobile and industrial emissions, agricultural fires, natural forest fires and the reaction of these chemicals among themselves.

Acidification of Water Bodies

Increase in the total amount of greenhouse gases in the air has turned most of the world's water bodies acidic. The greenhouse gases mix with the rainwater and fall as acid rain. This leads to the acidification of water bodies. Also, the rainwater carries the contaminants along with it and falls into the river, streams and lakes thereby causing their acidification.

Runaway Greenhouse Effect

This phenomenon occurs when the planet absorbs more radiation than it can radiate back. Thus, the heat lost from the earth's surface is less and the temperature of the planet keeps rising. Scientists believe that this phenomenon took place on the surface of Venus billions of years ago. This phenomenon is believed to have occurred in the following manner:

- A runaway greenhouse effect arises when the temperature of a planet rises to a level of the boiling point of water. As a result, all the water from the oceans converts into water vapour, which traps more heat coming from the sun and further increases the planet's temperature. This eventually accelerates the greenhouse effect. This is also called the "positive feedback loop".
- There is another scenario giving way to the runaway greenhouse effect. Suppose the temperature rise due to the above causes reaches such a high level that the chemical reactions begin to occur. These chemical reactions drive carbon dioxide from the rocks into the atmosphere. This would heat the surface of the planet which would further accelerate the transfer of carbon dioxide from the rocks to the atmosphere, giving rise to the runaway greenhouse effect.

In simple words, increasing the greenhouse effect gives rise to a runaway greenhouse effect which would increase the temperature of the earth to such an extent that no life will exist in the near future.

Measures to reduce the greenhouse effect

To stop climate change, we need to stop the amount of greenhouse gases, like carbon dioxide, from increasing. For the past 150 years, burning fossil fuels and cutting down forests, which naturally pull carbon dioxide out of the air, has caused greenhouse gas levels to increase. There are two main ways to stop the amount of greenhouse gases from increasing: we can stop adding them to the air, and we can increase the Earth's ability to pull them out of the air. This is called climate mitigation. There is not one single way to mitigate climate change. Instead, we will have to piece together many different solutions to stop the climate from warming. Below are descriptions of the main methods that we can use.

Shrink the footprint of food

Today, about a fifth of global carbon emissions come from raising farm animals for meat. For example, as cattle digest food they burp, releasing methane, a powerful greenhouse gas, and their manure releases the greenhouse gases carbon dioxide and nitrous oxide. And forests, which take carbon dioxide out of the air, are often cut down so that cattle have space to graze.

Fig. 16.5

Travel without making greenhouse gases

Using public transportation, carpooling, biking, and walking leads to fewer vehicles on the road and less greenhouse gases in the

Fig. 16.6

atmosphere. Cities and towns can make it easier for people to lower greenhouse gas emissions by adding bus routes, bike paths, and sidewalks.

Reduce, recycle and reuse

When people recycle close to half of their household waste, they can save around 1089 kg of carbon dioxide each year. Instead of throwing excess waste into the atmosphere, increasing the amount of carbon dioxide, one can instead buy products with minimal packaging. Reducing waste also involves purchasing reusable products rather than disposable ones like getting a reusable water bottle.

Buy energy-efficient products

When purchasing home appliances, it is essential that one looks at the energy-efficiency models. These home appliances come in various ranges of energy-efficient models; thus, there is a need to determine those that will ensure reduced emission of energy and greenhouse gases in return.

Grow on your own

The more people start growing their own plants for food, the higher amount of greenhouse gases we can eliminate from the air. We can reduce more food miles that are represented by a mile in which the food has to be transported from producer to consumer.

Generate electricity without emissions

Renewable energy sources include solar energy, geothermal energy, wind turbines, waste and biomass energy, and hydropower. Because they do not burn fossil fuels, these renewable energy sources do not release greenhouse gases into the atmosphere as they generate electricity.

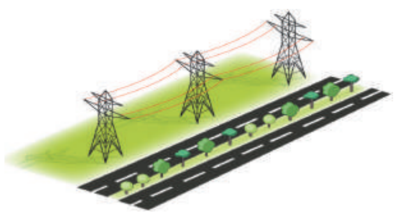


Fig. 16.7

Use less electricity

Taking steps to use less electricity, especially when it comes from burning coal or gas, can take a big bite out of greenhouse gas emissions. Worldwide, electricity use is responsible for a quarter of all emissions.

Some steps that you can take to use less electricity are simple and save money, like replacing incandescent light bulbs with LED bulbs that use less electricity, adding insulation to your home, and setting the thermostat lower in the winter and higher in the summer, especially when no one is home. There are also new technologies that help keep buildings energy efficient, such as glass that reflects heat, low-flow water fixtures, smart thermostats, and new air conditioning technology with refrigerants that don't cause warming. In urban and suburban environments, green or cool roofs can limit the amount of heat that gets into buildings during hot days and help decrease the urban heat island effect.

Reduce emissions from industry.

Manufacturing, mining for raw materials, and dealing with the waste all take energy. Most of the products that we buy — everything from phones and TVs to clothing and shoes — are created in factories, which produce up to about 20% of the greenhouse gases emitted worldwide.

There are ways to decrease emissions from manufacturing. Using materials that aren't made from fossil fuels and don't release greenhouse gases is a good start. For example, cement releases carbon dioxide as it hardens, but there are alternative products that don't create greenhouse gases. Similarly, bioplastics made from plants are an alternative to plastics that come from fossil fuels. Companies can also use renewable energy sources to power factories and ship the products that they create in fuel-saving cargo ships.

Take carbon dioxide out of the air

Along with reducing the amount of carbon dioxide that we add to the air, we can also take action to increase the amount of carbon dioxide we take *out* of the air. The places where carbon dioxide is pulled out of the air are called carbon sinks. For example, planting trees, bamboo, and other plants increases the number of carbon sinks. Conserving forests, grasslands, peatlands, and wetlands, where carbon is held in plants and soils, protects existing carbon sinks. Farming methods such as planting cover crops and crop rotation keep soils healthy so that they are effective carbon sinks. There are also carbon dioxide removal technologies, which may be able to pull large amounts of greenhouse gases out of the atmosphere.

Fig. 16.8

Activities 16.4

i. Explain what would happen to Earth in each scenario.

Without a natural Greenhouse Effect	With the natural Greenhouse Effect	With an enhanced Greenhouse Effect by pollution

ii. Write a list of human activities that contribute to the emission of greenhouse gases and explain what gas each activity produces the most.

Human activity	Greenhouse gas that produces

iii. Explain two consequences that the enhanced greenhouse effect due to human activity is having on Earth.

Cause	Effect

Activities 16.5

Create an ID card for each one of the Greenhouse Gases by completing the missing information.

- Naturally occurring and man made spaces explain how each gas occurs naturally and how it is created by human activities.
- Am I necessary? Space write Yes or No and explain why.

picture	Name	
	Chemical Formula:	
	Naturally occurring	
	Man-made	
	Am I necessary?	
Picture	Name	
	Chemical Formula:	
	Naturally occurring	
	Man-made	
	Am I necessary?	
Picture	Name	
	Chemical Formula:	
	Naturally occurring	
	Man-made	
	Am I necessary?	
Picture	Name	
	Chemical Formula:	
	Naturally occurring	
	Man-made	
	Am I necessary?	
Picture	Name	
	Chemical Formula:	
	Naturally occurring	
	Man-made	
	Am I necessary?	

16.4 Acid rain

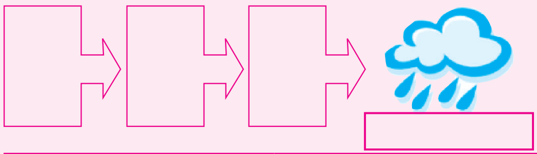
Acid rain is caused by a chemical reaction that begins when compounds like carbon dioxide, sulfur dioxide and nitrogen oxides are released into the air. These substances can rise very high into the atmosphere, where they mix and react with water, oxygen, and other chemicals to form more acidic pollutants, known as acid rain.

Acid Rain, as the name suggests, can be said as the precipitation of acid in the form of rain in the simplest manner. When atmospheric pollutants like oxides of carbon,nitrogen and sulphur react with rainwater and come down with the rain, then this results in Acid Rain. It can be extremely harmful to forests. Acid rain that seeps into the ground can dissolve nutrients, such as magnesium and calcium, that trees need to be healthy. Acid rain also causes aluminum to be released into the soil, which makes it difficult for trees to take up water.

Acid rain is precipitation that has unusually high levels of hydrogen ions (low pH). The water droplets are acidic because of atmospheric pollution. It is known to have harmful effects on aquatic animals, plants and infrastructure. The term “acid rain” was coined in 1872 by Robert Angus Smith.

Activities 16.6

How acid rain is made



Sulphur dioxide released when fuel is burnt	There are sulphur impurities in oil and coal	Falls as acid rain -pH 5.5 or less	The acid fumes dissolve in clouds

Causes of Acid Rain

The causes of acid rain are Sulphur and Nitrogen particles which get mixed with the wet components of rain. Sulphur and Nitrogen particles which get mixed with water are found in two ways either man-made i.e as the emissions that are given out from industries or by natural causes like lightning strike in the atmosphere releasing nitrogen oxides and volcanic eruptions releasing sulphur oxide.

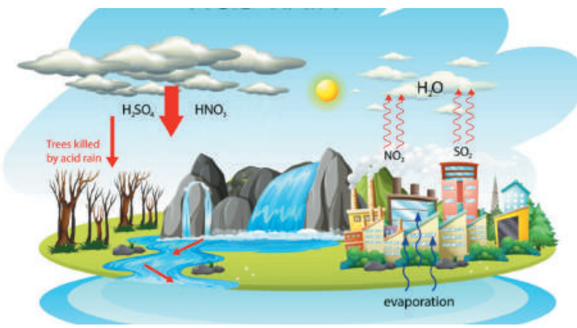


Fig. 16.9: Formation of aicd rain

The regular clean rain we experience, even though it is not clean i.e water and carbon dioxide react together to form weak carbonic acid which essentially by itself is not extremely harmful. The reaction occurring is :

$$H_2O\ (l) + CO_2\ (g) \rightleftharpoons H_2CO_3\ (aq)$$

The pH value of regular rainwater is around 5.7, giving it an acidic nature. The oxides of nitrogen and sulphur are blown away by the wind along with the dust particles. They settle on the earth's surface after coming down in the form of precipitation. Acid rain is essentially a by-product of human activities which emit oxides of nitrogen and sulphur in the atmosphere. Example – the burning of fossil fuels, unethical waste emission disposal techniques.

Sulphur dioxide and nitrogen dioxide undergo oxidation, and then they react with water resulting in the formation of sulphuric acid and nitric acid, respectively. The following reaction will clarify the acid formation reaction:

$$2SO_2\ (g) + O_2\ (g) + 2H_2O\ (l) \rightarrow 2H_2SO_4\ (aq)$$
$$4NO_2\ (g) + O_2\ (g) + 2H_2O\ (l) \rightarrow 4HNO_3\ (aq)$$

Acid rain is the rain that has been acidified, with a pH less than 5.6.

- Excessive amounts of sulfur and nitrogen released by cars and industrial processes get mixed with rain and result in precipitation that is highly acidic.
- These pollutants react with water vapours present in the atmosphere to form sulfuric acid and nitric acid respectively.

- Sulfur and Nitrogen particles may be released in the atmosphere due to anthropogenic causes or by natural causes.
- Anthropogenic causes include industrial emissions, burning of fossil fuels such as diesel and coal, incineration of garbage, production of paper.
- Natural causes could be release of sulfur during volcanic eruptions or nitrogen ions released in the atmosphere during a lightning strike. The chemical reaction occurs in the presence of lightning to form the nitric oxide. This further reacts with oxygen to form nitrogen dioxide.
- Furthermore, ozone, some other organic acids like formic and acetic acids also contribute to 5-20% acidity in total acid rain.

Activities 16.7

Experiment 1

Which water sample is acid rain?

Acid rain turns indicator paper orange or red. Test the water samples and see which one is acid rain.

Sample	1	2	3	4	5
Colour of indicator paper					
is it acid rain?					

Experiment 2

What does acid rain do to buildings?

Put some different kinds of rocks in acid rain. Draw what happens.

Chalk	Sandstone	granite	basalt	limestone

Effects of Acid rain

The effect of acid rain on a forest

Fig. 16.8

- Acid rain is very harmful to agriculture, plants, and animals. It washes away all nutrients which are required for the growth and survival of plants. Acid rain affects agriculture by the way it alters the composition of the soil.
- It causes respiratory issues in animals and humans.
- When acid rain falls down and flows into the rivers and ponds it affects the aquatic ecosystem. It alters the chemical composition of the water, to a form which is actually harmful to the aquatic ecosystem to survive and causes water pollution.
- Acid rain also causes the corrosion of water pipes, which further results in leaching of heavy metals such as iron, lead and copper into drinking water.
- It damages the buildings and monuments made up of stones and metals.

Real-Life Examples

Taj Mahal, one of the 7 wonders of the world, is largely affected by acid rain. The city of Agra has many industries which emit the oxides of sulphur and nitrogen in the atmosphere. People continue to use low-quality coal and firewood as a domestic fuel, adding to this problem. Acid rain has the following reaction with the marble (calcium carbonate):

$CaCO_3(s) + H_2SO_4(l) \rightarrow CaSO_4(s) + H_2O(l) + CO_2(g)$

The formation of calcium sulphate results in the corrosion of this beautiful monument.

- Statue of Liberty which is made of copper has also been damaged by the cumulative action of acid rain and oxidation for over 30 years and is, therefore, becoming green.
- Acid rains damage standing crops and forests.
- It has adverse impact on freshwater life, other aquatic life forms, insects etc.
- Acid rain can cause the ocean's pH to fall. This phenomenon is known as 'ocean acidification'. Though acid rain does not have huge impacts on oceans, they significantly affect shallower coastal waters.
- Excess nitrogen inputs from the atmosphere in the oceans promote increased growth of marine plants and phytoplankton which may result in more frequent harmful algal blooms and eutrophication.

Measures to Acid Rain

- The production of nitrogen oxides and sulfur oxides should be reduced.
- Renewable energy sources should be used.
- Public awareness should be raised about the causes and effects of acid rain.

Project Work

To understand the effects of acid rain on plant growth over the short term and extrapolate the results to better understand the effects of acid rain at larger scales.

Materials : 2 plant pots, enough potting soil (or garden soil) for each pot, one package of plant seeds (Sunflower seeds work well), 2 spray bottles,lemon juice,direct light source, permanent marker .

Procedure

i. Fill each pot with potting soil. Place several seeds in soil. You may want to begin with three pots in case the seeds in one do not take.
ii. With a permanent marker label one pot 'Acid rain' and the other pot 'Normal'.
iii. Water both pots and place them under a direct source of light.
iv. Repeat watering every day or every other day (depending on seed type) until each pot has a sprout with leaves.
v. Measure the height of your plants and record this data as Day 1. (Tip: Take photographs throughout to use in your presentation and analysis.)
vi. Fill both spray bottles with water. Select one spray bottle and add lemon juice at a quantity equal to 5 drops of lemon juice per one liter of water.
vii. From this point forward, water each plant as usual and then spray each plant with the acid mix or normal water as labeled. (Be sure to water the plant first and then spray the acid so as not to wash the acid off of the plant.) Follow this by measuring the plant every day.
viii. At the end of 14 days you should have sprayed the plants and measured their height every day (or every other day).
ix. Examine the growth in each of your treatments.
x. Write a report .

Exercise

A. Choose the correct one and put the tick mark(√)

i. Which gas is evolved when marble reacts with dilute hydrochloric acid ?

a. O_2 b. CO_2 c. NH_3 d. H_2

ii. Which of the following statement is correct ?

a. CO_2 is collected by upward displacement of air.
b. CO_2 is collected by downward displacement of air.
c. CO_2 is collected by upward displacement of water.
d. CO_2 is collected by downward displacement of water.

iii. Which insoluble substance is formed, when CO_2 gas is passed through lime water for short time ?

a. $CaSO_4$ b. $CaCO_3$ c. $Ca(HCO_3)_2$ d. CaO

iv. What is the ratio of ammonium chloride and calcium hydroxide in a mixture used to prepare ammonia gas in the laboratory.

a. 1:2 b. 2:3 c. 2:1 d. 3:1

v. Which of the following condition is necessary for Haber's process ?

a. Temperature, pressure and catalyst.
b. Temperature, pressure and promoter.
c. Temperature, catalyst and promoter.
d. Temperature, pressure, catalyst and promoter.

vi. Greenhouse gases are the gases that absorb the infrared radiations and create a ________ effect.

a. greenhouse b. acid rain c. heating d. cooling

vii. Which is an example of greenhouse gas-

a. halogen b. inert c. chlorofluorocarbons d. noble

viii. The causes of acid rain are ________ and Nitrogen particles which get mixed with the wet components of rain.

a. oxygen b. sulfur c. chlorine d. argon

vix. ________ is very harmful to agriculture, plants, and animals.

a. greenhouse gas b. acid rain c. oxygen gas d. inert gas

B. Differentiate between these pairs.

i. CO_2 and NH_3.
ii. Quick lime and lime water.
iii. Greenhouse and greenhouse gases
iv. Sulfur dioxide and CFC gas
v. cause of acid rain and cause of greenhouse effect

C. Explain the following:

i. Carbondioxide gas is collected by upward displacement of air.
ii. Ammonia is not collected over water.
iii. Ammonia turns red litmus paper into blue.
iv. Dilute sulphuric acid is not used in the laboratory preparation of carbondioxide gas.
v. Ammonia gas is passed through lime tower.

vi. Carbondioxide is used in fire extinguisher.
vii. The mouth of hard glass test tube is slanted down during laboratory preparation of ammonia gas.
viii. Ammonia gas is collected by downward displacement of air.
ix. The pH value of regular rainwater is around 5.7, giving it an acidic nature.
x. Sulfur and Nitrogen particles may be released in the atmosphere due to anthropogenic causes or by natural causes.
xi. When purchasing home appliances, it is essential that one looks at the energy-efficiency models.

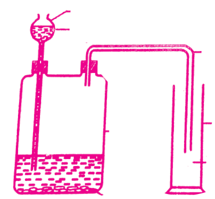
E. Answer the following questions :

i. What are the physical properties of carbondioxide ?
ii. Write any four chemical properties of carbondioxide.
iii. What are the uses of carbondioxide ?
iv. Draw a labelled diagram for laboratory preparation of carbondioxide gas and also write balanced chemical equation.
v. What is dry ice ? Write its use.
vi. Write any two general methods of preparation carbondioxide gas with chemical equation.
vii. What are the physical properties of ammonia gas ?
viii. Mention the chemical properties of ammonia with equations.
ix. Why is ammonia gas useful to us ?
x. Draw a labelled diagram for laboratory preparation of ammonia gas.
xi. What happens when
   a. Limestone is heated strongly?
   b. Quick lime dissolves in water?
   c. Charcoal burns in air?
   d. Carbondioxide gas is passed in lime water?
   e. Ammonium hydroxide is treated with dilute sulphuric acid?
   f. A glass rod dipped in HCl, is brought near the mouth of gas jar containing ammonia?
xii. What is meant by liquor ammonia ? Ammonia turns red litmus into blue. What does it show?
xiii. How do you test whether a gas is carbondioxide or not ?
xiv. What happens to moist blue litmus paper when it is dipped into carbondioxide ?
xv. Why carbondioxide is important for plant?
xvi. How is carbondioxide gas prepared in large scale ? Write the balanced chemical equation.
xvii. What is urea ? How is it formed ?
xviii. Why is it called greenhouse?
xix. What is greenhouse system?
xx. How is greenhouse made?
xxi. List gases which are responsible for the greenhouse effect.
xxii. Can a runaway greenhouse effect be stopped?

xxiii.What are 5 things we can change to reduce greenhouse effect?
xxiv.What measures you will take to reduce greenhouse effect?
xxv. What are 4 ways to reduce greenhouse gases?
xxvi.How Acid rain is formed?
xxvii.Why Acid rain is harmful?
xxviii.What is acid rain and how is it caused?
xxix.What are the effects of acid rain?
xxx. What will happen if we don't stop acid rain?
xxxi.What is acid rain? What are its harmful effects?
xxxii.What are three ways to reduce acid rain?
xxxiii.How does acid rain affect plants?
xxxiv.What is the primary source of acid rain?
xxxv.Can acid rain damage buildings?
xxxvi.Can acid rain burn your skin?
xxxvii.Write the equations of acid rain formations

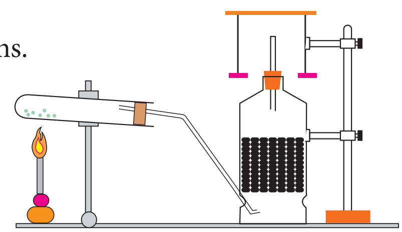
F. Diagrammatic Questions :

i. Study the given diagram and answer the questions below.



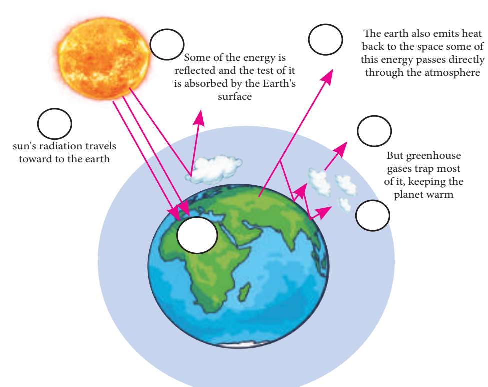
a. Find the mistake in the apparatus set up in the given diagram.
b. Which gas is being produced ? Write the balanced chemical equation of the reaction. Write its one use.

ii. Study the given figure and answer the following questions.



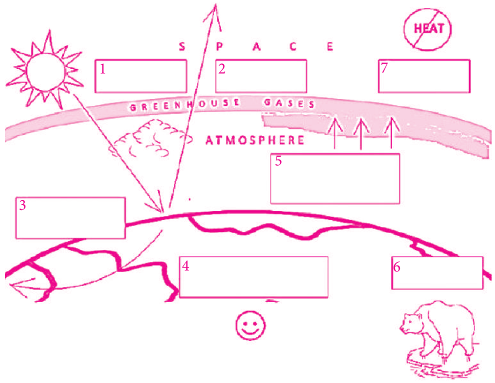
a. Which gas is collected in the gas jar ?
b. Write the balanced chemical equation involved in the process.
c. What will happen if quick lime is replaced in drying tower by conc. H_2SO_4?
d. Name the compound formed in the gas jar if the jar is moist.

iii. Order the steps from the Greenhouse Effect process write the number inside the circle. Then, describe each step on the chart below the diagram.



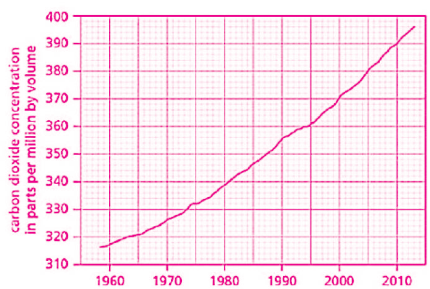
Step	Description- What happens in each step?
1	
2	
3	
4	
5	
6	

iv. Drag the labels on the right to complete the diagram showing how greenhouse effect occurs.



- The earth is warmed to keep us alive.
- Less heat leaves atmosphere.
- Sunlight reaches Earth
- Most heat should go back to space
- Earth becomes too hot causing issues.
- Greenhouse gases trap some heat.
- More heat is trapped because gases are thicker.

iii. Look at the graph about carbon dioxide levels over 50 years. Answer the questions.



a. in which year was carbon dioxide levels 355 parts per million? __________

b. What was the carbon dioxide level in 2010? __________ parts per million.

iv.

<table>
<tr><th>Section 1: Sourses of acid rain</th><th>Section 2: Formation of acid rain</th></tr>
<tr><td>


1. What fuel is burned in a power station?

____

2. Where is this fuel from?

____

3. Why is this fuel burned in a power station?

____

4. What gas is produced when coal is burned in a power station?

____

5. What gases are produce when fuel is burned in cars?

____
</td><td>
6. What 2 reactions occur when Sulfur Dioxide and Nitrogen Oxides react with water in rain clouds?

Reaction 1

____

Reaction2

____

7. Name the 2 acids produced in the rain clouds?

- __________

- __________
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Chapter 17 Metals

Total Estimated pariods (Th. 7+ Pr. 1=8)

Student's Learning Outcomes

After studying this unit, the students will be able to :

- introduce minerals and ores
- give the name to the main ores of iron, copper, silver, and aluminum
- give a general explanation of the methods of metallurgical processing

Georgius Agricola, (Latin), German Georg Bauer, (born March 24, 1494), Glauchau, Saxony [Germany]—died November 21, 1555, Chemnitz), German scholar and scientist known as 'the father of mineralogy'. While a highly educated classicist and humanist, well regarded by scholars of his own and later times, he was yet singularly independent of the theories of ancient authorities. He was indeed among the first to found a natural science upon observation, as opposed to speculation.

Introduction

There are 118 elements known till today. These elements are divided into three groups as metals, non-metals and metalloids. Among these 118 elements, more than 80 elements are metals. Most metals are found in combined state with other substances. Silver, gold and platinum are non-active metals. They are found in independent form. Metals are very useful to us. We use meals for various purposes like making weapons, machinery parts, engines of vehicles, electric wire, utensils, coins etc.

Metals are electropositive elements. They are hard, shiny, malleable and ductile. They are good conductor of heat and electricity.

Physical properties of metals

i. Metals are usually good conductors of heat and electricity as they have free valence electrons.

ii. They are usually found in a solid state at room temperature except mercury, gallium and cesium.

iii. They have high specific gravity (relative density).

iv. They have high melting and boiling points except mercury sodium and potassium.

v. They are usually malleable and ductile in nature.

vi. They have metallic lustre.

vii. They are usually hard in nature except group IA metals like lithium, sodium and potassium.

17.1 Introduction to minerals and ores

Minerals are naturally occurring inorganic solids with a crystalline structure and a definite range of chemical formula. A mineral occurring in sufficient quantity and containing enough metal to permit its recovery and extraction at a profit. Or, a mineral or an aggregate of minerals from which a valuable constituent, especially a metal, can be profitably mined or extracted is an ore. A mineral is composed of the same substance throughout. There are about 3000 different minerals in the world. Minerals are made of chemicals - either a single chemical or a combination of chemicals.There are 103 known chemical elements. Minerals are sorted into 8 groups.

Ores are concentrations of minerals in rock that are high enough to be economically extracted for use. All ores are minerals, but all minerals are not necessarily ores. A rock is made up of 2 or more minerals. You need minerals to make rocks, but you don't need rocks to make minerals. All rocks are made of minerals. A mineral is composed of the same substance throughout.

17.1.1 Concept of minerals and ores

Earth's crust contains some naturally occurring components called minerals in which metal compounds are found. The Earth is the main source of minerals and ores.

Ores can be said to be those minerals from which metal can be economically and easily extracted. These ores contain good percentage of metal. Metals are not always found in the free state. Metals like Potassium, Sodium, Calcium, Magnesium, etc are found in a combined state. From these Metal Compounds, a pure form of metals needs to be extracted. It should be kept in mind that all ores are minerals but all minerals are not ores. Minerals must occur naturally. It must be inorganic and solid . It must possess an orderly internal structure, that is, its atoms must be arranged in a definite pattern.It must have a definite chemical composition that may vary within specified limits.

Ores are those minerals from which metal are extracted conveniently and profitably. Oxides (e.g., bauxite, cuprites, hematite), carbonate ores (e.g., siderite), sulfides (e.g., copper glance), and halide ores (e.g., Horn silver) are the four main types of ores.

The process of removing metal from the ore is known as Metallurgy. The ore is generally associated with Earthy impurities like Sand, rocks, and limestone Known as Gangue or Matrix. A substance added to ore to remove the impurities is called flux. The combination of gangue with flux in ores forms a fusible material called Slag.

17.1.2 Difference between Ores and Minerals

Here we have provided the major differences between Minerals and Ores.

Minerals	Ores
All the naturally occurring substances that are present in the earth's crust are known as Minerals.	Ores are usually used to extract metals economically. A large number of ores are present.
All Minerals are not ores.	All ores are minerals.
Minerals are native forms in which metals exist.	Ores are mineral deposits.
For eg- Clay is a minerak of Aluminium	For eg- Bauxite is an ore of Aluminium

17.1.3 Some primary metals and their ores

Some primary metals are given below -

Metal	Ores
Iron	Haematite(Fe_2O_3),Magnetite(Fe_3O_4),Limonite($Fe_2O_3.3H_20$), Siderite($FeCO_3$)
Copper	Copper pyrite($CuFeS_2$), Cuprite(Cu_2O), Chalkocite (Cu_2S), Malachite($Cu(OH)_2.CuCO_3$)
Silver	Horn Silver($AgCl$), Argentite or Silver galance(Ag_2S), Silver copper galance ($(AgCu_2)_2S$, Ruby silver or Pryotite($3Ag_2S.Sb_2S_3$)
Aluminium	Bauxite($Al_2O_3.2h_2O$),Feldspar($KAlSi_3O_8$),Cryolite(Na_3AlF_6), China clay(Kaoline) ($Al_2Si_2O_7.2h_20$)

17.2 Methods for the processing of metals

Materials in their solid state are formed into desired shapes by the application of a force or pressure. The material to be processed can be in a relatively hard and stable condition and in such forms as bar, sheet, pellet, or powder, or it can be in a soft, plastic, or puttylike form. Solid materials can be shaped either hot or cold. Processing of metals in the solid state can be divided into two major stages: first, the raw material in the form of large ingots or billets is hot-worked, usually by rolling, forging, or extrusion, into smaller shapes and sizes; second, these shapes are processed into final parts and products by one or more smaller scale hot or cold forming processes.

After the material is formed, it is usually further altered. In materials processing, a 'removal' process is one that eliminates portions of a piece or body of material to achieve a desired shape. Although removal processes are applied to most types of materials, they are most widely used on metallic materials. Material can be removed from a workpiece by either mechanical or nonmechanical means. There are many methods of processing metals from their ores. Among them are mining, grinding, concentration, smelting, roasting, and electro-refining.

Mining method for processing of metals

There are four main mining methods: underground, open surface (pit), placer, and in-situ mining.

- **Underground** mines are more expensive and are often used to reach deeper deposits.
- **Surface** mines are typically used for more shallow and less valuable deposits.
- **Placer** mining is used to sift out valuable metals from sediments in river channels, beach sands, or other environments.

Fig. 17.1

- **In-situ** mining, which is primarily used in mining uranium, involves dissolving the mineral resource in place then processing it at the surface without moving rock from the ground.

Mining was commonly a labour-intensive process. It does not necessarily involve underground mining. Processes of decomposition may leave metal oxides or even native metals in surface soils or debris.

Modern-day mining operations extract valuable minerals which containing metals known as ore from underground mines "workings", surface mines "open pits", or previously disturbed areas such as waste rock dumps, stockpile pads, and tailings impoundments. The economic value of the metals intended for recovery and the chemical and physical characteristics of the ore body determines how the ore will be mined and the processing method that will be used to extract the metal.

The method used depends on the type of mineral resource that is mined, its location at or beneath the surface, and whether the resource is worth enough money to justify extracting it. Each mining method also has varying degrees of impact on the surrounding landscape and environment.

Grinding

The ores occur in nature as huge lumps. They are broken to small pieces with the help of crushers or grinders. These pieces are then reduced to fine powder with the help of a ball mill or stamp mill. This process is called pulverisation. Grinding is usually carried out in a sequence of operation by which the lump size is reduced step by step. The purpose of this method is to reduce size particles and to release impurities

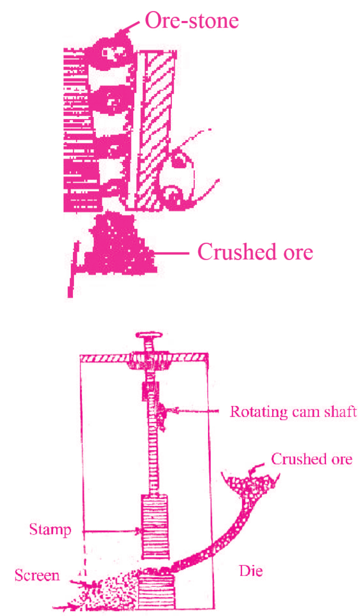


Fig. 17.2

Grinding is the common collective name for machining processes that utilize hard, abrasive particles as the cutting medium. Grinding refers to the process of breaking down, separating, sizing, or classifying aggregate material (e.g. mining ore). For instance rock crushing or grinding to produce uniform aggregate size for construction purposes, or separation of rock, soil or aggregate material for the purposes of structural fill or land reclamation activities.

Grinding is the most energy-intensive process in the ore processing chain. The issue of its intensification is especially urgent in the processing of iron ores, characterized by high strength. A known way to increase the efficiency of ore reduction is to use surfactant additives in grinding. For example, through crushing the mineral ore to a certain size and finishing by grinding it into powder, the ultimate fineness depends on the fineness of dissemination of the desired mineral.

The ore is generally obtained as big rock pieces. These big lumps of the ore are crushed to smaller pieces by using jawcrushers and grinders. It is easier to work with crushed ore. The big lumps of the ore are brought in between the plates of a crusher forming a jaw. One of the plates of the crusher is stationary while the other moves to and fro and the crushed pieces are collected . The crushed pieces of the ore are then pulverized (powdered) in a stamp mill . The heavy stamp rises and falls on a hard die to powder the ore. The powdered ore is then taken out through a screen by a stream of water.

Pulverization can also be carried out in a ball mill. The crushed ore is taken in a steel cylinder containing iron balls. The cylinder is set into revolving motion. The striking balls pulverize the crushed ore into fine powder.

Concentration

The process of removal of the gangue from Ore is known as Concentration or Dressing or Benefaction. There are numerous methods of concentration and the methods are chosen based on the properties of the ore.

Hydraulic Washing: This method concentrates the ore by passing it through an upward stream of water whereby all the lighter particles of gangue are separated from the heavier metal ore. This is a type of gravity separation.

Magnetic Separation: This involves the use of magnetic properties of either the ore or the gangue to separate them. The ore is first ground into fine pieces and then passed on a conveyor belt passing over a magnetic roller. The magnetic ore remains on the belt and the gangue falls off the belt.

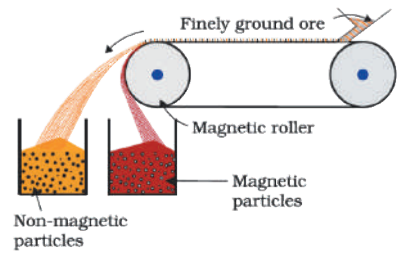


Fig: 17.3 Magnetic Separation

Froth Flotation Method: This method is mainly used to remove gangue from sulphide ores. The ore is powdered and a suspension is created in the water. To this are added, Collectors and Froth Stabilizers. Collectors (pine oils, fatty acids etc) increase the non-wettability of the metal part of the ore and allows it to form a froth. Froth Stabilizers (cresols, aniline etc) sustain the froth. The oil wets the metal and the water wets the gangue. Paddles and air constantly stir up the suspension to create the froth. This frothy metal is skimmed off the top and dried, to recover the metal.

Leaching: Leaching is used when the ore is soluble in a solvent. The powdered ore is dissolved in a chemical, usually a strong solution of NaOH. The chemical solution dissolves the metal in the ore and it can be extracted and separated from the gangue by extracting the chemical solution. Extraction of the Aluminium metal from Bauxite ore is done using this process.

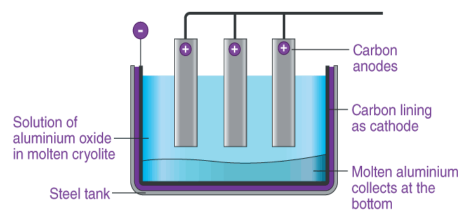


Fig: 17.4 Leaching of alumina from bauxide

Most of the large structures you see around you today have metallurgy to thank for their existence. What we learned now is just the beginning of the extraction of metals.

Smelting

Smelting is the process of reducing oxide ore with carbon at a high temp y technique to extract base metals from their ores with the help of heat and a chemical reducing agent. The process of obtaining a metal either as an element or as a simple compound from its ore by heating beyond the melting point in the presence of oxidising agents such as air and coke is known as smelting. Copper is the first metal to be smelted followed by tin, lead and silver. To achieve high temperatures required for smelting, furnaces with forced air drafts are used. In modern copper smelting, a reverberatory furnace is used.

Fig. 17.5

Smelting, a method by which a metal we separate from its material, either as a component or as a pure mixture. Moreover, by heating beyond the melting point, typically in the presence of oxidizing agents such as water or reducing agents such as coke.

Metal extraction process in which ore is heated at a high temperature in an enclosed furnace (usually mixed with purifying and/or heat generating substances such as calcareous and coke). Lighter mineral materials (impurities called slag and tailing) rise to the top after a reduction process and float on the molten metal. Smelting is the opposite of an oxidizing reaction to roasting.

We use a reverberatory furnace in the industrial smelt ore and a liquid, normally calcareous, into the rim, steel, and sulfur— and pull out the slag from the bott

In another (converter) furnace, a second heat treatment is needed to remove the iron from the mat. In modern ore treatment, in order to concentrate the metal ore as much as possible, different preliminary steps are usually performed before smelting. Besides, in the smelting process, they mix material with oxygen. For example, iron oxide — which we heat to a high temperature, allowing the oxide to bond with the hydrogen in the gas. Also, it flees as carbon monoxide and carbon dioxide. After that, they extract other impurities by applying a flux with which they combine to form a slag, which we collectively call gangue.

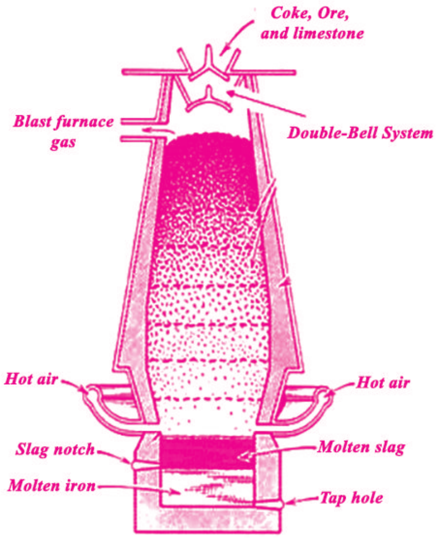


Fig. 17.6

Smelting is a process in which the oxide ore in a molten state is reduced by carbon or other reducing agents to free metal.

i. By using carbon as a reducing agent : This method is used for the isolation of iron, tin, and zinc metals from their respective oxides. The oxide ores are strongly heated with charcoal or coke. Reduction occurs by the action of carbon and/or carbon monoxide, which is produced by the partial combustion of coke or charcoal.

Although the ore has been concentrated in an earlier step, it is still contaminated with some gangue material which is finally removed in the reduction process by the addition of flux during smelting.

Flux is a chemical substance which combines with gangue at higher temperatures to form easily fusible material called slag which is not soluble in the molten metal. Flux are of two types :

Basic Flux : On heating, lime stone is converted into calcium oxide used as basic flux which combines with acidic impurities like silica in metallurgy of iron and forms fusible calcium silicate ($CaSiO_3$).

Acidic flux : SiO_2 is used as acidic flux to remove basic impurity of FeO in metallurgy of Cu.

The fusible slag, such as calcium silicate formed during smelting floats over the molten metal and is thus easily removed. Another advantage is that the slag provides a covering to the molten metal thus preventing it from getting oxidized by air.

ii. Other reducing agents : Oxide ores which cannot be reduced by carbon or metals which show affinity to carbon by forming metal carbides, are reduced by reducing agents like aluminium, sodium, magnesium or hydrogen. Oxide like chromium oxide or manganese oxide are reduced by aluminium powder is a highly exothermic reaction. This process is known as Goldschmidt's Alumino-thermite reduction method.

Heat is generated in the process due to the formation of Al_2O_3 which is a highly exothermic reaction. Titanium is obtained by the reduction of $TiCl_4$ (produced by the action of carbon and chlorine on TiO_2) by Mg in an inert atmosphere of argon (Kroll process).

iii. Self-reduction : This is applied to the sulphide ores of copper, mercury and lead . The ores are heated in air, a part of these sulphide ores is changed into the oxide or sulphate which then reacts with the remaining part of the sulphide ore to give the metal and sulphur dioxide. Copper produced at this stage is called Blister copper. The evolution of sulphur dioxide produces blisters on the surface of solidified copper metal.

Roasting

Roasting is a process in which ore is roasted to temperatures below its melting points, usually in the presence of air. A process called 'roasting' drives out the unwanted carbon or sulfur in the case of carbonates and sulfides, leaving an oxide that can be directly reduced. In an oxidizing environment, usually, they perform roasting. examples: Malachite, common copper ore is primarily copper carbonate hydroxide . This mineral undergoes thermal decomposition between 250° C and 350° C at 2CuO, CO_2, and H_2O.Carbon dioxide and water release into the atmosphere. Also, it leaves oxide from copper ii., which we can reduce directly to the copper.

In briefly, roasting is a process in which the concentrated ore is heated in a free supply of air at a temperature insufficient to melt it. The following changes take place during roasting :

i. Drying of the ore.
ii. Removal of the volatile impurities like arsenic, sulphur, phosphorus and organic matter.

Roasting is generally carried out in a reverberatory furnace or in a multiple hearth furnace.

Activities 17.1

i. Make a flow chart showing the various stages of metallurgical processing and present it to the class.
ii. Write down a explanation of the methods of metallurgical process.

Electro-refining

Electrolytic refining is a process of refining a metal (mainly copper) by the process of electrolysis. As far as the mechanism of the process is concerned, during electrolysis, a large chunk or slab of impure metal is used as the anode with a thin strip of pure metal at the cathode. In this setup, an electrolyte (metal salt aqueous solution) depending on the metal is often used.

The clean or pure metal is formed at the cathode when the electrical current of a sufficient voltage is applied by dissolving impure metal at the anode. Electrolytic refining is also sometimes referred to as Electrorefining.

It is necessary to choose the electrolyte and other conditions so that both anodic dissolution and metal deposition proceed with high efficiency while none of the impurity metals can move from the anode to the cathode. Clearly, there must be no passivation of the anode and the aim is to produce a deposit at the cathode of good quality, sometimes extremely crystalline. Additives are applied to the electrolyte when necessary to impose the right behaviour on both electrodes.

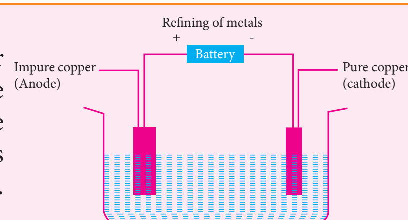
Electrolytic refining is the method of using electricity to refine impure metals. In this process, the anode is made of impure metal, and the cathode is made of a strip of pure metal. A solution is made with a soluble salt of the same substance as the electrolyte. When an electric current is transmitted, metal ions from the electrolyte are deposited as a pure metal in the cathode, and the impure metal from the anode dissolves in the form of ions into the electrolyte. Below the anode, the impurities metals are collected. It is called mud anode. In the electrolytic refining of copper, the electrolyte is a solution of acidified copper sulphate. The anode is impure copper, whereas the cathode is a strip of pure copper on passing electric current, pure copper is deposited on the cathode.

Many metals, such as copper, zinc, tin, nickel, silver, gold etc. are refined by electrolysis. In this process, the impure metal is made the anode and a thin strip of pure metal is made the cathode. The solution of the metal salt is used as an electrolyte. When current passes through electrolyte, the pure metal from the anode dissolves into the electrolyte. An equivalent amount of pure metal from the electrolyte is deposited on the cathode. The insoluble impurities settle down at the bottom of the anode and are known as anode mud whereas the soluble impurities go into the solution.

For example: In electrolytic refining of copper, the electrolyte is a solution of acidified copper sulphate. The anode is impure copper, whereas the cathode is a strip of pure copper. On passing electric current, pure copper is deposited on the cathode.

Activities 17.2

In a voltameter, place a copper sulfate solution. Pair the impure copper plate with the positive pole of the battery and the pure copper plate with the negative pole of the battery as the anode and cathode, respectively, as shown in the figure. Now apply current to the voltmeter.



Observation: The impure copper plate on the anode is being eroded, and pure copper is being added to the pure copper plate on the cathode.
Conclusion: In this way, pure copper can be obtained from impure copper using the electrorefining method.

Occurences and Extractions of some primary metals

Metals	Occurences	Extractions
Iron (Fe)	Iron is a reactive metals. It does not occur in free state. It is the second most abundant metal in the earth's crust. Iron is found in the forms of oxides, sulphate, carbonates etc. Haemoglobin of blood contains a little amount of iron.	Haematite is the chief ore of iron. Iron is extracted from haematite which contains about 72.5% iron. Haematite is found in mines. Sand, dust, clay etc. are removed from powder of Haematite with the help of magnetic separation method. Then, the ore is mixed with coke and heated strongly to get molten iron.

Copper (Cu)	Copper occurs combined in many minerals, such as chalcocite, chalcopyrite, bornite, cuprite, malachite, and azurite. It is present in the ashes of seaweeds, in many sea corals, in the human liver, and in many mollusks and arthropods.	The method used to extract copper from its ores depends on the nature of the ore. Sulfide ores such as chalcopyrite are converted to copper by a different method from silicate, carbonate or sulfate ores. Chalcopyrite (also known as copper pyrites) and similar sulfide ores are the commonest ores of copper. The ores typically contain low percentages of copper and have to be concentrated before refining (e.g., via froth flotation).
Silver (Ag)	The abundance of silver is 0.08 parts per million in the Earth's crust. It is almost exactly the same as that of mercury. Silver mostly occurs in sulfide ores, especially argentite. Argentite deposits also contain native silver when they occur in reducing environments. When it comes in contact with salt water, they are converted to chlorargyrite including horn silver.	The ore is first roasted with salt in the usual way, whereby the formation of base metal chlorides cannot be avoided entirely. After roasting, the ore is first subjected to leaching with water, in order to extract the base metal chlorides, and then with hyposulphite of lime, to extract the silver.
Aluminium (Al)	Aluminium is the most abundant element (8%) on the earth crust. It is an active metal. So, it is not found in free state. It is present in different compounds like oxides, Fluorides etc.	Bauxite is the chief ore of aluminium. Aluminium is extracted from bauxite. First of all, bauxite is heated at high temperature with sodium carbonate in the presence of carbondioxide gas to form aluminium oxide. Aluminium oxide is electrolysed and obtained 99% pure aluminium.

Project Work

i. Prepare a report on metal processing methods of mining, grinding, concentration, smelting, roasting, and electro-refining by watching audio-visual materials on the Internet and presenting them in class. Be sure to include the introduction, process, and conclusion of those methods in the report you prepare.

ii. Download some audio videos of gold mining in different rivers of Nepal from the internet and prepare a report about it. Have a wide class discussion to find out the reasons-why gold does not react chemically with other elements. Note down the facts discussed. Later, verify those facts with the help of the teacher. Write scientific conclusions on cardboard paper and paste them in the classroom.

Exercise

A. Choose the correct one and put the tick mark (√).

i. Mentals are usually __________ of heat and electriciy as they have free valence electrons

a. insulators b. good conductors c. bad conductor d. weak conductors

ii. __________ are naturally occurring inorganic solids with a crystalline structure and a definite range of chemical formula.

a. Ores b. Metals c. Materials d. Minerals

iii. The __________ is the main source of minerals and ores.

a. sun b. moon c. earth d. mars

iv. Which is not the example of oxide -

a. bauxite b. cuprites c. hematite d. siderite

v. Horn silver is __________ ore

a. sulfide b. oxide c. halide d. carbonate

vi. Which is not ore of iron-

a. Haematite b. Magnetite c. Limonite d. Chalkocite

vii. Which is not ore of copper-

a. Copper pyrite b. Limonite c. Chalkocite d. Malachite

viii. Which is not ore of silver-

a. Argentite b. Silver copper galance

c. Malachite d. Pryotite

ix. The correct statement for minerals is:

a. Clay is a minerak of Aluminium

b. Bauxite is an ore of Aluminium

c. Generally associated with Earthy impurities like Sand, rocks etc.

d. Usually used to extract metals economically.

x. The correct statement for ores is:

a. Present in the earth's crust b. Occur naturally

c. Bauxite is an ore of Aluminium d. Native forms in which metals exist.

xi. Which pairs are not the methods of processing metals?

a. evaporation, filteration b. mining, grinding

c. concentration, smelting d. roasting, electro-refining.

B. Match the following pairs

i. Silver	a. Malachite
ii. Iron	b. Argentite
iii. Copper	c. Kaoline
iv. Aluminium	d. Siderite

C. Complete the table given below :

Metals	Ores (At Least Four)
Iron	
Copper	
Silver	
Aluminium	

D. Differentiate between these pairs.

a. Minerals and Ores b. Haematite and Pryotite

c. Chalkocite and Bauxite d. Mining and Grinding

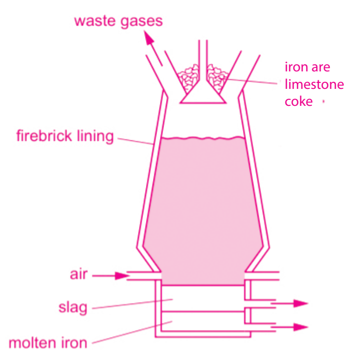
e. Smelting and Roasting d. Electro-refining and Concentration

E. Answer the following questions :

i. What is metals .Write the name of any four primary metals .
ii. What is minerals?
iii. Define an ore .
iv. What is the difference between minerals and ores?
v. What is mineral ore used for?
vi. What type of mineral is silver ?
vii. What are the main ores of Fe, Cu, Ag and Al ?
viii. Give the name of at least two ores, of the following metals :
    a. copper   b. Iron
    c. Aluminium   d. Silver
ix. What is metal processing? What is the reason for processing metals?
x. Name any six methods of metal processing.
xi. Write a short note:
    a. mining,   b. grinding
    c. concentration   d. smelting
    e. roasting   f. electro-refining.

F. Diagrammatic Questions :

i. The figure below shows the extraction of iron from iron ore using a blast furnace .State the name of any three iron ores.



ii. Match the following pairs

	i. Bauxite	a.	
	ii. Haematite	b.	
	iii. Copper pyrite	c.	
	iv. Horn Silver	d.	

Chapter 18

Hydrocarbon and its compound

Total Estimated pariods (Th. 4+ Pr. 1=5)

Student's Learning Outcomes

After studying this unit, the students will be able to :

- introduce hydrocarbons with examples
- distinguish between saturated and unsaturated hydrocarbons.
- for hydrocarbons having carbon numbers one to four, specify the IUPAC name, structural formula, and use
- write the type and structural formulas of alcohols based on the number of hydroxides
- find out the use of methanol, ethanol, and glycerol

August Kekule von Stradonitz, original name Friedrich August Kekulé, (born Sept. 7, 1829, Darmstadt, Hesse—died July 13, 1896, Bonn, Ger.), German chemist who established the foundation for the structural theory in organic chemistry. Kekule is also famous for having clarified the nature of aromatic compounds, which are compounds based on the benzene molecule. He determined the valence of carbon, and was the first scientist to propose that valence could be used to analyze molecules and show how atoms link up with each other in carbon chains or skeletons.

Introduction

We find different types of compounds around us. These compounds can be classified into two groups as organic compounds and inorganic compounds. Organic compounds are obtained from plants and animals where as inorganic compounds are obtained from minerals. Organic compounds are actually the compounds of carbon and hydrogen. These compounds are called hydrocarbons.

Activities18.1

Collect some objects that are used in daily life and are easily available around us. Cut or break them all into small pieces and set them on fire to separate the organic and inorganic compounds. Organic compounds burn, and inorganic compounds do not burn.

18.1 Hydrocarbons

The compounds which are made up of carbon and hydrogen are called hydrocarbons. Methane (CH_4), Ethane (C_2H_6), propane (C_3H_8), benzene (C_6H_6) etc are example of hydrocarbons. Hydrocarbons naturally occur in the form coal natural gas and petroleum product. On the basis of number of covalent bonds between carbon atoms, hydrocarbons can be divides into two groups.

i. Saturated hydrocarbons.

ii. Unsaturated hydrocarbons.

i. Saturated Hydrocarbon (Alkanes, paraffins)

Saturated hydrocarbons are the simplest class of organic compounds which are made of carbon and hydrogen atoms only. They contain two type of bonds carbon- hydrogen (C-H) and carbon - carbon single covalent bonds (C-C). Thus, saturated hydrocarbon are those hydrocarbon in which carbon atoms are bonded together by a single covalent bond only. Methane (CH_4), ethane (C_2H_6), propane (C_3H_8), butane (C_4H_{10}), etc. are some examples of saturated hydrocarbons.

The word saturated means carbon atoms, that are bonded by the sigma (σ) bond which is very stable, strong and hard to break. The saturated hydrocarbon (alkanes) contain single bond between carbon atoms which involve the overlapping of sigma orbital's since the electrons in the σ orbital's line on the axis between the two bonded carbon atoms and are strongly attracted. So, they are less exposed towards the attack of electrophiles (electron lovers).For this reason, saturated hydrocarbon are less reactive and stable.

Saturated hydrocarbons are represented by general formula (C_nH_{2n+2}), where n is any positive integer i.e. n=1,2,3,4,....................etc. are the number of carbon atoms. The first member of the family has the molecular formula (CH_4) where n = 1 and is called methane. The second member of the family has the molecular formula (C_2H_6) where n = 2 and is called ethane. The third member with molecular formula (C_3H_8) where n= 3 is called propane, similarly the fourth member of alkane with molecular formula (C_4H_{10}) where n=4 is called butane are the fifth member with molecular formula C_5H_{12} where n= 5 is called pentane and so on the molecular structures of some of them are giver below :

Name	Molecular Formula	Structural Formula	Condensed Formula
Methane	CH_4	$\begin{array}{ccccc} & & H & & \\ & & \vert & & \\ H & - & C & - & H \\ & & \vert & & \\ & & H & & \end{array}$	CH_4
Ethane	C_2H_6	$\begin{array}{ccccccc} & & H & & H & & \\ & & \vert & & \vert & & \\ H & - & C & - & C & - & H \\ & & \vert & & \vert & & \\ & & H & & H & & \end{array}$	$CH_3\,CH_3$
Propane	C_3H_8	$\begin{array}{ccccccccc} & & H & & H & & H & & \\ & & \vert & & \vert & & \vert & & \\ H & - & C & - & C & - & C & - & H \\ & & \vert & & \vert & & \vert & & \\ & & H & & H & & H & & \end{array}$	$CH_3\,CH_2\,CH_3$
n-Butane	C_4H_{10}	$\begin{array}{ccccccccccc} & & H & & H & & H & & H & & \\ & & \vert & & \vert & & \vert & & \vert & & \\ H & - & C & - & C & - & C & - & C & - & H \\ & & \vert & & \vert & & \vert & & \vert & & \\ & & H & & H & & H & & H & & \end{array}$	$CH_3\,CH_2\,CH_2\,CH_3$

<table>
<tr><td>n-Pentane</td><td>C_5H_{12}</td><td>H   H   H   H   H
| | | | |
H — C — C — C — C — C — H
| | | | |
H   H   H   H   H</td><td>$CH_3\,CH_2\,CH_2\,CH_2\,CH_3$</td></tr>
</table>

ii. Unsaturated Hydrocarbons

The hydrocarbons in which any two carbon atoms are bonded through double or triple covalent bonds and other through single covalent bonds are called unsaturated hydrocarbons. They are less stable and more reactive. Ethylene (C_2H_4), acetylene (C_2H_2), propyne (C_3H_4) etc, are example of unsaturated hydrocarbons. Unsaturated hydrocarbons are of two types on the basis of types of bond between carbon atoms namely alkenes and alkynes.

i. Alkenes (olefins)

Alkenes is an unsaturated hydrocarbon in which carbon atoms are bonded together by double covalent bond (C= C). Alkenes have two hydrogen atoms less than alkanes and are thus designated as unsaturated hydrocarbons. They are also called olefins. The general formula of alkenes C_nH_{2n}, where 'n' stands for number of carbon atoms and begins from 2 and onwards.

The first three alkenes with there molecular formula, condensed formula and structural formula are given in the table below.

<table>
<tr><th>Name</th><th>Molecular Formula</th><th>Condensed Formula</th><th>Structural Formula</th></tr>
<tr><td>Ethene
(ethylene)</td><td>C_2H_4</td><td>$H_2C = CH_2$</td><td>H   H
| |
C = C
| |
H   H</td></tr>
<tr><td>Propene</td><td>C_3H_6</td><td>$H_3C - CH = CH_2$</td><td>   H   H   H
    | | |
H — C — C = C
    | |
    H   H</td></tr>
<tr><td>Butene</td><td>C_4H_8</td><td>$H_3C - CH_2 - CH = CH_2$</td><td>   H   H   H   H
    | | | |
H — C — C — C = C
    | | |
    H   H   H</td></tr>
</table>

ii. Alkyne

Alkyne is an unsaturated hydrocarbon in which carbon atoms are bonded together by a triple bond ($C \equiv C$). The general formula of alkynes is $C_n\,H_{2n-2}$. Alkynes do not occur freely in nature because they are more reactive. Some alkynes with their molecular formula condensed formula and structural formula are given in the table below.

Name	Atomic Formula	Condensed Formula	Structural Formula
Ethyne (acetylen)	C_2H_2	$HC \equiv CH$	$H - C \equiv C - H$

<table>
<tr><td>Propyne</td><td>C_3H_4</td><td>$H_3C - C \equiv CH$</td><td>H
|
H — C — C ≡ C — H
|
H</td></tr>
<tr><td>Butyne</td><td>C_4H_6</td><td>$H_3C - CH_2 - C \equiv CH$</td><td>H   H
| |
H — C — C — C ≡ C — H
| |
H   H</td></tr>
</table>

S.N.	Hydrocarbon	Root word	No of bonds	Suffix	General name	General formula
1	saturated	Alk	C-C	ane	Alkane	C_nH_{2n+2}
2	unsaturated	Alk	C=C	ene	Alkene	C_nH_{2n}
4	unsaturated	Alk	C≡C	yne	Alkyne	C_nH_{2n-2}

Difference between Saturated and Unsaturated Hydrocarbons

S.N.	Saturated hydrocarbons	S.N.	Unsaturated hydrocarbons
1	The carbon atoms are bonded together by single covalent bond in them.	1.	The carbon atoms are bonded together by a triple or double covalent boned in them.
2	They have only one group which is alkane.	2.	They have two groups which are alkenes and alkynes.
3	They are less active.	3.	They have more active.

Difference between Alkane and Alkene

S.N.	Alkane	S.N.	Alkene
1	In it carbon atoms are bonded with a single covalent bond.	1.	In it carbon atoms are bonded with double covalent bond.
2	It is represented by a general formula C_nH_{2n+2}	2.	It is represented by general formula C_nH_{2n}.
3	It is less reactive.	3.	It is more reactive.
Example: ethane, propane, etc.		Example: ethene, propene etc.	

Homologous series

A homologous series is a group of organic compounds having similar structure and chemical properties in which the successive compounds differ by CH_2 group. Each member of such series is called homologous series.

Characteristics of homologous series

i. All the members of a homologous series can be represented by a general formula.
ii. Each successive member of a homologous series differs by CH_2.
iii. All the member of a series have similar chemical properties.

iv. All the member of a homologous series can be prepared by same general method.

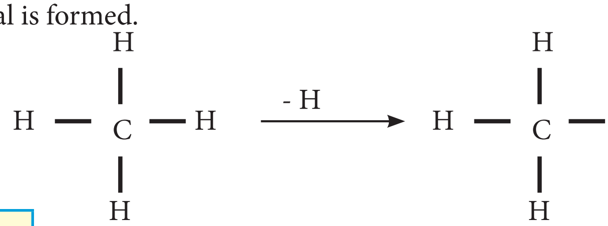
v. All members can show a gradual change in their physical properties such as specific gravity, melting point etc.

vi All the members of the same series have the same functional group like alcohol (-OH), ether (-O-), etc.

Alkyl radical

The group of atom formed by the removal of one hydrogen atom from alkane is called alkyl radical. The general formula of alkyl radical is C_nH_{2n+1}. For example, when one hydrogen atom is removed from methane, methyl radical is formed.

CH_4 (– H) = CH_3 methyl
C_2H_6 (– H) = C_2H_5 Ethyl
C_3H_8 (– H)= C_3H_7 Propyl



Methane   methly radical

Alkane $\xrightarrow{-H}$ Alkyl radical

Functional group

Atom or group of atoms radical on which chemical properties of compounds depend on is called functional group. Alkyl radical combines with function group to form organic compound.

S.N.	Name of the functional group	Symbol of the functional group	Organic compounds
1	Hydroxyl	- OH	Alcohol
2	Ether	- O -	ether
3	Amino	- NH_2	Amine
4	carboxylic acid	- COOH	Acid
5	Aldehyde (formula)	- CHO	Aldehyde
6	Keton	- CO	Ketone

For example,

CH_3^+ + OH^- $\longrightarrow$ CH_3OH
Alky group   Functional group   Organic compound (methyl alcohol)

$C_2H_5^+$ + OH^- $\longrightarrow$ C_2H_5OH
Ethyl alcohol

IUPAC Name, Structural Formula (carbon numbers one through three and n-butane only)

IUPAC Stands for International Union of Pure and Applied Chemistry. IUPAC system is the latest improved and worldwide accepted model of nomenclature of hydrocarbons. The IUPAC name of any compound consists of two part root word and suffix. While naming a hydrocarbon the root word is found on the basis of number of carbon atoms present and joined the suffix 'ane', 'ene' and 'yne' to the rootword.
For example.

$CH_3 - CH_3$
No. of carbon = 2 = eth
No. of bonds between carbon - carbon atoms = single = ane
Hence, the name of hydrocarbon eth + ane = ethane.

No. of Carbon atom	root word	Notation
C - 1	Meth	C_1
C - 2	Eth	C_2
C - 3	Prop	C_3
C - 4	But	C_4
C -5	Pent	C_5
C - 6	Hex	C_6
C - 7	Hept	C_7
C - 8	Oct	C_8
C - 9	Non	C_9
C - 10	Dec	C_{10}

e.g. $CH_3 - CH_2 - CH_3$ [Root word - prop primary suffix - ane. So, the name of compound is propane.

Some hydrocarbon and their compounds

There are many types of hydrocarbon and the compounds derived from hydrocarbons, Among them, we study the compounds like methane, ethane, propane, butane, alcohol, ether, glucose and glycerol.

Methane

Methane is a saturated hydrocarbon. It is the simplest and the first member of alkane series. It is also called marsh gas because it is formed by decomposition of organic matter. Natural gas contains about 83% methane gas. It is also found in *Gobar gas* and biogas. Its molecular formula is CH_4.

Molecular formula : CH_4.

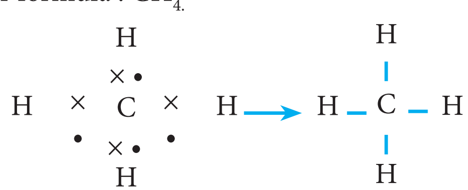


Fig. 18.1 Molecules structure of methane

Uses of methane

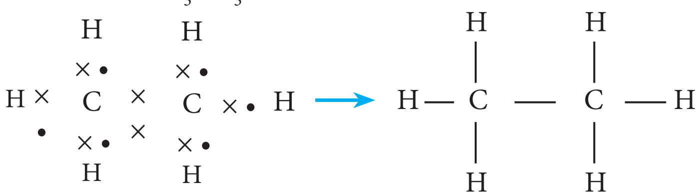
i. It produces a large amount of heat. So, it is used as a gaseous fuel in the form of LPG.
ii. It is used to manufacture methyl chloride, methyl alcohol and chloroform.
iii. Carbon black is obtained from methane which is required for rubber industries.
iv. It is used for making paints and printing inks.
v. It is also used for making hydrogen.

Ethane

Ethane is a saturated hydrocarbons. It is the second member of alkane series. It occurs in natural gas and petroleum mines. Its molecular formula is $C_2 H_{6.}$

Molecules formula : C_2H_6

condensed formula CH_3CH_3



Ethane

Fig: 18.2 Structure of ethane

Uses of ethane

i. As methane, it is also used as a gaseous fuel.

ii. It is used to make different types of compounds like ethyl chloridem ethyl alcohol, etc.

Propane

Propane is third member of saturated hydrocarbons. It is found in natural gas and petroleum mines. It is colourless and odourless gas. It is insoluble in water. It molecular formula is C3 H8.

Molecular formula C_3H_8

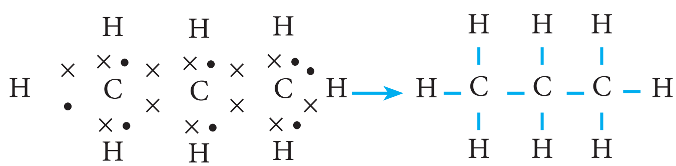


Fig: 18.3 Structural formula

Uses of propane

i. It is used as gaseous fuel.

ii. It is used in petroleum industries for cooling purpose as refrigerant.

iii. It is used to make different types of organic compounds.

Butane

Butane is the fourth member of saturated hydrocarbons. It is also found in natural gas and petroleum mines. Its molecular formula is C_4H_{10}.

Molecular formula C_4H_{10}

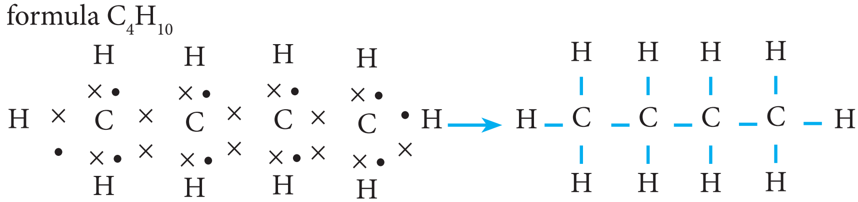


Fig: 18.4 Structural formula

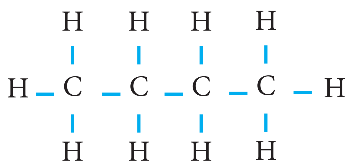
Uses of butane

i. It is used as fuel (mixture of methane and butane) in LPG.
ii. It is used as raw materials in making synthetic rubber.

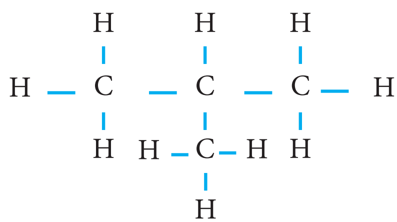
When butane is mixed with methane in high pressure, it forms a liquid fuel, which is called LPG or liquefied petroleum gas. It also used as a raw material to manufacture synthetic rubbers.

Isomers

In organic chemistry there are two or more compounds which are made up of equal number of like atoms. These compounds possess the same molecular formula but differ from each other in the structure of carbon chain and in properties are called isomers and the phenomenon is called isomerism. For example, n-butane and iso-butane have the same molecular formula (C_4H_{10}) but differ in the structure of the carbon chains in their molecules.



n-butane



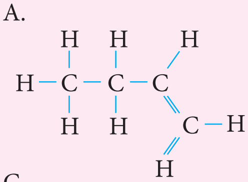
iso-butane

The n-butane has continuous chain of four carbon atoms while iso- butane has a branched chain. These two isomers have somewhat different properties eg. the boiling point of butane is - 0.5°C and that of iso-butane is -10.2°C.

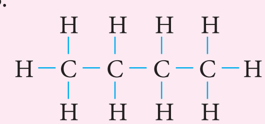
Activities18.2

i. Given below are the structures of four hydrocarbons:

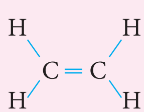
A.



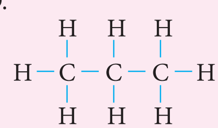
B.



C.



D.



Explain why all four compounds above are hydrocarbons.

ii. Classify the compounds A to D as either alkanes or alkenes.

Compond	Molecular formula	Alkane or alkene?

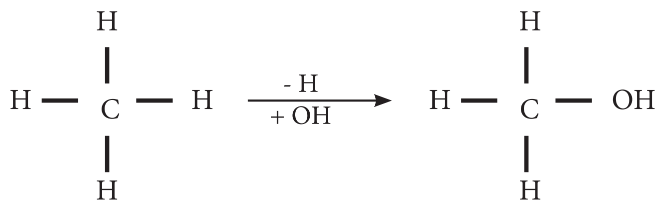
iii. The general formula for alkanes is C_nH_{2n+2}
What is the general formula for alkenes?

18.2 Alcohol

Alcohol is a organic compounds containing hydroxyl group (-OH). They are the derivatives of alkanes. They are formed by substituting of the hydrogen of alkanes by hydroxyl group. The -OH group bonded to a saturated hydro carbon is the functional group of alcohol. IUPAC name of alcohol is non as Ethanol. Its formula can be also written as CH_3-CH_2-OH or C_2H_5OH. Ethanol is a volatile, flammable, colorless liquid with a characteristic wine-like odor and pungent taste. On the basis of hydroxyl (-OH) present in the molecule alcohol is of three types. They are;

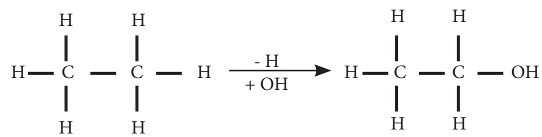
i. Monohydric alcohol

The alcohol having only one hydroxyl group (-OH) is called monohydric alcohol. In monohydric alcohol, one hydrogen is replaced by one hydroxyl group.



$$CH_4 \xrightarrow[+\,OH]{-\,H} CH_3OH$$

Methane *methly alcohol*

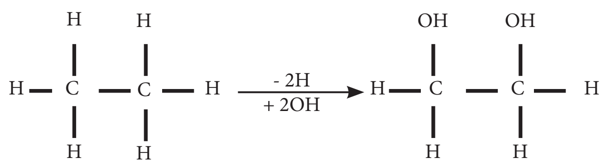


$$CH_3CH_3 \xrightarrow[+\,OH]{-\,H} CH_3\text{-}CH_2\text{-}OH$$

Ethane *Ethyl alcohol*

ii. Dihydric alcohol

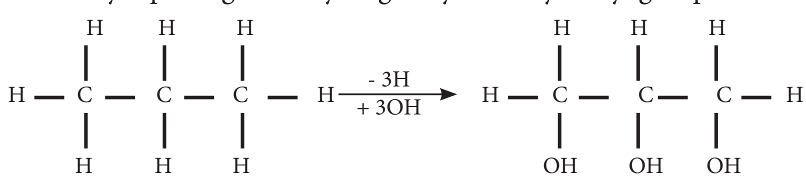
The alcohol having two hydroxyl groups (-OH) in a molecule is called dihydric alcohol. It is formed by replacing two hydrogen by two hydroxyl groups.



Ethane *Ethyl glycol*

iii. Trihydric alcohol

The alcohol having three hydroxyl groups in a molecule is called trihydric alcohol. It is formed by replacing three hydrogen by three hydroxyl groups.



Propane *Glycerol*

Some importance of alcohols

i. Methyl alcohol (CH_3OH)

It is also called methanol. It is a monohydric alcohol. It is formed, when one hydrogen of methane is replaced by one hydroxyl group.

Uses of methyl alcohol

i. It does not produce smoke on burning. So, it is used as fuel in sprit lamp.
ii. It is used as solvent for fats, oils paints etc.
iii. It is used to manufacture of dyes, paints, perfumes etc.
iv. It is used to make methyl chloride, formaldehyde etc.
v. It is used in dry cleaning.
vi It is used as anti- freeze for automobile radiation.

ii. Ethyl alcohol (C_2H_5OH)

It is also called ethanol. It is also monohydric alcohol. It is formed by replacing one hydrogen of ethane by one hydroxyl group.

Uses of ethyl alcohol

i. It is used as fuel.
ii. It is used as alcoholic beverages. It is used in thermometer as thermometric liquid.
iii. It is used as solvent of fat, oil, resin etc.
iv. It is used to make medicines.
v. It is used to preserve biological specimens.

iii. Glycerol [$C_3H_5(OH)_3$]

It is a trihydric alcohol. It is a derivative of propane. Its IUPAC name is propane 1, 2, 3 tri-ol. It is formed by replacement of three hydrogen atoms of propane by three hydroxyl group. It occurs in animal fats and vegetable oil. Water mixed glucerol is called glycerin.

Uses of glycerol

i. It is used as sweetening agent in confectionery beverages and medicines.
ii. It is used to make high quality soaps and cosmetics.
iii. It is used as a lubricant.
iv. It is used for preservation of tobacco and fruits.
v. It is used for making painting, inks and stamp pad inks.

Glycol ($C_2H_4(OH)_2$

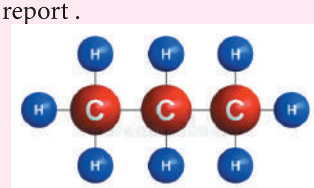
Glycol is any type of organic compound that belongs to the alcohol family, with two hydroxyl (-OH) groups attached to different carbon atoms in the molecule. Often, the word is applied to the simplest member of the class, which is ethylene glycol. Ethylene glycol, also known as 1,2-ethanediol and having the molecular formula $HOCH_2$-CH_2OH, is a colorless, oily liquid with a mild odour and sweet taste.

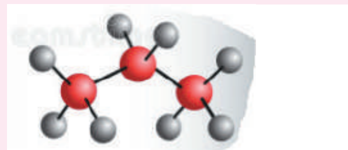
Uses of Glycol

Primarily, ethylene glycol is used in antifreeze formulations (with a percentage of 50%) and as a raw material in polyester manufacturing like polyethylene terephthalate (PET) (with a percentage of 40%).

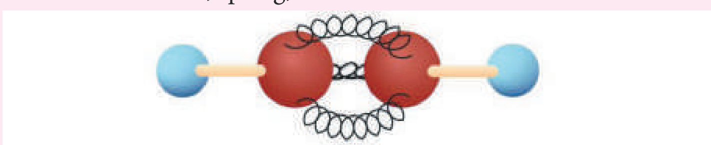
Activities18.3

i. You have given balls and stick model of three carbon atoms and eight hydrogen atoms and sufficent number of sticks . Make a model of propane (C_3H_8) as shown in picture. Write a report .

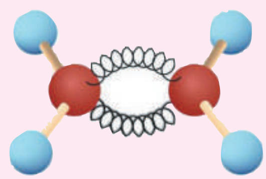


OR


ii. Prepare a model of acetylene as shown in the picture using a lump of clay or wheat flour, bamboo thin sticks, spring, and different colors.



iii. Prepare a model of ethene as shown in the picture using a lump of clay or wheat flour, bamboo thin sticks, spring, and different colors.



Project Work

Make a list of the various hydrocarbon-based products (e.g., soap, cosmetics, etc.) in your home. What are the hydrocarbons used in it? Write their introduction and usefulness and present them in the classroom.

Exercise

A. Choose the correct one and put the tick mark (√).

i. Which of the following is also known as marsh gas?
   a. propane b. butane c. Methane d. ethane

ii. What is the molecular formula of glycerol?
   a. $C_3H_5(OH)_3$ b. $C_3H_6(OH)_2$ c. $C_3H_4(OH)$ d. $C_3H_4(OH)_4$

iii. Having a low blood glucose is called ________
   a. Hyperglycemia b. Hypertension c. Hypermetropia d. Hypoglycemia

iv. What is the suffix of compound derived from formula C_nH_{2n+2}
   a. -yne b. -ene c. -ane d. -ine

v. What is the use of ethyl alcohol?

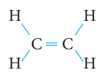
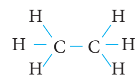
   a. Lubricant   b. ATP   c. Beverage   d. Fuel

vi. What is the functional group of alcohol?

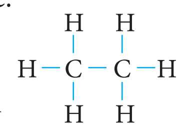
   a. CH_2 b. -CHO   c. -O -   d. - OH

vii. Structural formula of ethyne is

   a. $H-C \equiv C-H$ b. $H_3-C \equiv C-H$

   c.    d. 

viii. The image represents the structure of a carbon compound known as ethane. Which option explains the naming of ethane?



   a. the presence of functional group connected with a single bond
   b. as it contains two carbon atoms and a single bond connects the carbon atoms
   c. carbon compound with a total number of eight atoms are named as ethane
   d. as it contains six hydrogen atoms and a single bond connects the carbon and hydrogen atom

ix. Choose the coreect statement.

   a. The ethene molecule is made up of 2 carbon atoms and 4 hydrogen atoms.
   b. Each carbon atom shares three electrons with three hydrogen atoms to form three carbonhydrogen sigle covalent bonds.
   c. In ethan, the two carbon atoms share one pair of electrons among themselves tp form one carbon-carbon single covalent bond.
   d. All the above.

C. Differentiate between these pairs.

   i. Saturated hydrocarbon and unsaturated hydrocarbons
   ii. Alkane and alkenes
   iii. Alkynes and Alkane
   iv. Dihydric and trihydric alcohol

D. Explain the following:

   i. Ethane is a saturated hydrocarbons.
   ii. Glycerol is a trihydric alcohol.
   iii. Butene is an example of alkenes.
   iv. Methane gas is called marsh gas.
   v. Carbon is a basic elements or organic compound.
   vi. Alkenes are more reactive than the alkane.

E. Answer the following questions :

   i. What is hydrocarbon? Write its types with example.
   ii. What is alcohol? Mention its types and write down their molecular and structural formula.
   iii. What are the uses of ethyl alcohol?
   iv. What do you mean by homologous series? Write its characteristics.
   v. What is glucose? Write its two uses.
   vi. What does IUPAC stand for ? For what purpose was it established?
   vii. Define functional group and alkyl group.
   vii. Write the molecular and structural formulae of butane and state a common use of butane.

viii. Acetylene is an unsaturated hydrocarbon. Write down its cause on the basis of its structural formula.

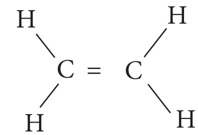
ix. Give the structural formula of ethylene. What type of bond is found between carbon and hydrogen in this compound ? Why is the bond between carbons weak?

x. What is glucose? Write its two uses.

xi. Write any two uses and harmful effects of formaldehyde.

xii. Write the properties of sucrose.

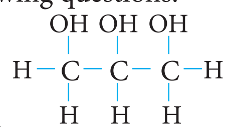
xiii. The structural formula of hydrocarbon is given.



   i. Write the name and type of the given hydrocarbon.

   ii. Write down the name structural formula and types of hydrocarbons formed in the reaction of given hydrocarbon with hydrogen gas.

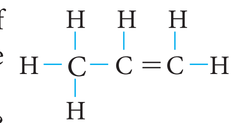
xiv. The structural formula of hydrocarbon is given. Answer the following questions.



   i. Which compound is formed if all 'OH' groups replaced by 'H' ?

   ii. Give a use of the compound formed in this way.

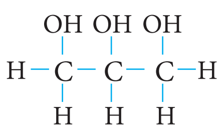
xv. A certain hydrocarbon has a structural formula as shown.

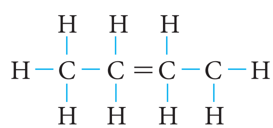


   i. Is this a saturated hydrocarbon or unsaturated hydrocarbon?

   ii. If the above mentioned hydrocarbon is made to react with plenty of hydrogen, a new hydrocarbon will be formed. Name and draw the structural formula of the hydrocarbon formed in this way.

xvi. What are the compounds of the following structural formula ? Write the type of hydrocarbon on the basis of the bond. Write any one use of each.

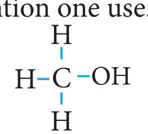
a. 

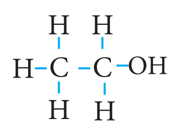
b. 

xvii. Give an example of trihydric alcohol and also mention its structural formula.

xviii. Write the structural formula and two uses of ethyl alcohol.

xix. On the basis of the given structural formula name the given organic compound and mention one use.

a. 

b. 

xx. Why are certain compounds called hydrocarbons? Write the general formula for homologous series of alkanes, alkenes and alkynes and draw the structure of the first member of each series .

xxi. You have three unlabelled test tubes containing ethanol, ethanoic acid and soap solutions. Explain the method you would use to identify the compounds in different test tubes by chemical test using litmus paper .

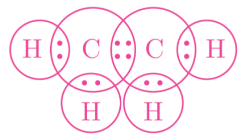
xxii. You have given balls and stick model of four carbon atoms and ten hydrogen atoms and sufficent number of sticks . In how many ways on can join the model of four carbon atoms and ten hydrogen atoms to form different molecules C_4H_{10}.

xxiii. Write the molecular formula of following compounds and draw their electron dot structures:

a. Ethane   b. Ethene   c. Ethyne

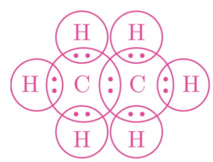
F. Diagrammatic Questions :

i. Below is the electron dot formula of the ethene molecule. Write the answer to the question mentioned below.



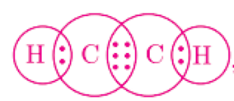
a. Write down its molecular, condensed, and structural formulas.
b. Is it a saturated or unsaturated hydrocarbon? Write for a reason.
c. Is it an alkyne or an alkyne? Write for a reason.

ii. Below is the electron dot formula of the ethane molecule. Write the answer to the question mentioned below.



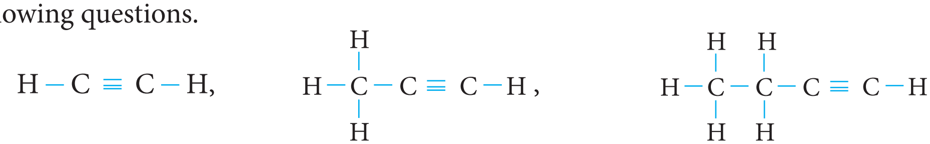
a. Write down its molecular, condensed, and structural formulas.
b. Is it a saturated or unsaturated hydrocarbon? Write for a reason.
c. Is it an alkane or an alkene? Write for a reason.

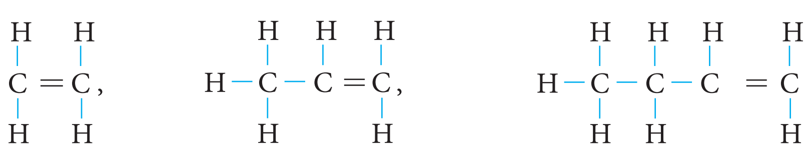
iii. Write the the name and molecular formula of the following compound. What type of compound is this?

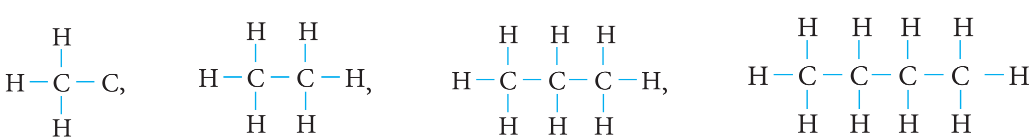


a. Alkyne or alkyne? Why?
b. Saturated or unsaturated? Why?

iv. Given below are the structural formulas of some compounds. Study it and answer the following questions.

a. 

b. 

c. 

a. Compounds of A, B, and C belong to which group? Why?
b. Explain the difference between A, B, and C in terms of carbon bonds.
c. Are these all hydrocarbons?Write for a reason.
d. Write down all of the molecular formulas.

Chapter 19

Materials Used in Daily Life

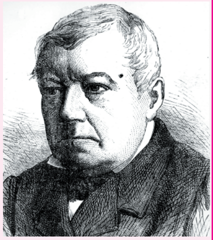
Total Estimated pariods (Th. 4+ Pr. 2=6)

Student's Learning Outcomes

After studying this unit, the students will be able to :

- introducing food preservatives and using them properly
- introduce cleaning chemicals and demonstrate proper use of them.
- be aware of precautions to be taken while storing and using toxic chemicals.
- identify and control industrial chemical pollution.

Christian Friedrich Schönbein, (born Oct. 18, 1799, Metzingen, Swabia—died Aug. 29, 1868, Sauersberg, near Baden-Baden), German chemist who discovered and named ozone (1840) and was the first to describe guncotton (nitrocellulose). His teaching posts included one at Epsom, Eng., before he joined the faculty at the University of Basel, Switz. (1828), where he was appointed professor of chemistry and physics in 1835. His discovery of guncotton began with an accident in his wife's kitchen.



19.1 Chemicals

Chemicals play an important part in our lives and we come across umpteen of them in our day-to-day activities. Our lives are completely dependent on chemicals. When we wake up, we need toothpaste and a toothbrush to clean our teeth; they are made up of certain chemicals. When we eat food, as soon as we swallow the first bite, chemical reactions start in our body immediately. It plays a vital role in our daily life, starting from the kitchen, where food preparation is a chemical reaction. Cleaning agents to clean our houses, clothes, etc., are also composed of chemicals. Even the human body is composed of various chemicals.

Fig. 19.1

Detergents are used for washing clothes since the chemicals present in them help in the removal of dirt in the form of solids or liquids. Similarly, the shampoo that we use for cleaning our scalp and hair includes a detergent ingredient that helps to reduce the tension in the water surface for saturating and rinsing our hair thoroughly. The fat is broken down by the shampoo to remove grease that is present in your hair. Besides these,our toothpaste is also made up of abrasives (calcium carbonate, aluminum hydroxide, etc.) and water, in addition to the other substances like dyes, sweeteners, microbe resisters, and sodium fluoride.

Chemicals like sodium sulfite powder are added to cleaning products so that we can protect our dishwasher or washing machine from corrosion. Sodium sulfite is an oxygen scavenger. When combined with oxygen that is present in the water, it forms sodium sulfate to bring down the content of dissolved oxygen to protect our dishwasher or washing machine against rust.

Chemicals are vital building blocks for anything present in this universe. Even the food that we consume is composed of chemical substances. Many chemical products are highly significant in the production and preservation of food. For example, we can use additives to extend the shelf life of certain foods.

Even the materials that are commonly used for food packaging include chemical substances. When it comes to crops and farm animals, other chemicals can also be utilized for fighting diseases or can be used in the form of production processes like decontamination treatment, cooking, heating, etc. You will commonly find these three kinds of chemical preservatives in your food:

- Sulphites, like sulphur dioxide,
- Nitrites, like sodium nitrite,
- Benzoates, like sodium benzoate.

These classes of chemicals are found in everyday foods that we buy. These chemicals kill the bacteria present in the menu or inhibit the growth and activities of specific varieties of bacteria. Apart from the active ingredients used in pharmaceutical preparations, chemical excipients are also extensively used in the pharmaceutical industry for several reasons. For example, some chemicals are used to produce medicine to increase the acceptability of the drug by the patient.

There are various uses for chemicals in the textile industry. Specific processes require highly specialized chemicals like water repellents, warp sizes, flame retardants, biocides, etc. Various combinations of chemicals are put to use while making cosmetics such as lipsticks, concealers, moisturizers, and others. They are added to provide a feel and texture to these beauty products. Chemicals used in the beauty industry, too, can be either natural processed chemicals or synthetic chemicals.

19.2 Food Preservatives

We use different food items on a daily basis. Some of them may rot after one or two days. What is used to prevent it ? Also, sometimes some fruits may need to ripen quickly. What is used in such a situation? Sometimes there is a tradition in your home to make food more tasty, colorful, and attractive. How is this possible? Synthetic chemicals are used to preserve food from rotting, ripening fruits, etc. Among those chemicals are preservatives, antioxidants, calcium carbide, and various colors.

Fig. 19.2

Preservatives are added to food to fight spoilage caused by bacteria, molds, fungus, and yeast.

Preservatives can keep food fresher for longer periods of time, extending its shelf life. Food preservatives also are used to slow or prevent changes in color, flavor or texture and delay rancidity. A food preservative is a substance or chemical that is added to food and beverages. It prevents decay of food happening due to microbes. Food preservatives are of two types:

i. Natural preservatives

ii. Artificial preservatives

Natural preservatives : Those preservatives which are derived from natural sources are called natural preservatives. For examples: oregano and raspberry extract, vinegar, alcohol, salt, sugar and castor oil, etc. Garlic and clove with honey, ginger cinnamon also make flavourful natural food preservatives.

Artificial preservatives: Chemical substances that delay or stop the growth of bacteria in foods, spoilage, and discoloration are called food preservatives. For example- Benzoates, sulphates, Propionates, Nitrates, and Sorbates. These artificial preservatives can either be added to the food or sprayed on it.

Other examples of food preservatives are Butylated Hydroxytoluene (BHT) and Butylated Hydroxy Anisole (BHA).

Food preservatives are also studied by dividing them into first and second classes.

Class of Food Preservatives

"Preservative" means any substance used to prevent, suppress or retard fermentation or acidification in, or any other process of decomposition of, any food. Preservatives are divided into following classes .

a. **First Class Preservatives:** The following preservatives are first-class preservatives, and these preservatives may be added in any quantity to any food.
   i. Common salt. ii. Sugar/sugar candy. iii. Dextrose. iv. Glucose. v. Wood smoke. vi. Spices. vii. Vinegar or acetic acid. viii. Honey. ix. Hops, and x. Alcohol.

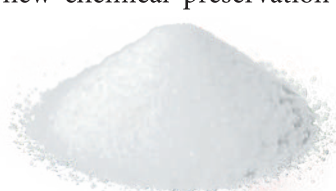
b. **Second Class Preservatives:** The following preservatives are second-class preservatives, and these preservatives may be added in any quantity to any food.
   i. Sodium or potassium nitrites. ii. Benzoic acid and salts thereof. ii. Sulphurous acid and sulphur dioxide.

Activities 19.1

Cut the seasonal ingredients, such as mango, chilly, lemon, carrot, radish, etc., into fine pieces. Dry it in the sun for some time. Divide it into two parts. Mix salt and oil in one part, put it in a glass jar, and keep it in the sun. Keep the other part in the same container. After a week, observe the pickles kept in both the jars. Write your conclusion.

Some Food Preservatives

Humans have been preserving food for generations, with the earliest known evidence of salt being used to preserve meat and shellfish. Traditionally, other techniques such as using sugar to preserve canned foods and pickling vegetables have become common preservation methods. While all of the preceding methods are still applicable today, new chemical preservation technologies are becoming more prevalent.



A. Salt : Salt, otherwise known as Sodium Chloride, is one of the most common preservatives that one can come across in the kitchen. It has been used for ages to both add flavor and to preserve foods such as meats, pickles, salmon, etc. The features that make it a prominently used preservative are its inexpensive and nontoxic nature. The chemical action by which salt preserves food is known as osmosis. Essentially, adding enough salt to the food items increases the salinity or salt concentration outside the cell wall of the pathogenic microorganisms.

B. Vitamin C (Ascorbic acid) : Ascorbic acid is an organic molecule that occurs naturally and has antioxidant effects. Plants, particularly citrus fruits, tomatoes, and green vegetables, contain ascorbic acid. Ascorbic acid and its sodium, potassium, and calcium salts are commonly used as antioxidant food additives. Because these chemicals are water-soluble, they are incapable of protecting non-polar lipids from oxidation. Ascorbic acid fat-soluble esters containing long-chain fatty acids can be employed as dietary antioxidants for this purpose. Many fruits and vegetables contain ascorbic acid.

C. Sodium Benzoate : Sodium benzoate is a food preservative that specifically added to prolong the shelf life of acidic food items such as vinegar, cold drinks, fruit juices, yogurt, etc. Sodium benzoate acts as a preservative by inhibiting the growth of several microorganisms including moths, fungi, and bacterias.

D. Nitrogen Gas : Most of us are familiar with a bag of chips filled with nitrogen gas. Nitrogen, an inert gas accounting for 79% of the atmosphere, is one of the most widely used preservatives in the food industry. The food companies use this distilled nitrogen in their packaging processes to prolong the shelf life and quality of their products. Nitrogen also provides cushioning to the chips and prevents them from undergoing any wear and tear during their transit.

E. Nitrate and Nitrites : In our previous example, we discussed that nitrogen is used to get rid of oxygen to preserve food; however, the compounds of nitrogen and oxygen known as nitrates and nitrites are widely used in the food industry as preservatives. The most commonly used nitrites and nitrates are sodium and potassium nitrite and sodium and potassium nitrate. These substances can be easily found on the ingredient label of several food items including bacon, ham, sausages, and hot dogs.

Fig. 19.3

F. Sulfites : Sulfites are compounds encompassing a variety of food preservatives that essentially contain. As a food preservative, sulfur dioxide acts as a broad-spectrum antibacterial, inhibiting bacteria, yeasts, and molds. It is prominently used in winemaking to prevent malolactic fermentation. Soft drinks, juices, jams, jellies, sausages, and dried or pickled fruits and vegetables are a few food items that contain these chemicals to prevent spoiling and discoloration. In winemaking, sulfites are a natural by-product of the fermentation process that works as a preservative against certain yeast and bacteria.

Fig. 19.4

G. Butylated Hydroxyanisole (BHA) : When it comes to the prese contain fats, one of the most common choices of preservatives is Butylated Hydroxyanisole (BHA). It has been added to foods to preserve fats and oils and keep them from becoming rancid. Moreover, it is also used to preserve and prolong the shelf life of food items that are cooked in fats because of its high thermal stability and antioxidant activity in baked food items. The common food items that contain BHA as a preservative include butter, lard, biscuits, beer, sweets, vegetable oils, snacks, glazed fruits, nuts, chewing, and meat products.

Fig. 19.5

Fig. 19.6

H. Butylated hydroxytoluene (BHT) : Butylated hydroxytoluene (BHT) is also a similar food preservative to Butylated Hydroxyanisole (BHA) that is often used to preserve food items that contain fats. Its preservative action also includes stopping the rancidity of fats in food items by free-radical scavenging. It's used to keep the odor, color, and flavor of food. BHT is found in a variety of packaging materials. It's also used to make shortening, cereals, and other fat-and-oil-based goods.

I. Calcium Disodium Ethylenediaminetetraacetate : Calcium Disodium Ethylenediaminetetraacetate is a salt of ethylenediaminetetraacetic acid that is primarily used for flavoring purposes and food preservation in canned food items. It is an antioxidant that works as a chelating agent in food preservation. It combines with free metal ions (such as Zinc, Iron, Copper, Magnesium, Manganese) which are often present in food & beverage, and prevents them from participating in chemical reactions that might cause discoloration and flavor or odor loss.

J. Polyphosphates : Polyphosphates are a class of polymeric compounds in which the structural unit phosphate is linked together by sharing oxygen atoms. The most commonly used polyphosphates in the food industry for preservation are Sodium polyphosphate , potassium polyphosphate , sodium calcium polyphosphate, and calcium polyphosphate. They're utilized to increase binding characteristics, limit moisture loss during heating and thawing, and keep items from drying out. This happens, for example, when meat sandwich fillings are cooked at a high temperature or when frozen chicken is reheated and loses a lot of fluid.

Importance of Food Preservatives

As we all know, food processing, preservation, transportation, and other processes are vulnerable to external pollution of microorganisms and spoilage corruption. Without food preservation, we are unable to preserve food for long periods of time, resulting in a significant increase in the likelihood of famine in food shortages, so food preservation is very important and necessary. The traditional methods of food preservation are usually dry, pickled, smoked, cellar storage, wine stains, and so on. With the continuous development of science and technology, chemically synthesized preservatives have become one of the most important additives in the food industry.

Therefore, in recent years, more and more food industries have abused chemical synthetic preservatives to extend the shelf life of food, but the study found that these chemical synthetic preservatives not only affect the original flavor of food but also the potential for human-induced cancer , teratogenic or cause food poisoning and other security risks. So people are concerned more and more with food safety .

In addition, the per capita consumption of dairy products is rapidly growing. In particular, the consumption of liquid milk has obviously risen. The frequent dairy safety incidents have given people more and more attention to this issue. On the other hand, commonly used antibiotics also have some side effects on the human body. Microbial inhibitory substances gradually enter people's attention.

There are some basic implications of food preservatives:

- The variety of food can be enjoyed in any different area and any season.
- The supply of food can be increased.

- The wastage of food will be reduced.
- There is no change in taste, color, and nutritive values of food with the right method of food preservation.
- People can taste food from any location.
- Can store the food more easily.
- Increasing the food products' shelf life.

Effects of Food Preservatives

Using a lot of preservatives has a negative impact on health. Listed below are some of the health problems that you may suffer from if you eat foods loaded with preservatives.

Heart Diseases : Cardiovascular diseases have become quite common and the presence of **preservatives** on food items is one of the main causes of increasing heart problems. Food preservatives can weaken the heart tissues. When you consume food items that have a residue of the preservative on the surface, it can increase the chances of heart damage.
Breathing Problems: Preservatives and chemicals present in food items also increase the chances of breathing problems. According to research, foods with preservatives from the diet can help reduce the symptoms as well as the severity of breathing problems and asthma. Some of the preservatives present in food items such as aspartame, sulfites, and benzoates aggravate breathing problems.
Cancer: One of the most harmful effects of preservatives on food items is their ability to transform into carcinogenic agents. Some of the food items consist of nitrosamines, a preservative that has nitrites and nitrates, which mix with the gastric acids and form cancer-causing agents. To ensure that you avoid eating this preservative, you need to avoid snacks or meals that are loaded with nitrites and nitrates.

Some other common problems are allergies, lung disease, egzema, hyperthyroidism,anemia, distraction, kidney disease, etc.

As a result, using natural food preservatives rather than chemical preservatives is becoming increasingly important in the future, and natural food preservatives will play an important role in the market.

Activities 19.2

Prepare a list of preservatives used in your home. What is the uses, importance and effects of those preservatives?

19.3 Introduction to cleaning chemicals/agents

What items are used for cleaning in your house? What are the traditional items used for cleaning? What is the items used for cleaning recently? Which of the traditional and modern cleaning products are less harmful? In this lesson, we will try to answer these questions. In some rural area and remot villages, sand, ash, and lime have been used for cleaning since time immemorial. Ashes are still used in villages to brush their utensils . In some places, there is a custom of using mud to wash hands. Similarly, lemon is used to remove stains.

However, in recent times, compared to these traditional cleaning products, various harmful chemicals such as soaps and detergents are being used. It has a bad effect on the human body and spreads chemical pollution. Detergents that use harsh chemicals are harmful to human health.

Cleaning chemicals help clean, degrease, sanitize, and disinfect surfaces. Degreasers remove water-insoluble substances from floors, machinery, parts, and tools. Surface disinfectants and sanitizers reduce the amount of germs and keep them from spreading on clean surfaces. Dilution control systems dilute and mix concentrated chemicals. Calcium, rust, and lime removers remove stains and mineral deposits. Specialized cleaning chemicals are available for removing or treating mold, mildew, adhesives, graffiti, furniture, carpets, hard floors, metal and stone, and pools and spas.

There are four main types of cleaning chemicals used in commercial kitchens:

- Detergents
- Degreasers
- Abrasives
- Acids

For effective cleaning, be sure to use the correct cleaning chemicals for the type of item to be cleaned, the cleaning method you'll be using and the type of soiling on the item. Learn about the four most common types of cleaning chemicals and when to use them.

i. Detergents

Detergents are the most common type of cleaning chemicals . They work by breaking up dirt or soil, making it easy to wash it away. The detergents used in commercial kitchens are usually synthetic detergents made from petroleum products and may be in the form of powder, liquid, gel or crystals.

Detergents are substances that contain soaps and/or surfactants (any organic substance/ mixture). Use them for washing or cleaning jobs for the household, institutional or industrial purposes, including:

- Dishwashing
- Handwashing
- Laundry washing
- Fabric softeners
- All-purpose cleaners
- Bleaching

There are many cleaning products that contain detergents and they come in various forms. Including powders, tablets, concentrated liquids, liquid capsules, pastes or cakes.

ii. Degreasers

Degreasers are sometimes known as solvent cleaners and are used to remove grease, grim, dirt and oil from hard surfaces such as oven tops, counters and grill backsplashes. Commercial kitchens generally use them. Methylated spirits or white spirit were commonly used as degreasers in the past. Most food businesses now try to use non-toxic, non-fuming degreasers in their operations to prevent chemical contamination.

Grease, oils and fats are organic dirt. Alkaline solutions and solvents break this down. Heavy-duty degreasers such as oven cleaners have a high pH (more alkaline). All-purpose cleaners for light dirt and dust have neutral pH.

Common Ingredients in Degreasers

- Sodium Carbonate (soap ash)
- Sodium Meta Silicate
- Ethylenediaminetetraacetate (EDTA)
- Sodium Tripolyphosphate

- Kerosene
- Xylene
- Methylated spirits / white spirit

As degreasers are high-alkaline cleaning agents they can be corrosive. High-alkaline cleaners and degreasers can cause chemical burns to the skin. Use degreasers in well-ventilated areas along with skin and eye protection. Some degreasing products contain ammonia or lye. Never mix this with bleach. Because it results in a chemical reaction, which will produce poisonous chlorine gas.

iii. Abrasives

Abrasives are substances or chemicals that depend on rubbing or scrubbing action to clean dirt from hard surfaces. In commercial kitchens, abrasives are usually used to clean floors, pots and pans. Abrasives should be used with care as they may scratch certain types of materials used for kitchen equipment such as plastic or stainless steel.

Abrasives are either powders or liquids you can use to wear off dirt from hard surfaces. Think of things such as sinks, floors, kitchen, and bathroom surfaces.The main ingredients in abrasives are usually small particles or minerals. The effectiveness of an abrasive agent depends on the coarseness of those particles. Their abrasiveness depends on the coarseness of the particles in the product.

For example, you can find fine grade of chalk (gilder's whiting)in silver polish. So that it doesn't scratch the silverware. Below are some of the other substances you can find in abrasive cleaners.

- Aluminum oxide
- Calcite
- Quartz
- Whiting (powdered chalk)
- Calcium carbonate
- Feldspar
- Silica

Housekeepers should always read the labels on abrasive cleaning agents. To make sure they use the appropriate product for the cleaning task at hand. Coarse abrasives can damage surfaces such as plastic, fiberglass, glass, non-stick cookware. As well as painted woodwork, plated metal, and highly polished metal. Housekeepers should also exercise caution when repeatedly using abrasive cleaners on hard surfaces such as sinks, bathtubs, and kitchen appliances. Because the abrasive agent gradually scratches the finish of these items.

The scratches become deeper over time and dirt becomes more deeply embedded. Requiring even stronger abrasives to clean out embedded dirtier and stains over time.

iv. Acids

Acid cleaners are the most powerful type of cleaning agent and should be used with care. If they are not diluted correctly, acid cleaners can be very poisonous and corrosive. Acid cleaners are generally used to remove mineral deposits and are useful for descaling dishwashers or removing rust from restroom facilities.

Cleaning agents with acidic properties react with water-soluble chemical deposits to produce water-soluble salts. Acids dissolve metals and are hence used to remove metal stains such as water stains in baths, hard water deposits around taps, tarnish on silver, copper, and brass, etc.

Weak acids include citric acid (lemon juice), acetic acid (vinegar). They are used for removing tarnish from copper and brass and mild water stains in baths.Strong acids are oxalic acid, phosphoric acid, hydrochloric acid, and sulphuric acid.

Soap

Soap is a cleaning agent. It is used for cleaning purpose. Soap is the sodium salt of long-chain fatty acids. Soap is prepared by boiling animals fats or vegetable oils with sodium hydroxide. Sodium hydroxide reacts with animal fats or vegetable oils to form soap and glycerol.

$$\underset{\text{oil/fat}}{C_3H_5(OOCR)_3} + 3NaOH \longrightarrow \underset{\text{soap}}{3NaOOCR} + \underset{\text{glycerol}}{C_3H_5(OH)_3}$$

Where, R is alkyl radical ($R= C_{17}H_{35}$).

Sodium stearate ($C_{17}H_{35}COONa$), sodium oleate ($C_{17}H_{33}COONa$) and sodium palmitate ($C_{15}H_{31}COONa$) are the examples of soap.

The process of making soap by hydrolysis of fats or oils with alkalis is called saponification. While making soap, various perfumes, colors, disinfectants, antiseptics and bleaching materials are also mixed in soaps.

Detergent

It is also a cleansing agent like soap. It is also called as sapless soap. Detergents are sodium salts of long chain benzene sulphonic acid. Detergents is mostly non- biodegradable and has more cleansing property.

Hydrocarbons are used to make detergents instead of animals fats or vegetable oil. So, it is cheaper than soap. Sodium lauryl sulphate, alkyl benzene sulphonate and sodium pyrophosphate are some common example of detergent. Detergents in the form of powder are called detergent powder.

Significance of cleaning chemicals

Cleaning chemicals play an essential role in our daily lives at home, in school and in the office. By safely and effectively removing soils, germs and other contaminants, they prevent the spread of infectious diseases and control allergens, such as dust and mold, helping us to stay healthy. Cleaning products also enable us to care for our homes and possessions.

Chemicals used for cleaning and in cleaning products, such as laundry detergents, bleaches, dishwashing products and other household cleaners, help improve cleaning efficiency, making homes, offices and other environments both easier to clean and more hygienic.

Chemicals in cleaning products like laundry detergent can help these products to perform just as well in cold water as in hot water, enabling consumers to save money and energy when washing their clothes. In addition, highly concentrated liquid laundry formulations made possible by chemistry require less packaging materials and generate less waste. Household cleaning products containing antibacterial cleaners not only remove dirt and soil, but they also can kill the germs that may cause illness.

Effects of cleaning chemicals

Many cleaning chemicals or household products can irritate the eyes or throat, or cause headaches and other health problems. Some product release dangerous chemicals, including volatile organic compounds (VOCs). VOCs are chemicals that vaporize at room temperature. Even natural fragrances such as citrus can react to produce dangerous pollutants indoors.

VOCs and other chemicals released when using cleaning supplies contribute to chronic respiratory problems, allergic reactions and headaches. Studies are underway to assess how these chemicals affect people who have asthma and other respiratory illnesses. Studies also link exposure to chemicals from cleaning supplies to occupational asthma and other respiratory illnesses.

Cleaning supplies and household products containing VOCs and other toxic substances can include, but are not limited to:

- Aerosol spray products, including health, beauty and cleaning products;
- Air fresheners;
- Chlorine bleach;
- Detergent and dishwashing liquid;
- Dry cleaning chemicals;
- Rug and upholstery cleaners;
- Furniture and floor polish; and
- Oven cleaners.

Never mix bleach or any bleach-containing product with any cleaner containing ammonia. The gases created from this combination can lead to chronic breathing problems and even death.

19.4 Toxic chemicals

The old saying, 'what you don't know can't hurt you,' isn't always good advice. When it comes to toxic substances, what you know can help you . Radon in basements, lead in drinking water, exhaust from vehicles, and chemicals released from landfills are just a few examples of toxic substances that can hurt you. By understanding how, you can reduce your exposure to chemicals and reduce your risk of harmful health effects.

Toxic chemicals are defined as any chemical that can cause death, temporary incapacity, or permanent harm to humans or animals through its chemical action on life processes. This includes all such chemicals, regardless of their origin or of their method of production, and regardless of whether they are produced in facilities, in munitions, or elsewhere.

In this way, a toxic chemical is a substance that can be poisonous or cause health effects. People are generally concerned about chemicals like polychlorinated biphenyls (PCBs) and dioxin, which can be found at some hazardous waste sites. Chemicals that we use daily, such as household cleaners, prescription and over-the-counter drugs, gasoline, alcohol, pesticides, fuel oil, and cosmetics, can also be toxic. Any chemical can be toxic or harmful under certain conditions. Chemicals can be toxic because they can harm us when they enter or contact our bodies.

Pesticides

Pesticides are chemical substances that are meant to kill pests. In general, a pesticide is a chemical or a biological agent such as a virus, bacterium, antimicrobial, or disinfectant that deters, incapacitates, kills, pests. This use of pesticides is so common that the term pesticide is often treated as synonymous with plant protection product. It is commonly used to eliminate or control a variety of agricultural pests that can damage crops and livestock and reduce farm productivity. The most commonly applied pesticides are insecticides to kill insects, herbicides to kill weeds, rodenticides to kill rodents, and fungicides to control fungi, mould, and mildew.

These are grouped according to the types of pests which they kill:

- Insecticides – insects
- Rodenticides – rodents (rats & mice)
- Fungicides – fungi
- Herbicides – plants
- Bactericides – bacteria
- Larvicides – larvae

Based on how biodegradable they are:

- **Biodegradable:** The biodegradable kind is those which can be broken down by microbes and other living beings into harmless compounds.
- **Persistent:** While the persistent ones are those which may take months or years to break down.

Another way to classify these is to consider those that are chemical forms or are derived from a common source or production method.

Chemically-related pesticides:

- **Organophosphate:** Most organophosphates are insecticides, they affect the nervous system by disrupting the enzyme that regulates a neurotransmitter.
- **Carbamate:** Similar to the organophosphorus pesticides, the carbamate pesticides also affect the nervous system by disrupting an enzyme that regulates the neurotransmitter. However, the enzyme effects are usually reversible.
- **Organochlorine insecticides:** They were commonly used earlier, but now many countries have been removed Organochlorine insecticides from their market due to their health and environmental effects and their persistence (e.g., DDT, chlordane, and toxaphene).
- **Pyrethroid:** These are a synthetic version of pyrethrin, a naturally occurring pesticide, found in chrysanthemums(Flower). They were developed in such a way as to maximise their stability in the environment.
- **Sulfonylurea herbicides:** The sulfonylureas herbicides have been commercialized for weed control such as pyrithiobac-sodium, cyclosulfamuron, bispyribac-sodium, terbacil, sulfometuron-methyl Sulfosulfuron, rimsulfuron, pyrazosulfuron-ethyl, imazosulfuron, nicosulfuron, oxasulfuron, nicosulfuron, flazasulfuron, primisulfuron-methyl, halosulfuron-methyl, flupyrsulfuron-methyl-sodium, ethoxysulfuron, chlorimuron-ethyl, bensulfuron-methyl, azimsulfuron, and amidosulfuron.
- **Biopesticides:** The biopesticides are certain types of pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals.

Precautions for storage and use of Pesticides

- Store pesticides in a clean, cool, dry, and well-ventilated building. Always lock the area to prevent entry by children and untrained persons. Mark the storage facility with an appropriate warning sign.
- Maintain proper temperature control. For example, if emulsion-type materials freeze, the emulsion may be destroyed, resulting in loss of effectiveness and possible serious plant injury.
- To avoid the danger of cross-contamination, do not store herbicides with other pesticides.
- Keep dry materials above liquid materials.
- Do not store pesticides where food, water, feed, seeds, fertilizers, or personal protective clothing and equipment (such as respirators) can become contaminated.
- Store pesticides in their original containers. Never store pesticides in any food or drink containers.
- Do not remove the labels.
- Keep lids tightly closed.
- Check containers frequently for leaks.
- Clean up spilled chemicals promptly and properly. Dispose of broken or damaged containers and any pesticide waste in an approved and safe manner as directed on the product label.

Activities 19.3

What pesticides are being used to kill or control harmful insects in your fields or gardens? After observation and inquiry, make a list of its positive and negative aspects and present it in the classroom.

Insecticides

Insecticides are chemicals used to control insects by killing them or preventing them from engaging in undesirable or destructive behaviors. Such substances are used primarily to control pests that infest cultivated plants or to eliminate disease-carrying insects in specific areas.

They are classified based on their structure and mode of action.Many insecticides act upon the insect's nervous system (e.g., cholinesterase inhibition), while others act as growth regulators or endotoxins. Most insecticides are sprayed or dusted onto plants and other surfaces traversed or fed upon by insects.

Insecticides work in different ways. Some insecticides disrupt the nervous system, whereas others may damage their exoskeletons, repel them or control them by some other means. They can also be packaged in various forms including sprays, dusts, gels, and baits. Because of these factors, each insecticide can pose a different level of risk to non-target insects, people, pets and the environment.

Precautions for storage and use of Insecticides

- To reduce storage problems, buy only enough insecticides for one season's use.
- Keep insecticides in their original containers with the labels intact.
- Store in a separate, locked cabinet or other secure structure, away from children and pets.
- Do not store insecticides in cabinets near food, medical supplies or cleaning products.
- Do not store insecticides near water supplies.

- Flammable insecticides should be stored away from sources of heat, flame, or spark.
- Store insecticides in a dry area to prevent the deterioration of containers.
- Inspect insecticides containers frequently for damage.
- Using more than one insecticide product in the same location can increase or decrease each one's effectiveness. It may also result in a greater risk to health and/or the environment.
- Insecticidal baits can be used instead of spraying large areas, especially for social insects like ants. This can decrease the risk of exposure, but remember to place baits where children and pets won't have access.

Rodenticides

Rodenticide, any substance that is used to kill rats, mice, and other rodent pests. Warfarin, sodium fluoroacetate), alpha-naphthylthiourea, and red squill are commonly used rodenticides. These substances kill by preventing normal blood clotting and causing internal hemorrhaging. Fumigants such as sulfur dioxide, carbon monoxide, hydrogen cyanide, and methyl bromide are also effective rodenticides. Phosphorus paste, barium carbonate salt, and powders such as zinc phosphide, white arsenic, thallium sulfate, strychnine, strychnine sulfate, and calcium cyanide are mixed with bait and placed where rodents will find and eat them. All these poisons are toxic to other animals, and most cause death by disturbance of nervous-system functions. Red squill, a rodenticide derived from the bulbs of a lilylike subtropical plant, is slower-acting and less toxic to animals other than rodents because it is removed from the stomach by vomiting—a reflex that is absent in rodents.

Precautions for storage and use of Rodenticides

- Store rodenticides in their original container: do not transfer to smaller food storage containers or something similar.
- If you have any of the older forms of rat poison around the house, you may want to throw them out and buy safer bait.
- Rodenticide should always be stored in cool, dry places that cannot be reached by children or pets. Avoid using rat poison in your kitchen.

Acids

Acid is used for domestic and industrial purposes. As acids are more harmful, accidents are more likely. Special care should be taken when using strong acids. Acids can be divided into mineral acids (acids used in the laboratory) and organic acids. Mineral acids include hydrochloric acid, hydrofluoric acid, sulfuric acid, phosphoric acid, nitric acid, etc. Similarly, organic acids include citric acid, carbonic acid, lactic acid, ethanoic acid, etc.

Hydrochloric acid is a strong, highly corrosive acid. It has many industrial and laboratory uses, such as producing polyvinyl chloride (PVC), leather processing, steel production, and the purification of table salt. Hydrochloric acid is also a component of gastric acid in the stomach, where it is used in digestion. Hydrofluoric acid is a weak acid, albeit highly corrosive. Hydrofluoric acid dissolves glass and metals, so it has to be stored in plastic containers. Hydrofluoric acid is used for etching glass, industrial cleaning of metals and the manufacture of electronics. It is also used to synthesise fluorinated compounds such as Teflon and Prozac.

Phosphoric acid is a weak tribasic acid. This means that phosphoric acid can donate up to three protons per molecule. The majority of phosphoric acid produced is used in the manufacture of fertilisers. Other uses include the production of activated carbon (which is used to clean sewage), as an acidifying agent in food, and in anti-rust treatment.

Nitric acid is a strong acid, commonly used as an oxidant in the laboratory. It is also used in organic chemistry to introduce nitro ($-NO_2$) functional groups into compounds. Nitro groups are important in the creation of many dyes, explosives and pharmaceuticals.

Sulfuric acid is a strong dibasic acid. It is widely used in the chemical industry as a catalyst for reactions, such as esterification and nitration. As well as a catalyst, sulfuric acid is a reagent in many reactions, including the sulfonation of benzene . Sulfuric acid is used in car batteries. When sulfuric acid donates a proton, the resultant anion, hydrogensulfate, is stabilised by resonance, meaning that the negative charge is shared between more than one oxygen atom.

Precautions for storage and use of acid

- If you are storing strong acids such as hydrochloric acid and sulfuric acid, it is better to use a cabinet that is constructed from a corrosive resistant material such as polyethylene. If you are storing weaker acids, they can be safely stored in a metal cabinet that has a corrosive resistant lining.
- Label all containers fully.
- Provide a specific storage space for each acid, and ensure return after each use.
- Use appropriate resistant secondary containers for corrosive materials. This protects the cabinets and will catch any leaks or spills due to breakage.
- Seal containers tightly.

Chlorines

Chlorine is an element used in industry and found in some household products. It is sometimes in the form of a poisonous gas. Chlorine gas can be pressurized and cooled to change it into a liquid so that it can be shipped and stored. When liquid chlorine is released, it quickly turns into a gas that stays close to the ground and spreads rapidly. Chlorine gas can be recognized by its pungent, irritating odor, which is like the odor of bleach. The strong smell may provide adequate warning to people that they are exposed. Its most important use is as a bleach in the manufacture of paper and cloth, but it is also used to make pesticides (insect killers), rubber, and solvents. Chlorine is used in drinking water and swimming pool water to kill harmful bacteria. It is also as used as part of the sanitation process for industrial waste and sewage. Household chlorine bleach can release chlorine gas if it is mixed with certain other cleaning agents. When chlorine gas comes into contact with moist tissues such as the eyes, throat, and lungs, an acid is produced that can damage these tissues.

Precautions for storage and use of Chlorine

- A room used to store chlorine must have easy access, be kept locked, and be equipped with adequate shelving (spill barriers and seismic considerations), spill controls and containment.
- Chlorine must be separated from incompatible materials by at least 20 feet or stored in separate secondary containment and kept dry.
- Chlorine gas storage requires special considerations, including sealed storage, ventilation.
- Excessive quantities of chlorine are often stored on a site. Check with local fire departments and keep quantities within their limits.

- Emergency response plans and training of operators for emergencies (includes the use of ammonia spray to test for leaks in cylinders) are often lacking. Planning and training are necessary and required.
- Employees may mix up the organic form of chlorine in erosion feeders with the inorganic form of chlorine causing an explosion or fire. Training could prevent such occurrences.

19.5 Chemical Pollution

Chemical pollution is defined as the presence or increase in our environment of chemical pollutants that are not naturally present there or are found in amounts higher than their natural background values. Most of the chemicals that pollute the environment are man-made, resulted from the various activities in which toxic chemicals are used for various purposes.

Chemical pollutants mostly result from various human activities like the manufacturing, handling, storing, and disposing of chemicals. These occur in industrial places and activities such as oil refineries, coal power plants, construction, mining & smelting, transportation, agricultural use of pesticides and insecticides, as well as household activities.

The chemical industry is another example in this sense, mainly because it is usually linked to polluted waste streams. In fact, the waste streams from chemical industry are now strictly controlled and treated before being released into the environment. But this was not always the case in the past and many rivers and surface water bodies were contaminated by the numerous waste streams coming from various chemical plants, as well as other industrial sources. Even though measures were taken to reduce this type of pollution, its effects are still visible. Household chemicals involve a variety of chemical products and mixtures that can easily become chemical pollutants when released into the environment. Even the everyday detergents are chemical compounds that may pollute our environment.

Management of Chemical Pollution

We have little control over pollution outside. Yet when it comes to our homes, we should be able to live in a healthier environment. Unfortunately, our lifestyle choices can cause a great deal of pollution in the indoor environment as well. Toxins in your home exposes your family to relatively minor health irritants causing adverse health effects from eye irritation, nasal congestion, headaches, and dizziness, to major health risks such as cancer and damage to the liver or central nervous system. The young and the elderly are at a higher risk of developing these health conditions.

Chemicals and dust pollution exists everywhere in our homes, from the couch, in mattresses where you sleep, teflon kitchen pans you cook with, hand washing soaps and liquids, and detergents, to the vinyl shower curtains, carpets, canned foods, and perfumes. Although it is difficult to eliminate the presence of chemicals in our home, we can do many simple things to live in a safer, healthier home.

Ways to manage chemical pollution in our home

i. Reduce levels of Volatile Organic Compounds (VOCs)

VOC's are harmful chemicals found in several home products like new carpets, paint, plywood and pressed wood products, air fresheners, deodorants, and tobacco. You can minimize exposure to VOC's by

- Stop smoking inside the home.
- Avoid buying high VOC products like pressed wood. Instead, buy solid wood or old furniture.
- Improve the ventilation in your home. When possible keep the doors and windows open. Place an air-purifier in the house.
- Controlling the humidity can lower the presence of some VOC's. Use a dehumidifier to keep the humidity levels in check.

ii. Filter drinking water

Even if you stay in an area where the water quality is good, there can be small traces of contaminants such as lead, chlorine, E. coli, pesticides in the water. Filtering the water can remove these pollutants.

iii. Use chemical free cleaning products

Most standard home cleaning products have harsh chemicals that are bad not only for the health of your family, but also pollute the rivers and lakes when washed down the drain. As an alternative to this chemical products, try the following –

- Use natural home cleaning solutions such as baking soda, lemon, and vinegar.
- Use microfibre cloths to dust your home without the use of chemical sprays
- Switch to chemical free laundry powder.
- Use non toxic, environmentally friendly home cleaning products

iv. Reduce toxins in garden

- Use pesticides and fertilizers that contain fewer chemicals.
- Use only as much fertilizer as needed.
- Purchase a soil-test kit from your local garden store to determine when the fertilizer needs to be added.

Pollution caused by cement and its management

Cement is the primary material for building and civil engineering construction. Cement is employed in housing, dams, bridges, industrial construction, roads, etc. Therefore, cement is a basic material that is employed in all kinds of construction altogether.

But, it is also a cause of pollution. The main environmental issues associated with cement production are the consumption of raw materials and energy use, as well as emissions into the air.

There are some major environmental impacts that we can identify, such as solid waste, wastewater, flue gas, and noise. The cement industry requires a large amount of energy to use in the whole process, and to generate this, non-renewable resources are required. Even though some renewable resources are used in some industries still a large amount of fossil fuel used for this process. So, due to this matter, major impacts on the environment are carbon dioxide (CO_2) , carbon monoxide(CO), Nitrous oxide (NO_2), Sulfure dioxide (SO_2), and VOCs.

The emission of those gases into the atmosphere is not only causing environmental problems but also affecting public health. Climate change, global warming, ozone depletion, acid rain, biodiversity loss, reduced crop productivity, etc. Water is used at some stages in cement production process. Waste water discharge to the environment causes to contaminate water sources (rivers, ground water sources).

Noise pollution occurs during the whole process of the cement production process. From preparing raw materials, from the clinker burning and production process, from material storage, the heavy machines large fans used in the process. The main problem from dust emission is reduced visibility and air quality and it contains toxic metal and compounds. When dust is washed it may pollute water and also cause harmful health effect to humans.

In the cement industry, waste can be dividing as hazardous waste and non-hazardous waste.

Some other methods to manage pollution caused by cemet are:

i. Use less cement—for example, by reducing the overspecification of cement in concrete mixes and encouraging the use of supplementary cementitious materials like ground glass pozzolans to partially replace cement in concrete mixes.

ii. Make cement kilns more efficient so they require less fuel. Substituting clinkers with fly ash, which is readily available and reduces emissions and fuel consumed for producing clinkers.

iii. Ultimately transition to truly cleaner fuels—for example, electrification from renewable sources if and where possible, as well as green hydrogen.

iv. Using electrostatic precipitators and other measures to control industrial pollution and air quality.

v. Using alternative fuel resources.

vi. Large amounts of carbon dioxide and nitrous oxides are produced in manufacture of cement. 30 per cent of limestone used in cement production becomes carbon dioxide. Emissions can be reduced by lowering temperatures at which different cement varieties are manufactured, but this requires altering the composition of cement.

Pollution caused by glass and its management

Glass consists mainly of silica, which is a natural raw substance like sand. A massive amount of energy is needed to heat the raw materials to make glass. During the melting of the raw materials for glass, gas pollutants can be released such as sulphur dioxide and carbon dioxide. And since glass requires materials to be mined for its production – silica sand, soda ash and dolomite – this has all the associated environmental impacts with mining such as land degradation and dust and runoff from the mines reaching water sources. Silica sand mining can cause silicosis, a condition caused by tiny silica particles reaching the lungs, so there is also a considerable impact to human health. Around 20 per cent of the raw materials used to make glass are lost as CO_2 and other gases.

Some methods to manage pollution caused by glass are:

i. One advantage of glass is that it is more durable than plastic. A typical glass bottle can typically be reused between 12 and 20 times before it is too damaged to be used, meaning it can be reused more often. Very often, however, they are thrown away after a single use. And hence, reuse glass bottles and cans. Just recycling isn't enough. We need to change our mindset and move to things like refilling bottles, bottle return schemes, and the like if we are going to cut these environmental impacts.

ii. Different heavy metal compounds are mixed in the glass to impart colors and specific applications. Iron, in its trivalent form, in combination with barium oxide, gives a reddish brown color to the glass matrix; in its divalent form, with chromium, it produces a deep green color; and with sulfur, it gives a dark amber color. Manganese imparts a purple and a weak yellow or brown color in its trivalent and divalent stages, respectively, and provides stability and strength to the glass object. This coloring process impacts the environment, we must use simple glass .

iii. Various colorless glasses, such as soda lime, borosilicate, vitreous silica, etc., are broadly nonhazardous, with respect to metal . So , we can use these glasses .
iv. Pollution resulting from hazardous glass (HG) is widespread across the globe, both in terms of quantity and associated health risks. In waste cathode ray tube (CRT) and fluorescent lamp glass, mercury and lead are present as the major pollutants. So, we must use less of this.

Pollution caused by ceramics and their management

A ceramic is any of the various hard, brittle, heat-resistant and corrosion-resistant materials made by shaping and then firing an inorganic, nonmetallic material, such as clay, at a high temperature. Common examples are earthenware, porcelain, and brick. The earliest ceramics made by humans were pottery objects (pots or vessels) or figurines made from clay, either by itself or mixed with other materials like silica, hardened and sintered in fire. Later, ceramics were glazed and fired to create smooth, colored surfaces, decreasing porosity through the use of glassy, amorphous ceramic coatings on top of the crystalline ceramic substrates.

The major environmental impact of the ceramic tiles is air pollution, which leads to several impacts on earth like, ozone layer depletion, global warming, acidification as well as eutrophication.Ceramic art and pottery has a wide variety of hazards. The specific hazards and precautions can be divided into four areas:

- working with clay
- glazing and coloring
- firing in a kiln
- potential leaching of finished ware

Clay

Clays are minerals composed of hydrated aluminum silicates, often containing large amounts of crystalline silica. Other impurities may include organic matter or sulfur compounds. Sometimes, grog (ground firebrick), sand, talc, vermiculite, perlite, and small amounts of minerals such as barium carbonate and metal oxides, are added to modify clay properties. Clays can be worked by hand or on the potter's wheel, or cast in a clay slurry into molds.Clay is made by mixing dry clay with water in clay mixer. Clay slip is made by adding talcs which themselves can be contaminated with fibrous asbestos or asbestos-like materials. Clay can cause a variety of problems, some of which are given below:

- There have been known cases of silicosis, or "potter's rot, from chronic inhalation of large amounts of free silica during clay mixing. Symptoms of silicosis include: shortness of breath, dry cough, emphysema, and high susceptibility to lung infections such as tuberculosis. The disease may take years to develop. Silica dust exposure is not hazardous by skin contact or ingestion.
- Chronic inhalation of kaolin is moderately hazardous, and can result in kaolinosis, a disease in which the lungs become mechanically clogged.
- Asbestos is extremely toxic by inhalation and possibly by ingestion. Asbestos inhalation may cause asbestosis, lung cancer, mesothelioma, stomach cancer, and intestinal cancer.

Management for clay

- Use premixed clay to avoid exposure to large quantities of clay dust.Clay storage and mixing should take place in a separate room. Bags of clay (and other pottery materials) should be stacked on palettes or grids off the floor for easier clean-up. All clay mixers should be equipped with local exhaust ventilation to remove fine silica dust particles from the air.

- Clay mixers should be equipped with proper machine guards so that they cannot be opened to add clay or water while the mixer blades are turning.

Glazes

Glazes used to color or finish clay pieces are a mixture of silica, fluxes and colorants. Common fluxes include lead, barium, lithium, calcium and sodium, and are used to lower the melting point of silica. The actual colorants, which are an assortment of metal oxides usually account for less than 5% of the glaze by weight. Originally, soluble raw lead compounds including red lead, white lead, galena, and litharge were used as fluxes in low-fire glazes. Lead frits and good housekeeping greatly lowered the number of potters that had been poisoned by these highly toxic lead compounds. Frits are made of melted minerals and metal compounds that are sintered and ground into powder form. While lead frits are sometimes assumed to be insoluble and nontoxic, leaching tests with acids have shown that many frits are as soluble as raw lead compounds and, in fact, there have been cases of lead poisoning from both inhalation or ingestion of these.

Management for glaze

Use lead-free glazes. If the glaze does not state "lead-free" or "leadless" on the label, assume it contains lead until proven otherwise. Lead glazes should only be used on non-foodware items. Design lead-glazed pieces so that they won't be used for food or drink. Lead-glazed pottery should be labeled as lead-containing. Consider wearing a respiratory when weighing and mixing powdered. Wet glazes are not an inhalation hazard. Good housekeeping procedures and cleanup of spills reduce the risk of inhalation or ingestion of toxic dusts. Wet mop spilled powders. Gloves should be worn while handling wet or dry glazes.Good dilution ventilation or local exhaust ventilation should be available when applying solvent-containing glazes.

Kilns

Electric kilns and fuel-fired kilns are used to heat the pottery to the desired firing temperature. The most common type are the electric kilns. Heating elements heat the kiln as electric current passes through the coils. The temperature rises until the kiln is shut off. Fuel-fired kilns are heated by burning gas (natural or propane), oil, wood, coke, charcoal or other materials. Propane gas or natural gas is used most often. The fuels produce carbon monoxide and other combustion gases. Fuel-fired kilns are usually vented from the top through a chimney. The early stages of bisque firing involves the oxidization of organic clay matter to carbon monoxide and other combustion gases. Sulfur breaks down later producing highly irritating sulfur oxides. Also, nitrates and nitrogen-containing organic matter break down to nitrogen oxides.

Galena, cornish stone, crude feldspars, low grade fire clays, fluorspar, gypsum, lepidolite and cryolite can release toxic gases and fumes during glaze firings. Carbonates, chlorides, and fluorides are broken down to releasing carbon dioxide, chlorine, and fluorine gases. At or above stoneware firing temperature, lead, antimony, cadmium, selenium and precious metals vaporize and the metal fumes can either escape from the kiln, or settle inside the kiln or on ceramic ware in the kiln. Nitrogen oxides and ozone can be generated from oxygen and nitrogen in air. Kiln can cause a variety of problems, some which are given below:

- Chlorine, fluorine, sulfur dioxide, nitrogen dioxide, and ozone are highly toxic by inhalation. Bisque firings of high-sulfur clay have caused the production of great amounts of choking sulfur dioxide. Other large acute exposures to gases are not common. Inhalation of large amounts of these gases can result in severe acute or chronic lung problems. Long-term inhalation of low levels of these gases can cause chronic bronchitis and emphysema. Fluorine gas can also cause bone and teeth problems.

- Many metal fumes generated at high temperatures are highly toxic by inhalation. Since lead vaporizes at a relatively low temperature, it is especially hazardous.
- Carbon monoxide from fuel-fired kilns or the combustion of organic matter in clays is highly toxic by inhalation and can cause oxygen starvation. One symptom of carbon monoxide poisoning is an intense frontal headache, unrelievable by analgesics.
- Hot kilns produce infrared radiation, which is hazardous to the eyes. There have been reports of cataracts, from years of looking inside the hot kilns.

Management for Kilns

Do not use lead compounds at stoneware temperatures since the lead will vaporize.Lumber, paper, solvents, or other combustible and flammable materials should not be stored in kiln areas. Always check that the kiln has shut off. If gas leaks are suspected (e.g. gas odor): shut off gas at the source; shut off power to the kiln room at the circuit breaker; and call the gas company. Test for leaks with nonfat, soapy water or use approved leak-detection solutions.

Special Processes

While most glaze firings refer to firing a glaze-coated pot in the kiln, special processes sometimes are used. Salt glazing and raku firing are two examples.

Salt Glazing

This process involves throwing wet salt (sodium chloride) into the heated kiln while the bisque ware is being fired. Wet salt at high temperatures decomposed to sodium and chlorine. The sodium reacts with the bisque ware to form a glaze. Large amounts of hydrogen chloride gas and possibly chlorine are also formed.

Sodium carbonate (washing soda) can also be used. Carbon dioxide is generated instead of hydrogen chloride.

Problems

Hydrogen chloride gas is highly toxic by inhalation. Health effects are both similar and more irritating compared with most other kiln gases. Often, local environmental protection laws ban salt kilns.

Hydrogen chloride and water vapor form hydrochloric acid, which can corrode metal fittings in the area.

Management

Substitute safer sodium carbonate for sodium chloride. Sodium chloride salt glazing should only be done outdoors. Kilns should be equipped with canopy hoods and chimney stacks that are tall enough to disperse the hydrogen chloride safely.

Raku Firing

Raku involves first firing ware at a low temperature in a regular gas kiln, and then removing the still hot pieces and placing in them in sawdust, leaves or other organic materials for a reduction phase.

Problems

The reduction step produces large amounts of smoke and carbon monoxide. Treated wood or other materials can yield an exposure to highly toxic preservatives or pesticides, such as arsenic and chromium compounds.

Management for Raku Firing

Raku should only be done outdoors because of smoke. Be careful to not locate raku near air intakes or open windows of buildings. Do not use materials that have been treated with preservatives or pesticides for the reduction phase.

Pollution caused by plastics and their management

Plastic is defined as a material that contains an essential ingredient an organic substance of large molecular weight. It is also defined as polymers of long carbon chains.

The word, plastic, was derived from the word 'Plastikos' meaning 'to mould' in Greek. Fossil fuels have compounds containing hydrogen and carbon (hydrocarbon) which act as building blocks for long polymer molecules. These building blocks are known as monomers, they link together to form long carbon chains called polymers.

In nature, there is no waste that does not decompose. Humans, however, have invented plastic which will always be 'unnatural' in the environment because of its properties. Making plastic is inexpensive and the applications of the material are endless. Because plastic is so widely used, it almost always ends up in the environment, causing more plastic pollution. And not just because someone leaves a piece of plastic on the street instead of putting it in a waste bin.

Of all the plastic we use, 40% is used just once. Every year we use several billion items such as bags, bottles, trays, and food packaging. Supermarkets are full of it. Some people are careless with packaging and leave it behind as litter. But there are also places where people can't do otherwise because there is no waste collection system. It is without a doubt that even if most people do their best, much of that single-use plastic enters the environment, being one of the biggest cause of plastic pollution.

Some methods to manage pollution caused by plastic are:

i. Reduce Your Use of Single-Use Plastics
ii. Support Legislation to Curb Plastic Production and Waste
iii. Recycle Properly
iv. Participate In (or Organize) a River Cleanup
v. Avoid Products Containing Microbeads
vi. Spread the Word

Pollution caused by fibers and their management

A fiber is a matter, which is either natural or manufactured, that forms the basic element of fabrics and other textile structures. There are two types of fiber based on origin: natural and synthetic. Cotton, wool, and silk are natural fibers as they are directly extracted from plants and animals. At the same time, nylon, rayon, etc., are synthetic fibers as they are manmade fibers with several repeating units manufactured in laboratories by various chemical processes using petroleum products, also known as petrochemicals, as raw materials. Polyester and other synthetic fibers, such as nylon, are major contributors to microplastic pollution in the environment.

Some methods to manage pollution caused by fibers are:

i. Reducing the use of synthetic fibers and shifting to natural fibers such as wool, cotton, silk, and linen, despite the fact that synthetic fibers are less expensive and natural fibers have additional environmental costs such as water and land-use issues; large-scale use of bacteria that could aid in biodegradation of the fibers for reuse; substituting synthetic fibers with biosynthetic fibers that are both recyclable and biodegradable; blending synthetic fibers with natural fibers .

ii. Reducing the use of synthetic materials, which are by-products of petroleum and are non-biodegradable. Synthetic products take a long time to decompose, creating long-term pollution.

iii. Nylon is hard to recycle, making it hard to decompose, accumulating landfills more. Polyesters are easy to recycle, which makes them less harmful to society. Recycled polyesters are used to make eco-fashion, which is fashion that is more eco-friendly.

iv. Synthetic fibers also taint the bodies of water. So, from waste products derived from textile factories to dyes, they are all flushed into our waterways and sewers, making the environment more harmful and dangerous. As a result, we chose another option for this .

Pollution caused by chemical fertilizers and their management

Fertilizer use is no doubt beneficial to plant in providing deficient nutrients; also they have several other conveniences such as the cheaper source of nutrient, higher nutrient content and its solubility hence immediate availability, then it's required in less amount, which makes it more acceptable than organic fertilizer. There is abundance of evidence that inorganic fertilizers can improve the yield of crop significantly. Fertilizers raise soil fertility so that the yield of crops is independent and no longer be limited by the deficient amounts of plant nutrients. Despite these benefits, fertilizer has several negative effects on the environment because of its growing consumption and lowering nutrient use efficiency. Therefore, the major challenge in intensive agricultural production systems is to combine intensive cultivation with high nutrient use efficiency. Soil nutrient level gets decreased over time when crop plants get harvested, and these nutrients get replenished either through natural decomposition process or by adding fertilizers. Hence fertilizer is an essential component of modern agriculture.

Some methods to manage pollution caused by chemical fertilizer are:

To eliminate the pollution hazards due to chemical fertilizers, improved nutrient use efficient fertilizers particularly nitrogen should be adopted by using organic manures, controlled-release or slow-release fertilizers. Using different Nano-fertilizers which have the greater role in enhancing crop production this will reduce the cost of fertilizer for crop production and also minimize the pollution hazard. Current resources should be overhauled in favour of the sustainable use of resources, also boosting the production simultaneously. We can use -

a. **Biofertilizer:** It is defined as a substance which contains living micro-organisms and is known to help with the expansion of the root system and better seed germination. A healthy plant usually has a healthy rhizosphere which should be dominated by beneficial microbes. Biofertilizers differ from chemical and organic fertilizers in the sense that they do not directly supply any nutrients to crops and are cultures of special bacteria and fungi. The production technology for biofertilizers is relatively simple and installation cost is very low compared to chemical fertilizer plants .

b. **Slow-Release Fertilizers:** It involves the release of the nutrient in a slower manner than common fertilizers. However, the rate, pattern, and duration of release are not well controlled. But the rate, pattern, and duration of release are well known in controlled release fertilizers . Different types of slow or controlled release fertilizers are:

i. Organic- N Low-Solubility Compounds for e.g. Urea-formaldehyde (UF) and Isobutyledene-diurea (IBDU).

ii. Fertilizers in Which a Physical Barrier Controls the Release for e.g., the coated fertilizers coated with organic polymer coatings that are either thermoplastic or resins and fertilizers coated with inorganic materials such as sulfur- or mineral-based coatings etc.

iii. Inorganic Low-Solubility Compounds: Fertilizers such as metal ammonium phosphates and partially acidulated phosphates rock (PAPR).

c. **Nanofertilizers:** 'Nanofertilizers are synthesized or modified form of traditional fertilizers, fertilizers bulk materials or extracted from different vegetative or reproductive parts of the plant by different chemical, physical, mechanical or biological methods with the help of nanotechnology used to improve soil fertility, productivity and quality of agricultural produce. Nanoparticles can be made from bulk materials.

d. **Application Efficiency:** Application of any fertilizer should be done at an economic rate other than optimum rate. Also application from right source, rate, placement & time will reduce the adverse effect on both the crop and the environment. Various techniques that maintain and enrich the soil fertility & the soil humus content should be used like using compost, manure, agro-forestry, green manure, mulch manure etc

Pollution caused by soaps and their management

The main atmospheric pollution problem in soap manufacturing is odor. The storage and handling of liquid ingredients (including sulfonic acids and salts) and sulfates are some of the sources of this odor. Vent lines, vacuum exhausts, raw material and product storage, and waste streams are all potential odor sources. Control of these odors may be achieved by scrubbing exhaust fumes and, if necessary, incinerating the remaining volatile organic compounds (VOCs).

Odors emanating from the spray dryer may be controlled by scrubbing with an acid solution. Blending, mixing, drying, packaging and other physical operations may all involve particulate emissions. The production of soap powder by spray drying is the single largest source of dust in the manufacture of synthetic detergents. Dust emissions from other finishing operations can be controlled by dry filters such as baghouses. The large sizes of the particulate from soap powder operations means that high efficiency cyclones installed in series can achieve satisfactory control.

The following methods are used to manage pollution caused by shoaps:

i. Use natural and eco-soaps
ii. Clean up with natural products
iii. Avoid spending too much on products for your house
iv. Industrial wastewater from soap industries represents a heavy pollution source on their receiving water body. The government should strictly control this cause of pollution.
v. Reduce the amount of soap you use.

Pollution caused by detergents and their management

The exhaust air from detergent spray drying towers contains two types of air contaminants: (a) fine detergent particles and (b) organics vaporized in the higher temperature zones of the tower. Dust emissions are generated at scale hoppers, mixers, and crutchers during the batching and mixing of fine dry ingredients to form slurry. Conveying, mixing, and packaging of detergent granules can also cause dust emissions. Pneumatic conveying of fine materials causes dust emissions when conveying air is separated from bulk solids. For this process, fabric filters are generally used, not only to reduce or to eliminate dust emissions, but also to recover raw materials.

The dust emissions principally consist of detergent compounds, although some of the particles are uncombined phosphates, sulfates, and other mineral compounds.

The following methods are used to manage pollution caused by detergents:

i. Water pollution caused by detergents is now a big concern in the global context. Nonylphenol, a hazardous chemical present in detergents, is known to enter water bodies and the food chains. It bio-accumulates and can pose serious environmental and health risks. It has been detected in human breast milk, blood and urine, and is associated with reproductive and developmental effects in rodents. It is recommended to find substitutes of nonylphenol.

ii. Many laundry detergents contain approximately 35 to 75 per cent phosphate salts. Phosphates can cause a variety of water pollution problems. For example, phosphate tends to inhibit the biodegradation of organic substances. Non-biodegradable substances cannot be eliminated by public or private wastewater treatment.Some phosphate-based detergents can also cause eutrophication. Phosphate-enrichment can cause the water body to become choked with algae and other plants. Eutrophication deprives the water of available oxygen, causing the death of other organisms. Reduce the use of such types of detergent in daily life.

iii. Detergents are capable of destroying the external mucus layers that protect the fish from bacteria and parasites, causing severe damage to the gills. Mostly fish die when detergent concentrations are near 15 parts per million (ppm); however, detergent concentrations as low as 5 ppm will kill fish eggs. We are not washing our clothes in ponds, rivers, and lakes with detergents .

Activities 19.4

i. Write an essay about chemical pollution and its management.
ii. Make a list on chemical pollutant. How do you manage such type pollutant in your community.

Project Work

Research the sources of chemical pollution at the local level and prepare a short report on their effects and mitigation measures.

Exercise

A. Choose the correct one and put the tick mark (√).

i. Our lives are completely dependent on----

a. elements b. copounds c. chemicals d. Preservatives

ii. Which is not preservatives-

a. Sulphites, like sulphur dioxide b. Nitrites, like sodium nitrite
c. Carbon monoxide d. Benzoates, like sodium benzoate

iii. We can use _________ to extend the shelflife of certain foods.
   a. chemicals b. subtances c. additives d. preservative
iv. Preservatives are added to food to fight spoilage caused by______, molds, fungus, and yeast.
   a. virus b. insect c. disease d. bacteria
v. How many types of food preservatives
   a. Four b. Three c. Two d. None of these .
vi. Vinegar, alcohol, salt, sugar and castor oil are examples of-
   a. Natural preservative b. Artificial preservative
   c. Compound preservative d. Chemical preservative
vii. Benzoates, sulphates, propionates, nitrates, and sorbates are examples of-
   a. Natural preservative b. Artificial preservative
   c. Compound preservative d. Chemical preservative
viii. Which is not first class preservative
   a. Sodium b. Acetic acid c. Honey d. Alcohol.
ix. Which is not second class preservative
   a. Potassium nitrites b. Benzoic acid
   c. Sulphurous acid d. Acetic acid
x. Which is not correct
   a. salt, ascorbic acid b. sodium benzoate,nitrogen gas
   c. nitrate, nitrite d. methan, sulfites
xi. _________chemicals help clean, degrease, sanitize, and disinfect surfaces.
   a. Preservative b. Cleaning c. Additive d. Ashes
xii. Which is not cleaning chemicals -
   a. Detergents b. Degreasers c. Acids d. Muds
xiii. Kerosene is-
   a. Detergents b. Degreasers c. Abrasives d. Acids
xiv. _________chemicals are defined as any chemical that can cause death, temporary incapacity, or permanent harm to humans or animals through its chemical action on life processes.
   a. Preservative b. Toxic c. Abrasive d. pollution
xv. Chemical pollution-
   a. is a substance that can be poisonous or cause health effects.
   b. refers to the contamination of our environment with chemicals that are not found there naturally.
   c. is substance added to foods to inhibit the growth of micro-organisms.
   d. a concentrated liquid with an exceptional tolerance for medium and hard waters.

B. Differentiate between these pairs.

i. Natural preservatives and Artificial preservatives
ii. First class preservative and Second class preservative
iii. Alcohol and Benzoic acid
iv. BHA and BHT
v. Detergents and Soap
vi. Detergents and Degreasers
vii. Abrasives and Acids
viii. Plastics and Fibers

C. Explain the following:

i. Detergents are used for washing clothes.
ii. Chemicals are vital building blocks for anything present in this universe.

iii. There are various uses for chemicals in the textile industry.
iv. We use toothpaste for washing our teeth.

D. Answer the following questions :

i. What are chemicals? Why are chemicals important in our lives?
ii. What are the preservaties? Write down the names of any four local preservaties.
iii. What is the similarity between sulphites, nitrites and benzoates in the context of chemical preservatives ?
iv. Write down the five advantages and disadvantages of preservatives
v. What are natural preservatives? Write down five examples of them.
vi. What are artificial preservatives? Write down five examples of them.
vii. What is the important of preservative?
viii. What are cleaning chemicals? Write down the name of five of them.
ix. What are toxic chemicals? Write down five precuations to be taken while storing and using them.
x. What is chemical pollution? How do control industrial chemical pollution.
xi. Introduce any three of the chemicals used in cleaning. Also, write the importance and effects of those chemicals.
xii. Write an introduction to any of three toxic chemicals. Also, write the precautions to be taken while storing and using those chemicals.
xiii. Name any five chemicals that cause chemical pollution. Write the measures to manage the pollution spread by those chemicals.

F. Diagrammatic Questions :

i. The picture below shows the method of food preservation. In the picture, 1, 2, 3, and 4 are trying to show which method they use. Write about each method in brief.
(Pickling, Drying, Cooling and Sugar/Salting)

ii. The picture below shows a cement factory in Udaipur, Nepal. Common people have complained that this factory has spread pollution. How did the factory spread pollution? What are the measures to prevent it?