ગુજરાત રાજ્યના શિક્ષણવિભાગના પત્ર-ક્રમાંક
મશબ/1211/415/ છ, તા. 11-04-2011--થી મંજૂર

SCIENCE AND TECHNOLOGY

Standard 9

(Semester I)

PLEDGE

India is my country.
All Indians are my brothers and sisters.
I love my country and I am proude of its rich and varied heritage.
I shall always strive to be worthy of it.
I shall respect my parents, teachers and all my elders and treat everyone with courtesy.
I pledge my devotion to my country and its people.
My happiness lies in their well-being and prosperity.

રાજ્ય સરકારની વિનામૂલ્યે યોજના હેઠળનું પુસ્તક

Gujarat State Board of School Textbooks
'Vidyayan', Sector 10-A, Gandhinagar-382010

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PREFACE

The Gujarat State Secondary and Higher Secondary Education Board has prepared new syllabi in accordance with the new national syllabi prepared by the NCERT based on NCF 2005 and core-curriculam. These syllabi are sanctioned by the Government of Gujarat.

It is a pleasure for the Gujarat State Board of School Textbooks to place before the students this textbook of **Science and Techonology Standard 9, (Semester I)** prepared according to the new syllabus.

Before publishing the textbook, its manuscript has been fully reviewed by experts and teachers teaching at this level. Following suggestions given by teachers and experts, we have made necessary changes in the manuscript before publishing the textbook.

The board has taken special care to ensure that this textbook is interesting, useful and free from errors. However, we welcome any suggestion, from people interested in education, to improve the quality of the textbook.

H. K. Patel GAS
Director
Date : 1-9-2013

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First Edition : 2011, Reprint 2011, 2012, 2013

Published by : H. K. Patel, Director, on behalf of Gujarat State Board of School Textbooks, 'Vidyayan', Sector 10-A, Gandhinagar

Printed by :

FUNDAMENTAL DUTIES

It shall be the duty of every citizen of India :

(a) to abide by the Constitution and respect its ideals and institutions, the National Flag and the National Anthem;

(b) to cherish and follow the noble ideals which inspired our national struggle for freedom;

(c) to uphold and protect the sovereignty, unity and integrity of India;

(d) to defend the country and render national service when called upon to do so;

(e) to promote harmony and the spirit of common brotherhood amongst all the people of India transcending religious, linguistic and regional or sectional diversities; to renounce practices derogatory to the dignity of women;

(f) to value and preserve the rich heritage of our composite culture;

(g) to protect and improve the natural environment including forests, lakes, rivers and wild life and to have compassion for living creatures;

(h) to develop the scientific temper, humanism and the spirit of inquiry and reform;

(i) to safeguard public property and to abjure violence;

(j) to strive towards excellence in all spheres of individual and collective activity so that the nation constantly rises to higher levels of endeavour and achievement.

* Constitution of India : Section 51-A

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1 Motion

1.1 Introduction

Dear students, come out of home and walk around. You would find that many things are stationary and many things are moving. People walking on a road, moving vehicles, birds flying in the sky, light rays coming from the sun etc., are in motion. The stationary objects on the earth like roads, bridges, trees, buildings are also in motion due to rotation of the earth. Blood being circulated in a body, air, going into the lungs and coming out of lungs, water flowing in a river, tides of river etc. are examples of motion. The earth around the sun, the sun in the milky way galaxy, and the milky way galaxy with respect to other galaxies, are in motion. Some of the motions are invisible. For example, motion of the molecules of gas, motion of air, motion of sound waves. Such motions are experienced indirectly.

Thus, each object in the universe is in motion. Some of them are moving along a straight line, some are moving along a circular path, or a curved path whereas some have vibrational motion. In this chapter we study, the simplest, motion along a straight line. For description of such a motion we will understand concepts of physical quantities like distance, displacement, velocity and acceleration.

1.2 Concept of Motion

When is a body said to be in motion or stationary ? If position of a body changes with time it is said to be in motion. If its position does not change with time it is said to be stationary. Is this answer correct ? Let us clarify.

Suppose you are sitting in a school bus along with your school bag. Bus is going towards the school. If you look at your school bag, it is told to be stationary. If you look out through window you would see the trees, buildings and poles of electricity are found to be in motion. If your friend, standing on the road sees you and your bag, he observes you and your bag are in motion, whereas for him building and trees are stationary.

Now, it should be clear that the body whether it is in motion or stationary, depends on the position of observation also. Thus motion is relative.

Activity 1 : Have you experienced your train moving when you have been sitting in a train which is stationary on a platform ? Discuss your experience with your friend.

1.3 Position, Distance and Displacement

It is necessary to decide position of the body, if its motion is to be described. The point which is used as a reference to indicate the position of a body is called reference point. Reference point can be selected as per your convenience. If someone asks you, " Where is Gandhinagar". This question may have many answers. For example, "at 30 km distance from Ahmedabad or at 130 km distance from Vadodara." In the first answer Ahmedabad and in the second answer, Vadodara are the reference places. Thus in the description of position of a body reference point must be mentioned.

Distance: Length of the path of motion of an object during given time period is called distance or path length travelled by the object.

Displacement: In given time interval change in position of a body in given direction is called displacement.

If the body is on x_1 and x_2 positions at times t_1 and t_2 respectively, its displacement in time interval $\Delta t = t_2 - t_1$ can be determined as follows:

Displacement s = Final position – Initial position

$$= x_2 - x_1 \quad 1.3.1$$

Equation 1.3.1 gives the magnitude of displacement. Direction of the displacement is from the initial position to the final position. Let us understand the difference between distance and displacement clearly using following example.

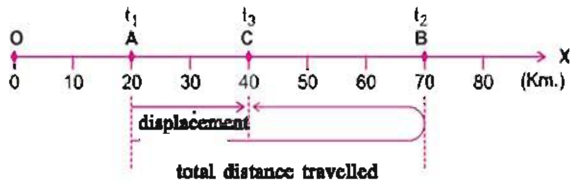

Figure 1.1 Distance and displacement

Suppose a car is moving in the direction of X-axis. As shown in figure 1.1 at time t_1 the car is at A, at time t_2 car reaches B and comes to C at time t_3. Here O is reference point.

Now, in time period $\Delta t = t_3 - t_1$

Path length or distance travelled

= length of path of motion from A to B + length of path of motion from B to C

= AB + BC

= (70 – 20) + (70 – 40)

= 80 km

Displacement of the car

= Final position – Initial position

= (Position of point C) – (Position of point A)

= 40 – 20 = 20 km

Here displacement of car is 20 km. But direction of displacement of car is also important. Magnitude of displacement without description of direction is meaningless. To describe displacement, the direction is also necessary besides magnitude of displacement. In the example given above car undergoes displacement of 20 km in positive X- direction.

If car, after travelling along path A – B – C – A comes back to point A

Total distance = AB + BC + CA

= 50 + 30 + 20 = 100 km

Displacement = Final position (A) – initial position (A)

= 20 – 20 = 0

Since, in this case, initial and final positions are same, displacement would be zero.

Now if the car reaches point O by travelling along A - B - C - A - O path, total distance travelled would be 120 km and,

Displacement = position of O – position of A

= 0 – 20 = – 20 km

Here displacement is from A to O i.e. 20 km in nagative X direction.

From the three cases given above it is clear that **path length is always positive whereas displacement can be positive, negative or zero.** Distance travelled by a body gives total length of path of motion, whereas displacement shows final effect of the motion only. Displacement does not give information about the path on which body has travelled.

To describe displacement, magnitude and direction both are required. Such physical quantities are known as vector quantities. To describe total length of path of motion, direction is not needed, only its magnitude is important. Such physical quantities are known as scalar quantities.

SI unit of distance and displacement both, are in metre (m). In practice often units like centimetre (cm) and kilometre (km) are also used.

In Physics quantities are mainly divided in to two parts :

(1) scalar quantity and (2) vector quantity.

Scalar quantity : The quantity, which requires only magnitude for complete description, is known as a scalar quantity e.g. mass, volume, density, temperature, distance, time, speed, work etc.

Vector quantity : The quantity, which requires magnitude as well as direction also, is known as vector quantity e.g. displacement, velocity, acceleration, momentum, force etc.

(You will study more about vectors and scalars in Std XI (science)

Illustration 1 : Circumference of a circular path is 314 m. AB is its diameter. A cyclist starting his motion from A reaches B along the circular path. Calculate distance travelled by him and also find his displacement. (π = 3.14)

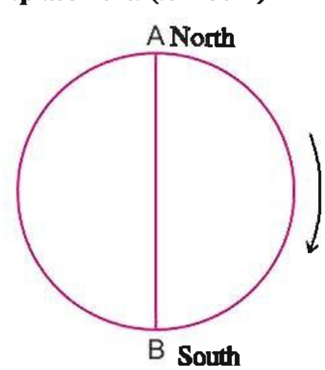

Figure 1.2 Circular path

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Solution : Distance travelled by the cyclist

$= \frac{1}{2}$ (circumference of the circle)

$= \frac{1}{2} \times 314 = 157$ m

Now circumference of the circle

$\therefore 2\pi r = 314$

$\therefore r = \frac{314}{2 \times 3.14} = 50$ m

Displacement of the cyclist

$s = AB = 2r$

$= 2 \times 50 = 100$ m;

from North to South direction.

Think : If the cyclist after starting from point A travels along circular path and comes back to point A what would be the distance travelled and displacement ?

(Ans : Distance = 314 m, Displacement = 0 m !!)

Illustration 2 : A person walks 50 m in north direction and from there he walks 30 m in west direction. Now he / she walks 50 m distance in south direction. Find the distance travelled by the person and displacement.

Solution : Path of motion of the person is shown in the fig. 1.3.

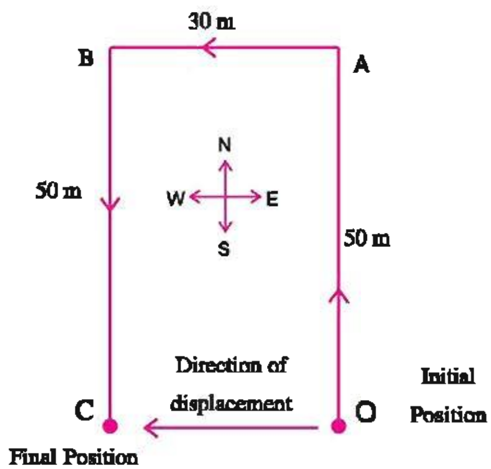


Figure 1.3

Total distance travelled by the person

= OA + AB + BC

= 50 + 30 + 50 = 130 m

Displacement of the person

= Final position – Initial position

= Position of C – position of A

= 30 – 0 = 30 m

Here, direction of displacement of the person is from O to C i.e. in the west direction.

1.4 Uniform and Non-uniform Motion

Suppose you are going from Ahmedabad to Mumbai in your car at high speed. In the first hour car travels 70 km, in the second hour the car travels 70 km, in the third hour car travels 70 km and in the fourth hour also car travels 70 km distance. Here the car travels equal distance in same intervals of time. So, the car is said to be in uniform motion.

If an object travels equal distance in the same intervals of time, the object is said to be moving with uniform motion.

Suppose another car is moving on the city-road. Due to traffic it would have to slow down. If the road is trafficless, car moves with considerable speed and stops near traffic signal. Thus car cannot travel equal distance in equal intervals of time, so it is said to have non-uniform motion.

If an object in motion, does not travel equal distance in same interval of time it is said to have non-uniform motion.

Generally, in daily life, most of the vehicles move with non-uniform motion.

Activity 2 : For a moving car, odometer readings taken at 15 minutes interval are given in table 1.1. Discuss with your friends about the time intervals in which the car has uniform motion and the time intervals in which car has non-uniform motion.

Table 1.1

Time	Odometer Readings (km)
8:00	5450
8:15	5465
8:30	5480
8:45	5495
9:00	5510
9:15	5530
9:30	5560
9:45	5570
10:00	5585

1.5 Speed, Average Speed and Uniform Speed

Many times in daily life it becomes necessary to know which vehicle is moving fast and which vehicle is moving slow. Suppose a train takes two hours to reach Vadodara from Ahmedabad, and another train takes eight hours to reach Mumbai from Ahmedabad. Which train out of these two is faster ? In order to answer this question let us define the physical quantity named 'speed'.

$$\text{Speed} = \frac{\text{Distance travelled by a body}}{\text{Time to travel this distance}}$$

$$v = \frac{s}{t}$$

Distance travelled by a body in unit time is called speed. In other words **ratio of distance travelled by a body and time taken for it is known as speed.** Speed is a scalar quantity. This means you don't have to bother about direction for describing speed. SI unit of distance is metre/second, symbolically it is written as m/s or m s^{-1}. For speed kilometre/hour (km/h), kilometre/minute (km/min), centimetre/second (cm/s) like units are also used.

In daily life we come across non-uniform motion of objects frequently. Their speeds are found to be different in different intervals of time. In this case to know 'effective speed' a physical quantity named average speed is used. Average speed is defind as follows :

Average Speed : Ratio of total distance travelled to total time taken is called average speed.

$$\text{Average Speed} = \frac{\text{Total distance travelled}}{\text{Total time taken to travel distance}}$$

Like speed, average speed is a scalar quantity. Also units of speed and average speed are the same. Remember, if speeds of two moving bodies are to be compared, units of their speed must be the same.

Remember, **average speed is not the average of various speeds. In fact average speed is the average of values of speeds evaluated over equal intervals of time.** For example, speed of a motorcycle in first 10 minutes is 40 km/h, in next 10 minutes it is 50 km/h and in last 10 minutes it is 30 km/h. Average speed of this motorcycle in the interval of 30 minutes is

$$v_{av} = \frac{40\text{ km/h} + 50\text{ km/h} + 30\text{ km/h}}{3} = 40\text{ km/h}$$

Let us consider a few examples to understand how to obtain average speed in different conditions.

Illustration 3 : An object, travelling along a straight path, covers 25 m distance in 4 s. In next 6 s it covers 50 m distance. What is the average speed of the object ?

Solution : Total distance travelled by the object = 25 m + 50 m = 75 m

total time = 4 s + 6 s = 10 s

$$\text{Average speed } (v_{av}) = \frac{\text{distance}}{\text{time taken for distance}}$$

$$\therefore\ v_{av} = \frac{75\text{ m}}{10\text{ s}} = 7.5\text{ m/s}$$

Illustration 4 : A motor car travels first 30 km of its journey on a highway at 60 km/h and next 30 km at 90 km/h with uniform speed. Calculate average speed.

Solution :

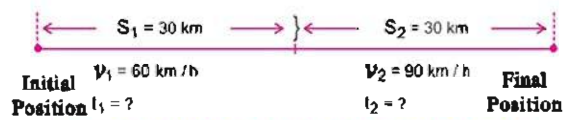


Figure 1.4 Motion of the car in straight path

Time taken by car to travel first 30 km

$$t_1 = \frac{s_1}{v_1} = \frac{30\text{ km}}{60\text{ km/h}} = \frac{1}{2}\text{ hour} \quad (\because\ v = \frac{s}{t})$$

Time taken by car to travel another 30 km at 90 km/h uniform speed t_2

$$t_2 = \frac{s_2}{v_2} = \frac{30\text{ km}}{90\text{ km/h}} = \frac{1}{3}\text{hour}$$

$\therefore$ Average speed of the car

$$= \frac{\text{Total distance travelled by the car}}{\text{Total time taken for the distance}} = \frac{s_1 + s_2}{t_1 + t_2}$$

$$= \frac{30\text{ km} + 30\text{ km}}{\frac{1}{2}\text{ h} + \frac{1}{3}\text{ h}}$$

$$= \frac{60\text{ km}}{\frac{5}{6}h} = 72\text{ km/h}$$

Note : Here, average speed is not the average of speeds.

(i.e. it is not $\frac{60+90}{2} = 75$ km/h)

Uniform speed : If a body in motion travels equal distance in equal interval of time, its speed in each interval of time remains constant. The body moving at constant speed is said to be moving with uniform speed.

Activity 3 : During rainy season you must have seen lightning and heard the thunder sounds. Do they occur at the same time ? or Lightning is seen first followed by hearing sounds of thunders ? Discuss your experience with friends.

If time difference is experienced, find the time difference using digital clock. Using this time interval, find the distance of place of lightning from earth's surface. (Speed of sound = 340 m/s)

1.6 Velocity, Average Velocity and Uniform Velocity

Velocity : Since speed is a scaler quantity, direction of a moving object is not taken into consideration. In order to study how fast and in which direction the object reaches the final position, a physical quantity named velocity is defined as follows :

Displacement of an object in unit time is called velocity of the object.

$$\text{Velocity} = \frac{\text{displacement}}{\text{time taken for displacement}}$$

$$\therefore \ v = \frac{s}{t} \qquad 1.6.1$$

Velocity is a vector quantity. It is in the direction of displacement. Its SI unit is m/s. For practical uses its units cm/s and km/h are also used.

For an object performing non-uniform motion the value of its velocity keeps changing. In such circumstances, to study motion of the object, a physical quantity named average velocity is taken help of.

Average velocity :

Ratio of total displacement of an object to total time taken for the displacement is known as average velocity.

$$\text{Average velocity} = \frac{\text{displacement of the object}}{\text{time interval for it}} \qquad 1.6.2$$

If the object is at x_1 and x_2 at time $t = t_1$ and $t = t_2$ respectively, displacement $\Delta x = x_2 - x_1$ as time interval $\Delta t = t_2 - t_1$

So, Average velocity

$$v_{av} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{\Delta x}{\Delta t} \qquad 1.6.3$$

Average velocity is denoted by v_{av}, $< v >$ or $\bar{v}$. Magnitude (and direction also !) of average velocity, depends only on its displacement. Path taken by the body to reach the final position is not taken into consideration.

Illustration 5 : For the path of motion of a person shown in illustration (2) if a person takes 100 s to travel from initial position to the final postition, calculate average speed and average velocity of the person.

Solution : t = 100 s

Total distance travelled by the person = 130 m

Displacement of the person = 30 m (towards the west direction)

$$\text{(i) Average speed} = \frac{\text{Total distance travelled}}{\text{Total time taken}}$$

$$= \frac{130}{100} = 1.3 \text{ m/s}$$

$$\text{(ii) Average velocity} = \frac{\text{displacement of a person}}{\text{time period}}$$

$$= \frac{30}{100} = 0.3 \text{ m/s}$$

Average velocity of the person = 0.3 m/s (from initial position to west direction.)

Illustration 6 : A train takes 2 hours to reach Vadodara from Ahmedabad. The same train takes 3 hours while coming back to Ahmedabad. Distance between Ahmedabad and Vadodara is 100 km. Calculate average speed and average velocity of the train.

Solution :

Total distance travelled by the train = (100 + 100) km = 200 km

Total displacement of train = 0 m (train comes back to original place)

total time period = 2 h + 3 h = 5 h

Average speed of train

$$= \frac{\text{total distance travelled by train}}{\text{time period}}$$

$$= \frac{200 \text{ km}}{5 \text{ h}} = 40 \text{ km/h}$$

$$\text{Average velocity of train} = \frac{\text{Displacement of train}}{\text{time period}}$$

$$= \frac{0}{5 \text{ h}} = 0 \text{ m/s}$$

Here, initial position and final position of the train are same, so, its displacement is zero and hence magnitude of average velocity also be zero.

Uniform Velocity : If velocity of a body in motion remains constant or uniform with time, it is said to be with constant or uniform velocity.

When a body is in uniform motion in a certain direction its velocity remains constant. Remember, for motion with constant velocity the following two conditions should be satisfied :

(1) Speed of the body should be constant.

(2) Direction of motion of the body should not change.

If magnitude of velocity of a moving object or its direction of motion or if both are changing, velocity of the object is said to be changing.

1.7 Acceleration

Velocity of a body performing non-uniform motion changes with time. With time, magnitude of velocity of the body either increases or decreases or magnitude of velocity fluctuates or direction of its motion changes. A physical quantity named acceleration is defined to study such changes in velocity with time.

Acceleration : Change in velocity of an object in motion in unit time is called acceleration or **rate of change in velocity of a object in motion is called acceleration.**

$$\text{Acceleration} = \frac{\text{Change in velocity}}{\text{time}} \qquad 1.7.1$$

If initial velocity of a moving body is u and in time t it aquires velocity v, acceleration in this time period is given by

$$a = \frac{\text{final velocity} - \text{initial velocity}}{\text{time}} = \frac{v-u}{t} \qquad 1.7.2$$

(i) If $v > u$, velocity of the object increases with time and so, acceleration is positive. The object is said to have accelerated motion. Direction of acceleration is in the direction of velocity.

(ii) If $v < u$, velocity of the object decreases with time and so, acceleration is negative. In this case the object is said to have retarded motion. Direction of retardation is in the direction opposite to that of velocity.

Acceleration is also vector quantity like velocity. Its SI unit is metre/second^2 (symbol: m/s^2). Its CGS unit is cm/s^2.

Illustration 7 : A vehicle starting its motion from rest, travels along a straight path and aquires 36 km/h velocity in 10 s. Now due to application of breaks, its velocity reduces to 18 km/h in 5 s. Find acceleration in both the cases.

Solution : For first case,

Initial velocity, $u = 0$

Final velocity $v = 36 \frac{\text{km}}{\text{h}} = \frac{(36 \times 1000)\text{ m}}{(3600)\text{ s}} = 10 \text{ m/s}^2$

Time interval $t = 10$ s

Acceleration of vehicle, $a = \frac{v-u}{t}$

$$= \frac{(10 - 0)\text{ m/s}}{10\text{ s}} = 1 \text{ m/s}^2$$

For second case,

Initial velocity $u = 36$ km/h $= 10$ m/s

Final velocity $v = 18 \text{ km/h} = \frac{(18 \times 1000)\text{ m}}{(3600)\text{ s}} = 5 \text{ m/s}$

Time interval $t = 5$ s

Acceleration of vehicle $a = \frac{v-u}{t}$

$$= \frac{(5-10)\text{ m/s}}{5\text{ s}} = -1\text{m/s}^2$$

Here acceleration is negative so vehicle performs retarted motion.

Uniform accelerated motion : For a body moving along straight path if increases in its velocity is equal in equal interval of time, it is said to have constant acceleration. Such a motion of a body is said to be uniformly accelerated motion. A ball falling freely from top of a tower is an example of uniformly accelerated motion. (See fig. 1.5.)

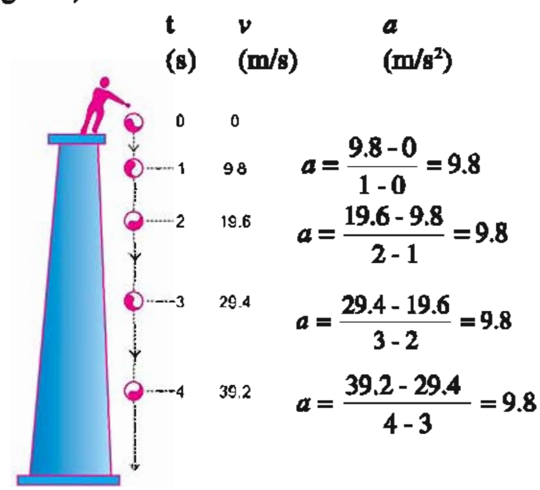


Figure 1.5 Uniform accelerated motion

In figure 1.5 position, velocity and acceleration of the ball are shown at each second, from figure it is clear that in each time interval of 1 second increase in velocity of the ball is same so it is said to perform uniform accelerated motion or motion with constant acceleration. Acceleration of the ball is 9.8 ms^{-2} i.e. **increase in velocity of ball per second is 9.8 m/s.**

If the rate of change in velocity from object is non-uniform, the motion is said to be non-uniform accelerated motion. For example acceleration of vehicle on a road having considerable traffic changes very often. Thus its motion is non-uniform accelerated motion.

1.8 Graphical Representation of Motion

Motion of a body along straight path can be studied easily using graph. Various aspects of motion of a body can be easily described and analysed.

How would you plot a graph ?

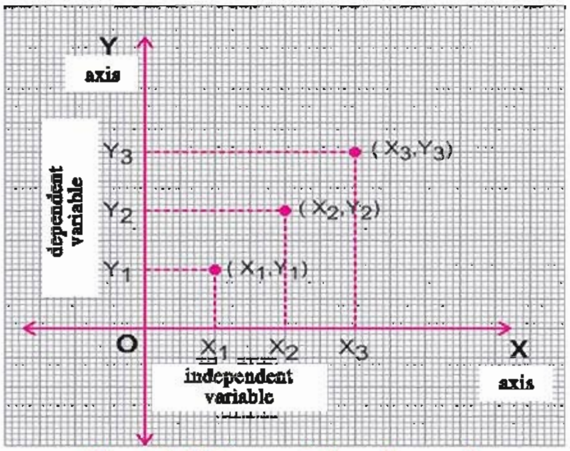


Figure 1.6 Representation of a graph

(i) As shown in the figure 1.6 draw two mutually perperdicular lines OX and OY line. OX is called X-axis and OY is called Y axis. Point of intersection of these axes is called origin. Its co-ordinates are (0, 0).

(ii) Indicate independent variable quantity on X- axis and dependent variable quantity on Y- axis. For example, in graph of *u* velocity-time (Read as velocity versus time)

Velocity is dependent quantity and it is taken along Y-axis whereas time is independent quantity and it is taken along X-axis.

(iii) Show values of both the variables on X-axis and Y-axis using proper scale.

Generally on origin values of both the variables are taken to be zero.

(iv) Show each ordered pair (x, y) formed by independent variable x and dependent variable y on graph paper by points.

(v) Draw a smooth curve joining all these points. Shape of the graph would be a line or a curve depending on type of data.

Here we would learn about two types of graphs to study motion of a moving object.

(1) Distance – time (2) Velocity – time.

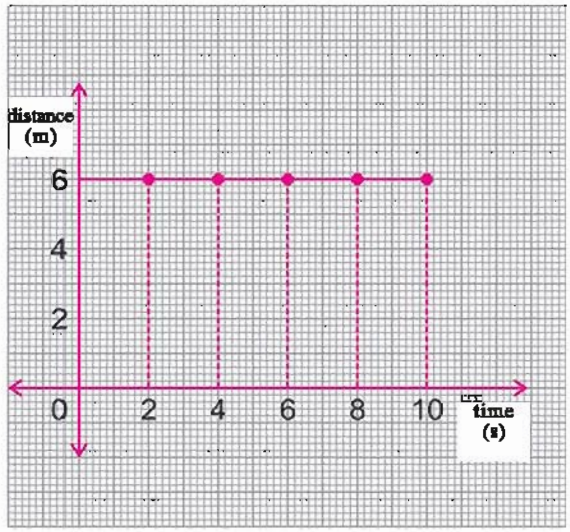


Figure 1.7 An object is in stationary position

(1) Distance – time graph and its uses.

(i) Distance–time graph enables us to know about type of motion

(a) If an object is stationary, its distance from origin does not change. So, distance – time graph is a line parallel to time axis (X-axis). The distance–time graph in fig. 1.7 shows that the object is at distance of 6 m distance from the origin.

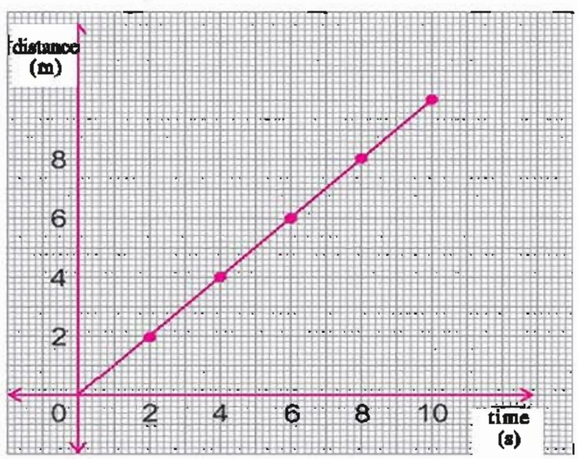


Figure 1.8 Uniform motion of a body

(b) If distance – time graph of a body in motion is a straight line, body is said to be performing uniform motion. (See fig. 1.8.)

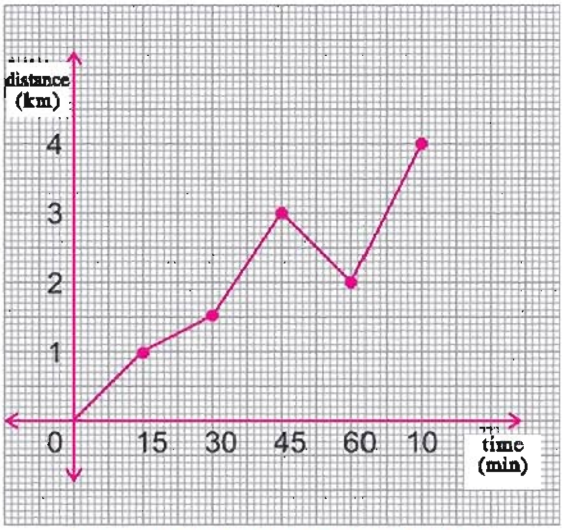


Figure 1.9 Non-uniform motion of a body

(c) If the distance-time graph of a body in motion has 'ups and downs' or non-linear, body is said to have non-uniform motion.

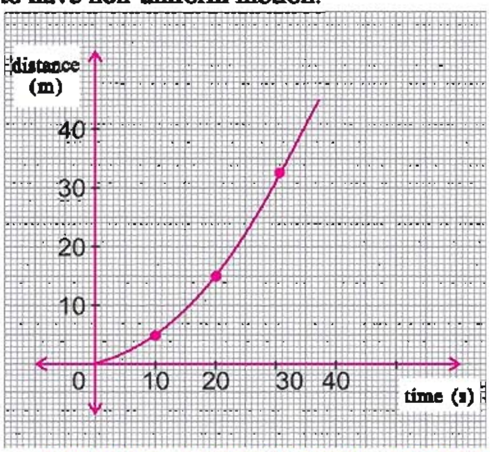


Figure 1.10 Uniform accelerated motion of a body

(d) If distance-time graph of a body in motion is parabolic, as shown in figure 1.10, the motion of the body is said to be uniform accelerated.

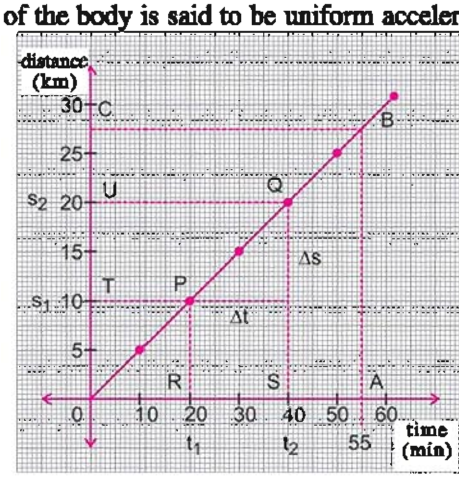


Figure 1.11 Distance-time graph of a bus

(ii) **Using distance-time graph, position of a body in motion can be estimated.** We can also find the time for the object to reach certain position.

In fig. 1.11, distance-time graph for a bus having uniform motion is shown. To know the position of bus at t = 55 min, draw a line perpendicular to time axis at a point A indicating $t = 55$. This line intersects graph at point B. Now draw a perpendicular to distance axis from B. This perpendicular intersects distance axis in C. Point C shows 27.5 km. Thus at time $t = 55$ min bus would be at distance 27.5 km. In the same way, we can determine time when the bus would reach a distance 7.5 km. Find it from graph. (**Ans. :** 15 min)

(iii) **Speed (magnitude of velocity) of the body in motion can be determined by determining slope of the line obtained in distance-time graph of a body having uniform motion.**

To determine speed of the bus from graph shown in fig. 1.11 consider any part PQ of the graph. Draw perpendiculars, from both the points P and Q, on X-axis and Y-axis respectively. Here the bus travels distance TU in time period RS.

$$\text{Speed of bus} = \frac{TU}{RS} = \frac{(s_2 - s_1)\text{km}}{(t_2 - t_1)\text{ min}} = \frac{\Delta s}{\Delta t}$$

This ratio is called the slope of distance-time graph.

$$\therefore \text{ Speed} = \frac{(20 - 10)\text{ km}}{(40 - 20)\text{ min}} = \frac{10\text{ km}}{20\text{ km}}$$

$$= \frac{10\text{ km}}{20/60\text{ kh}} = 30\ \frac{\text{km}}{\text{h}}$$

Speed of the bus = 30 km/h

When a body performs uniform motion, slope of any part of the graph is same.

Activity 4 : Bharti and Sonal are going to school on their bicycles with uniform velocities. Bharti leaves home at 7:00 am and Sonal at 7:10 am and travel on the same path. Data about their distance travelled at different time are given in table.

Table 1.2

	Time(hour) am	7:00	7:10	7:20	7:30	7:40
Bharti	Distance Travelled	0 km	1.5 km	3.0 km	4.5 km	6.0 km
Sonal	Distance Travelled	-	0 km	3.0 km	6.0 km	-

(i) Plot distance – time graph for the motion of both bicycles on the same graph paper.

(ii) Decide, from the graph, whose speed is more, speed of Bharti or speed of Sonal ?

(iii) Where (distance) and when will Sonal and Bharti meet each other ?

(iv) Who would reach early, Bharti or Sonal ?

(2) Velocity-time graph and its uses

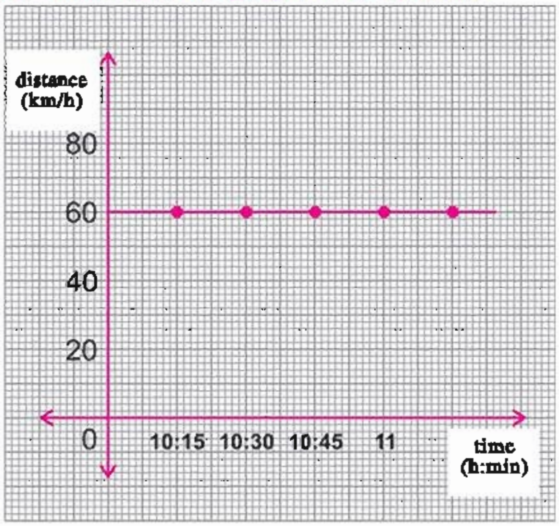


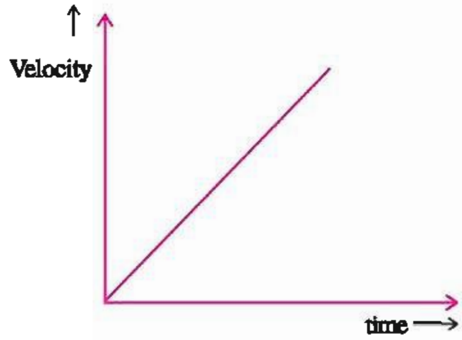
Figure 1.12 Velocity-time graph for uniform motion

(i) Velocity-time graph enables us to know whether the motion is uniform motion or non-uniform motion. Graph for uniform motion is parallel to time-axis (x-axis) (See fig. 1.12.)

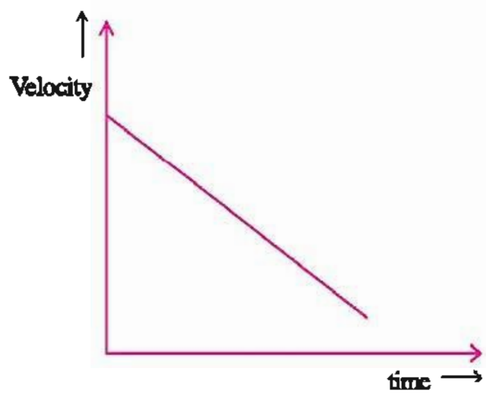
If velocity-time graph, instead of being parallel to x-axis, is found to be any of the shapes shown in fig. 1.13 (a, b, c) or any other shape, the motion of the body is said to be non uniform.

(ii) Information about changes in magnitude of velocity can be obtained from velocity-time graph. In this graph magnitude of slope of graph shows the acceleration.

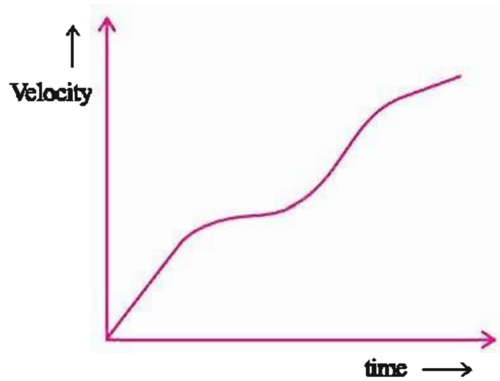
Here graph in fig. 1.13 (a), shows that there is continuous increase in velocity, i.e. motion of the body is accelerated motion.



(a) Uniform acceleratal motion



(b) Uniform retarded motion



(c) Non-uniform accelerated motion

Figure 1.13 Velocity-time graph for objcet in motion

(iii) From velocity-time graph of an object distance travelled by a body in certain time can be determined. **For any body in motion, distance travelled by a body in given time interval is equal to the area enclosed by the graph.** Let us understand this by an example.

Illustration 8 : Velocity of a vehicle moving along a straight path changes as shown in the fig. 1.16. Find initial acceleration, final acceleration and the total distance travelled.

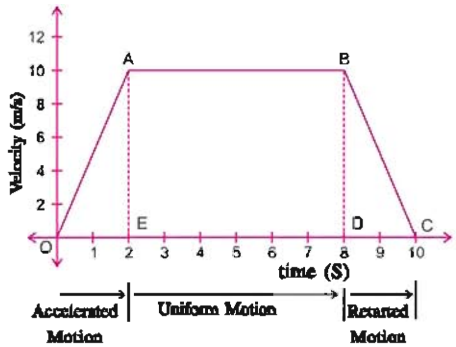


Figure 1.14 Graph of Velocity – time

Solution : First of all we will calulate initial aecleration,

$u = 0$ m/s, $v = 10$ m/s, $t = 2$ s

$$\therefore a = \frac{v - u}{t} = \frac{10 - 0}{2} = 5 \text{ m/s}^2$$

Retardation in final stage

$u = 10$ m/s, $v = 0$ m/s, $t = 2$ s

$$\therefore a = \frac{v - u}{t} = \frac{0 - 10}{2} = -5 \text{ m/s}^2$$

Total distance travelled by the vehicle

= Area of trapezium OABC

= Area of Δ AEO + Area of rectangle ABDE + Area of Δ BDC

$= (\frac{1}{2} \times OE \times AE) + (AE \times AB) + (\frac{1}{2} \times DC \times BD)$

$= (\frac{1}{2} \times 2 \times 10) + (10 \times 6) + (\frac{1}{2} \times 2 \times 10)$

$= 10 + 60 + 10 = 80$ m

Illustration 9 : For two cars A and B in motion distance–time graph is shown in fig. 1.15.

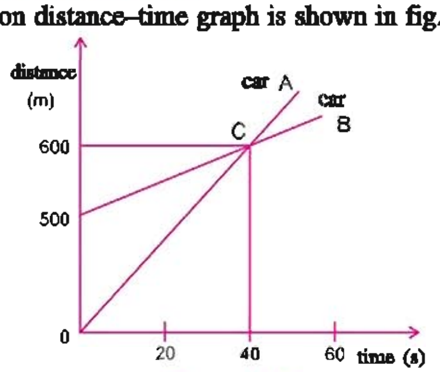


Figure 1.15

(a) State initial positions of car A and car B.

(b) When and at how much distance from the origin, these two cars would meet ?

(c) Final speed of car A and car B.

Solution :

(a) Initial position of car A is origin O and car B is at 500 m distance from origin at that time.

(b) Graphs for both the cars intersect each other at point C. Co-ordinates of C are (40 s, 600 m) i.e. both the cars would meet each other after 40 s at a distance of 600 m from origin.

(c) Speed of car A = $v_A = \frac{\text{Distance}}{\text{Time}} = \frac{600 - 0}{40 - 0}$

$= 15$ m/s

Speed of car B = $v_B = \frac{\text{Distance}}{\text{Time}} = \frac{600 - 500}{40 - 0}$

$= 2.5$ m/s

1.9 Equations of Uniformly Accelerated Motion

Suppose a body is travelling with uniform acceleration along a straight path.

Its initial velocity at time t = 0 is u, at its final velocity at t = t is v.

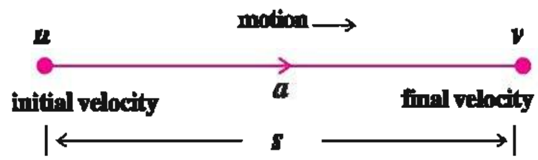


Figure : 1.16

As per definition of acceleration,

$$a = \frac{v - u}{t}$$

$\therefore at = v - u$

So, $v = u + at$ 1.9.1

Now distance travelled by the object

= Average velocity × time

$$s = \frac{u + v}{2} \times t$$

substituting value of u from eq. 1.9.1

$$= \frac{1}{2}(u + u + at) \times t$$

$$= \frac{1}{2}(2u + at) \times t$$

$$s = ut + \frac{1}{2}at^2 \quad 1.9.2$$

Squaring both the sides of equation 1.9.1

$v^2 = (u + at)^2$

$v^2 = u^2 + 2uat + a^2t^2$

$v^2 = u^2 + 2a\,(ut + \frac{1}{2}at^2)$

$v^2 = u^2 + 2as$ (From eq.1.9.2)

or $v^2 - u^2 = 2as$ 1.9.3

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Equations (1.9.1), (1.9.2) and (1.9.3) are known as equations of motion. **Remember, if body has retarded motion, consider negative value of 'a' in the above equations and then calculate.**

Illustration 10 : A stationary train, when starts motion, acquires velocity of 72 km/h in 5 minutes. Motion of train is uniformly accelerated motion (i) Calculate acceleration of train in 5 min. (ii) Calculate distance travelled by train in 5 min.

Solution :

$u = 0$ m/s

$$v = \frac{72\text{ km}}{\text{h}} = \frac{(72 \times 1000)\text{ m}}{3600\text{ s}} = 20\text{ m/s}$$

$t = 5$ minutes $= 5 \times 60 = 300$ s

(i) Acceleration of the train

$$a = \frac{v-u}{t} = \frac{(20-0)\text{ m/s}}{300\text{ s}} = \frac{1}{15}\text{ ms}^{-2}$$

(ii) Distance travelled by the train,

$$s = ut + \frac{1}{2}at^2$$

$$= (0 \times 300) + \frac{1}{2} \times \frac{1}{15} \times (300)^2$$

$= 3000$ m

$= 3$ km

or,

$$s = \frac{v^2 - u^2}{2a}$$

$$= \frac{(20)^2 - (0)^2}{2 \times \frac{1}{15}}$$

$$= \frac{400 \times 15}{2}$$

$= 3000$ m $= 3$ km

Illustration 11 : When brakes are applied to a car running on a straight road retardation of 4 m/s^2 is produced. It stops after 3 s. Calculate the distance travelled after brakes are applied.

Solution :

$a = -4\text{ m/s}^2$ $t = 3$ s

$v = 0$ m/s $u = ?$ $s = ?$

$v = u + at$

$u = v - at$

$= 0 - (-4\text{ m/s}^2)(3\text{ s})$

$\therefore = 12$ m/s

Thus car was running at 12 m/s when brakes were applied. Distance travelled after brakes are applied.

$$s = ut + \frac{1}{2}at^2$$

$$= (12 \times 3) + \frac{1}{2}(-4)(3)^2$$

$= 36 - 18$

$s = 18$ m

Thus car will travel 18 m after applying brakes and then it will stop.

Now do you understand why some minimum distance is desired between the moving vehicles ?

Illustration 12 : A scooterist, in moving with speed at 36 km/h sees an obstacle, 35 m away from him. When brakes are applied retardation of 2 m/s^2 is produced. Would he be able to avoid the accident ?

Solution :

$$u = 36\text{ km/h} = \frac{36 \times 1000\text{ m}}{3600\text{ s}} = 10\text{ m/s}$$

Suppose scooter stops after travelling a distance s. Thus final speed of the scooter is 0

$\therefore v = 0, a = -2\text{ m/s}^2, s = ?$

$2as = v^2 - u^2$

$$\therefore s = \frac{v^2 - u^2}{2a}$$

$$= \frac{0 - (10)^2}{2(-2)} = \frac{0 - 100}{-4} = 25\text{ m}$$

Thus scooter would travel 25 m and obstacle is 35 m away, so accident would be avoided.

1.10 Derivation of Equation of Uniformly Accelerated Motion Using Graph

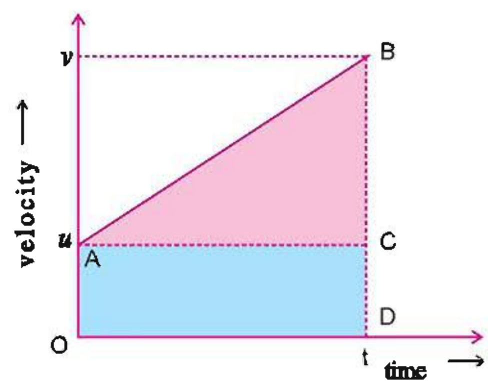


Figure 1.17 Derivation of equations of uniformly accelerated motion using graphical method

Suppose an object is moving with uniform acceleration a. At time $t = 0$ its velocity is u and at time $t = t$, its velocity become v. Velocity–time graph is shown for an object in motion in fig. 1.17.

As per definition of Acceleration,

$$a = \frac{v - u}{t}$$

$\therefore$ $at = v - u$ 1.10.1

or $v = u + at$ 1.10.2

Now distance (s) travelled by the object in time 't' is equal to area A B C D O enclosed below velocity–time graph in this time-interval.

$\therefore$ s = Area of region ABCDO

= Area of rectangle ACDO + Area of Δ ACB

$$= (OA \times OD) + (\frac{1}{2} \times AC \times BC)$$

$$= ut + \frac{1}{2}(t)(v - u)$$

$\therefore$ $s = ut + \frac{1}{2}at^2$ (from eq. 1.10.1) 1.10.3

Now distance = average velocity × time

But, average velocity = $\frac{v + u}{2}$

and from equation 1.10.2, $t = \frac{v - u}{a}$

$\therefore$ From equation 1.10.4

$$\text{distance, } s = \frac{v+u}{2} \times \frac{v - u}{a}$$

$$= \frac{v^2 - u^2}{2a}$$

or $2as = v^2 - u^2$ 1.10.4

Equation 1.10.2, 1.10.3 and 1.10.5 are the equations of uniformly accelerated motion.

1.11 Uniform Circular Motion

If a body performs motion with constant speed along a circular path, its motion is called uniform circular motion.

Here, note that speed (the magnitude of velocity) remains constant, not velocity. Direction of velocity of a body in uniform circular motion, is different at each point on the circular path. On the circular path at any point velocity is in the direction of the tangent drawn at that point. (A line lying in the plane of the circle if intersects circle at only one point, the line is known as a tangent to the circle at that point. Line segment joining the centre of the circle and the point of contact of tangent and circle, is always perpendicular to the tangent).

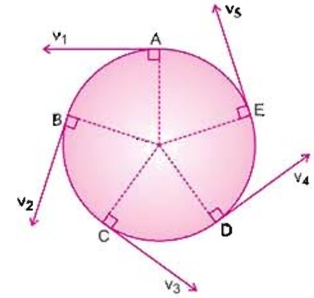


Figure 1.18 Unifom circular motion

As shown in the Fig. 1.18, consider a body performing uniform circular motion along the circle of radius 'r' in anticlock wise direction. When this object is on points A, B, C, D and E, directions of its velocities are shown. Here, note that the direction of velocity is different at different points but as it performs uniform circular motion, speed is constant.

$$v_1 = v_2 = v_3 = ...v_5 = v$$

If the body completes one revolution along circular path in time *t*, its speed can be determined as follows :

$$v = \frac{\text{Distance travelled}}{\text{Time}}$$

$$= \frac{\text{Length of the curcular path}}{\text{Time}}$$

$$v = \frac{\text{Circumference}}{\text{Time}} = \frac{2\pi r}{t} \qquad 1.10.5$$

Here v is also known as linear speed of the body performing uniform circular motion.

Can uniform circular motion be considered to be motion with uniform velocity ? (Think over, please!) Remember, here magnitude of the velocity remains constant, but the direction of the velocity constantly changes. So in fact **uniform circular motion is accelerated motion.**

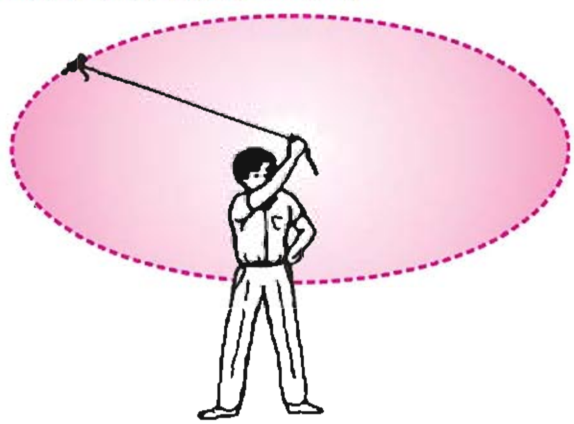


Figure 1.19 A Stone moving along a circular path with constant speed.

Activity 5 : Take a string and tie a stone at its one of the ends (Of course firmly !) Hold its second end in your hand and whirl it so that the stone performs circular motion. Be careful so that its speed remains constant. So motion of the stone is uniform circular motion.

Now if you want to know the direction of its velocity at a point, release it at that point, and observe the direction in which it goes. (Carry out this activity in open ground with nobody nearby, please !) Repeat this action four/five times. You might have observed that the stone travels in different directions every time. Also its direction is along the tangent drawn at a point on circular path from where it is released. Also, after it is released, it travels along a straight line. Thus direction of velocity keeps changing every moment in case of uniform circular motion.

Illustration 13 : Orbit of an artificial satellite at distance 42260 km from earth is circular. It completes 1 revolution around the earth in 24 hours. Calculate its linear speed. ($\pi = 3.14$)

Solution :

r = 42,260 km, t = 24 h

$$\text{Linear speed} = v = \frac{2\pi r}{t} = \frac{2 \times 3.14 \times 42260}{24}$$

$$= 11{,}058 \text{ km/h}$$

What have we learnt ?

- If position of a body changes with time the body is in motion, else it is stationary. Description of state of motion of a body depends on the place from where the observation is made.
- Length of path of motion of a body in given time is known as distance or path-length.
- Change in position of the body in definite direction in given time-period is called displacement.

  Displacement indicates the shortest distance between the initial position and final position.
- If a body in motion covers equal distance in equal interval of time, the body is said to have uniform motion. Velocity of such a body is constant.
- Distance travelled by a body in motion in unit time is called speed of the body. Its SI unit is m/s or ms^{-1}.
- Displacement of a moving body in unit time is called velocity of the body. Its SI unit is m/s or ms^{-1}. Velocity is a vector quantity. It is in the direction of displacement.
- Rate of change in velocity is known as acceleration. Its SI unit is m/s^2 or ms^{-2}. If this rate of change is negative it is retardation or deceleration.
- Equations of uniformly accelerated motion.

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

$$2as = v^2 - u^2$$

- Slope of distance-time graph gives speed or magnitude of velocity
- Slope of velocity-time graph gives magnitude of acceleration. Area enclosed by graph, time-axis and time limits give distance.

EXERCISE

1. Select the proper choice from the given multiple choices :

(1) For which of the following physical quantities it is necessary to indicate direction along with its magnitude ?

(A) Speed (B) Path-length (C) Displacement (D) Temperature

(2) A sprinter completes a round on a circular path of circumference 400 m, what is his displacement ?

(A) 400 m (B) 200 m (C) 100 m (D) zero

(3) Constant speed of a train is 54 km/h. What is its speed in unit 'm/s' ?

(A) 15 (B) 90 (C) 1.5 (D) 9

(4) A scooterist travels at 30 km/h along a straight path for 20 min. How much distance has he travelled ?

(A) 1.5 km (B) 6 km (C) 10 km (D) 90 km

(5) A cyclist travels 5 km in the east direction. Then he travels 12 km in the south direction. What is the magnitude of displacement of the cyclist ?

(A) 17 km (B) 13 km (C) 7 km (D) zero

(6) If velocity–time graph for a body in motion is a straight line parallel to time axis, what type of motion is the body performing ?

(A) body would be stationary (B) non-uniform motion

(C) motion with constant acceleration (D) motion with constant velocity

(7) Which type of motion is described by a graph in Fig. 1.20 ?

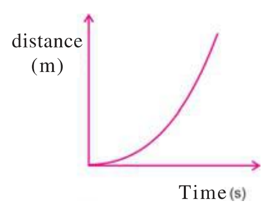


Figure 1.20

(A) uniform motion

(B) uniformly accelerated motion

(C) non-uniform accelerated motion

(D) body is stationary

(8) Velocity of a vehicle increases from 5 m/s to 15 m/s in 5 s. What is the magnitude of acceleration ?

(A) 4 m/s^2 (B) 4 m/s (C) 2 m/s (D) 2 m/s^2

(9) Velocity–time graphs for vehicles A and B are shown in Fig. 1.21. Which vehicle has accelerated motion and which vehicle has retarded motion ?

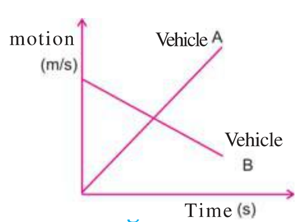


Figure 1.21

(A) Vehicle A - retardation, vehicle B–acceleration

(B) Vehicle A-acceleration, vehicle B–retardation

(C) Both vehicles A and B–acceleration.

(D) Both vehicles A and B–retardation.

(10) Accelaration of a car in motion is 1.5 m/s^2. How much is the increase in velocity in 4 s ?

(A) 6 m/s (B) 4 m/s (C) 3 m/s (D) 2.66 m/s

2. Answer the following questions in short :

(1) What is displacement of a body in motion, in unit time called ?

(2) Give the SI unit of acceleration.

(3) What is change in velocity of a moving body in unit time called ?

(4) If final velocity of a moving body is less than its initial velocity, what type of motion its body is performing ?

(5) What type of distance-time graph is obtained for a body having uniform motion ?

(6) What is the type of motion of a body performing uniform circular motion ?

(7) Can average speed of a body in motion be non-zero ? Can its average velocity be zero ?

(8) Give an example of retarded motion.

3. Answer the following questions in detail :

(1) Explain uniform and non-uniform motion.

(2) Distinguish between distance and displacement.

(3) Explain average speed.

(4) State differences : Speed and Velocity

(5) State differences : Acceleration and Retardation

(6) Derive the equations of uniformly accelerated linear motion using algebraic method.

(7) Explain uniform circular motion.

(8) State uses of velocity–time graph for a moving body.

4. Solve the following examples :

(1) Ramesh goes for morning walk along a semicircular path of 100 m radius. He starts from eastern end and reaches western end. Calculate the distance travelled by him and his displacement.

(**Ans. :** Distance = 314 m. Displacement = 200 m from east to west direction)

(2) Sprinter runs 100 m distance in 10 s. Find his average speed in m/s and km/h. (**Ans. :** 10 m/s, 36 km/h)

(3) A moving body travels distance s with constant speed v_1 and travels distance s with uniform speed v_2. prove that his average speed is $\frac{2v_1 v_2}{v_1 + v_2}$

4) A vehicle, on straight path, covers some distance in 15 min with uniform speed 48 km/h and remaining distance in 15 min at uniform speed 56 km/h. Calculate average speed of vehicle. (Ans. : 52 km/h)

(5) Kalpesh, before going out, takes the reading of odometer of his motorcycle. It was 8,245 km. Driving at uniform velocity of 60 km/h for 30 min on a straight highway, he reaches his friend's village. What would be the odometer reading of his motorcycle there ? (Ans. : 8275 km)

(6) Velocity of a car moving with 72 km/h reduces to 18 km/h in 10 s. Find its retardation. (Ans. : 1.5 m/s^2)

(7) Retardation produced, due to brakes, in a moving train is 0.5 m/s^2. Train stops after 40 s after application of brakes. If train is to stop on a certain place on platform, what should be the distance from platform, of a place where brakes are applied ? (Ans. : 400 m)

(8) A cyclist performs motion with constant speed on a circular path of riding 66 m. If he takes 132 s to complete one round, calculate his average speed.

(Ans. : 3.14 m/s)

(9) For a particle in motion distance-time graph is shown in figure 1.22. From graph answer the following : (i) During which time period particle is stationary ? (ii) Find magnitude of velocity in OA, AB and BC parts.

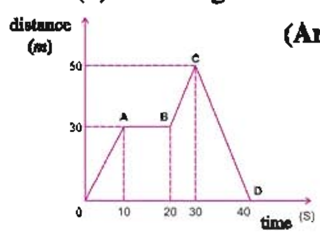


Figure 1.22

(Ans. : (i) Particle is stationary during time 10 s to 20 s)
(ii) Velocity in OA part = 3 m/s
Velocity in AB part = 0 m/s
Velocity in BC part = 2 m/s)

(10) For moving train velocity-time graph is shown in the Fig. 1.23

(i) What is the maximum speed of the train and how long it is maintained ?

(ii) What are the accelerations in OA AB and BC part ?

(iii) Find total distance travelled by the train.

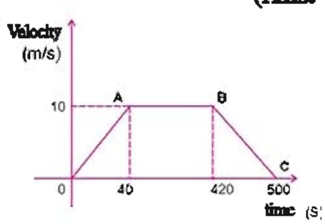


Figure 1.23

(Ans. : (i) Maximum speed 10 m/s. It is maintained from t = 40 s to t = 420 s i.e. for 380 s
(ii) Acceleration in OA part = 0.25 ms^{-2}
Acceleration in AB part = 0
Retardation in BC part = 0.125 ms^{-2}
(iii) Total distance = 4.4 km)

2 Force and Laws of Motion

2.1 Introduction

In Chapter-1 we have studied about physical quantities like distance, displacement, velocity and acceleration in order to describe motion of an object. During this study we did not bother about the reasons due to which body comes into motion or why changes in motion occurred ? In this chapter we shall discuss motion of the body, reasons for motion and properties of a body which is in motion. For this first of all we will study effect of force on the body. We shall study the thoughts of Galileo and Aristotle about motion, law of inertia, and Newton's laws of motion. In the end we shall study Archemede's principle and relative density.

2.2 Effect of External Force on State of A Body

In routine we experienced that when a stationary body is pushed, it comes into motion. When brakes are applied to a bicycle it comes to rest. In order to bring body into motion, it is to be pushed, pulled or kicked. All these actions are based on concept of force. Now question arises 'What is force ?'. Actually force cannot be seen but its effects can be experenced.

Figure 2.1 Pushing, pulling or hitting objects change their state of motion

When external force is applied on a body, effects seen in the state of body, are as follows :

(i) **Shape of the body changes :** For example, when spring is stretched there is increase in its length. Inflated balloon is pressed between two palms, its shape changes.

(ii) **Position of the body changes :** For example, when a book lying on a table is pushed, it moves, its position changes.

(iii) **State of motion of body changes :** A stationary body can be brought in motion and a body in motion can be brought to halt. For example, when a stationary ball is hit by a bat it comes in to motion and a moving car on application of brakes comes to halt.

(iv) **Velocity of a moving body changes :** When force acts on it, its velocity increases or decreases or direction of its velocity changes. For example, when a cricketer hits a 'six' there is increase in velocity of the ball and direction of velocity of ball also changes.

In this discussion we have seen that in order to bring a stationary body into motion or to bring a moving body to halt contact with the body is necessary. Such forces are called **contact forces.**

Activity 1 : Spread some iron-pins on a wooden table. On the same table place a magnet near pins. Observe pins. Do pins remain stationary or they come in to motion ? Why pins move towards the magnet even though there is no contact between pins and the magnet ? Think.

Activity 2 : Toss a ball in air. Observe its motion. Observe the time periods in which there is increase in velocity and decrease in velocity. Why there is a change in velocity of the ball ?

Discuss both the activities, given above, with your friend.

In both the cases discussed above, the object experiences force without contact. Such a force is called **field force.** In the first case iron pins experience the force due to magnetic field of the magnet. In the second case gravitational force of the earth acts on the ball.

2.3 Balanced and Unbalanced Forces

Activity 3 : As shown in figure 2.2, put a wooden block on smooth surface of a table. Fix hooks on both the sides of the block and tie strings A and B.

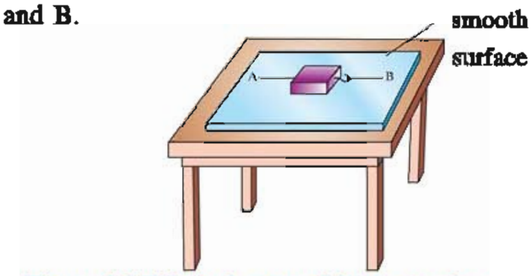


Figure 2.2 Effect of external forces on the wooden block

(i) Pull end A of the string tied to the block, observe, what happens ? Block moves towards left. Now, when you pull B end of the string, block moves towards right. Thus, due to application of one force, block comes in motion from stationary state.

(ii) Now what would happen, if A end of the string is pulled with more force compared to B end of the string ? Here, under the effect of resultant force of the two forces, block moves towards left. In this case forces acting on the block are said to be unbalanced forces.

(iii) Now pull the strings with equal force applied on both the sides A and B. Does block come in motion ? No, why ? Here while doing this we have applied forces of equal magnitude in opposite directions. Under the effect of these two forces, wooden block remains stationary. In this case forces are said to be balanced forces. Thus balanced forces and unbalanced forces can be defined as follows.

Balanced forces : The forces under whose combined effect there is no change in the stationary state or state of motion of a body, are known as balanced forces.

Resultant force of balanced forces is zero. So, a stationary body remains, stationary and the body in motion retains its motion with constant velocity. Some times under the effect of balanced forces shape of the body may change.

Unbalanced forces : The forces under whose combined effect, a stationary body comes in motion or velocity of a moving body changes. (change in speed or direction or both), are known as unbalanced forces. Resultant force of unbalanced forces is not zero.

2.4 Aristotle's Thought About Motion

Greek philosopher / thinker (384 B.C. – 322 B.C.) believed that if motion of a body is to be maintained, one has to keep applying external force. What made Aristotle to believe so ? Think. He considered some experience in daily life to be a fundamental law of nature, and on the basis of that he gave his thoughts. In order to know about the laws of nature regarding force and motion one has to imagine the situation in which there are no forces opposing motion, like force of friction. Galileo did the same and developed, deep understanding about motion. Today most of Aristotle's thoughts about motion are found to be wrong.

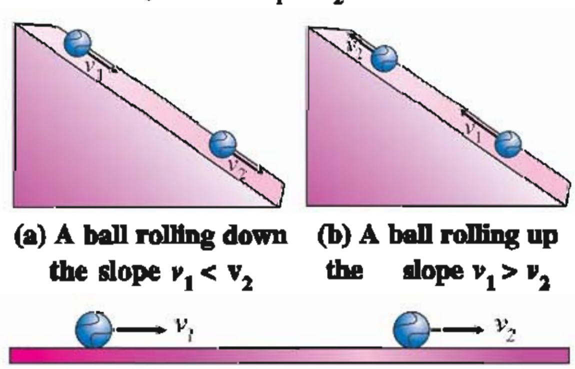
Aristotle Galileo

Figure 2.5 Aristotle and Galileo

2.5 Galileo's Experiments and Law of Inertia

Galileo (1564 AD to 1642 AD) performed experiments for motion of a body on a slope. From the observations of his first experiment he noted.

(i) When a ball moves downwards its velocity increases i.e. ball has an accelerated motion. (See fig. 2.4 (a)($v_1 < v_2$).



(a) A ball rolling down the slope $v_1 < v_2$ (b) A ball rolling up the slope $v_1 > v_2$

(C) A ball moving on the horizontal frictionless surface, $v_1 = v_2$

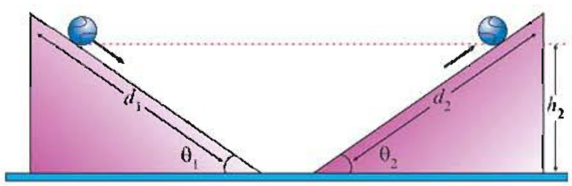
Figure 2.4

(ii) When the ball moves, upward on a slope, its velocity decreases. i.e. ball has the retarded motion (See fig. 2.3(b) ($v_1 > v_2$)).

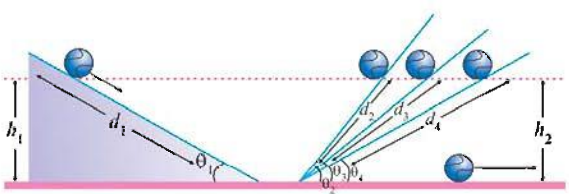
(iii) From the two observations made above Galileo inferred that if a body is moving on a frictionless horizontal plane surface, there might not be any change in its speed. It should keep moving with constant velocity. (See fig. 2.4 (c), $v_1 = v_2$).

Galileo stated, on the basis of his observations of this experiment, that in order to maintain motion with constant velocity external force is not needed.

Later Galileo used frictionless slopes to study the motion of ball on them. His observations were as follows :



Galileo's experiment of two slopes
Figure 2.5



Galileo's experiment of slopes at different angles
Figure 2.6

(i) If a ball is allowed to move down from one slope, it attains almost the same height on the other slope. Since slope angles are same here ball travels equal distances on both the slopes. In this case $\theta_1 = \theta_2$, $d_1 = d_2$ and $h_1 = h_2$. Here angles θ_1 and θ_2 are known as angles of inclination of slopes (Angle made by slope with horizontal surface)

(ii) Keeping angle of inclination constant for the first slope if angle of inclination of the second slope is reduced, yet ball acquires the same height on the second slope. But it travels larger distance on the second surface

(See figure 2.6 $\theta_4 < \theta_3 < \theta_2 \Rightarrow d_4 > d_3 > d_2$ all time $h_1 = h_2$.)

From these observations Galileo inferred that if the angle of inclination of the surface is made zero then ball will continue its motion on frictionless surface for infinite distance. This is an ideal situation. Proving Aristotle to be wrong, on the basis of such experiments Galileo said that in order to change velocity of a body, unbalanced external forces are required, but in order to maintain the motion with constant velocity no unbalanced external force is required.

As a result of Galileo's logical and revolutionary thoughts, development of classical mechanics started. Its base is formed by three laws of motion given by Sir Issac Newton (1642 AD – 1727 AD).

When does a stationary body come into motion ? What is meant by a force ? Answers to such questions are obtained from Newton's first law of motion.

2.6 Newton's First Law Of Motion

Newton's first law of motion is as follows :

An object at rest or in uniform motion will remain at rest or in uniform motion unless an unbalanced force acts on it.

Thus unless an unbalanced force acts on a body, it tries to maintain its state of motion, either steady state or state of motion with constant velocity. Such a property of a body is called **intertia.** Word inertia has its roots in Latin word 'inert'. 'Inert' means the one which cannot be changed. **The property of a substance able to which it opposes the charge in its state of motion is called as inertia.** Newton's first law of motion is Galileo's law of motion.

In our daily life we experience the effect of inertia. When you are standing or sitting in a bus, what happens when bus starts its motion all of a sudden ? You lean backwards with jerk. This phenomenon can be explained by Newton's first law. Initially you and bus both were stationary. When bus comes in to motion, your seat (if you are standing on your feet) comes in to motion but upper part of your body opposes this move to go in state of motion from stationary state, due to inertia and tries to remain stationary. So you lean backward. Phenomenon just opposite to this also takes place. When bus is moving if brakes are applied all of a sudden passengers lean forward. Why fastening of seat belt is insisted in cars or planes, you could have understood now.

If a person tries to alight from a movning bus he falls. His body is also in motion along with bus. When he puts his feet on stationary earth his feet come to rest; but upper part of his body tries to be in motion due to inertia, and person pulls forward. If he/she walks faster then after alighting from bus he/she can be saved from this situation.

Activity 4 : Have you ever tried to stop running ? While running can you remain stationary ? Why does sprintler continues to run even after crossing a 'Finish' line ? Why dust particles are separated when a quilt is beaten by a stick ? Why fruits fall down when the tree is shaken ?

Try to get answers to these questions on the basis of law of inertia.

Activity 5 : Put a card paper on a glass as shown in the Fig. 2.7 (used card can be used). Put a 5 rupee coin on it. Now push the card paper

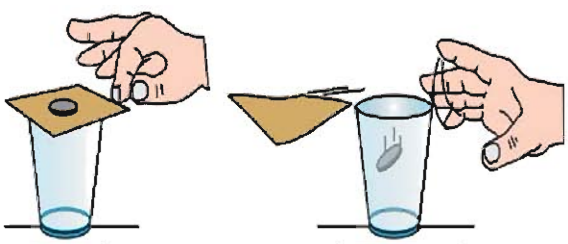


Figure 2.7 Intertia of a coin

horizontally. What happens ? On pushing paper coin falls in the glass. Why ? Initially both card paper and coin were at rest. When card paper is pushed, it comes in motion. But coin tries to maintain its state of rest. So when it loses the support of paper, it falls in the glass.

Activiby 6 : You would be playing carrom. Fill up of a stack four-five carrom coins in the middle and flick the striker to the lowest coin, what happens ? You must have observed that the coin at bottom only comes in motion. Other coins remain stationary due to inertia (see figure 2.8)

Figure 2.8 Intertia of a coin of carrom

Inertia and mass : In the discussion, so far we have seen that each object tries to maintain its original state. This property of the substance is known as inertia. Is inertia of each object same ?

We know that it is easier to move an empty box compared to a box filled with books. Football when kicked, it goes far away. But with the same force if you kick a large stone what will happen ? Perhaps it would not move even. What will happen if the force applied to drive the train is equal force which is just enough to drive a bicycle ? In all three cases heavier bodies like box filled with books, stone or train maintain their state due to larger inertia. Light bodies have less inertia so their state of motion can be changed easily. Thus **mass of the body indicates measure of its inertia.** A body with larger mass has larger inertia and a body with less mass has less inertia.

Remember : Newton's first law gives definition of force which is as follows :

"The external effect which can change the state of motion or steady state of a body is called force."

2.7 Newton's Second Law of Motion

Before understanding Newton's second law of motion, let us understand one important physical quantity momentum. For this let us understand some examples.

(i) Suppose two vehicles, one light (like bicycle) and other heavy (like truck) are moving with equal velocities. Our experience says that we have to use less force to stop bicycle whereas for truck we need to apply more force to stop.

(ii) Take a very light stone and throw it towards glass plate. Now with same velocity throw a larger stone towards glass plate. What is the result seen ? There is no effect of very light stone whereas due to heavy stone more force is applied on the glass and it breaks.

From both the examples discussed above it is clear that force depends on the mass of the object.

(iii) You must have enjoyed bursting balloons using a gun in a fair. Here in the gun small green grams are used as bullets. If you throw a green grams by your hand towards the balloon, balloon would not burst. But the same green gram is fired from gun it bursts balloon. Why did balloon burst here ? Due to green gram ? Due to velocity of green gram ? In fact velocity of a green gram shot from a gun is very high, due to which a balloon bursts.

From all these examples you must have understood that in the study of motion and force, mass of the body and its velocity have equal importance. The physical quantity relating these two physical quantities is momentum. This physical quantity gives as additional information.

Momentum : The product of mass of an object and its velocity is called momentum of the object

Momentum = mass × velocity

$p = mv$ 2.7.1

Momentum is a vector quantity. Direction of momentum is in the direction of velocity SI unit of momentum is kg m/s.

Suppose you are driving a car. In order to stop the car, if you apply brake slowly, (Here force applied is less) velocity of car will reduce slowly and it will come to halt after some time. If you want to stop car immediately, you have to apply brakes with larger force. Here large force is applied and car will stop soon. In both the cases initial momentum of car is mv and final momentum is zero. This means change in momentum is same. But in the second case the change is to be done rapidly, so larger force was applied.

Thus force is related to change in momentum and time taken for it, and this relation is obtained from Newton's second law of motion, which is given below.

The time rate of change in momentum is directly proportional to the resultant of external force and change in momentum is in the direction of the resultant external force.

Suppose initial velocity of an object with mass m is u, and under the influence of some force F, after time t, its velocity becomes v then,

Initial momentum of the object

$p_i = mu$ 2.7.2

Find momentum of the object

$P_f = mv$ 2.7.3

∴ The change in momentum in time t

$$\Delta p = p_f - p_i$$

∴ As per Newton's second law of motion,

$$F \propto \frac{\Delta p}{t}$$

$$\propto \frac{p_f - p_i}{t}$$

$$\propto \frac{mv - mu}{t}$$ (from equation.2.7.2 and 2.7.3)

$$\therefore F = K\frac{m(v-u)}{t}$$

But according to definition of acceleration.

$$\frac{(v-u)}{t} = a$$

$F = Kma$ 2.7.4

Here unit of force is selected in such a way that value of proportionality constant K can be taken to be 1

∴ $F = ma$ 2.7.5

Thus force = mass × acceleration

Thus as per Newton's second law of motion :

"External force acting on a body is equal to product of mass and acceleration of the body."

Thus, Newton's second law of motion gives magnitude of force.

Force is a vector quantity and it is in direction of acceleration. SI unit of force is obtained from SI units of mass of acceleration.

Unit of force = unit of mass × unit of acceleration

1 newton = 1 kg × 1m/s²

or 1N = 1 kg m/s²

Unit of force is named in memory of Issac Newton (Symbol : N)

1N force can be defined as follows :

The force which can produce acceleration of 1m/s² in a body of mass 1 kg is called 1 newton force.

Unit of force in CGS system is g cm/s² or 'dyne'. Relation between newton and dyne can be obtained as follows :

$$1\text{newton} = 1\frac{\text{kg m}}{\text{s}^2}$$

$$= 1000 \text{ g} \times 100\frac{\text{cm}}{\text{s}^2}$$

$$= 100000 \text{ g cm/s}^2$$

So, 1 newton = 10^5 dyne 2.7.6

Newton's second law of motion is consistent with the first law. When external force acting on the body F = 0, as per F = ma, acceleration of the body is also zero.

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If a body is stationary or it is moving with constant velocity $a = 0$, thus unless external force acts on a body it maintains in stationary state or state of motion, which is Newton's first law of motion. Remember : **In the study of motion, stationary state of a body or state of motion with constant velocity are considered to be equivalent.**

Illustration 1 : A car of mass 1000 kg is moving with 90 km/h velocity and a truck of 6000 kg is moving with 18 km/h velocity. Whose momentum is more ?

Solution :

Truck	Car
m = 6000 kg	m = 1000 kg
v = 18 km/h	v = 90 km/h
$= \frac{18 \times 1000}{3600} \frac{m}{s}$	$= \frac{90 \times 1000}{3600} \frac{m}{s}$
= 5 m/s	= 25 m/s
Momentum of truck	Momentum of car
$p = mv$	$p = mv$
= (1000)(25)	= (6000)(5)
= 25,000 kg m/s	= 30,000 kg m/s

Illustration 2 : Calculate the force necessary to produce acceleration of 3 m/s^2 in a body of 10 kg mass. What will be the value of acceleration if force is doubled ?

Solution :

m = 10 kg, $a = 3\ m/s^2$ F = ?

Force $F = ma = 10 \times 3 = 30$ N

Thus 30 N force is necessary to produce 3 m/s^2 acceleration in a body of 10 kg mass.

If the force is doubled i.e.

$F = 2 \times 30\ N = 60\ N$

Acceleration produced in a body is :

$$a = \frac{F}{m} = \frac{60\ N}{10\ kg} = 6\ m/s^2$$

Illustration 3 : In 4 seconds velocity of a body of mass 50 kg increases from 2 m/s to 10 m/s. Calculate the necessary force ?

Solution :

m = 50 kg, u = 2 m/s, v =10 m/s

t = 4 s F = ?

$F = ma$

$$= m\left(\frac{v-u}{t}\right) = 50\left(\frac{10-2}{4}\right) = 100\ N$$

Illustration 4 : A body of 5 kg mass is moving with velocity 20 m/s. In 5 seconds its velocity is increased to 30 m/s. Calculate change in momentum and hence calculate necessary external force.

Solution :

m = 5 kg, u = 20 m/s, v = 30 m/s

t = 5 s, F = ?

Change in momentum $= p_f - p_i$

$= mv - mu$

$= m(v - u)$

$= 5(30 - 20) = 50$ kgm/s

$$\text{External force, } F = \frac{p_f - p_i}{t} = \frac{50}{5} = 10\ N$$

Illustration 5 : On a stationary body of mass 10 kg, a constant force of 50 N is applied. How much distance would the body travel in 2 s ?

Solution :

m =10 kg, F = 50 N, t = 2 s

From $F = ma$

Acceleration of the body $a = \frac{F}{m} = \frac{50}{10} = 5\ m/s^2$

Distance travelled by a body having uniformly accelerated motion in second t.

$$s = ut + \frac{1}{2}at^2$$

Here body is initially stationary, $u = 0$

$$s = 0 + \frac{1}{2}(5)(2)^2 = 10\ m$$

Illustration 6 : An object of mass 5 kg is moving with velocity 4 m/s. A constant force of 20 N acts on the object. Calculate its velocity after 3 s.

Solution : m = 5 kg u = 4 m/s

F = 20 N t = 3 s

Acceleration of a object from $F = ma$

$$a = \frac{F}{m} = \frac{20}{5} = 4\ m/s^2$$

For a uniformly accelerated object, velocity at time t,

$v = u + at$

$= 4 + (4)(3) = 16$ m/s

Illustration 7 : 12 N force produces 3 m/s^2 acceleration in a body of mass m and produce accleration of 6 m/s^2 in a body mass m_2 . If both the same force is applied after tieing these two bodies together what will be the value of acceleration produced ?

Solution : F =12 N, $a_1 = 3\ m/s^2$, $a_2 = 6\ m/s^2$

$$\text{Mass of object (1) } m_1 = \frac{F}{a_1} = \frac{12N}{3\ m/s^2} = 4\ kg$$

$$\text{Mass of object (2) } m_2 = \frac{F}{a_2} = \frac{12N}{6\ m/s^2} = 2\ kg$$

Mass after tieing them together

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$m = m_1 + m_2 = (4 + 2) = 6$ kg

When 12 N force is applied on mass in acceleration produced in,

$$a = \frac{F}{m} = \frac{12N}{6\,kg} = 2\ m/s^2$$

Illustration 8 : A ball of 150 g is thrown at 20 m/s towards the batsman. He hits the ball in the direction oppsite to intial direction of motion with velocity 25 m/s. If the ball is hit in 0.01 s, calculate change in momentum of the ball and force applied by the batsman on the ball.

Solution : $m = 150\ g = \frac{150}{1000}\ kg = 0.15\ kg$

$u = 20$ m/s, $v = 25$ m/s, $t = 0.01$ s

Initial momentum of the ball

$p_i = mu = (0.15)(20) = 3$ kgm/s

Final momentum of the ball after being hit

$p_f = mv = (0.15)(-25) = -3.75$ kgm/s

Here negative sign indicates that direction of motion of the ball after hitting is opposite to initial direction of motion of the balls.

Change in momentum of the ball

$\Delta p = p_f - p_i = (-3.75 - 3) = -6.75$ kgm/s

So change in momentum of the bat = 6.75 kgm/s

Force applied by the bat,

$$F = \frac{\Delta p}{t} = \frac{6.75}{0.01} = 675\ kg\ m/s^2 = 675\ N$$

2.8 Impulse of Force

Product of force and the time period for which force is acting is called impulse of force.

If, on an object, force F acts for time t.

Then

Impulse of force = force × time

$I = F \times t$

$I = F \times t$

$= \Delta p$ 2.8.1

(As per Newton's second law of motion)

Like force, impulse of force is also a vector quantity. Direction of impulse of force is same as the direction of force. Unit of impulse of force is kg m/s or Ns.

It is clear from Newton's second law that the force acting on a body depends on the change in momentum of the body and the time in which this change taken place. Let us understand this through an example.

We know that cricketer pulls his hands backwards while catching the ball. When he does so, momentum of the ball reduces slowly, and time t required for this increases. As per $F = \frac{\Delta P}{t}$, as t increase, magnitude of F decreases. As a result cricketer can catch the ball, easily, without any injury.

A karate player in order to break a brick, hits it quickly, so in a short time there is a large change in momentum and as per $F = \frac{\Delta p}{t}$ as large force acts on the brick and it breaks.

Before catch After catch

Figure 2.9

2.9 Newton's Third Law of Motion

Newton's third law of motion is stated below :

During interaction between two bodies the force exerted by the first body on the second body is equal and opposite to that exterted by second body on the first body.

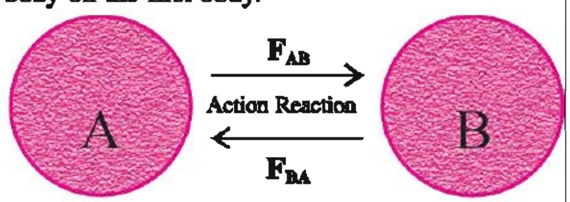

Figure 2.10 Action and Reaction

Press a spring by your hand. You would feel that the spring applies the force in opposite direction. Thus during interaction of two bodies A and B, if force exerted by body A and body B is F_{AB} and force exerted by body B on body A is F_{BA} as per Newton's third law.

$$F_{AB} = -F_{BA}$$

If we call F_{AB} 'action' then F_{BA} is called 'reaction'. Here any of the two can be called action, and the other would be reaction.

Newton's third law of motion can also be stated as follows. **Action and reaction are equal in magnitude and are in opposite direction.**

Here, action and reaction are acting at same time on different objects. According to Newton's third law single force does not exist. Forces are always in pair. In order to understand this let us consider some examples

(i) A book lying on a table exerts force equal to its weight (W) on the table; which can be considered to be action. But due to this force book does not move downwards. So there should be a force balancing this force such that effective force is zero. This is possible only if table applies reaction force (R) equal to weight of the book in opposite direction (upwards) $R = -W$. This proves that action and reaction are of equal magnitude and are in opposite direction.

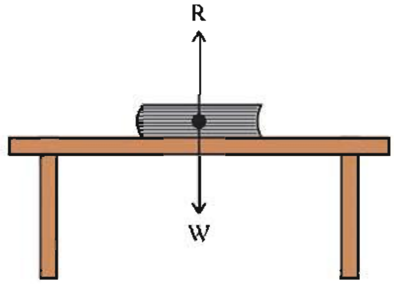

Figure 2.11 Action and Reaction forces

(ii) When a person walks then force is applied by his feet on the soil which can be considered to be action. At the same time force of reaction is applied on his feet by the soil, due to which the person can walk ahead.

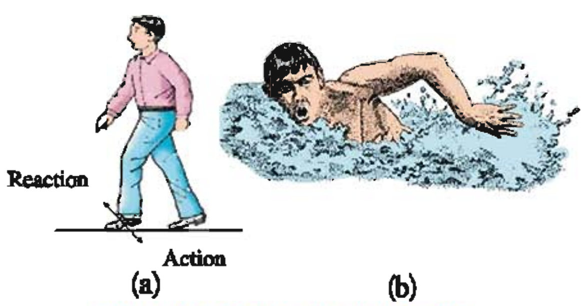

Figure 2.12 Practical examples of the Newtons third law of motion

(iii) A swimmer pushes water backward by his hands and he moves forward.

(iv) Gas produced due to combustion of fuel in a rocket comes out with tremendous speed from a nozzle, as a result rocket in pushed up.

(v) When a bullet is fired from a gun, bullet goes ahead and gun is pushed backward. Here gun applies force on bullet (Action), whereas the bullet applies equal force (reaction) in backward direction.

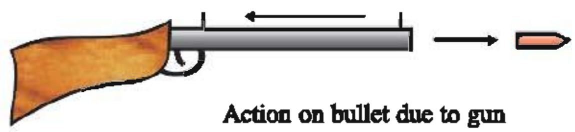

Figure 2.13 Action acting on bullet and reaction acting on gun

Activity 7 : Take a large balloon. Inflate it and tie its opening by a thread. Now take a piece of a straw and fix it on balloon using plastic gum-tape. Pass a thread through the straw and tie it with wall as shown in figure.

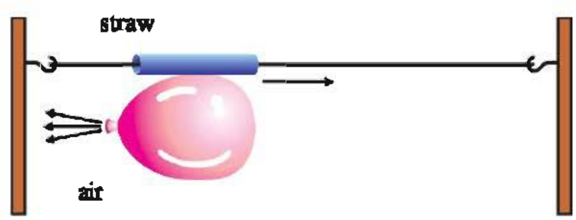

Figure 2.14 Motion of a balloon

Now remove the thread from its opening. Air will come out of the balloon. Observe motion of the balloon. Discuss with your friends how Newtons third law is used here.

2.10 Law of Conservation of Momentum

Suppose masses of two moving balls A and B are m_1 and m_2 and having initial velocities are u_1 and u_2. Here $u_1 > u_2$. Suppose during their interaction they collide near point O at time t.

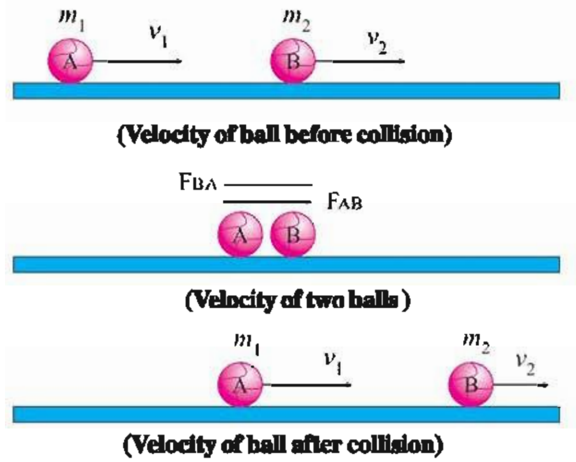

Figure 2.15 Collision of two spheres

Force exerted by ball B on A during this interaction is F_{AB}. As per Newton's third law of motion Force acting on ball B due to ball A would be F_{BA}. After this collision velocities of ball A and B would be v_1 and v_2. (See fig. 2.15.)

(Here we don't have to worry about magnitudes of v_1 and v_2)

There is no other external force acting on spheres.

Before collision :

Momentum of ball A $p_A = m_1u_1$ 2.10.1

Momentum of ball B $p_B = m_2u_2$ 2.10.2

Total initial momentum $p_i = m_1u_1 + m_2u_2$ 2.10.3

After collision :

Momentum of ball A $p_A' = m_1v_1$ 2.10.4

Momentum of ball B $p_B' = m_2v_2$ 2.10.5

Total final momentum $p_f = m_1v_1 + m_2v_2$ 2.10.6

Now according to Newton's second law of motion :

$$F_{BA} = \frac{p_A' - p_A}{t} = \frac{m_1v_1 - m_1u_1}{t} \quad 2.10.7$$

$$F_{AB} = \frac{p_B' - p_B}{t} = \frac{m_2v_2 - m_2u_2}{t} \quad 2.10.8$$

As per Newton's third law of motion

$$F_{AB} = -F_{BA}$$

$$\frac{m_1v_1 - m_1u_1}{t} = -\frac{m_2v_2 - m_2u_2}{t}$$

$$m_1v_1 - m_1u_1 = -(m_2v_2 - m_2u_2)$$

$$m_1v_1 + m_2v_2 = m_1u_1 + m_2u_2 \quad 2.10.9$$

Final momentum(P_f) = Initial momentum (P_i)

Thus during interaction of two balls total momentum before collision is equal to total momentum after collision. From this discussion we get a very important law of physics, Law of conservation of momentum as follows :

In absence of external force total momentum of a system comprising of two or more interacting bodies is constant.

Here we have obtained law of conservation of momentum from Newton's second and third law. This law is equally valid for systems like system of particles and system made of electron and proton like small particles. Law of conservation of linear momentum is fundamental and universal.

Illustration 9 : A bullet of 20 g is fired horizontally from a pistol of 2 kg mass with velocity 150 ms^{-1}. How much would be the velocity of pistol in backward direction after firing the bullet ?

Solution : Mass of bullet m_1 = 20 g = 0.02 kg

Mass of pistol m_2 = 2 kg

Initial velocity of bullet u_1 = 0 m/s

Initial velocity of pistol u_2 = 0 m/s

Final velocity of the bullet = v_1 = 150 ms^{-1}

Final velocity of the pistol v_2 = ?

According to law of conservation of momentum

$$m_1v_1 + m_2v_2 = m_1u_1 + m_2u_2$$

$$(0.02)(150) + (2)(v_2) = (0.02)(0) + (2)(0)$$

$$v_2 = -\frac{(0.02)(150)}{2} = -1.5 \text{ ms}^{-1}$$

Here, negative sign indicates that motions of pistol and bullet are in opposite direction.

2.11 Friction

According to Newton's first law in absence of external force body should maintain its motion with constant velocity. But instead of velocity remaining constant it reduces gradually and after travelling some distance body comes to halt. This force which opposes motion of the body is called as force of friction.

When a body moves on a surface, keeping contact with the surface, force exerted by the surface on moving body, which opposes motion of the body is called frictional force.

Remember frictional force is always in the direction opposite to the direction of motion. Magnitude of frictional force depends on roughness or smoothness of the surface and material of the surfaces in contact.

If a body is moving on a smooth surface, frictional force acting on the body is less and frictional force offered by rough surface is more.

Origin of friction is roughness of the surface at atomic level.

A smooth surface, if observed through a powerful microscope, is found to be rough and elevation and depression of surface are seen on the surface. When such surfaces come in contact with each other, projections of one surface fit in the other's depressions and that forms a 'cold welding'. As a result when a surface tries to move over the other, a force opposing this motion arises. It is called frictional force.

When an object is sliding over a surface the frictional force arising is called kinetic frictional force. When a body is rolling over the surface without sliding the frictional force arising is called rolling frictional force.

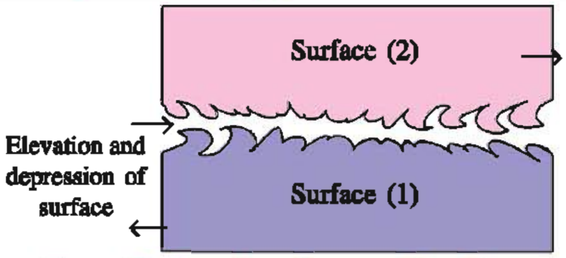

Figure 2.16 Roughness in a smooth surface

Factors affecting frictional force.

Activity 8 : As shown in figure 2.17 place a wooden block having hook on a table. Tie a string with the hook and pass it over the pulley and tie pan with the other end of the string. When weights are kept in pan external force (mg) would act on block.

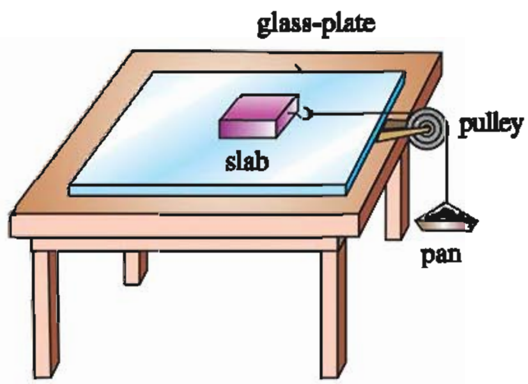

Figure 2.17 Study of the factors affecting frictional force

Gradually increase the weights in the pan and for each weight see if the block starts moving or not. Unless the external force balances the frictional force block would not move. This force opposing motion of block is called static frictional force. In this way place the minimum weight in pan for which block starts moving.

This weight (mg) is called maximum static frictional force. Under the influence of an external force block performs accelerated motion. Now reduce weight in the pan so that block performs motion with constant velocity. The frictional force acting in this condition is called kinetic friction.

(i) Now take a block of some mass but it should have larger contact area and repeat the activity.

(ii) Now repeat the activity by increasing the mass of the block.

(iii) Now place a glass plate on the table and put the block on it and for both the cases discussed above note down the minimum weights for which block starts moving.

From this activity you may get the following inferences :

(i) Frictional force depends on roughness or smoothness of the surface in contact.

(ii) Frictional force does not depend on the contact area.

(iii) Frictional force depends on mass of the moving object.

Advantages and disadvantages of friction

Advantages of friction

(i) Friction between tyre and road enables us to have controlled motion of the vehicle. When brakes are applied friction only helps to stop the vehicle.

(ii) Due to friction between sole and soil any animal is able to walk or run. Try to walk with skates in your feet. What happens ?

(iii) Thanks to friction, as it enables us to write on paper using pen or pencil.

(iv) When meteors enter the earth's atmosphere with tremendous speed, they burn off due to friction of atmosphere. Here friction is essential for the existence of mankind.

List other advantages of friction.

Disadvantages of friction :

(i) Motion is opposed.

(ii) Wear and tear is caused in tyres and footwear due to friction.

(iii) Friction causes wear and tear in the parts of a vehicle.

List other disadvantages of friction.

Control of friction :

What do we do to reduce friction ? Think.

- We use grease, oil, graphite etc. as lubricant in machines to reduce friction.
- We use ball bearings and roller bearings in vehicles and machines to reduce friction.
- We use oil to reduce friction in engine.
- Shape of the vehicles is designed keeping aerodynamics in mind so that friction with air can be reduced.
- Hovrvercrafts are developed which can move on layer of air formed between soil or water and hovercraft.
- Powder is sprinkled on the board while playing the carrom.

What have you learnt ?

- Under the influence of an external force (i) shape of the body may change. (ii) Position of the body may change (iii) State of motion of the body may change. (iv) Velocity of the body may change.
- If under composite effect of forces there is no change in stationary state of a body or state of motion, forces are said to be balanced forces. Under the influence of the forces if a stationany body comes in motion or moving body comes to halt the forces are called unbalanced forces.
- Unless the unbalanced force acts on a body, body tries to maintain its stationary state or state of uniform motion. Such a property of a body is called intertia. It depends on mass of the body.
- Product of mass and velocity of body is called momentum of a body.
- Magnitude of external force acting on a body is equal to product of mass and acceleration. $F = ma$
- Effect of force on a body depends on (i) magnitude of force (ii) time for which force acts on the body (iii) direction of force.
- During interaction of two bodies the force exerted by one body on the other is equal and opposite to the force exerted by the second body on the first.
- Forces are always in pairs. They act on different bodies.
- In absence of the external force total momentum of a system made up of two or more interacting bodies remains constant.
- When a body in contact with a surface is moving, the force which opposes the motion of the body, offered by the surface is called force of friction.

EXERCISE

1. Select the proper choice from the given multiple choices :

(1) Which law of motion given by Newton gives magnitude of force ?

(A) First (B) Second (C) Third (D) None

(2) What is the unit of momentum ?

(A) kg m/s (B) kg ms (C) kg m/s^2 (D) m/s

(3) 1 newton = ________dyne

(A) 10^3 (B) 10^4 (C) 10^5 (D) 10^6

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(4) What is product of force and the time for which force act called ?

(A) Momentum (B)Acceleration (C) Inertia (D) Impulse of force

(5) A constant force of 5 N is applied on a body of 10 kg mass, with how much acceleration will it move ?

(A) 2 m/s^2 (B) 0.5 m/s^2 (C) 50 m/s^2 (D) 5 m/s^2

(6) Which of the following vehicle has the least inertia ?

(A) Bicycle (B) Scooter (C) Car (D) Truck

(7) How much force is needed to produce acceleration of 80 cm/s^2 in a body of mass 500 g ?

(A) 0.04 N (B) 0.4 N (C) 4 N (D) 4000 N

(8) Unit of which physical quantity is same as that of unit of impulse of force ?

(A) Force (B) Acceleration (C) Momentum (D) Velocity

(9) Newton's second and third law lead to which important law of physics?

(A) Law of pressure (B) Archimedes principle

(C) Law of conservation of momentum (D) Law of conservation of energy

(10) For which type of surface magnitude of frictional force would be less ?

(A) Glass surface (B) Wooden surface

(C) Sandy surface (D) Rocky surface

(11) On which factor the frictional force doesn't depend ?

(A) Mass of the object (B) Material of the surface

(C) Contact area (D) none of these

(12) Which substance cannot be used to reduce friction ?

(A) Oil (B) Grease (C) Gum (D) Graphite

(13) Which of the following physical quantity is scalar ?

(A) Mass (B) Force

(C) Impulse of force (D) Momentum

2. Answer of following questions in short :

(1) What is the resultant force of balanced forces ?

(2) Which law of motion given by Newton defines force ?

(3) What does rate of change in momentum give ?

(4) Write an expression of impulse for force.

(5) What is the force offered by a surface in contact, which opposes motion, called ?

(6) Which force arises between a body and surface when body rolls on the surface without sliding ?

(7) State Newton's third law of motion.

(8) State law of conservation of momentum.

(9) State SI and CGS units of force.

(10) What is the resultant force acting on a bicycle moving with constant velocity of 1 m/s ?

(11) Which is the direction of motion of a body in motion ?

3. Answer the following questions in detail :

(1) Which are the effects seen on a body when external force acts on it ?

(2) Explain contact forces and field forces with example.

(3) Explain Newton's first law of motion.

(4) State Newton's second law of motion and deduce $F = ma$.

(5) State Newton's third law of motion and give its practical examples.

(6) State and derive law of conservation of momentum.

(7) State advantages and disadvantages of friction.

(8) State measures to be taken to control friction.

(9) Give scientific reasons :

(1) A cricketer pulls his hands backward while catching a ball.

(2) A person alighting suddenly from a moving bus falls down.

(3) One cannot walk or run with skates in feet.

4. Solve the following example :

(1) Momentum of a car moving with velocity of 72 km/h is 20,000 kg m/s. How much is its mass ? (**Ans. :** 1000 kg)

(2) Find the force needed to produce acceleration of 2 m/s^2 in a body of 10 kg mass. If 30 N force is applied on this body, how much acceleration will be produced ? (**Ans. :** 20 N, 3 m/s^2)

(3) Velocity of a body of mass m_1 is 10 m/s and velocity of a body of mass m_2 in 108 km/h. If their momenta are equal find ratio of their masses. (**Ans. :** 3:1)

(4) How much force is needed to increase velocity of a body of 4 kg mass, by 1.5 m/s every second ? (**Ans. :** 6 N)

(5) When 15 N force is applied on a body of mass m_1 acceleration produced is 3 m/s^2. Now it is tied with a body of mass m_2 and the same force is applied on a composite body and acceleration produced is 2 m/s^2. Find mass of both the bodies. (**Ans. :** $m_1 = 5$ kg, $m_2 = 2.5$ kg)

(6) A motorcycle moving with 90 km/h speed stops after 10 s after applying brakes. If the total mass of motorcycle including rider is 200 kg, find force applied by brakes on motorcycle. **(Ans. :** 500 N)

(7) A body of 10 kg mass is moving with 15 m/s. In 10 s its velocity increases to 25 m/s. Find change in momentum and hence find force required for this change. **(Ans. :** 10 N)

(8) A car starting from stationary state, in 10 s, acquires speed of 30 m/s. If mass of car is 400 kg how much force is acting on car ?

(Ans. : 1200 N)

(9) Two balls of 100 g and 200 g are moving along the same line and direction with velocities of 1 ms^{-1} and 2 ms^{-1} respectively. They collide and after the collision, the first, ball moves at a velocity of 2 ms^{-1}. Determine the velocity of second ball. **(Ans :** 1.5 mg^{-1})

(10) A bullet of mass 10 g is fired from a rifle. The bullet passes through a barrel in 0.003 s and moves at the velocity of 300 m/s. Calculate the force applied on the bullet by the rifle. **(Ans :** 1000 N)

3 Gravitation

3.1 Introduction

In the previous chapter we studied that until an external (unbalanced) force acts on a body, the body at rest remains at rest and a body under motion continues its motion (with constant velocity). Further, when a body is dropped from a height without applying any force, the body moves downwards with accelerated motion. This shows that 'some force' must be acting on the body in downward direction towards the earth.

Further we know that the earth is spherical and it rotates about its imaginary axis in the space. Why don't we fall down even though the earth is rotating about its axis ? Due to which reason the moon revolves around the earth ? Why the earth and other planets revolve around the sun ? While investigating about the answers of these questions Sir Isaac Newton (1642 AD - 1727 AD) said that 'gravitational force' is responsible for such phenomena.

In this chapter we shall study the universal law of gravitation, acceleration due to gravity, free fall of an object under the influence of gravitational force, the difference between mass and weight of a body, pressure, Archimedes' principle and relative density.

3.2 Gravitational Force

Gravitational force is the weakest force amongst the fundamental forces in the nature (invisible, but most important). **Any two bodies of the universe, possessing mass, attract each other. This force of attraction is called gravitational force.** Under the influence of this gravitational force, the planets revolve around the sun and satellites revolve around respective planets.

It is said that once Newton was sitting under an apple tree and he saw an apple falling from the tree (or an apple fell on him). From this incidence Newton thought that a force which attracts the apple towards the earth, and hence a similar force must be attracting the moon towards the earth, and the earth towards the sun. In general, Newton showed that every object of the universe (small or big, light or heavy, nearby or far away) attracts other object towards it. Therefore **gravitational force is said to be universal force.** The magnitude of gravitational force depends on the mass of the object and the distance between them.

Thus the motion of the moon around the earth along a circular path is due to the centripetal gravitational force. In the same way the planets of the solar system revolve around the sun due to the gravitational force.

3.3 Universal Law of Gravitation

"Every object of the universe attracts other object. The force of attraction between the two objects is proportional to the product of their mass and inversely proportional to the square of the distance between them. The direction of this force is along the line joining the centres of the objects."

This statement is known as **Newton's universal law of gravitation.**

Newton showed that due to this reason the moon which is moving on a straight path, gets attracted towards the earth at every point along its path, and hence the moon revolves around the earth.

To understand the revolution of the moon around the earth we can do the following activity :

Activity 1 : Take a piece of a string.

- Tie a small stone at its one end. Holding the other end of the string, whirl it round and round (See fig. 3.1)
- Observe the motion of the stone.
- Release the string.
- Now, observe the direction of motion of the stone.

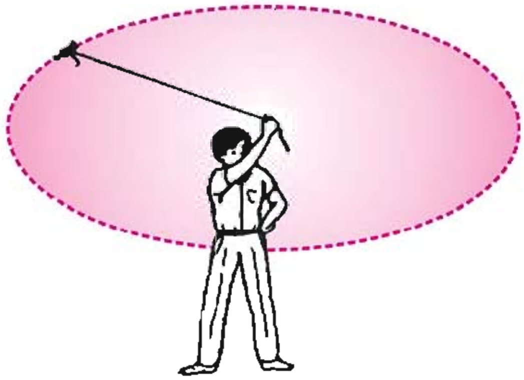
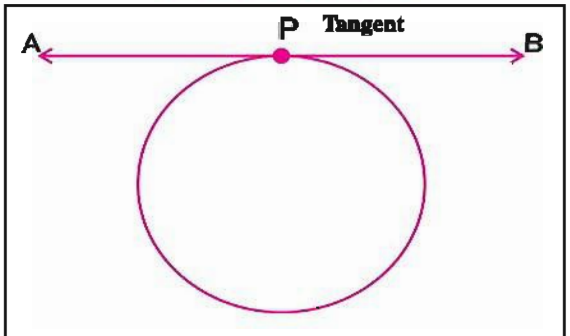


Figure 3.1 A stone moving along a circular path with constant speed

Untill the string is released, the stone moves along a circular path with constant speed and its direction changes at every point of its path. The force responsible for this is provided by the string towards our hand (towars the centre of the circle, which is centripetal). When the string is released, the stone moves away along a tangent at that point in a straight path.

Only for information



A straight line 'AB' drawn in such a way that it touches any point 'P' of a circle is called tangent to the circle at point 'P.

Figure 3.2 The gravitational force acting between two objects

As shown in fig. (3.2) let two objects of mass m_1 and m_2 are lying at a distance r from each other. According to the Newton's law of gravitation these objects attract each other. This force of attraction is called the gravitational force. This gravitational force is along the direction joining the centres C_1 and C_2 of the two objects.

F_{12} = gravitational force acting on object 1 due to object 2 (From C_1 to C_2)

F_{21} = gravitational force acting on object 2 due to object 1 (From C_2 to C_1)

According to Newton's third law these two forces are equal and opposite (i.e. $F_{12} = -F_{21}$, here negative sign indicates opposite direction). The magnitude of gravitational force acting between the two objects is

$$F_{12} = F_{21} = F \qquad 3.3.1$$

According to the universal law of gravitation

$$F \propto m_1 m_2 \qquad 3.3.2$$

and $$F \propto \frac{1}{r^2} \qquad 3.3.3$$

From equations (3.3.2) and (3.3.3)

$$F \propto \frac{m_1 m_2}{r^2} \qquad 3.3.4$$

$$\therefore F = G\frac{m_1 m_2}{r^2} \qquad 3.3.5$$

Equation (3.3.5) is the mathematical form of Newton's universal law of gravitation. Here G is the constant of proportionality. **At any place in the universe and at any time, the value of G is found to be constant for any two bodies. Thus G is called the universal constant of gravitation.**

From equation (3.3.5)

$$G = \frac{F r^2}{m_1 m_2} \quad \frac{N m^2}{kg^2}$$

Thus the SI unit of the universal constant of gravitation is $N\ m^2\ kg^{-2}$. The value of G is $6.67 \times 10^{-11}\ N\ m^2\ kg^{-2}$ which is very small. Practically the value of G was measured for the first time by **Henry Cavendish** (1731 AD to 1810 AD).

If we know the mass of two objects and the distance between their centres, we can calculate the gravitational force acting between them, using equation (3.3.5).

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Illustration 1 : If the masses of Dhvanit and Rajesh are respectively 42 kg and 50 kg, and they are 1 m away from each other, then what is the gravitational force acting between them ?

Solution :

Here $m_1 = 42$ kg, $m_2 = 50$ kg, r = 1 m

$$\therefore F = G\frac{m_1 m_2}{r^2} = 6.67 \times 10^{-11} \times \frac{42 \times 50}{(1)^2}$$

$$\therefore F = 1.4 \times 10^{-7} N$$

This shows that the gravitational force acting between Dhvanit and Rajesh is negligible.

Illustration 2 : An apple of mass 150 gram falls on the surface of the earth from negligible height (in comparison with the radius of the earth) due to gravitation. Calculate the gravitational force acting between the apple and the earth. Also calculate the acceleration produced in both of them due to gravitational force.

Mass of the earth = 6×10^{24} kg

Distance between the centre of the earth and the apple is, r = 6.38×10^6 m

Solution :

Mass of apple m_1 = 150 g = 0.150 kg

Mass of the $m_2 = 6 \times 10^{24}$ kg

Distance between the centre of the earth and the apple is, r = 6.38×10^6 m

$$\therefore F = G\frac{m_1 m_2}{r^2}$$

$$= 6.67 \times 10^{-11} \times \frac{0.150 \times 6 \times 10^{24}}{(6.38 \times 10^6)^2}$$

$$= 1.47 \text{ N} = 1.47 \text{ kg m s}^{-2}$$

Acceleration produced in the apple due to gravitational force of the earth

$$a_1 = \frac{F}{m_1} = \frac{1.47 \text{ kg m s}^{-2}}{0.150 \text{ kg}} = 9.8 \text{ m s}^{-2}$$

Thus the apple rushes towards the earth with acceleration of 9.8 m/s^2

Acceleration produced in the earth due to this gravitational force of the apple is

$$a_2 = \frac{F}{m_2} = \frac{1.47 \text{ kg m s}^{-2}}{6 \times 10^{24} \text{ kg}} = 2.45 \times 10^{-25} \text{ m s}^{-2}$$

Thus, the earth moves towards the apple with an acceleration of 2.45×10^{-25} m s^{-2}

Note :

Here $a_1 \neq a_2$ and $a_2 << a_1$. Hence the accelerated motion of an apple can be observed, but the accelerated motion of the earth cannot be observed. This happens because the mass of the earth is many times larger than that of the apple.

Illustration 3 : A coconut of 1.5 kg falls from the coconut tree of certain height (which is negligible in comparison to the radius of the earth) with acceleration due to gravity of the earth. Find the gravitational force of the earth acting on the coconut. With which acceleration will the coconut fall down ?

(Mass of the earth = 6×10^{24} and

Distance between the centre of the earth and the coconut = 6.38×10^6 m)

Solution :

Mass of the coconut m_1 = 1.5 kg

Mass of the earth $m_2 = 6 \times 10^{24}$ kg

Distance between the centre of the earth and coconut r = 6.38×10^6 m

$$F = G\frac{m_1 m_2}{r^2} = \frac{6.67 \times 10^{-11} \times 1.5 \times 6 \times 10^{24}}{(6.38 \times 10^6)^2}$$

$$= 14.7 \text{ N} = 14.7 \text{ kg m s}^{-2}$$

Hence acceleration produced in the coconut after it is detached from the tree due to gravitation.

$$a = \frac{F}{m_1} = \frac{14.7 \text{ kg m s}^{-2}}{1.5 \text{ kg}} = 9.8 \text{ m/s}^2$$

Thus, coconut moves towards the earth with acceleration of 9.8 m/s^2.

Note :

By looking at the results of the illustrations 2 and 3, it can be observed that the gravitational force acting on an apple of 150 gram is 1.47 N, whereas the gravitational force on the coconut of 1.5 kg is 14.7 N (ten times more). Even though the gravational force acting on the coconut is 10 times more than that on an apple, but the acceleration produced in both of them is 9.8 m/s^2, which is equal. Why is it so ? Think about it.

(Whatever happened is good that an apple fell on Newton's head and he gave the law of gravitation. What would have been happened if Newton had been sitting under a coconut tree ?)

Illustration 4 : The moon revolves around the earth due to the gravitational force of the earth acting on it. If the mass of the earth is 6×10^{24} kg, and mass of the moon is 7.3×10^{22} kg, and at one moment the distance between their centres is 3.84×10^{8}, then calculate the gravitational force between them. What will be the acceleration of moon due to the gravitational force ?

$(G = 6.67 \times 10^{-11}\ N\ m^2\ kg^{-2})$

Solution : Here mass of the earth $m_1 = 6 \times 10^{24}$ kg

mass of the moon $m_2 = 7.3 \times 10^{22}$ kg

Distance between the centres of the earth and the moon $r = 3.84 \times 10^{8}$ m

$G = 6.67 \times 10^{-11}\ N\ m^2\ kg^{-2}$

From equation (3.3.5) the gravitational force acting between the earth and the moon is

$$F = G\frac{m_1\ m_2}{r^2}$$

$$= \frac{6.67 \times 10^{-11} \times 6 \times 10^{24} \times 7.3 \times 10^{22}}{(3.84 \times 10^{8})^2}$$

$\therefore\ F = 1.98 \times 10^{20}$ N

The acceleration produced in the moon due to the gravitational force is

$$a = \frac{F}{m_2}\ \frac{1.98 \times 10^{20}}{7.3 \times 10^{22}} = 0.0027\ m/s^2$$

Note :

In illustrations 2 and 3, the values of gravitational acceleration of the apple and the coconut were $9.8\ m/s^2$, in comparison with acceleration of the moon $0.0027\ m/s^2$ (which is very much less than $9.8\ m/s^2$)

3.3.1 Importance of the Universal Law of Gravitation :

The universal law of gravitation explained several phenomena which were not explained previously :

(i) the force that binds us to the earth.

(ii) the revolution of the moon around the earth

(iii) the revolution of planets around the sun

(iv) the tide and ebb that arise due to the moon and the sun.

3.4 Free Fall and Acceleration Due to Gravity

When an object is released (freely) from a certain height, without applying any external force, it moves downwards under the effect of gravitational force. Here the motion of the object is said to be **free fall.**

Freely falling object is at rest initially, so its initial velocity is zero. When the object is released, it undergoes an **accelerated motion** under the effect of gravitational force.

Galileo carried out many experiments regarding freely falling bodies (objects). He showed that the acceleration of the freely falling body does not depend on the mass or shape of the body. Once Galileo released two stones of different masses from the top of the leaning tower of Pisa in Italy, and showed that they reach the earth at the same time. He said that due to friction with air, the lighter object reaches slightly later on the earth. If this hurdle is removed then both the objects would reach the earth simultaneously with same acceleration.

Activity 2 : Put an inverted steel plate on the floor. Take four to five objects of different mass, like rubber, marble, small stone, different coins etc. Release two objects of different masses from certain height simultaneously so that they fall on the steel plate. The two objects would fall freely under the effect of gravitational force. When both objects fall on the steel plate sound will be heard. Do you hear their sound separately or simultaneously ? Why ?

Now take two coins of 5 rupees each. Put one coin of 5 rupee on a straight paper (of the size of 10 rupee note) and hold another coin alone. Now release both the objects simultaneously. Which object falls first, 5 rupee coin alone or the coin kept in the paper ? Why ?

3.4.1 Acceleration due to gravity :

If the mass of the earth is M_e and its radius is R_e, then the gravitational force acting on the body of mass m, lying at a distance r ($r \geq R_e$) from the centre of gravity of the earth is

$$F = G\frac{m\,M_e}{r^2} \qquad 3.4.1$$

According to Newton's second law of motion the force acting on a body is equal to the product of its mass and acceleration.

$$\therefore F = m\,a \qquad 3.4.2$$

The acceleration produced in a body due to the gravitational force of the earth is known as acceleration due to gravity. If the acceleration due to gravity is denoted by 'g', then equation (3.4.2) can be written as :

$$F = m\,g \qquad 3.4.3$$

Comparing equations (3.4.1) and (3.4.3) we get

$$m\,g = G\frac{m\,M_e}{r^2}$$

$$\therefore g = \frac{G\,M_e}{R_e^2} \qquad 3.4.4$$

For a body lying on or near the surface of the earth, taking $r = R_e$ we get

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$$g = \frac{G M_e}{R_e^2} \qquad 3.4.5$$

In equation (3.4.5)

G = Universal constant of gravitation,

= 6.67×10^{-11} N m^2 kg^{-2}

M_e = Mass of the earth = 5.976×10^{24} kg, and

R_e = equatorial radius of the earth

= 6378 km = 6.378×10^6 m

Hence,

$$g = \frac{6.67 \times 10^{-11} \times 5.976 \times 10^{24}}{(6.378 \times 10^6)^2}$$

$$\therefore g \cong 9.8 \text{ m/s}^2$$

Equation (3.4.5) shows that the value of 'g' (on the earth's surface) does not depend on the mass of the object. Hence every object whether small or big, hollow or solid, light or heavy, falls freely with same gravitational acceleration. Freely falling object moves down with constant acceleration of g = 9.8 m/s^2.

The value of 'g' is different on different planets and their satellites. The value of acceleration due to gravity 'g' on any planet could be calculated using the following relation :

$$g_p = \frac{G M_p}{R_p^2} \qquad 3.4.6$$

where M_p = Mass of the planet

R_p = Radius of the planet

Illustration 5 : Taking the mass of the moon to be 7.3×10^{22} kg and the radius to be 1740 km, calculate the acceleration due to gravity 'g_m' on the moon. Compare it with the acceleration due to gravity 'g_e' on the earth.

Solution :

Mass of the moon $M_m = 7.3 \times 10^{22}$ kg

Radius of the moon R_m = 1740 km = 1.74×10^6 m

$$\therefore g_m = \frac{G M_m}{R_m^2} = \frac{6.67 \times 10^{-11} \times 7.3 \times 10^{22}}{(1.74 \times 10^6)^2}$$

$$\therefore g_m = 1.608 \text{ m/s}^2$$

Now, $\dfrac{\text{gravitational acceleration on the earth } (g_e)}{\text{gravitational acceleration on the moon } (g_m)}$

$$= \frac{9.8 \text{ m/s}^2}{1.608 \text{ m/s}^2} = 6$$

Thus, $g_e = 6\, g_m$ or

$$g_m = \frac{1}{6} g_e \qquad 3.4.7$$

Thus value of gravitational acceleration on the surface of the moon is almost one-sixth of the gravitational acceleration on the earth's surface.

3.5 Variation in the Magnitude of 'g'

Value of 'g' depends on the following factors.

(1) As you know that the earth is not a perfect sphere. It is swollen at the equator and is depressed or flat near the poles. So earth's polar radius is less than its equatorial radius.

i.e. (R_e) equator > (R_e) pole

Due to this reason the value of g at equator is less than that of g at poles. Remember that as we go from equator (Latitude = 0^0) to poles (Latitude 90^0), g increases gradually.

Table 3.1

Variation in the value of 'g' with latitude at sea level

Latitude	'g' Acceleration due to gravity (m/s^2)
0^0	9.78039
0	9.78195
20^0	9.78641
30^0	9.79329
40^0	9.80171
50^0	9.81071
60^0	9.81918
70^0	9.82608
80^0	9.83059
90^0	9.83217

Table 3.2

Value of 'g' at different heights on 45^0 Latitude

Height (km)	'g' Gravitational acceleration of (m/s^2)
0	9.806
1	9.803
4	9.794
8	9.782
16	9.757
32	9.710
100	9.600
500	8.530
1000	7.410
3,80,000 (moon)	0.00271

Note : Data 3.1 and 3.2 are given in Table for information only, not for examination.

(2) Due to earth's rotation about its axis, the value of 'g' is maximum at poles and it is the least at equator (you would study its reason in Std. XI Sciece).

(3) The value of 'g' is the maximum on the surface of the earth. It is clear from equation (3.4.5) that the value of 'g' decreases as we move upward from the earth's surface (See table 3.2).

(4) The surface of the earth is divided into soil and water. On the soil also, mountains, plains, valleys are there. Even soil has different composition of rocks and minerals in different places. Water in ocean, rivers, lakes etc. has slightly different densities. So the density of the earth in not same everywhere. Due to this reason variation in 'g' is found at different places.

Here note that difference in value of 'g' at different places is very small or negligible. So for day to day life value of 'g' is taken as 9.8 m/s^2.

3.5.1 Equations of motion for a freely falling body :

Previously we derived the equations of motion for uniformly accelerated motion as :

$$\left.\begin{aligned} v &= u + at \\ s &= ut + \frac{1}{2}at^2 \\ 2as &= v^2 - u^2 \end{aligned}\right\} \quad 3.5.1$$

For a freely falling body from height h; we have s = h, the initial velocity $u = 0$, and acceleration a = gravitational acceleration 'g' Hence.

$$v = gt \quad 3.5.2$$

$$h = \frac{1}{2}gt^2 \quad 3.5.3$$

$$v^2 = 2gh \quad 3.5.4$$

The motion of a body projected vertically upwards is retarded motion. Here the retardation is also g = 9.8 m/s^2, but its direction is opposite to the gravitational acceleration. So the value of 'g' is taken to be negative. In such cases the body is thrown upwards by applying an external force, hence the initial velocity is not zero. After reaching maximum height it comes at rest for a moment. So its final velocity is zero. (After this the body will come down under the effect of gravitation).

For a body performing motion along straight line vertically upwards, equations of motion can be obtained by putting $u = u$, $v = 0$, $a = -$ g and s = h in equations (3.5.1) as follows :

$$u - gt = 0 \Rightarrow u = gt \quad 3.5.5$$

$$h = ut - \frac{1}{2}gt^2 \quad 3.5.6$$

$$u^2 = 2gh \quad 3.5.7$$

Now let us consider some illustrations of a freely falling body.

Illustration 6 : A ball, when released from the top of a multi-storied building reaches the bottom in 2 s. Find the height of the building. Calculate the velocity of the ball when it reaches the earth ($g = 9.8\ m/s^2$)

Solution : t = 2 s, g = 9.8 m/s^2, h = ?, v = ?

Height of the building, $h = \frac{1}{2}gt^2$

$$= \frac{1}{2} \times 9.8 \times (2)^2$$

$$\therefore h = 19.6 \text{ m}$$

Final velocity of the ball when it falls on the earth,

$v = gt = 9.8 \times 2 = 19.6$ m/s

(v can also be calculated using $v^2 = 2gh$)

Illustration 7 : Calculate velocity of the ball, released from 10 m height, when it touches the ground. ($g = 9.8\ m/s^2$)

Solution : $g = 9.8\ m/s^2$, $h = 10\ m$, $v = ?$

$$v = \sqrt{2gh}$$

$$= \sqrt{2 \times 9.8 \times 10}$$

$$= \sqrt{196}$$

$$\therefore v = 14\ m/s$$

Illustration 8 : A ball when thrown vertically upward reaches maximum height after 1 s and then returns. Calculate its initial velocity. Also calculate maximum height.

Solution : (Here we will have to use equations 3.5.5 to 3.5.7)

To calculate initial velocity, $u - gt = 0$

$$\therefore u = gt = 9.8 \times 1 = 9.8\ m/s$$

To calculate maximum height, $u^2 = 2gh$

$$\therefore h = \frac{u^2}{2g} = \frac{9.8 \times 9.8}{2 \times 9.8} = 4.9\ m$$

(Also find this height using, $h = ut - \frac{1}{2} gt^2$)

Now let us perform an activity to calculate 'g' using a freely falling body.

Activity 3 : Take an empty plastic bottle and make a small hole at its bottom. Fill it with water by keeping your finger on the hole to close it. Now keep the bottle at 1 m height from the ground and allow the water to fall, drop by drop. Measure time for 50 drops to reach the ground using stop watch. (For this purpose any digital watch or stop watch may be enough, even some mobile phones have this facility.) Repeat this activity for 3-4 times and find out average time for 50 drops to reach the ground. (This would be approximately 22.5 s) Calculate time for 1 drop to reach the ground

(which is approximately $= \frac{22.5\ s}{50\ drops} = 0.45\ s$)

Now using $h = \frac{1}{2} gt^2$, calculate 'g' as

$$g = \frac{2h}{t^2},$$

where h = 1 m,

and t = 0.45 s

$$g = \frac{2h}{t^2}$$

$$= \frac{2 \times 1}{(0.45)^2}$$

$$= 9.87\ m/s^2$$

3. 6 Mass and Weight

We consider mass and weight to be synonyms in daily life, (In fact beam balance gives us mass and not weight) but mass and weight are different physical quantities as far as physics is concerned.

You know that **quantity of matter in a given body is its mass. Gravitational force acting on a body at a given location is its weight at that location.** This means, weight is the product of mass and local value of 'g'.

Thus, weight = mass × gravitation acceleration

$$\therefore W = mg \qquad 3.6.1$$

It is clear from equation (3.6.1) that weight of a body depends on the local value of g. As value of g is not same everywhere, even on the earth also, there will be difference in weight of the same body at different places. Weight of the body is a little less at equator than at the poles. Also value of 'g' decreases as we go upward from the surface of the earth. Due to this reason weight of the body will reduce as we go upward. Here, note that mass of the body is same every where, earth or moon or anywhere else. But as value of 'g' is not same everywhere, so the weight of a body of given mass is different at different places.

Let us understand the following points of the difference between mass and weight

Mass	Weight
(1) Quantitiy of matter in a body is known as mass.	(1) Gravitational force acting on a body is known as weight.
(2) Mass is a scalar quantity.	(2) Weight is a vector quantity. Its direction is in the direction of gravitational force.
(3) Mass of body = m	(3) Weight of the body W = mg
(4) SI unit of mass is kilogram.	(4) SI unit of weight is newton as it is a force.
(5) It is measured using beam balance.	(5) It is measured using spring balance.
(6) Mass of a body (at rest) remains constant.	(6) Weight of the body is not constant. It depends on local value of 'g'.
(Note : However on the spring balance, if the marking is in terms of kg, weight can be measured.)	

Illustration 9 : Calculate the weight of a body of mass 5 kg on the surface of the earth.

($g = 9.8\ m/s^2$)

Solution :

$$W = mg = 5\ kg \times 9.8\ m/s^2$$
$$= 49\ kg\ m/s^2 = 49\ N$$

Illustration 10 : Calculate weight of body of 30 kg mass on the surface of the earth and the moon. ($g_e = 6\ g_m = 9.8\ m/s^2$)

Solution :

Weight on the earth	Weight on the moon
$W = mg_e$	$W = mg_m$
$= 30\ kg \times 9.8\ m/s^2$	$= 30\ kg \times \frac{9.8}{6}\ m/s^2$
$= 294\ kg\ m/s^2$	$= 49\ kg\ m/s^2$
$\therefore W = 294\ N$	$\therefore W = 49\ N$

Illustration 11 : If weight of a body on the earth is 196 N, calculate its mass. ($g = 9.8\ m/s^2$)

Solution :

Here weight $W = 196\ N = 196\ kg\ m/s^2$

$$\therefore m = \frac{W}{g} = \frac{196\ kg\ m/s^2}{9.8\ m/s^2} = 20\ kg$$

Illustration 12 : Weight of a body on the earth is 98 N. Calculate acceleration produced in the body when 30 N force is applied on it ?

($g = 9.8\ m/s^2$)

Solution :

$W = 98\ N = 98\ kg\ m/s^2$, $F = 30\ N$, $m = ?$, $a = ?$

The mass of a body of 98 N weight is

$$m = \frac{W}{g} = \frac{98\ kg\ m/s^2}{9.8\ m/s^2} = 10\ kg$$

Acceleration produced in the body of 10 kg when 30 N force is applied

$$a = \frac{F}{m} = \frac{30\ N}{10\ kg} = \frac{30\ kg\ m/s^2}{10\ kg} = 3\ m/s^2$$

3.7 Thrust and Pressure

Do you know why the camel is called the ship of desert ? Why the area of wheels (tyres) in heavy vehicles is kept more (or more wheels) ? To understand this we have to understand the thrust acting in a particular direction and the pressure developed per unit area. For this let us do following activities.

Activity 4 : As shown in figure (3.3) suppose you have to fix a poster on a cardboard. For this you have to press pins using thumb. When you apply force on the head of the pin, the thrust of the force acts on the thin (sharp) end of the pin, due to which the pin gets into the cardboard easily.

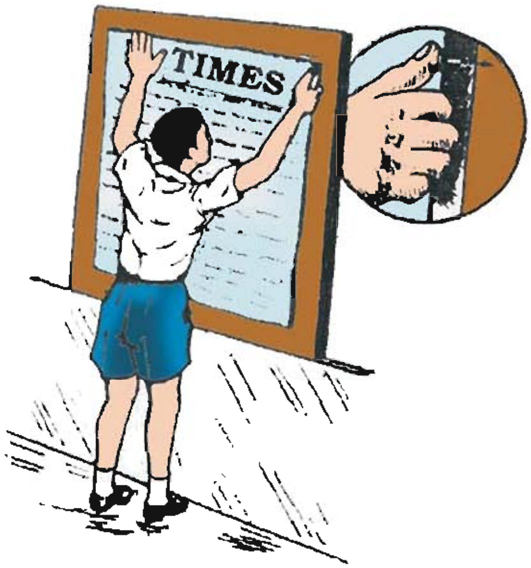

Figure 3.3 To fix the poster on a cardboard, pressure is applied on the head of the pin

Activity 5 : Take two similar nails. Now try to insert the sharp pointed end of one nail in a wooden board using a hammer. Take another and try to insert the head of the nail in the same wooden board using hammer. In which position can you easily insert the nail in the wooden board ? Why ?

Activity 6 : Take a bottle of narrow neck, filled with water. Keeping your palm open (straight), put the bottle vertically in it. Now again put the closed and inverted (water filled) bottle in your palm with its narrow head. In which case does the bottle remain more stable ? In which case does the bottle produce more thrust in your palm ? Why ? When the bottle is kept in the palm with its broader end in it, it produces thrust in the palm. But when the bottle is inverted and narrow head end is in palm, the same thrust is exerted by smaller area of bottle deeps more in the palm giving more thrust. Thus the effect of thrust depends on the area on which it is acting.

3.7.1 Pressure : The force acting per unit area, in a direction perpendicular to it is called pressure on the surface.

$$\therefore \text{ Pressure (P)} = \frac{\text{Force (F)}}{\text{Area (A)}} \qquad 3.7.1$$

It can be said from equation (3.7.1) that the pressure can be increased by reducing the area. For example in knife, axe, nail etc, the area of the edge (or sharp point) is very small. So applying small force, more pressure can be produced. Similarly from equation (3.7.1) it can be said that, for given force, the pressure can be decreased by increasing the area. For example, the base of multi-storied building and the dam is kept broader. There are more wheels in a heavy truck. The performer in a circus keeps a broad wooden plank on his chest before an elephant puts its foot on his chest.

The SI unit of pressure is N/m^2. In the memory of French scientist Pascal (1623 AD – 1662 AD) the **unit of pressure is also called Pascal (Symbol Pa).**

> **(Joke :** Once the scientists like Einstein, Newton etc. were playing hide and seek in the heaven. It was Einstein's turn to search all. The scientists were hiding. When Newton found that he will be caught, he drew a square of 1m x 1m and stood up in it. When Einstein showed him, he shouted that Newton is caught, Newton is caught. Then Newton replied that you are wrong ! I am N/m^2, So I am Pascal. **Not for exam.)**

3.8 Archimedes' Principle and Floating Bodies

You would have observed that when you go for swimming in a pond, river, swimming pool or sea water, your body becomes lighter. In the same way when a bucket filled with water is pulled up from a well or water tank, it is felt lighter till it is immersed in the water. But as soon as the bucket comes out of water it is felt heavier. Why is it so ?

When an object (insoluble in a liquid) is partially or completely immersed in the liquid, then the upward pressure acting on its lower surface is more than the downward pressure acting on its upper surface. As a result of this, force acts on the object in the upward direction, due to which the object shifts upwards by the liquid and it is felt lighter. **The property of a liquid to push the immersed object in upward direction is known as buoyancy.**

The net upward force acting on a body partially or completely immersed in a liquid is known as **buoyant force.** To calculate the buoyant force acting on an object immersed in a liquid, Archimedes showed that,

"When an object is partially or completely immersed in a liquid, the buoyant force acting on it is equal to the weight of the liquid displaced by the object." which is called Archimedes principle.

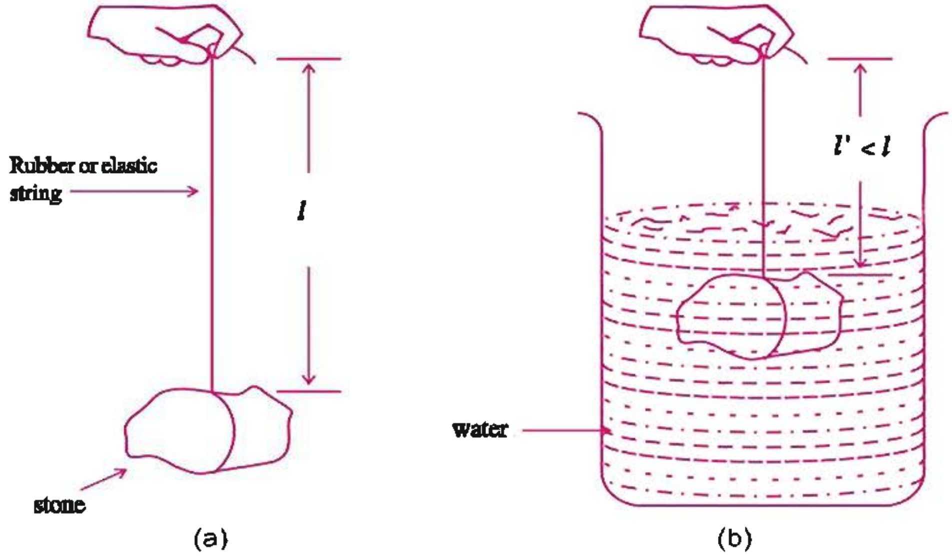

Figure 3.4 The decrease in length of rubber string and decrease in weight of the stone when immersed in liquid.

As shown in figure, take a small, heavy piece of a stone. Take a rubber string or an elastic string. (A rubber used to bind hair or a rubberring used to pack the sweet box can be cut from one side and can be used). Tie down one end of this rubber string with the stone. Suspend the stone by holding other end of the rubber string as shown in figure (3.4 – a). You can observe that length of rubber string increases. Measure the length '*l*'. Now immerse the stone slowly in water as shown in figure (3.4 – b). You can observe that as the stone dip slowly in water, water level rises in the beaker and the length of the rubber string also decreases. Measure the length *l'* of the string.

Repeat this activity for other objects like wooden block, iron piece, or stone pieces of different size and shape. What did you observe ?

3.8.1 Relative density : You know that the ratio of mass of an object and its volume is known as density of the object. i.e.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} \qquad 3.8.1$$

Density (ρ) is a scalar quantity. The SI unit of density is kg/m^3. The density of a given material is always the same. Objects of different materials have different values of density. For example the density of gold is 19300 kg/m^3, where as the density of water is 1000 kg/m^3. From the density of material, its purity can be checked (decided).

Activity 7 : Take a plastic bottle and fill pure water in it upto certain height. Draw a mark on the bottle pointing the upper surface of water in it. Now measure the mass of the filled bottle. Empty the bottle in a vessel. Add some salt in water and mix it up till the water become salty. Again fill the bottle with this salty water up to the same marking (same volume), and measure the mass of the filled bottle. Does the mass of bottle increase ? Similarly do this activity by mixing salt, sugar or fine soil with different proportions in the water and fill the bottle upto same mark. Do you get different mass of bottle each time ? Did you find that by mixing soluble substances in water, the mass of water changes ? If some one mixes sand or white stones in rice or sugar, will you be able to catch him ? If another oil is mixed in ground nut oil will you be able to distinguish ?

Some times the density of an object is compared with the density of water. For this purpose the **ratio of density of an object and the density of the water is taken. It is known as the relative density or specific density of the object.**

$$\therefore \text{Relative density of the object} = \frac{\text{Density of the object}}{\text{Density of water}} \qquad 3.8.2$$

As relative density is the ratio of two densities, it is unitless.

From equation (3.8.2)

$$\text{Relative density of gold} = \frac{\text{Density of gold}}{\text{Density of water}}$$

$$= \frac{19300 \text{ kg /m}^3}{1000 \text{ kg/m}^3}$$

$$= 19.3$$

If the relative density of an object is more than 1, then it will sink in water. But if the relative density of the object is less then 1, then it will float on water.

Activity 8 : Fill a bucket with water upto three - fouth level. Now put your empty lunch box (may be made of plastic or metal) in water. It will float on water. Now fill the lunch box with popcorn or murmura and again put it on the surface of water. Does it float ? Now fill the lunch box completely with water and then put it on the surface of water in the bucket. What happens now ? Keep the empty lunch box floating on the surface of water and then fill it with sand slowly and slowly. Does it sink in water before it is completely filled with sand ? Why ?

Illustraion 13 : The relative density of silver is 10.8. The density of water is 1000 kg/m³. Hence calculate the density of silver.

$$\text{The relative density of silver} = \frac{\text{Density of silver}}{\text{Density of water}}$$

$$\therefore \text{Density of silver} = \text{Density of water} \times \text{Relative Density of silver}$$

$$= 1000 \text{ kg/m}^3 \times 10.8$$

$$= 10800 \text{ kg/m}^3$$

3.9 Projectile Motion with Initial Horizontal Velocity

When a ball is released from the top of multi-storied building, it performs accelerated motion in the downward direction under gravitational force. But if the ball is thrown in the horizontal direction, what happens ? What type of motion does the ball perform ? Is there any horizontal force acting on the ball after it is thrown ? Here there is no horizontal force acting on the body after it is thrown. Then what can be said about the state of its horizontal motion ? According to Newton's first law of motion it should travel in the horizontal direction with uniform velocity.

Does any force in the vertical direction act on it ? You would say, "Yes, gravitational force is acting downwards." So due to effect of this downward force it has accelerated motion in downward direction. Thus in this case the body possesses two types of motions : (i) motion with uniform velocity in horizontal direction and (ii) accelerated motion in downward direction. As a result the body has mixed effect of both the motions. Such a motion is known as projectile motion. Path of the projectile motion is parabolic.

What have you learnt ?

- Every object of the universe attracts other object. The force of attraction between the two objects is proportional to the product of their masses and inversely proportional to the square of the distance between them. The direction of this force is along the line joining the centres of the objects. This statement is known as Newton's universal law of gravitation.
- When an object is released (freely) from a certain height, without applying any external force, it moves downwards under the effect at gravitational force. This motion of bail is called freefall.
- Freely falling object is at rest initially, so its initial velocity is zero. When the object is released, it undergoes an accelerated motion under the effect of the gravitational force.
- The acceleration produced in a body due to the gravitational force of the earth is known as acceleration due to gravity.
- The quantity of matter in a body is known as its mass. The gravitational force acting on a body at a given location is known as the weight of the body at that

location. This means that the weight of a body at any location is equal to the product of the mass of the body and the gravitational acceleration at that location.

- The force acting per unit area of a surface, in a direction perpendicular to it is called pressure on the surface.
- The property of a liquid to apply an upward thrust on a completely or partially immersed body is known as buoyancy. The net upward force acting on a body partially or completely immersed in a liquid is known as buoyant force.
- When a body is partially or completely immersed in a liquid, the buoyant force acting on it is equal to the weight of the displaced liquid. This is Archimedes' principle.
- The ratio of mass and volume of a body is known as its density.
- The ratio of density of an object and density of the equal volume of water is known as relative density or specific density of the object.
- If the relative density of the body is more than 1, the body will sink in water, but if it is less than 1, the body will float on water.

EXERCISE

1. Select the proper choice from the given multiple choices.

(1) When an object is released freely from certain height without applying any external force, then the object

(A) will move upwards with accelerated motion

(B) will move downwards with accelerated motion

(C) will move downwards with constant velocity

(D) will move upwards with constant velocity

(2) The earth ___________ about its (imaginary) axis.

(A) revolves (B) rotates

(C) moves with constant acceleration (D) remains steady

(3) The earth and other planets ___________ around the sun.

(A) revolve (B) rotate

(C) moves with constant acceleration (D) remain steady

(4) An object moving in (upward) direction opposite to the gravitational force of earth performs ___________ .

(A) accelerated motion (B) motion with constant velocity

(C) oscillations (D) retarded motion

(5) The weight of an object at equator is ___________ the weight of the object at the pole.

(A) equal to (B) slightly more than

(C) slightly less than (D) 9.8 times

(6) The mass of an object ....

(A) varies at different locations

(B) remains constant

(C) can be measured using spring balance

(D) is in the direction of gravitational force.

(7) The density of water is ....

(A) 1 kg/m^3 (B) 1000 kg/m^3

(C) 1000 g/cm^3 (D) 19300 kg/m^3

(8) The direction of weight of an object is in .... direction.

(A) East (B) North

(C) Upward (D) Gravitational force

(9) If the density of an object is more than that of water, then that object will ....

(A) sink in water (B) float on water

(C) dissolve in water (D) not become wet in water

(10) The relative density ....

(A) has unit of kg/m^3 (B) has unit of g/cm^3

(C) has unit of kg/m^2 (D) is unitless

(11) The increase in velocity of a freely falling body in one second is ....

(A) 9.8 m/s^2 (B) 9.8 m/s (C) –9.8 m/s^2 (D) –9.8 m/s

(12) The mass of an object of 6 kg, on the surface of moon is ....

(A) 1 kg (B) 36 kg (C) 6 kg (D) $\frac{1}{6}$ kg

(13) Practically the value of G for the first time was measured by ....

(A) Newton (B) Cavendish (C) Archimedes (D) Galileo

(14) 1 Pascal = 1 ....

(A) m/s^2 (B) $Nm^2 kg^{-2}$ (C) N/m (D) N/m^2

(15) The initial velocity of a freely falling body is ....

(A) more (B) less (C) zero (D) 9.8 m/s

2. Answer the following questions in short :

(1) On what factors does the value of gravitational force depend ?

(2) Due to which force does the moon revolve around the earth in circular motion ?

(3) Write the Newton's universal law of gravitation.

(4) Why G is called universal constant of gravitation ?

(5) What do you mean by free fall ?

(6) Which type of motion is described by a freely falling body ?

(7) What do you mean by weight of an object ?

(8) Give definition of pressure.

(9) Write the Archimedes principle.

(10) What is the value of gravitational acceleration on moon, as compared to the gravitational acceleration on the earth ?

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(11) In which direction does the buoyant force act on an object immersed in liquid ?

(12) What will be the mass of a man of 60 kg on the moon ?

(13) What will be the decrease in velocity of an object thrown upwards ?

(14) What will be the velocity of a stone thrown upwards at its maximum height ?

3. Answer the following questions :

(1) Which phenomena were explained by the universal law of gravitation ?

(2) Explain buoyancy and buoyant force.

(3) Explain the relative density by giving an illustration.

(4) From the equations of uniformly accelerated motion, obtain equations for a freely falling body.

(5) From the equations of uniformly accelerated motion, obtain equations for a body moving in upward direction.

(6) Give the difference between the acceleration due to gravity 'g' and the universal constant of gravitation 'G'.

(7) Define pressure for the applied force. If the area increases or decreases, then that will be the change in pressure ? Explain and give proper illustrations.

(8) Explain the universal law of gravitation and obtain its mathematical form.

(9) Give the difference between mass and weight.

(10) Explain the density and relative density of an object.

4. Solve the following examples :

(1) Two spherical bodies, each of 100 kg, are separated by 1m. Calculate gravitational force exerted by each on the other.
($G = 6.67 \times 10^{-11}\ Nm^2/kg^2$)

(**Ans.** : 6.67×10^{-7} N)

(2) The earth revolves around the sun under the influence of gravitational force. If the mass of earth is 6×10^{24} kg, the mass of the sun is 2×10^{30} kg, and the distance between their centres is 1.5×10^{11}m, then calculate the gravitational force between them. What will be the acceleration of the earth under the effect of gravitational force ?
($G = 6.67 \times 10^{-11}\ Nm^2\ kg^{-2}$)

(**Ans.** : 3.557×10^{22} N, 0.0059 m/s^2)

(3) Mass of the Jupiter is 2×10^{27} kg and its radius is 7.14×10^7 m. Calculate gravitational acceleration on its surface. ($G = 6.67 \times 10^{-11}\ Nm^2\ kg^{-2}$)

(**Ans.** : 26.17 m/s^2)

(4) A ball is released from the top of a tower and it reaches the ground in 3 s. Calculate the height of the tower, and velocity of the ball when it touches the ground. ($g = 9.8\ m/s^2$)

(**Ans.** : h = 44.1 m; v = 29.4 m/s)

(5) Calculate velocity of a body, released from 40 m height, when it touches the ground. ($g = 9.8\ m/s^2$) (**Ans.** : 28 m/s)

(6) A ball thrown vertically upwards reaches the maximum height in 2 s and then it returns. Calculate the initial velocity with which it was thrown. Also calculate the maximum height attained by it.

(**Ans.** : u = 19.6 m/s; h = 19.6 m)

(7) Calculate the weight of a body of 10 kg mass on the earth. ($g = 9.8\ m/s^2$)

(**Ans.** : W_m = 98 N)

(8) Calculate weight of a body of 60 kg mass on the earth and the moon.
($g_e = 6\ g_m = 9.8\ m/s^2$) (**Ans.** : Weight on the earth 588 N ;
Weight on the moon = 98 N)

(9) Calculate the mass of a body whose weight on the earth is 245 N.
($g = 9.8\ m/s^2$) (**Ans.** : 25 kg)

(10) Weight of an object on the earth is 392 kg. Calculate acceleration produced in the body if 80 N force is applied on it ($g = 9.8\ m/s^2$).
(**Ans.** : $a = 2\ m/s^2$)

(11) The mass of an empty beaker of 500 ml is 250 g. What will be the density of the empty beaker ? (Neglect the volume of material of the beaker). What will be the relative density of the empty beaker ? If water of 100 ml, 200 ml, 300 ml is filled in the beaker, what will be the density of beaker filled with water each time ? What will be the relative density ? Put the calculated values in the given table.

Density of water = 1000 kg/m^3, 1ml = $10^{-6} m^3$

Mass of beaker m_1 (kg)	Volume of beaker V m^{-3}	Volume of water filled in beaker *V* m^{-3}	Mass of water filled in beaker m_2 (kg) = v × 1000	Mass of beaker with water $m = m_1 + m_2$ (kg)	Density of beaker with water $\rho = m/v$ (kg/m^3)	Relative Density of beaker with water $\frac{\rho}{1000}$
0.25	5×10^{-4}	0	0	0.25		
0.25	5×10^{-4}	1×10^{-4}	0.1	0.35		
0.25	5×10^{-4}	2×10^{-4}	0.2	0.45		
0.25	5×10^{-4}	3×10^{-4}	0.3	0.55		

How much water must be filled in beaker so that it sinks in a bucket filled with water ? Think.

Answer :		
	500	0.5
	700	0.7
	900	0.9
	1100	1.1

4 Properties of Matter

4.1 Introduction

If we look around the environment, we will be able to see many types of things which have different shapes, volumes and texture. Each thing of this universe is made up of a substance which is named as "matter" by the scientists. The food that we eat, the air that we breathe, stone, cloud, tree, star and animal and also small drop of water or small particle of sand-each thing is matter. We will come to know that all the things mentioned above occupy 'space' and they have 'mass'. In other words they have mass and volume.*

From last so many ages, the human beings are trying to understand the environment. Every Indian philosopher has classified matter into five fundamental elements. These five fundamental elements are air, earth, fire, space and water. According to their opinion, all living and non-living things are made up of these five elements. Ancient Greek philosophers have also arrived at this type of conclusion in the matter of classification of matter.

Matter is made of particles : For a long time two schools had expressed their views regarding matter. One school believed that matter is continuous like a log of wood. Other school believed that matter is made of small particles like the particles of the sand. By doing certain activities like preparing solution of sugar or salt, it can be said that matter is made up of particles. The particles of this matter are very small. If we think of one crystal of a substance, there may be one million small particles. When such a crystal decomposes or dissolves, it is changed to many small particles.

Characteristics of particles of matter :

(1) There is space between particles of the matter. When one substance mixes with the other or dissolves in a solvent and forms a solution, these small particles are arranged in this space of substances.

(2) The particles of the matter are continuously moving. This can be proved by certain activities. They are continuously moving because they possess kinetic energy. With the increase in temperature, their kinetic energy increases.

(3) The particles of the matter can mix into with each other on their own because there is space between them. This phenomenon is known as diffusion of particles. With the increase in temperature, the rate of diffusion increases and so the matter dissolves easily and faster in hot solvents.

(4) The particles of matter attract each other. There is attractive force between particles which keep them together. If we move from one type of matter to the other type, the strength of this attractive force changes.

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*S.I. unit of mass is kilogram (kg). The S.I. unit of volume is (meter)^3 or cubic meters. The common unit of measuring volume of liquid is litre (L). Hence

1 litre (L) = 1 (m^3) or 1 decimeter cube

1 litre (L) = 1000 (cm^3) or centimeter cube

1 litre (L) = 1000 (ml)

Hence : 1 millilitre = 1 cm^3 or 1ml = 1 cc

Matter can be classified in two ways : (1) On the basis of physical properties viz. solid, liquid and gas and (2) On the basis of their chemical composition viz. elements, mixture and compound.

4.2 States of Matter : Classification of Substances)-Solid, Liquid, Gas)

If we study the substances present around us, it can be seen that they are in the form of solid, liquid or gas. e.g. ice, water and water vapour. Thus the three states of matter are – solid, liquid and gas.

In the modern science the states of matter accepted are five. Over and above, solid, liquid and gas, the other two states are plasma and Bose Einstein condensate.

Plasma : This state possesses very high energy containing and highly excited particles. These particles are like ionised gas to which electron remains attached. Plasma is there in fluorescent tubes and neon sign bulbs. In the neon sign bulbs, there is neon gas. In fluorescent tube there is either helium or any other gas. Gas gets ionised that is to say when electrical energy is passing through them, they acquire electric charge. When this electric charge is acquired, plasma is formed which shines in bulb or tube. Its colour depends on the nature of the substance or the gas that is filled in. The sun and the stars, shine because there is plasma present in them. The reason for production of plasma in stars and sun is very high temperature.

Bose-Einstein Condensate : The Indian physicist Satyendra Nath Bose in 1920 made certain calculations about the fifth state of the matter. On the basis of this foundation Albert Einstein predicted one state of matter which is called Bose-Einstein Condensate (BEC). In 2001, Eric A Cornel and Carl E. Wieman and E. Wiemann of America were awarded the Nobel prize in physics for obtaining Bose - Einstein Condensate state. Very less density - the density of the air of the order of hundred thousand[th] time, when cooled at very low temperatures, BEC is formed. You can have more information on the website www.Chem 4kids .com

The reason for the existence of these states is the deviation in their characteristics :

(1) Solid substance (Solid state of matter) : Solid substance has definite shape and volume. There is no effect of external pressure on it and so they do not compress. Solid substances are not fluid. Solid substance can be broken by applying external force but it is difficult to change their shapes. Hence, they are rigid. We are able to press sponge because there is air inside the space which goes out but the state cannot be changed.

(2) Liquid substance (Liquid state of matter) : The liquid substance shas no definite shape and so it assumes the shape of the vessel in which it is poured. It has definite volume. Liquid can flow and is not rigid. Hence they can be said to be fluid solid and liquid fluid can diffuse in liquid. The gases of atmosphere escepecially oxygen and carbon dioxide diffuse in water and dissolve to some extent. These gases are useful for the existence of marine animals and vegetation. Thus, gas can also diffuse in liquid. The rate of diffusion of liquid is more than that in solid. The reason for this is the fact that the particles in liquid state can freely move in comparison to that of solid state. There are more spaces in liquid also. Liquid can be compressed as compared to solid. There is negligible decrease in volume of liquid. This is known as compression.

(3) Gaseous substance (Gaseous state of matter) : The gaseous substance has not its own definite shape or volume. The compression of gas is its characteristic. Small quantity of gas can be spread in the whole vessel. More quantity of gas can be filled in by applying pressure. **CNG (Compressed Natural Gas)** used in vehicles, **LPG (Liquified Petroleum Gas)** used for household purposes and **PNG (Piped Natural Gas)** are filled in cylinders under high pressure. Oxygen cylinders used in hospitals are containing oxygen gas at high pressures is due to the compression of oxygen gas. It is then used as per the requirement. These compressed gases are very convenient for transportation.

We without entering into the kitchen, if any sweet smelling item is being cooked, we can know because the sweet smell of the cooked item spreads in the gaseous form and reaches to our nose. This means that the rate of diffusion of gas is higher than solid and liquid. The particles in the gaseous state, are moving randomly with very high speed, and so are spread in all the parts of the vessel. When they strike with the walls of the container, they produce pressure.

The force that exists between the particles in the solid, liquid or gaseous state of matter is known as intermolecular force. These component particles are considered as atoms / molecules. The particles present in solid, liquid and gaseous states have been shown in fig. 4.1

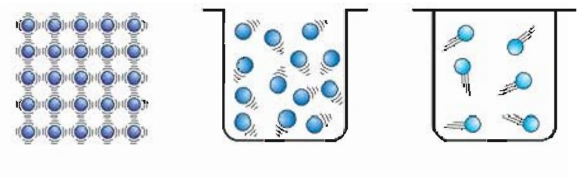

Figure 4.1 Molecular form of Solid, Liquid and Gas

The intermolecular forces keep these component particles strongly bound in solid substance and so they are very near to each other. The number of atoms in unit volume is high in solid and so its density is more than that of liquid or gas. Hence, it cannot be compressed. The arrangement of its molecules is very regular which is known as lattice arrangement. In a crystal, its components having regular geometrical shape are arranged very regularly and their intermolecular forces are maximum.

In liquid state the intermolecular forces between its component particles is strong enough to keep the liquid in quantity (group) so that it can flow. They have no definite shape. In comparison to solids, the distance between the particles is more in liquids. Hence, intermolecular forces are weaker.

The intermolecular forces between particles in the gaseous form is very less. Hence the components of this state can move freely in the vessel and they collide with each other and also with the wall of the container. Because of this, the pressure is created. The distance between the particles in the gaseous state is more than that in solid or liquid and so they do not get attracted or repelled. As the number of particles per unit volume is less in gases, their density is lower than that of solid or liquid.

4.3 Effect of Temperature and Pressure On State of Matter

There are different effects of temperature and pressure on the definite amount of all the three states of matter. The effect of temperature and pressure on solid and liquid is not so noticeable, but there is definite effect on them if the changes in pressure and temperature are very large. With the increase in temperature, the heat absorbed in the form of energy. The crystal of the solid expands (swells) because the kinetic energy of the composite molecules increase and the composite particles experience lot of vibration and occupies more space. Because of the vibrations of the composite particles, they leave their space. Hence the solid substance melts and becomes liquid. Thus the transfer of the particles is called translation. The temperature at which solid substance changes the liquid state at one atmosphere pressure is called its melting point. Melting point of ice is **273.16K*** If heat is supplied to ice, it is converted to water and temperature remains constant; then where is the heat has gone ? It is not seen and also not noted on thermometer and so it is called latent heat of fusion. The latent heat of fusion of ice is 0.33 kJ per gram.

With the increase in temperature of the liquid substance, the kinetic energy of the composite particles increases and liquid is converted to its gaseous state which we call as evaporation. With the increase in temperature, the liquid starts boiling and it is necessary to know where the absorbed heat has gone because when liquid boils, the temperature remains constant. This heat is used up latently in converting liquid to boil, the temperature remains constant. This heat is used up in converting liquid into vapour. Hence, it is called latent heat of vaporisation. The boiling point of water is 373.16 K and its latent heat of vaporisation is 2.259 kJ per gram. The temperature at which the liquid boils at one atmosphere pressure is called its boiling point.

From above, it can be said that with increase in temperature, solid $\rightarrow$ liquid $\rightarrow$ gas states change and with decrease in temperature gas $\rightarrow$ liquid $\rightarrow$ solid states change. Here, one thing is to be noted. When certain substances are in solid state and heat is supplied to them they do not change into liquid state but directly changes to gaseous state. e.g. camphor or ammonium chloride (salamoniac). This phenomenon is known as sublimation. When these substances are cooled they change directly from gaseous state to solid state. The latent heat associated with it is called latent heat of sublimation.

As studied earlier, the solid, liquid or gaseous states of matter is due to the distance between their composite particles. As seen earlier, when pressure is increased on liquid, it is converted to solid. This effect is less than when the pressure is increased on gaseous substance and converted to liquid. The effect of pressure on solids is negligible, more on liquids and most on gases.

Can you tell what is dry ice ? You can think, what will happen to carbon dioxide gas if the pressure on it is increased and is changed to solid

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*Kelvin (K) is the SI unit of temperature. 0^0C= 273.16 K but for convenience, we take 0^0C= 273 K. 273 is added to convert temperature from Celsius scale to Kelvin scale e.g. (25^0C = 25 + 273 = 298 K) and 273 is subtracted from Kelvin temperature to convert it to Celsius scale.

e.g. **373 K – 273 = 100^0C**

state. Carbon dioxide is obtained as white substance in solid state whose temperature is very low. It is called dry ice. It is used to create coolness. Dry ice is used in cold storages and also in the container of ice-cream so that it does not melt. Similarly by decreasing the temperature and increasing the pressure, air can be liquified and the composite gases present in it can be separated.

1 atmosphere = 1.01×10^5 Pa. The pressure of air in atmosphere is called atmospheric pressure. The atmosphereic pressure is 1 atmosphere at the sea level and it is taken as common (general) atmospheric pressure. The other units of pressure are bar and torr. They are related as follows :

1 atmosphere = 76 centimeter = 1 bar =
760 millimeter = 760 torr = 1.01×10^5 Pa.

We are familiar with the unit of atmosphere.

4.4 Element, Mixture and Compound

It is necessary to understand the effect of physical and chemical changes before they are classified as element, mixture and compound on the basis of the chemical composition of the substance.

In physical change, the physical form or physical property changes but chemical identity (composition) is not changed. e.g. Dissolution of sugar in water is a physical change. Sugar and water maintain their identity in the solution and on evaporation of the solution, one of the components water is removed as vapour and the second component sugar is obtained in solid form. Thus physical change is reversible.

In a chemical change, there is reaction between one or more than one substances and new types of substances are formed. e.g. as iron rusts in moist air, iron combines with moisture and oxygen of air and forms rust (Iron oxide). Here, rust is formed by the chemical reaction of iron and oxygen. Iron and oxygen cannot be obtained back from this compound by physical methods. This means that the change is irreversible. Iron and oxygen, after combining, lose their properties and a substance having new properties is formed.

Elements : French scientist Lavoisier (1743-94) attempted to give explanatory definition of element. Element is the basic form of a substance or a basic unit of substance. It cannot be obtained in other simple substances by its chemical decomposition. As the brick is the basic unit of a building, similarly, element is the basic unit of every substance. Any element is formed of only one type of atom.

The atoms of different elements are different. Thus, the element has its specific properties which do not possess similarity with properties of other elements.

Hydrogen, nitrogen, oxygen, chlorine, iron, gold, platinum, sodium, radium, radon etc. are elements. At present 114 elements are known out of which 92 elements are obtained from nature. The remaining elements are artificially prepared by synthesis in the laboratory.

For special information :

(i) At present the total number of elements known is 114.
(ii) 92 elements are available in nature. The remaining are obtained by scientists by synthesis.
(iii) Most of the elements are in solid state.
(iv) Eleven elements are in gaseous state at room temperature.
(v) Two elements are in liquid state at room temperature – Mercury and bromine.
(vi) Galium and Cesium can turn into liquid at temperatures slightly higher than room temperature.

Activity 1 : Write symbols of 92 elements available in nature and prepare the chart showing their states (solid, liquid or gas).

Mixture : Some substances are such that they are prepared by mixing two or more than two substances. e.g. The two substances, oxygen and nitrogen present in air are elements, while salt and water in sea water are the compounds. These mixed substances are the compounds. These mixed substances maintain their original properties. They can be separated by physical methods. e.g. O_2 and N_2 gases can be obtained by liquefaction of air and water and salt from sea water by evaporation. Thus, the substances formed by such mixing are called mixtures. The composition of the components in the mixture can be variable i.e. they are not definite like that in compound. They maintain their own properties.

Activity 2 : Take a mixture of common salt and sand in one beaker. Add water to it. Stir it. The common salt will dissolve in water. Sand being insoluble will remain in beaker without dissolution. Filter this solution with the help of a filter paper. Sand will remain on filter paper and solution of common salt will be collected in an evaporating dish. Now heat slowly the evaporating dish. Water will go out as steam and crystals of common salt will be obtained. Thus sand and common salt are obtained back with their original properties by the physical methods filtration and evaporation. Hence, it can be said that it is a mixture. Soil and cold drinks do not contian single substances but they are mixtures. Whatever may be the source of obtaining the substance but their characteristic properties are same. Thus, it can be said that mixture contains more than one substance.

4.5 Types of Mixture :

Mixtures are of two types :

(1) Homogeneous and (2) Heterogeneous

(1) Homongeneous mixture : If we dissolve sugar in water and prepare a solution then it is a true solution and it is a mixture. This mixture is homogeneous because the components are uniform in the whole solution and its formation in the whole solution is also same. It appears like a single substance. Such a mixture is called homogeneous mixture. The formation of each part in sugar solution is same. Such solutions can be prepared having different proportions (10%, 20%, 30% etc.). The concentration of solutions will be different but they will be the solutions having homogeneous mixture.

Water is the best and universal solvent. It dissolves several types of substances and make the solutions of these substances. Hence, water is called universal solvent. Generally there are two components in a solution. One component whose quantity (amount) is less in solution is called a solute and the second component whose quantity (amount) is more in solution is called a solvent. The total (aggregrate) system is called solution. e.g. suppose we dissolve 10 grams of sugar in 100 grams of water and prepare a solution then sugar (less quantity - 10 grams) is called solute and water (more quantity - 100 grams) is called solvent and the solution of sugar (total system) is called solution. This solution is a homogeneous solution. The other similar example is air, which is a homogeneous mixture of compounds in gaseous states. All the gases present in air are physically mixed in one another but chemically they do not react with each other and maintain their original properties. When salt is added to water and solution is prepared, the molecules and the ions in the solution are distributed equally and as a result homogeneous mixture is formed. Such solutions are called true solutions. The particles of the solute distributed in the solvent of the solution are especially only one type of molecules and ions. The particles of the solute are arranged in the space between particles of the solute.

(2) Heterogeneous mixture : In a heterogeneous mixture, each component of the mixture is seen different, the properties of each component (substance) are different. In a heterogeneous mixture, when two or more than two substances are mixed they are immiscible but can be found in different physical parts separated by a thin differentiating boundary. The structure of the mixture in such parts is found to be different. Hence, their properties are different. e.g. In a mixture of sodium chloride (salt) and iron powder, both iron and salt can be separately seen. Similarly in a mixture of any salt and sulphur in the different parts of the mixture yellow particles of sulphur are seen. Hence, it is a heterogeneous mixture. In the same way, when oil and water are mixed the mixture obtained is heterogeneous, because they are distributed in two separate layers. The proportion of the components in a heterogeneous mixture is not definite compared to homogeneous mixture where they are definite. In a heterogeneous mixture the particles of one component cannot be accommodated in the space of other component.

Compounds : Two or more than two elements combine together and form a compound. The elements present in the compound lose their original properties and a new substance with new different properties is formed. Hence, the original properties of the element are not observed and they cannot be obtained back from the compounds by physical methods. If a compound is formed by more than one method, their proportion and chemical structure are definite. e.g. NaCl can be obtained by mixing NaOH and HCl or by reacting solid sodium with dichlorine gas or by reacting sodium carbonate with HCl, but the structure of NaCl and the proportion of its components is the same. The elements combining to form compound are in their definite (constant) proportion of weight. This is called law of definite (constant) proportion. As mentioned above, NaCl obtained by any of the three methods, the proportion of Na : Cl is definite i.e. 23:35.5 or the percentage proportion of Na ($\frac{23}{58.5} \times 100 =$ 39.32%) and of Cl ($\frac{35.5}{58.5} \times 100 = 60.68\%$) remains definite (constant).

Table 4.1

Mixture	Compound
(1) Elements or compounds mix with each other and prepare a mixture and no new compound is formed.	(1) Elements react and a new compound is formed.
(2) Mixture shows the properties of the components present in it.	(2) In the new substane formed in compounds the component substances change their properties and a substance with new differnet properties is formed.
(3) In the mixture the proportion and the composition are variable	(3) The composition and proportion of each new substance formed is always definite.
(4) Component elements can be separated by physical methods.	(4) The component elements can be separated only by chemical or electrochemical methods.

In the table 4.1 the differences between mixture and compound are given.

4.6 Solution and Types of Solution

Solution is a homogeneous mixture of two or more than two substances. You come across different types of solutions in your every day life viz lemon water or sharbat, soda water etc. are the examples of solution. In a solution one component whose quantity (amount) is less is called solute and the other component whose quantity (amount) is more is called solvent. Solvent dissolves solute in solution and the aggregate homogeneous mixture is called solution. This is an example of true solution.

We understand that solution means liquid state but we have the illustrations of solutions in solid state as well as in gaseous state. e.g. Alloy* (a solid solution of one metal in the other metal) and air (Gaseous solution of gaseous substances in a gaseous substance). The solutions are homogeneous at the particle level. e.g. the taste of lemon sharbat is same in any part of the solution.

Thus the examples of solution can be shown as below :

Solvent	Solute	Solution	State
Water	Sugar	Sugar solution	Liquid
Copper	Zinc	Brass	Solid
Nitrogen	Oxygen	Air	Gas

Properties of true solutions :

(i) True solutions are homogeneous mixtures.

(ii) The diameter of the particles of the solution is less than 1Nanometer(nm)= (10^{-9}m). They cannot be seen with (naked) unaided eye.

(iii) They are not able to scatter the light passing through them because of their very small size of solute particle. Hence, we are not able to see the path of light from these solutions.

(iv) The particles of the solute cannot be separated from their mixture in solution formed by physical method like filtration.

(v) The particles do not settle down if the solution is kept without disturbing it. This means that these solutions are stable. Such solutions are called true solutions.

* **Alloys :** Alloys are solid mixtures of two or more metals or mixture of metals and non-metals which cannot be separated into their components by physical methods. Even then alloys are called mixtures because they show the properties of each of its components and it is also variable. For example brass. In one of its type the mixture is 30% Zn and 70% Cu. In its other type the composition is 40% Zn and 60% Cu in the mixture.

Types of solution :

Suspension solution : Earlier we have studied about true solutions. Sometimes the solute substance instead of being soluble in solvent and forming homogeneous mixture, it disperses (they seem like floating) in the solvent. Solution obtained in this way is called suspension solution. Suspension is a heterogeneous mixture. The particles of two solutes do not dissolve but remain floating everywhere in the quantity of the medium. The particles in suspension solution can be seen with unaided (naked) eye.

When sparingly soluble barium sulphate is dissolved in water and its solution is prepared, the particles of barium sulphate disperse in water (scatters) and opaque medium is formed. Small size particles of barium sulphate are found floating in insoluble form in water i.e. to say they remain suspended in the solution and can be seen by naked eye. The solution of lime stone in water is also an example of suspension solution.

Properties of suspension solution :

(i) Suspension solution is a heterogeneous mixture.

(ii) The suspended particles can be seen with naked eyes.

(iii) The suspended particles scatter the light passing through them and so their path can be observed.

(iv) If the suspension solution is kept without disturbing it, the particles of the solute settle down. i.e. to say the suspension solutions are not stable.

(v) They can be separated from the mixture and the solution after settling of the particles is not able to scatter the light.

True solutions : Earlier we have studied in the begining about the solutions and discussed their properties. They are for the true solution. Sugar solution, solution of salt are true solutions.

Colloidal solution : Suppose we take few drops of milk or ink and add to water and then stir with a glass rod and try to see through the solution, we will not be able to see and if we allow the light of the torch to pass through it, we will be able to see the path of the light. If we keep this solution undisturbed, the particles of the solute will not settle down. i.e. to say the solution will appear to be stable. In this heterogeneous soluble substance (dispersed phase) is found dispersed in solvent (dispersion medium). Such solutions are called collodial solutions or sols.

Their properties are as follows :

(i) Colloidal solution is a heterogeneous mixture, even though it appears as homogeneous mixture.

(ii) Particles of solute (dispersed phase) in solvent (dispersion system) which is called a colloid.
(iii) Particles of the colloid are distributed everywhere in the solution.
(iv) The solute component of it cannot be separated by physical method like filtration, but can be separated by an appartus like ultracentrifuge.
(v) Their solute particles are bigger in size than solute particles in true solution but smaller than the solute particles which are insoluble. (10^{+4} to 10^{+5}nm).
(vi) They scatter the ray of light which is known as Tyndall effect. Similar Tyndall effect you can observe if you see a ray of sunlight passing from a small hole in a closed room.
In this, there is air (gaseous dispersion medium) and the dust particles are (solid dispersing phase). Hence it is a gaseous colloid (Aerosol).
(vii) If colloidal solution is kept without disturbance, the particles do not settle down. Hence they are stable.

Some examples of colloid includes milk, foam, cheese, smog, cloud, facial cream, certain medicines etc. They are in use in our everyday life.

4.7 Concentration of Solution (weight and volume based) :

The concentration of a solution expresses the known quantity of a solute in a known quantity of a solvent. The concentration of a solution can be expressed in many ways but we shall study the following two methods in this unit.

(1) Weight based (2) Volume based.

(1) Weight based : In the weight based method the weight of known solute dissolved in known weight of solvent is expressed. Generally, it is expressed in percentage and so it is written as W/W%.

In the second method based on volume the known weight of solute dissolved in known volume of solvent is expressed. It is also generally expressed in percentage and is written as W/V%.

(2) Volume based : In the volume based method, the known volume of solute in known volume of solvent is expressed. It is also expressed in percentage and is written as V/V%.

Both these methods will be clear by the following illustration :

Suppose W gram of solute substance is dissolved W gram of solution then the percentage concentraion will be $\frac{w}{w} \times 100$

Suppose W gram of solute substance is dissolved in V ml. of solution then the percentage concentration will be $\frac{W}{V} \times 100$.

4.8 Saturated and Unsaturated Solution

At normal temperature, solute dissolves in the solvent according to its capacity which is called solubility at that temperature. If more solute is added to it, it does not dissolve but remains as more substance without being soluble. Such a solution is called a saturated solution. Hence, normally when more substance is added after it being dissolved and the solution is heated and then cooled, saturated solution will be obtained.

The solution containing less concentration than the solubility of solute at constant temperature is called unsaturated solutions. If more solute is added to it, it dissolves. Solubility depends on temperature and the type of the solvent.

4.9 Atom of Matter (substance) and Atomic Theory of Matter

Extremely small particle of an element is called an atom. The smallest particle obtained by dividing matter and which cannot be further divided is called an atom.

John Dalton of England in 1804 gave the laws of chemical combination which explains the existence of atoms. The following are the assumptions of Dalton's atomic theory :

(1) Element is made up of extremely small particles size (about 10^{-8} cm) which cannot be seen with naked eye. This particle is called an atom and it is the smallest indivisible particle of an element.
(2) All the atoms of any one element are same and their weights and properties are alike. Atoms of any one element are different from the atoms of other element. Thus atoms of every element have their independent identity.
(3) Atom can not be created or it cannot be destroyed. Under normal circumstances the atom of one element cannot be changed into atom of other element. (This is possible only by nuclear reaction).
(4) When a chemical combination between two or more than two elements takes place, their atoms combine in some definite proportion which can be expressed by simple whole number. Such small particles formed from atoms is called molecule. Molecule is bigger than atom.
(5) Atom being extremely small and indivisible, it maintains its existence during physical or chemical change. For example, by combination of Na and Cl, NaCl will be obtained and not any other substance.

According to Dalton's atomic theory, hydrogen gas molecule is formed of atoms of hydrogen gas.

i.e one molecule of H_2 is obtained from 2 H atoms. In the modern nomenclature H_2 is known as dihydrogen. Similarly oxygen molecule is made up of two oxygen atoms and it is known as dioxygen. Because of chemical reaction between hydrogen and oxygen, one molecule of water H_2O is obtained by combination of two atoms of hydrogen and one atom of oxygen. The source of water or the method of formation of water may be anyone but the number of hydrogen and oxygen atoms in water and their total weight is always definite. The proportion of H:O is 1:8 in water and it is same and definite.

4.10 Molecule

Atoms of definite type combine chemically and form molecule. Atom is the smallest particle of element and molecule is the smallest particle of a compound.

Under normal conditions, it possesses independent existence and has its own specific properties. If the number of atoms present in a molecule is one, two, three, four, five, six etc, then the molecule is called monoatomic, diatomic, triatomic, tetraatomic, pentaatomic, hexaatomic etc. respectively and if number is still more, then it is called polyatomic. Molecules can be of same atoms (e.g. H_2, O_2 etc.) or can be two or more different atoms (e.g. HCl, H_2O, $KMnO_4$ etc.) Some examples are given in table 4.2.

In the figure 4.1 the shapes of certain molecules are shown.

Table 4.2

Atoms	Molecule	Number of atoms	Name and formula of molecule or compound
He	Monoatomic	1	He - Helium (Monohelium)
H	Diatomic	2	H_2 - Dihydrogen can be written
H,Cl	Diatomic	2	HCl - Hydrogen chloride
H,O	Triatomic	3	H_2O - Dihydrogen oxide (water)
P	Tetraatomic	4	P_4 - Tetraphosphorous
K, Mn, O	Polyatomic	6	$KMnO_4$ - Potassium tetraoxomanganate.

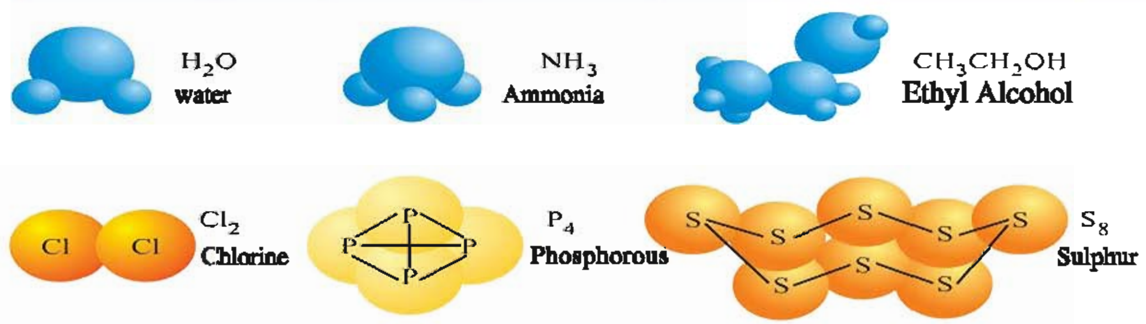

Figure 4.1 The Shapes of certain molecules

In the structural formula, atoms are arranged with one another in definite arrangement. Viz. H-O-H

The properties of the element or compound depend on the arrangement of atoms or molecules. The elements which are in molecular form are expressed by their molecular formula. viz. Cl_2–dichlorine, P_4–tetraphosphorus, S_8–octa sulphur.

4.11 Molecular Mass and Atomic Mass (Molecular weight and Atomic weight) *

Atomic mass : As the atom of each element possesses separate mass, every element has its characteristic atomic mass. It is difficult to find mass of an atom having very small volume (size). With the help of instrument like mass spectrometer, the mass of the atom can be known considering the mass of certain atom as standard. The IUPAC (International Union of Pure and Applied Chemistry) institution has accepted that the atomic mass of carbon element can be considered as standard and the mass of any other element can be found out by relation. Considering the mass of carbon-12 isotope of carbon as standard its atomic mass is accepted as 12; $\frac{1}{12}$ th part of

* In the modern method, atomic mass instead of atomic weight and molecular mass instead of molecular weight terms are accepted, you have studied earlier the difference between weight and mass.

* amu is expressed as u.

atomic mass of carbon-12 is the atomic mass of hydrogen. i.e. 1 amu. Similarly atomic mass of oxygen is 16 amu.

Atomic masses of some common elements are given in Table 4.3.

Table 4.3

Elements	Symbol	Atomic mass(amu)	Elements	Symbol	Atomic mass(amu)
Aluminium	Al	27.0	Magnesium	Mg	24.0
Argon	Ar	40.0	Manganese	Mn	55.0
Boron	B	11.0	Mercury	Hg	200.0
Bromine	Br	80.0	Nitrogen	N	14.0
Calcium	Ca	40.0	Oxygen	O	16.0
Carbon	C	12.0	Phosphorus	P	31.0
Chlorine	Cl	35.5	Potassium	K	39.0
Copper	Cu	63.5	Silicon	Si	28.0
Fluorine	F	19.0	Silver	Ag	108.0
Gold	Au	197.0	Sodium	Na	23.0
Helium	He	4.0	Sulphur	S	32.0
Hydrogen	H	1.0	Tin	Sn	119.0
Iron	Fe	56.0	Zinc	Zn	65.0
Lead	Pb	207.0			

Molecular mass : The molecular mass of any molecule or a compound can be obtained by making use of atomic masses of atoms present in that molecule or compound. If we know the molecular formula of a molecule or a compound then knowing the number of each atom and multiplying it with its atomic mass and finally adding up the total mass of all the atoms, the molecular mass can be obtained. This will be clear from the following example.

The molecular formula of water is H_2O. This means that there are two H atoms and one O atom in it. The atomic mass of H is 1 amu and that of oxgen is 16 amu and so molecular mass of H_2O can be calculated as follows :

$H_2O = 2 \times H + O = 2 \times 1 + 1 \times 16 = 2 + 16 = 18$ amu

The formula of ionic compound NaCl is Na^+Cl^-. Here, Na^+ and Cl^- atoms are in ionic forms. We should remember that the mass of the electron is very less (0.00055 amu). Hence, if atom receives an electron or loses an electron the mass of the ion can be taken to be equal to that of its atomic mass. Hence, molecular mass of Na^+Cl^- will be

$1 \times Na^+ + 1 \times Cl^-$

$1 \times 23 + 1 \times 35.5 = 58.5$ amu

When the compound is in such an ionic form, we can call molecular mass as formula mass. The molecular masses of some common substances are given in Table 4.4.

Table 4.4

Name of molecule or compound	Molecular Formula	Molecular mass(u)*	Name of Molecule or Compound	Molecular formula	Molecular mass
Dihydrogen	H_2	2.00	Sodium hydroxide	NaOH	40.0
Dioxygen	O_2	32.00	Sodium carbonate decahydrate	Na_2CO_3, $10H_2O$	286.0
Dichlorine	Cl_2	71.00			
Methane	CH_4	16.00	Calcium chloride dihydrate	$CaCl_2$, $2H_2O$	147.0
Ammonia	NH_3	17.00			
Carbon dioxide	CO_2	44.00	Copper sulphate pentahydrate	$CuSO_4$, $5H_2O$	249.5
Hydrochloric acid	HCl	36.50			
Sodium chloride	NaCl	58.50	Sulphuric acid	H_2SO_4	98.0
Silver nitrate	$AgNO_3$	170.00	Phosphorus trichloride	PCl_3	137.5

4.12 Mole Concept

Atomic mass and molecular mass are only simple numbers. This numbers indicate relative masses.

In our normal life we come across many terms like kilogram, pound, ton, etc for mass. Over and above we are using some collective terms like one dozen banana, one score of kites, one gross of screws etc. One dozen means 12 nos, one score means 20 nos and one gross means 144 nos. Thus to express some individual thing we use such collective terms. We know that element is made up of very small particles which means that there are innumerable atoms in it. It is extremely difficult to count such small particles or innumerable atoms. In a laboratory, we take definite weight of a substance during the experiment but it is extremely difficult to count that how many atoms or molecules are present. Hence, the scientist proposed one concept to relate mass, weight and amount and it is called 'mole', as 1 dozen = 12 nos. 1 score = 20 nos and 1 gross = 144 nos. Similarly 1 mole = 6.022×10^{23} nos. is accepted. It is called Avogadro number. Reactions studied in chemistry are expressed in moles. Let us understand the meaning of this unit. Generally we write,

1 mole .... = 6.022×10^{23} ....

In the blank space on both the sides, words like atom, molecule, ion, proton, electron are useful in chemistry. If we write for a fun, then we can write words like stones, oranges, men, cows, buffaloes in the blank space on both the sides. Which means that mole is a number and so it is unitless.

Let us see how number of moles can be determined ? If it is an atom, knowing its atomic mass, if a molecule, knowing its molecular mass, if an ion knowing its ionic mass, if a compound knowing its molecular mass, from their formula, the number of moles can be calculated. The numbers of components in this mass will be equal to one Avogadro number (N_A) = 6.022×10^{23} is accepted. As seen earlier the atomic masses of elements are related with $\frac{1}{12}$th gram of carbon. From the mass of the substance, moles can be calculated and from number of moles, the number of particles can be calculated with the help of Avogadro number. Let us take some examples.

Atomic mass of carbon (C) = 12 amu (u)
= 1 mole carbon

Molecular mass of water(H_2O) = 18 amu (u)
= 1 mole of water

Molecular mass of dioxygen molecule = 32 amu (u)
= mass of 1 mole of dioxygen

Molecular mass of dichlorine molecule = 71 amu(u)
= mass of 1 mole of dichlorine

Molecular mass of tetraphosphorus (P_4) molecule
= 124 amu (u)
= mass of one mole of tetra phosphorus

Molecular mass of hydrogen chloride (HCl) compound = 36.5 amu (u)
= mass of 1 mole of hydrogen chloride

Molecular mass of carbon tetrachloride (CCl_4)
= 154 amu (u)
= mass of 1 mole of carbon tetrachloride

If follows from the above discussion that the mass of 1 mole number of any element, molecule or compound is the molar mass of that element, molecule or compound, we call it as molar mass or molecular weight or molecular mass. The unit of molar mass is gram/mole or grammole^{-1}. For calculation of number of moles, the following formula can be used :

$$\text{Mole} = \frac{\text{mass of atom, molecule or compound in grams}}{\text{mass of atom, molecule or comound in grammole}^{-1}}$$

Let us be familiar with mole concept from some examples and carry out calculations.

Example 1 : (1) Find the number of atoms and molecules in (i) 11.5 gram sodium and (ii) 58.5 gram NaCl respectively and calculate their moles.

Solution :

(i) Molecular mass of sodium = 23 gram mole^{-1}

∴ Number of moles of atoms of sodium

$$= \frac{\text{mass of sodium in grams}}{\text{atomic mass of sodium (grammole}^{-1})}$$

$$= \frac{11.5}{23} = 0.5 \text{ mole}$$

According to Avogadro number, the number of atoms of sodium = mole × Avogadro number (N_A)

$= 0.5 \times 6.022 \times 10^{23}$ atom mole^{-1}

$= 3.011 \times 10^{23}$ atoms

(ii) Molecular mass of NaCl = 58.5 gram mole^{-1}

∴ Number of moles of NaCl molecules

$$= \frac{\text{mass of NaCl in grams}}{\text{molecular mass of NaCl (grammole}^{-1})}$$

$$= \frac{58.5}{58.5} = 1.0 \text{ mole}$$

According to Avogadro number, thus number of molecules of NaCl

= mole × Avogadro number

= 1 mole × 6.022×10^{23} molecules $mole^{-1}$

= 6.022×10^{23} $molecules^{-1}$

Example 2 : In some quantity of dichlorine 9.033×10^{23} molecules are present. What will be the moles of dichlorine and what will be its weight in grams ?

Solution : The formula of dichlorine is Cl_2 and its molecular mass will be 2 × 35.5 =71.0 grams $mole^{-1}$. Dividing the number of molecules of dichlorine 9.033×10^{23} in the amount by Avogadro number 6.022×10^{23} moles of dichlorine will be obtained.

$$\therefore \frac{9.033 \times 10^{23}}{6.022 \times 10^{23}} = 1.5 \text{ mole}$$

Mass of dichlorine in the amount

= mole × molecular mass (gram$mole^{-1}$)

= 1.5 × 71

= 106.5 gram Cl_2.

Example 3 : Find the number of molecules of H_2SO_4 present in 4.9 gram sulphuric acid and calculate its moles.

Solution : Molecular mass of H_2SO_4 =

$= 2 \times H + 1 \times S + 4 \times O$

$= 2 \times 1 + 1 \times 32 + 4 \times 16$

$= 2 + 32 + 64$

$= 98$ gram $mole^{-1}$

∴ According to Avogadro number

1 mole H_2SO_4 = 6.022×10^{23} molecules of H_2SO_4

$$\frac{\text{gram sulphuric acid}}{\text{gram mole}^{-1}\text{ sulphuric acid}} = \frac{4.9}{98} = 0.05 \text{ mole}$$

∴ 4.9 gram H_2SO_4 = mole. × Avogadro number

= $0.05 \times 6.022 \times 10^{23}$ molecules $mole^{-1}$

= 0.3011×10^{23} or 3.011×10^{22} molecules

4.13 Percentage Proportion of Elements In the Compound

To determine molecular formula of any compound, first of all it is necessary to know the elements present in it and its composition. Generally, the composition of the compound is expressed by the percentage of component elements of the compound. From this information, the simple formula of the compound can be determined. The relative proportion of atoms of each element present in the compound is expressed by this simple formula. Hence, this formula is called Empirical formula of the compound. This chemical formula expressing relative proportion of component elements of a compound is called empirical formula.

The empirical formula of a compound can be determined by following steps :

(1) Mention the symbol of all the elements present in the compound.

(2) Determine the percentage of all the elements present in the compound.

(3) Find the ratios of the percentage of the elements and their atomic masses.

(4) Find out the smallest ratio from the ratios obtained for each element and divide all the ratios by the smallest ratio.

(5) Determine the empirical formula of the compound on the basis of the whole number obtained for each element.

(6) Compare the mass determined by empirical formula and the molecular mass determined by any suitable method. If the mass by empirical formula and molecular mass are in the proportion 1:1, 1:2 or 1:3, multiply the empirical formula by 1, 2, or 3 respectively to determine molecular formula.

From the following example, the determination of empirical formula and molecular formula will be clear.

Example 4 : The percentages of carbon and hydrogen in a hydrocarbon compound are 85.7% and 14.3% respectively. Find its empirical formula. If the value of molecular mass determined for the hydrocarbon is 42 gram $mole^{-1}$, then determine its molecular formula.

Solution :

(1) In a hydrocarbon C and H are present.

(2) Percentage element 85.7 and 14.3.

(3) Ratio of percentage of element and its atomic mass

$$\frac{85.7}{12} = 7.15 \text{ and } \frac{14.3}{1} = 14.3$$

(4) Ratio of atoms of elements

$$\frac{7.15}{7.15} = 1 \text{ and } \frac{14.3}{7.15} = 2$$

(5) Ratio of simple whole number 1 : 2

(6) Empirical formula CH_2

(7) Mass calculated on the basis of empirical formula = 12 + 2 × 1 = 14

The multiplication number (n) can be determined from the ratio of molecular mass and empirical formula mass.

$$\text{Multiplication number (n)} = \frac{\text{Molecular mass}}{\text{Mass calculated according to empirical formula}}$$

$$\frac{42}{14} = 3$$

$\therefore$ n = 3

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As the empirical formula mass and molecular mass formula are in the ratio 1:3, the empirical formula will have to be multiplied by 3. Hence, $(CH_2)_n = (CH_2)_3 = 3 \times CH_2 = C_3H_6$

Thus the molecular formula of the hydrocarbon compound is C_3H_6 which is formula of Propene.

Example 5 : In an organic compound the percentages of carbon, hydrogen and oxygen are 40%, 6.7%, 53.3% respectively. Determine the empirical formula of this compound. If molecular mass is 30 grammole^{-1} determine its molecular formula.

Solution :

(1) Elements in compound C H O

(2) Percentage of element 40 6.7 53.3

(3) Ratio of percentage of element and its atomic mass $\frac{40}{12} = 3.33, \frac{6.7}{1} = 6.7, \frac{53.3}{16} = 3.33$

(4) Ratio of atoms of element

$\frac{3.33}{3.33} = 1; \frac{6.7}{3.33}; 2; \frac{3.33}{3.33} = 1$

(5) Ratio of simple whole number 1:2:1

(6) Empirical formula CH_2O

(7) Mass calculated according to empirical formula $12+2\times1+16=30$

The ratio of mass calculated from empirical formula and the molecular mass of compound is

∴ Multiplication number (n) =

$$\frac{\text{Molecular mass}}{\text{Mass calculated from empirical formula}} = \frac{30}{30} = 1$$

Mass of empirical formula and molecular formula has 1:1 proportion, so the empirical formula will be the same as molecular formula.Hence molecular formula of the compound will be CH_2O or HCHO which is formula of fomaldehyde.

What have you learnt ?

- You have studied about classification of substances, physical and chemical changes in this unit.
- The physical states of matter are solid, liquid, gas, plasma and Bose-Einstein condensate, from chemical point of view, element, mixture and compound.
- You have learnt about matter in gaseous state and PNG and LPG used for household purpose and CNG used for vehicles.
- You have studied about effect of temperature and pressure on the states of matter.
- Learnt about elements, compounds and types of mixture-homogeneous and heterogeneous.
- Studied about suspension solution, collodial solution, true solutions.
- Studied about concentration of solutions - weight, volume based as well as saturated solution.
- Learnt about matter, atoms and atomic theory as well as molecule, atomic mass, molecular mass and mole concept.
- You have also learnt about percentage masses of element, empirical formula and molecular formula.

EXERCISE

1. Select the proper choice from the given multiple choices :

(1) In which state of a substance, it has the shape ?

(A) Liquid and gas (B) Liquid (C) Gas (D) Solid

(2) What is the proportion of hydrogen and oxygen by weight in water ?

(A) 1:16 (B) 1:8 (C) 16:1 (D) 8:1

(3) Who was the scientist to make attempts for giving explanatory definition of element ?

(A) Rontgen (B) Dalton (C) Rutherford (D) Lavoisier

(4) What is the change in substance when temperature is increased ?

(A) Weight decreases (B) Weight increases

(C) Volume decreases (D) Volume increases

(5) What is incorrect about gas ?

(A) Intermolecular forces are maximum (B) Shape is not definite

(C) Volume is not definite (D) Is compressible

(6) Which of the following is the universal solvent ?

(A) Water (B) Petrol (C) Benzene (D) Alcohol

(7) What is air ?

(A) Stone (B) Element (C) Compound (D) Mixture

(8) Which of the following is the example of aerosol ?

(A) Paint (B) Milk (C) Sponge (D) Cloud

(9) Which of the following is gel ?

(A) Ghee (B) Sponge (C) Milk (D) Butter

(10) What is the molecular formula of sulphur ?

(A) S_8 (B) S_2 (C) S_4 (D) S

(11) What is atomic mass of He in amu (*u*) units ?

(A) 8 (B) 9 (C) 2 (D) 4

(12) Which of the following is a monoatomic molecule ?

(A) Nitrogen (B) Hydrogen (C) Helium (D) Oxygen

(13) What is called the colloidal form having dispersion medium liquid and dispersing phase gas ?

(A) Gel (B) Foam (C) Aerosol (D) Emulsion

(14) How many molecules are there in one mole of a compound ?

(A) 60.22×10^{-23} (B) 6.022×10^{-23}

(C) 60.22×10^{23} (D) 6.022×10^{23}

(15) What is the molecular mass of H_2O ?

(A) 18 *u* (B) 17 *u* (C) 16 *u* (D) 15 *u*

2. Anower the tollowing questions in short :

(1) What is called intermolecular forces ?

(2) What is physical change of matter ? Give three examples.

(3) What is chemical change of matter ? Give three examples.

(4) Write effect of temperature on state of matter.

(5) Write effect of pressure on state of matter.

(6) Give definition of homogeneous mixture.

(7) Give definition of heterogeneous mixture.

(8) What is called true solution ? Give example.

(9) What is called suspension solution ? Give example.

(10) What is called collodial solution ? Give example.

(11) What is called Tyndall effect ?

(12) What is called dispersed phase ?

(13) What is called dispersion medium ?

(14) Give definition of saturated solution.

(15) What is called molar mass (molecular mass) ?

(16) What is called empirical formula ?

(17) Which theory was proposed by John Dalton ?

(18) Give definition of element. Give examples of liquid metal and liquid non-metal element.

(19) Give definition of mixture. Mention the types of mixture and give one example of each.

(20) Mention types of following mixtures :

(1) Starch mixed in sugar (2) Water mixed in milk (3) Iron powder mixed in tea (4) Kerosene mixed in petrol

3. Answer the tolloeing questions in detail :

(1) Explain giving examples the difference between physical and chemical change.

(2) Explain homogeneous and heterogeneous mixture and give two examples of each.

(3) What is meant by concentration of solutions ? How is it expressed ?

(4) What is meant by atomic mass and molecular mass ?

(5) What is meant by mole ? What is its unit ? What is meant by molar mass ?

(6) What is Tyndall effect ? Which solutions show this effect ? Why ?

(7) Write assumptions of Dalton's atomic theory.

(8) Find molecular masses of $K_2Cr_2O_7$ and $Cr_2(SO_4)_3$.

(9) Calculate the number of atoms of nitrogen present in 42 grams of nitrogen gas.

(10) Calculate the number of atoms of phosphorus and chlorine present in PCl_5.

(11) Suppose somebody is giving you one atom of gold per second. In how much time he will be able to give you one mole of gold (Au) ?

(12) Calculate percentage elements present in ammonium chloride (NH_4Cl)

($N = 14, H = 1, Cl = 35.5$)

(13) In a hydrocarbon, the percentages of carbon and hydrogen are 85.7 % and 14.3% respectively. Find its empirical formula. If its molecular mass is 58 grammole^{-1} determine the molecular formula of the hydrocarbon.

(14) Calculate the number of molecules present in 42 grams sodium hydrogen carbonate ($NaHCO_3$). ($Na = 23, H = 1, C = 12, O = 16$)

(15) The number of atoms present in a compound is found to be 12.044×10^{23} What will be the number of moles of this compound ?

(16) Suppose you drink 90 ml of water. How many molecules of water will enter into your stomach ?

5 Structure of Atom

5.1 Introduction

The substance is made up of molecules or atoms. Atom is the smallest, indivisible particle having independent existence. This concept was developed by John Dalton in the 19th century. It was useful in understanding the chemical reactions and the properties of gases as well as useful in expressing relative masses of different atoms. The experiments carried out during 1895 and 1905, have substantiated the explanation about structure of atom.

It has been proved from the study of hydrogen spectrum, that hydrogen atom contains one electron and from the study of spectrum of sodium, it has been proved that there are more than one electrons in its atom.

5.2 Fundamental Experiment of Electric Discharge Tube and Discovery of Electron

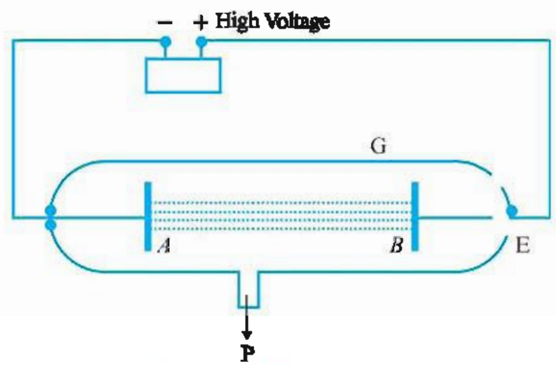


Figure 5.1 Cathode Rays

In the Figure 5.1, the line diagram of electric discharge tube is given. Vacuum is created in this discharge tube with the help of vacuum pump P. A and B are metal plates in the tube, which are cathode and anode respectively. When they are connected to high voltage, the cathode rays are produced from cathode A and as they have negative charge they move towards the anode with speed. This cathode rays are really the flow of electrons having negative charge and it is deviated under the effect of electromagnetic field. Scientists J. J. Thomson and Crookes proved from the experimental observations that the cathode rays emitted from cathode is the flow of electron and this flow of electrons possesses negative charge.

5.3 X-ray and Radioactivity

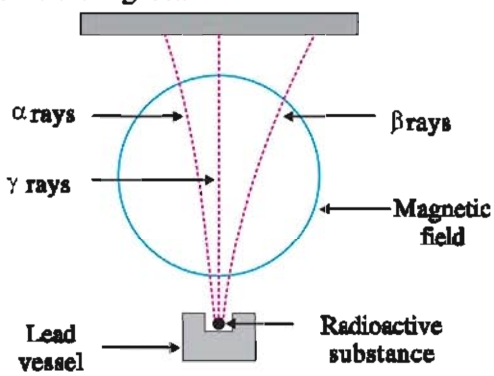
In 1896, Rontgen produced cathode rays by passing electric current in electric discharge tube but when these rays struck with the wall of the tube or anticathode, a new type of rays were produced from them. These rays were travelling in a straight line like the light rays but when passed through electromagnetic radiation, they were not deviated. In addition, they were able to pass through the opaque substance like black paper. These rays also affected the photographic plate covered by opaque substance. These unknown rays were called X-rays. Now they are also known as Rontgen rays.

Cathode rays is the beam of electrons. While X-rays are electromagnetic waves having very short wavelength. If the electrons having very high velocity are stopped by putting some type of resistance (anticathode) the X-rays are produced.

X-rays are mostly used in medical science. X-rays are used to detect a fracture in the bone, to observe defect in lungs, to diagnose cancer of oesophagus and to diagonise physical disabilities.

In 1889, scientist Ernest Rutherford designated two types of radiations from radioactive atom like uranium as alpha (α) rays and beta (β) rays. Afterwards French scientist Willard discovered third type of rays which he called γ-rays. With the help of the strong electromagnetic field it is shown that α- rays possess positive electric charge and β - rays possess negative electric charge while γ- rays do not possess any electric charge.

Alpha (α) rays are fast moving helium nuclei (He^{2+}) and their penetration power is least. Beta (β) rays are fast moving electrons and their penetration power is more than α - rays. Gamma rays are electromagnetic rays and their penetration power is the highest.



Radiations emitted from radioactive substance in presense of magnetic field.

From the systematic study it has been shown that the rays emitted from certain minerals are not able to pass through opaque substance like black paper. Obviously, these rays must have been emitted from the atoms. From this it is clear that certain atoms can be divided and they are unstable.

Atoms must have been made up of at least two types of very small particles. Some of these very small particles must be possessing positive electric charge and some other very small particles must be possessing negative electric charge. In addition the number of particles possessing positive charge and particles possessing negative charge must be equal because the atom on the whole is electrically neutral. The very small particles possessing positive electric charge were given the name protons and the very small particles possessing negative charge were given the name electrons.

5.4 Atomic Model Proposed by Thomson

Thomson's atomic model : Scientist Thomson first of all proposed atomic model describing arrangement of protons and electrons in atom. In this model, atom is like a spherical ball and the positive electric charge is uniformly spread on its total volume.

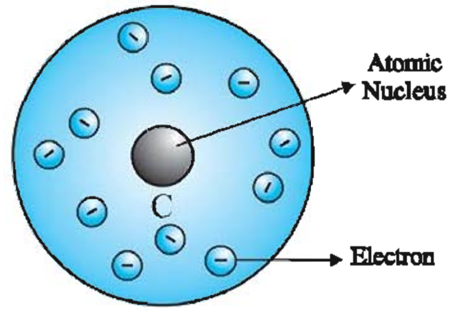


Figure 5.3

In this spherical ball protons possessing positive electric charge and the negative electric charge possessing electrons are arranged at definite places. If we accept this imagination then because of the attraction of positive and negative electric charges they should mix with each other and become chargeless. Over and above, this, the arrangement could not explain the different chemical properties of different elements. Thus, this model was not accepted.

5.5 Experiments of Ernest Rutherford

In the combined atom composed of proton and electron, the proton possessing positive electric charge is 1836 times heavier than the electron possessing negative charge. How these two types of very small particles are arranged in an atom can be explained from Rutherford's experiment. Rutherford presented the experiment to show how very small electrons are arranged an the atom.

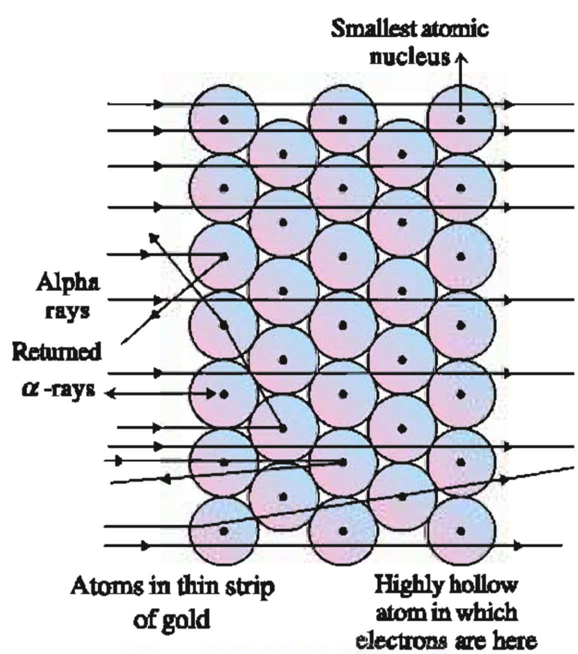


Figure 5.4 Rutherford's experiment : Scattering of α-rays by foil of gold

Rutherford made alpha (α) rays emitted from radioactive element polonium (Po) incident from one side on the foil (0.004 mm thick) of gold.

If the atom is completely filled uniformly in its volume, then all the α rays should return (reflect) after striking the gold foil and should be deviated more or less but Rutherford observed that most of the rays passed through in straight way from the gold foil, while very few rays returned in a different path after striking the gold foil.

The proportion of alpha rays returning after deviation and the alpha rays passing through in straight way was about 1:1200.

From this Rutherford determined that in the middle of the atom of gold there must be very small, heavy and positive electric charge possessing centre (nucleus.). Around this centre (nucleus) electrons with negligible weight and possessing negative charge (particles) must have been arranged. Only very less alpha rays were returning after striking with the nucleus of the atom. Most of the alpha rays were passing through and so the atom must be hollow.

When the thickness of the gold foil was doubled, the number of alpha particles reflecting after striking was also doubled. Rutherford found out from calculations that atomic nucleus is 10^5 times smaller than the total area of the atom. The radius of the atom is 10^{-8} centimeter (10^{-10} meter) and the radius of the nucleus is 10^{-13} centimeter (10^{-15} meter). Hence, we can say that atom is relatively hollow. In the centre of the atom heavy nucleus is there which is responsible for the mass of the atom and the electrons possessing negligible mass are arranged around the nucleus.

The arrangement of electrons around the nuecleus of an atom containing protons was explained by scientist Niels Bohr.

Upto 1910, proton (p^+) and electron (e^-) were the two fundamental particles discovered. Mass of proton is 1836 times more than that of electron. Hence, the atom can be described by placing all the protons in the nucleus and arranging same number of electrons moving around it. Mass of proton is 1.00723u and mass of electron is 0.00055u. In SI units u is written instead of amu. (atomic mass unit.)

5.6 Atomic Model of Bohr

Bohr proposed atomic model in 1912. Bohr mentioned that electrons are moving around the nucleus in atomic levels at a definite distance from the positively charged nucleus. This atomic level at a definite distance from the centre (nucleus) is called energy level or orbit. The electron continuously moving in this orbit does not lose energy and so such orbits are called stationary orbits. The energy of the orbit which is nearest to the nucleus is least. The energy of the orbits away from the mucleus gradually increases.

According to atomic model of Bohr, the arrangement of the electrons around the atomic nucleus can be shown as follows :

(i) The first orbit nearest to the nucleus (K orbit) can accommodate two electrons.

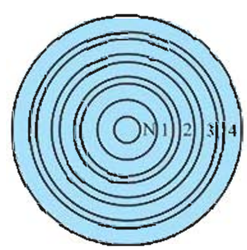
(ii) The second orbit (L orbit) can accommodate 8 (eight) electrons.

(iii) The third orbit (M orbit) can accommodate 18 (eighteen) electrons.

(iv) The fourth orbit (N orbit) can accommodate 32 (thirty two) electrons.

(v) In second, third, fourth orbits there are subsidiary orbits which are called orbitals. We shall study the difference between orbit and orbital later on.

(vi) Generally the electrons are arranged in an order. After filling the first orbit with electrons, the extra electrons are arranged stepwise.



n = Fourth level (N level)
n = Third level (M level)
n = Second level(L level)
n = First level (K level)
N = Centre of Atom

Figure 5.5 Orbits of an atom

The number of protons or electrons in neutral atom of element is called atomic number (Z) of an element. In the table 5.1 the structure of atoms showing arrangements of electrons according to Bohr's atomic theory of elements no. 1 to 20 are given.

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Table 5. 1 Distribution of electrons in orbits of first 20 elements of periodic table

Name of element	Symbol	Atomic number	Number of protons	Number of neutrons	Number of electrons	Arrangement of electrons in orbits				
						K	L	M	N	Valency
Hydrogen	H	1	1	-	1	1	-	-	-	1
Helium	He	2	2	2	2	2	-	-	-	0
Lithium	Li	3	3	4	3	2	1	-	-	1
Beryllium	Be	4	4	5	4	2	2	-	-	2
Boron	B	5	5	6	5	2	3	-	-	3
Carbon	C	6	6	6	6	2	4	-	-	4
Nitrogen	N	7	7	7	7	2	5	-	-	3
Oxygen	O	8	8	8	8	2	6	-	-	2
Fluorine	F	9	9	10	9	2	7	-	-	1
Neon	Ne	10	10	10	10	2	8	-	-	0
Sodium	Na	11	11	12	11	2	8	1	-	1
Magnesium	Mg	12	12	12	12	2	8	2	-	2
Aluminium	Al	13	13	14	13	2	8	3	-	3
Silicon	Si	14	14	14	14	2	8	4	-	4
Phosphorus	P	15	15	16	15	2	8	5	-	3,5
Sulphur	S	16	16	16	16	2	8	6	-	2
Chlorine	Cl	17	17	18	17	2	8	7	-	1
Argon	Ar	18	18	22	18	2	8	8	-	0
Potassium	K	19	19	20	19	2	8	8	1	1
Calcium	Ca	20	20	20	20	2	8	8	2	2

5.7 Valence Electrons and Valency

The electrons present in an atom are arranged in different orbits having increase in energy around the nucleus. When electrons are arranged, the electrons in the outermost orbit are responsible for emission spectra and the chemical properties of the elements. They are called valence electrons. The number of electrons in the valence orbit is the valency of the atom.

Valency = Number of electrons in valence orbit

5.8 Discovery of Neutron

Rutherford had suggested in 1920 that the element helium (He) after hydrogen (H) has two protons and so its mass should be almost double of that of hydrogen but it was found to be about four times. So it was necessary to know the reason behind the increase in mass. There is a possibility of the existence of particles having mass almost equal to that of proton (1.00833u). These particles are mentioned as neutrons (n). Eventhen, for a number of years there was no direct proof of existence of neutrons. But Chadwick in 1932 doing research on radioactivity discovered this fundamental particle of the atom called neutron. Neutron does not possess any type of electric charge. It is neutral and its mass is almost equal to the mass of proton and is 1838 times more than that of electron. Hence the mass of an atom of any element is the sum of number of protons and number of neutrons in the nucleus. It is called atomic mass.

$\therefore$ A = p + n

For example, the atomic mass of carbon possessing six protons and six neutrons is equal to 6+6=12. Similarly the atomic mass (A) of sodium possessing 11 protons and 12 neutrons is equal to 11 + 12 = 23

5.9 Isotopes and Radioactivity

From the experimental observations of mass spectrometer it has been found that mass of atoms of certain elements have more than one value. Such type of different mass possessing atoms are called isotopes of each other.

Suppose the number of protons in atomic nucleus of two or more than two atoms of an element is same but the number of neutrons is different; then there will be change in atomic masses of the same element.

The atomic masses of these isotopes are different but their chemical properties are similar.

The word isotope means iso = same and topos = place. Thus the atoms of the elements whose position in the periodic table is same are called isotopes.

e.g. Hydrogen atom has three isotopes :

protium (^1_1H), deuterium (^2_1H) or (D), tritium (^3_1H) or (T)

The number of neutrons in protium is 0 (zero). The number of neutrons in deuterium is 1 and that in tritium is 2. They are called isotopes because the number of neutrons is different.

Similarly, $^{16}_{8}O$ has two other isotopes $^{17}_{8}O$ and $^{18}_{8}O$. $^{232}_{92}U$ has other isotopes $^{235}_{92}U$ and $^{238}_{92}U$.

The isotopes of some elements having high atomic masses possess the property of radioactivity. e.g. Uranium (U). In fact, this is an old concept because element like lead (Pb) possesses high atomic mass even then it is not radioactive. The other radioactive elements like uranium having unstable nucleus emits very small particles like alpha and beta and neutral gamma rays. As the atomic mass of an element increases, the number of protons increases and along with that if number of neutrons also increases, the atom becomes unstable and so they are radioactive. If the ratio of neutrons to protons exceeds 1.6, the property of radioactivity is acquired.

Radioactive isotopes are used in determining age of old trees, age of fossils of man and animals, radiometric dating, medical treatments, industries etc and also in the treatment of diseases like cancer.

What have you learnt ?

– You have developed the understanding about substance, being made up of molecule or atom and it is the smallest indivisible particle.
– Discussed about the discovery of electron and fundamental experiments of electric discharge tube.
– The achievements of various scientists, Thomson, Crookes, Rontgen, Dalton and Rutherdford have been discussed in this unit.
– Discussion of α-rays and radioactivity α, β, γ radiations.
– Thomson's atomic model, Rutherdford's experiment, Bohr's atomic model, discovery of neutron.
– You have been able to learn about valence electrons and valency as well as isotopes.
– You have been able to learn about radioactivity and its utility.

EXERCISE

1. Select the proper choice from the given multiple choices :

(1) What is correct from the following about cathode rays ?

(A) Positively charged particles (B) Negatively charged particles

(C) Radiations (D) Beam of electrons

(2) What is correct from the following about X-rays ?

(A) Beam of electrons (B) Electromagnetic waves

(C) Positively charged particles (D) Negatively charged particles

(3) Who is the discoverer of X-rays from the following ?

(A) Willard (B) Rontgen (C) Rutherdford (D) Chadwick

(4) Who discovered the particles emitted with γ-rays other than the γ-rays ?

(A) Willard (B) Rontgen (C) Chadwick (D) Rutherdford

(5) Which particles possess positive electric charge ?

(A) X-rays (B) β - particles (C) γ radiation (D) α particles

(6) Which scientist discovered neutrons ?

(A) Thomson (B) Rutherdford (C) Niels Bohr (D) Chadwick

(7) According to Rutherdford's suggestion how many times smaller should be the atomic nucleus than the total area of an atom ?

(A) 10^{15} (B) 10^{10} (C) 10^{8} (D) 10^{5}

(8) Which radiation was discovered by Willard ?

(A) α-rays (B) β-rays (C) γ-rays (D) X-rays

(9) Which of the elements, has electronic configuration 2, 8, 7 arrangement in atomic structure ?

(A) Br (B) Cl (C) F (D) I

(10) In which atom the electronic configuration 2, 8, 2 is available ?

(A) Fe (B) Mg (C) Mn (D) Mo

(11) Which of the following does not undergo deviation ?

(A) β-rays (B) α-rays (C) γ-rays (D) X-rays

2. Answer the following questions in short :

(1) What is indicated by hydrogen and sodium spectrum ?

(2) What is cathode rays ?

(3) What effect is experienced by cathode rays in electromagnetic field ?

(4) Give difference between cathode rays and α-rays ?

(5) Write properties of X-rays.

(6) Write uses of X-rays.

(7) How X-rays can be produced from flow of electrons ?

(8) What information about atomic nucleus was given by Rutherdford from his experiment ?

(9) What type of rays are obtained from uranium metal ?

(10) α-rays possess positive charge and β-rays possess negative charge. How can this be indicated ?

(11) Why Thomson's atomic model was not accepted ?

(12) On what basis Rutherford said that atom is hollow ?

(13) Mention the symbols of first, second and third orbit of an atom and how many electrons can be accommodated in each of them.

(14) Give definitions : Atomic number, atomic mass, isotope.

(15) What is called a stationary (stable) orbit ?

(16) What is called a valence electron ?

(17) Mention the importance of valence electrons.

(18) Which scientist and by which discovery invented neutrons ?

(19) Give names of isotopes of hydrogen. Mention the number of protons and neutrons in them.

(20) Which isotopes are called radioactive ? Give examples.

(21) Give information about properties of isotopes.

(22) Mention the importance of radioactive isotopes.

(23) Give arrangement of electrons of following elements in their orbits :

$_{11}Na$, $_{13}Al$, $_{19}K$, $_{16}S$, $_{8}O$

(24) Write electronic structure of following atoms on the basis of Bohr's model :

$_{10}Ne$, $_{12}Mg$, $_{15}P$, $_{17}Cl$, $_{20}Ca$

3. Answer the following questions in detail :

(1) Write in brief about the production of cathode rays and its properties.

(2) Mention the production of X-rays, its properties and uses.

(3) Explain Rutherford's experiment in brief and give the results.

(4) Write a short note about Niels Bohr's atomic model.

(5) Write a short note on discovery of neutron.

(6) Write a short note on isotopes and radioactivity.

(7) What is meant by valency ? What is the relation between valency and electronic structure ? Explain it.

6 The Fundamental Unit of Life : The Cell

6.1 What are living organisms made up of ?

Cell word is derived from the Latin word "cellula" which means room. The English scientist Robert Hooke (1665) had made a primitive microscope. While observing a thin layer of a bottle cork, a structure like honeycomb was found which are introduced as "cells". This event was very small and insignificant in the history of science but till today in Biology the word "cell" is used.

Activity 1 : Take one slice of an onion with the help of a forcep. Peel off the layer of the thin epidermis of onion. Put the layer immediately in the watchglass containing water so it will not get dried. Now take a glass slide and put a drop of water on it. Now take out small pieces of epidermis from the watch glass and put it on the slide with water droplet. Now put a drop of safranine solution on this piece and put the coverslip on it in such a way that the bubbles air do not enter it.

Now, this transitory, establishment is getting prepared, and observe it in microscope under low power and then under high power. This small structure we see is the fundamental unit of onion root. This structure is called a cell. This type of structure is found not only in onion but in all the living beings.

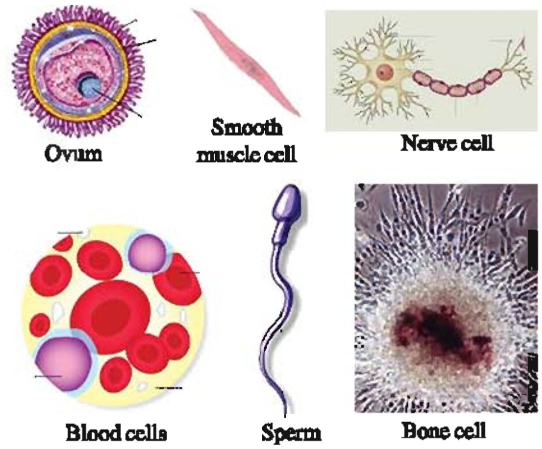
Important Contribution of Several Scientists

Year	Name of the Scientist	Contributiona of invention
1665	Robert Hooke	By observing the thin layer of cork in primary microscope used the word 'cell' for the structure found in it.
1674	Leuvwenhoek	Observed nucleus through simple microscope.
1831	Robert Brown	Described the nucleus characteristic spherical body in plant cells.
1839	Schleiden and Schwann	Observed plant tissue and studied animal tissue. Proposed cell theory. All tissues are made up of cells, cell is the fundamental unit of life.
1840	Perkinje	In living cells used the word 'protoplasm.'
1953	Watson and Crick	Proposed double helical model of DNA molecules.

After the invention of microscope, it was found that only one cell creates the whole of the organism. e.g. *Amoeba, Paramoecium, Chlamydomonas* and bacteria. These living beings are known as unicellular organisms. In multicellular organisms cells are gathered for different functions in different organs. For e.g. several fungi, plants and animals. Every multicellular organism originates from one cell. The cell gets divided and produces own type of cells. Thus, all cells are originated from early pre-existing cells.

Activity 2 : Prepare temporary mounting by taking leaf peels, tip of roots of onion and even peels of onion of different sizes. You can also prepare temporary mounting by taking leaves of maize, mustard and tradescantia. By this activity you say that in different parts of multicelluler plants, the shape, size and structure of cells are different. By this activity it can be known that in higher level of organisms there is a similarity in cell membrane, cytoplasm, organelles and nucleus of all the cells.

In several organisms different types of cells are present. Several cells of human body are depicted in the below given figure. In human body the nerve cells are found to be biggest cell.



Different types of cells in Human Body

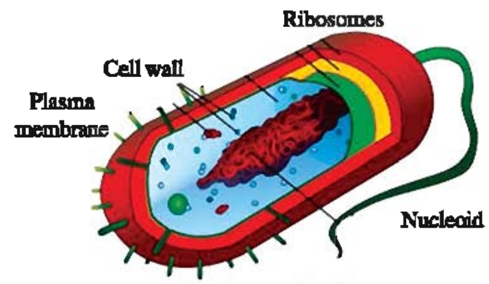
The shape and size of living organisms are related with their specific functions. For e.g. the shape of the animal like amoeba constantly getting changed. How the cells of living organism perform certain fundamental functions ? In multicellular organisms there is a division of labour for various functions e.g. Human beings. These clearly indicates that in human body various parts perform different functions. In human, heart pump performs the function of pump for blood circulation and the stomach performs the function of digestion. In each cell structure performing a specific functions are present which are known as organelles of the cell.

6.2 What is structural organisation of cell ?

From above description we know that specific component in the cell is called organelles. How the organisation of the cell takes place ? If we observe the cell under microscope it is found that in every cell, three main characteristics are found, cell membrane, nucleus, and cytoplasm.

All processes take place in cell through its organelles.

6.2.1 Prokaryota : In the cells of bacteria and blue green algae nucleus is not developed. Since the nucleus is of primary level in such cells they are called prokaryota. In prokaryota nucleoprotein is found in mass form and in its nucleus, nuclear membrane is completely absent. Such nucleus is called nucleoid.



Prokaryotic cell

6.2.2 Eukaryota : In the nucleus of eukaryotic cell, a clear nuclear membrane and nucleolus are found. Such well developed nucleus containg cell is called as Eukaryotic cell.

6.3 Cell Organization

In organization of cell various types of structures and organelles are found. Now we will study in detail.

6.3.1 Cell Membrane : Membrane surrounding cytoplasm is called cell membrane. Thus, cell membrane is the outer covering of a cell. In bacteria, plants and animals, the presence of cell membrane is seen. Cell membrane is living, thin, flexible, delicate and selective permeable membrane. Cell membrane constitutes 75% phospholipid and remaining 25% of protein, cholesterol and polysaccharide.

The gases like carbon dioxide or oxygen pass through cell membrane at the time of diffusion. In the process of diffusion the substances are constantly entered into less concentrated area from more concentrated area. These take place many times in cells. Due to accumulation of CO_2 inside the cell, the concentration of CO_2 in the cell increases as compared to the concentration outside the cell. Because of this CO_2 from inside of the cell diffuses out. In the same way due to increasing concentration of O_2 outside the cell, O_2 diffuses in the cell. Thus diffusion plays an important role in gaseous exchange between the cell as well as its external environment.

Osmosis : When two solutions of different concentrations are separated by semipermiable membrane then molecules of solute move from lower concentration to higher concentration.

If plant cell or animal cell is put into sugar solution or salt solution, what will happen ? Any one of the following three incidents may take place :

(1) If the concentration of water around the cell is more than that in the cell, then water enters into the cell through osmosis. Such type of solution is known as hypotonic solution. As water enters, the cell swells up.

(2) If the concentration of solution is the same inside and out side the cell then there will not be any exchange. Such type of solution is known as isotonic solution.

(3) If the concentration of water outside the cell is less than inside the cell, then water moves out of the cell by the process of osmosis. Such type of solution is known as hypertonic solution. Due to the phenomenon cell shrinks. This is known as plasmolysis.

Activity 3 : Osmosis and egg : To remove shell of an egg keep egg in dilute HCl solution. Shell of an egg is made up of $CaCO_3$. A thin outer skin is seen around the egg. Now put the egg in clean water and observe after 5 minutes. Due to osmosis water enters into the egg and it swells.

Now place similar deshelled egg in a concentrated salt solution and observe after 5 minutes, the egg shrinks.

Activity 4 : The same activity can be performed with dry grape and apricot. Keep dry grape or apricot in simple water for few minutes. In the same way keep swelled grape or apricot in concentrated salt solution or sugar solution for few minutes. Now you will come to following conclusions.

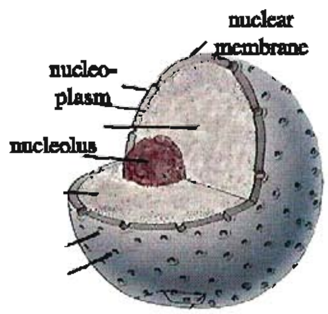
(A) Water enters into dry grapes and it swells up.

(B) While keeping in higher concentrated salt solution grapes loses the water and shrinks. Unicellular fresh water organisms and most of plant cells get water through osmosis. Absorption of water through plant root is an example of osmosis.

6.3.2 Cell Wall : In plant cell, apart from cell membrane, a shield outside the cell is called cell wall. Cell wall is non-living and freely permits the entry of substanes. The cell wall is made up of cellulose, hemicellulose and pectin, which give mechanical strength. The cell uses the cell wall for the protection of cytoplasm and cell membrane. It maintains the shape of the cell. Apart from this, it protects the cells from water absorption away from the cell wall. This phenomenon is called plasmolysis. We can observe this phenomenon by the following activity.

Activity 5 : By peeling off the leaf skin of tradescantia and putting on the slide there seen small pigment of green substance through highpower microscope. This green substance is known as chlorophyll. Now put concentrated sugar solution or salt solution. Wait for sometime. The water moves out of the leaf cells after osmosis process. Now observe this leaf under microscope. You will find that components of the cell separate from the cell wall. This seeming change is so explained that the outer medium being hypertonic, the water comes out because of plasmolysis from the cell of the leaf. Put some tradescantia leaves into boiling water for some time. In this way the cells of the leaves will die. Now remove the leaves from the water on and out the slide and watch through the microscope. Put simple sugar or salt solution on the leaves. Wait for sometime and observe. In this experiment, you will see that plasmolysis doesn't take place. This means that in boiled water osmosis doesn't take place or say in other words, it is proved form this experiment that the property of selective permeability is found only in living cell membrane.

6.3.3 Nucleus : It is main and round cellular organelle situated in the middle of the cell. Around which double nuclear envelope separates nucleus from cytoplasm. This nuclear envelope has many pores and it encloses nucleoplasm. In nucleoplasm, two types of nuclear structures, neucleolus and chromatin are found. The number of nucleolus is one or more but no membrane is found around it. In nucleolus there is plenty of protein and the origin of ribosome takes place from this site. Chromatin is a thin fibre like mass of interwined chromosomes which is made up of genetic material DNA and protein. DNA molecules found in chromosomes have information of inherited characteristics, and these characteristics of the parents are found in next generation. The working component in DNA is called gene. In certain organisms like bacteria, nuclear region of the cell is not clear, because of the absence of nuclear membrane. Such unclear nuclear region having nucleic acid is known as nucleoid. In these organisms nuclear membrane is not found. Such cells are called Prokaryotic cell. (Pro = primitive, karyot = nucleus). Organisms in which nuclear envelope is present are known as Eukaryotic organisms.



Nucleus

The function through organelle in eukaryotic cell is done through cytoplasm in prokaryotic cells.

Activity 6 : To observe the animal cell in microscope. Take a glass slide and put a drop of water on it. Take an ice-cream eating spoon and scrap the internal part of your cheek slowly. Now look at the spoon whether any matter is collected in it. Now put this matter slide with the help of a needle. Put a drop of methaline blue on the substance. After that don't forget to put a coverslip on the substance. Watch the slide under microscope and observe the shape of the cell. In every cell, dark stain round or oval shaped structure is nucleus.

6.3.4 Cytoplasm : The part of cell between cell membrane and nuclear membrane is called cytoplasm. The mass which is found inside the cytoplasm is called endoplasm whereas transparent cell membrane outside is called ectoplasm. In cytoplasm, apart from various organelles insoluble waste and collected substance such as starch, glycogen and fat are found. In cytoplasm almost 90% is water. In cytoplasm, protein fibres like tubulin, actin and keratin and found. These protein fibres are helpful in maintaining the shape of the cell. To perform various functions, the cell has organelles. In these organelles nucleus, mitochondria, chloroplast, golgi body, endoplasmic reticulum and ribosomes are included. These organelles do protein synthesis, photosynthesis and ATP synthesis.

6.4 Cell Organelles

In eukaryotic cells many chemical reactions take place in various organelles of the cells. These organelles being very minute can be seen only through electron microscope. We will study about such organelles.

6.4.1 Endoplasmic Reticulum : It is found in all animal and plant cells. But it is absent in red blood cells. Endoplasmic reticulum is connected with the external part of nucleus at one end while the other end is connected with cell membrane. Endoplasmic reticulum are of two types.

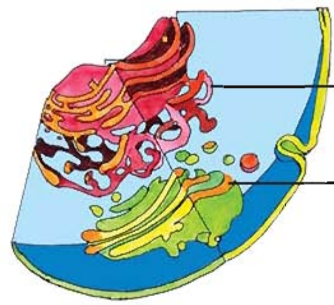
(1) Rough ER - On the surface of it ribosomes are found which perform protein synthesis.

(2) Smooth ER - On the surface of it no ribosomes are found. ER are found in three forms.

(i) **Cisternae** - Which is expanded flat, branchless and tubular structure filled with fluid .

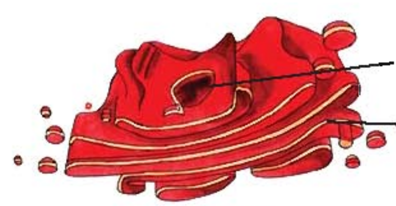
(ii) **Vesicle :** It is a round or oval structure and found in cytoplasm freely.

(iii) **Tubules :** It forms a network with cisternae and vesicles which is small and its surface is smooth. Endoplasmic reticulum acts as a transmitary system between cytoplasm and nucleus. Smooth ER apart from the synthesis, storage and dispersion of glycogen, creates lipids, streoids and toxins in liver cells and protects form medicine.



Different Types of Endoplasmic Reticulum

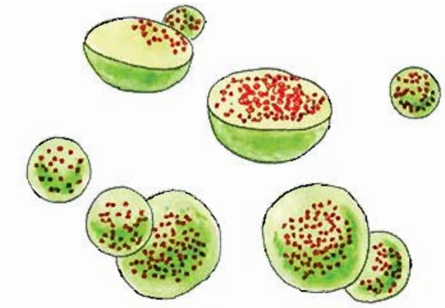
6.4.2 Golgi body : Proper description of golgi body was done by a scientist Camilo Golgi. In plant cells, these organelles are known as dictyosomes. In different types of cells, the number of golgi is either one or more than that. In the micro - structure of golgi, three components are found : (1) flat bags of cisternae (2) micro tubules (3) large vacuoles. These three components are filled with or without granular substances. In golgibody, cisternae is found parallel and arranged in stacked form, flat and dish shaped bags. Sometimes these bags are connected with each other and forms network structure. The origin of vesicles and tubules takes place in the form of bud from cisternae. There is absence of golgi in bacteria, blue - green algae, mature sperm and in the blood - cells of mammals. The origin of golgi takes place from the membrane of smooth ER. The storage of synthesised protein takes place in ribosomes in ER, in the cisterne of golgi body. Besides this it helps to secret and transmit by packaging the substances like lipoprotein, glycolipid, phospholipid etc.



Golgi body

6.4.3 Lysosomes : In lysosomes the organelles are converted into structure like small round bags in cytoplasm, producing enzymes for digestion of food particles. The formation of enzymes of lysosome is made by rough ER. Lysosome performs the functions of intercellular digestion, so they are called digestive bags. It protects the body from infection by destroying bacteria and virus entering from outside in the cell.

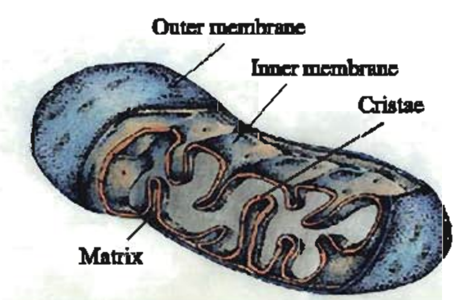
During disturbance in cellular metabolism destruction of cells take place. The lysosome enzymes come out and destroy the cell by digesting all the organelles of the cell. Thus lysosome is known as "Suicidal bags" of the cell.



Lysosome

6.4.4 Mitochondria : Mitochondria is ultra minute body. It is tubular, rod shaped or round and is distributed into cytoplasm. Around every mitochondrium double membrane covering is found, in which the outer membrane is porous whereas internal membrane is folded. Hence the internal surface area is much larger than the outer surface. This folded structure is known as criseae. In which at the upper side F_1 microparticles or oxysomes are present. The internal cavity of mitochondria is filled with intercellular substance which is cells gel like protein and possesses ribosomes of small size, atoms of DNA and phosphates. The mitochondria are not found in the red blood cells of mammals and bacteria

In mitochondria, cellular respiration takes place. Mitochondria transform carbohydrate and lipid from the cells into CO_2 and H_2O. Because of oxidation, it gets free energy and ATP is formed . Thus, in mitochondria the synthesis of ATP takes place and hence it is known as "Power House" of the cell. Thus, ATP is general cellular fuel which is used by the cell in the energy required for functions. Mitochondria create its own protein so, it is a semiautonomous organelle.



Mitochondria

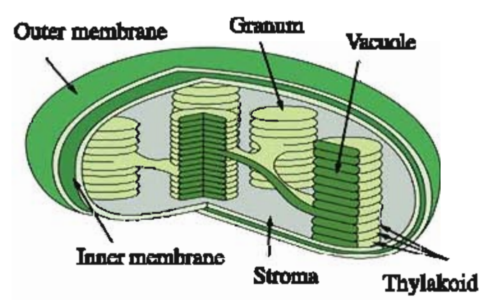
6.4.5 Plastids : Plastids are found in almost all the plant cells. Like mitochondria, in chloroplast too, its own genome and ribosomes are found. Chloroplast has self replication ability and divide independently. There are three types of plastids.

(1) Chloroplast - Green colour plastids

(2) Chromoplast -Except green colour plastids

(3) Luecoplast - Colourless plastids

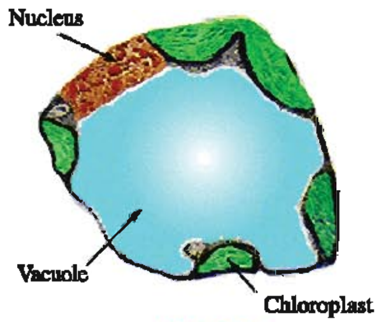
Chloroplasts are found in green coloured algae and higher level plants. The green pigment found in chloroplast. It is called chlorophyll. It produces food by photosynthesis and so it is called the kitchen of the cell. Every chloroplast is covered with double membrane. The chloroplast has two specific area : (1) Grana and (2) Stroma. It contains grana. Every granum is stack of membrane bounded, flattened discoid sacs like structures containing the molecules of chlorophyll and is called thylakoid. In thylakoid chlorophyll is found which is the main functional unit of chloroplast. Stroma is a common substance, in which grana are found. In grana various enzymes of photosynthesis, atoms of starch, DNA and ribosomes are found. Granum is the place of photoreaction of photosynthesis whereas the place of dark reaction is stroma. Chloroplast absorbs the light energy and uses it for preparing food for the plants. Chromoplast impart different colours to flowers from which the insects are attracted for pollination. Whereas Lucoplast stores food in the form of starch, fat and protein.



Internal Structure of Chloroplast

6.4.6 Vacuoles : Vacuoles are filled with fluid or hard substance covered with membrane. These are one type of storage bags. In plant cells vacuoles are big, specific and permanent. In mature plant vacuoles takes almost 90% of the space of the cell. Since the place of vacuoles is in the middle of the cell, the nucleus and other organelles of the cell are pushed towards cell wall. The membrane found surrounded vacuoles is called tonoplast. The solution of cell sap filled in the vacuoles is like water. It is full of sugar, amino acids, proteins and minerals.

In animal cells, the vacuoles are small and temporary in which water, glycogen and protein are stored. In organisms, vacuoles are found which perform the function of osmoregulation. In *Amoeba* and *paramecium* food vacuoles are found, which digest food. In animals, vacuoles perform the functions of digestion and osmoregulation whereas vacuoles keep the plant cells rigid and turgid.



Vacuoles

What have you learnt ?

- Cell is a fundamental and important unit of life.
- Around cells, membrane is found which is made up of lipid and protein.
- Membrane is an active part of a cell. Through membrane, the transport of substances towards internal as well as external sides takes place.
- Cell wall is found only in plant cell which is made up of cellulose and is located outside the membrane.
- Due to the presence of cell wall the cells of plant, fungi and bacteria do not get torn even in hypotonic medium.
- In Eukaryotic cells, nucleus is separated from cytoplasm by double membrane.
- The function of endoplasmic reticulum is to synthesize protein and fate synthesize.
- In the structure of golgi, three substances are found. Lipoprotein, glycolipid and phospholipid. Golgi body synthesize Lipoprotein, Glycolipid and Phosplipid. It is also responsible for packing and forwarding of these substances.
- In most of the plants three type of plastids are present. (1) Chloroplast performs photosynthesis, (2) Chromoplast impart various colours to flowers, whereas (3) Luecoplast store food.
- In matured plant cells vacuoles are found which keeps plant cells rigid and turgid. They also store food.
- In prokaryotic cell, membrane based organelles absent are their genes are made up of nucleic acid.

EXERCISE

1. Select the proper choice from the given multiple choices :

(1) Largest cell in human body is

(A) liver cell (B) nerve cell
(C) muscle cell (D) kidney cell

(2) Who has given word cell ?

(A) Robert Hooke (B) Robert Brown
(C) Watson and Crick (D) Flamming

(3) Which organelle is the power house of the cells ?

(A) Plastids (B) Mitochondria
(C) Golgi (D) Nucleus

(4) Which organelle is considered as a suicide bag ?

(A) Centrosome (B) Mesosomes
(C) Lysosomes (D) Chromosome

(5) Double membrane is absent in.

(A) Mitochondria (B) Chloroplast
(C) Nucleus (D) Lysosomes

(6) Which cell organelle is found only in plant cell ?

(A) Mitochondria (B) Nucleus

(C) Plastids (D) Ribosomes

(7) Organism in which membrane is absent surrounding nucleus and organelles.

(A) Prokarytes (B) Eukaryotes

(C) Haploid (D) Diploid

(8) In plant cells membrane surrounding vacuoles is known as

(A) Cell membrane (B) Tonoplast

(C) Cell wall (D) Nucleolus

(9) In animal cell lacking nucleus would also lack in

(A) Ribosomes (B) Lysosomes

(C) Chromosomes (D) Endoplasmic reticulum

2. Answer the following questions in short :

(1) Write down any two characteristics of a Prokaryotic cell.

(2) Name the discoverers of nucleus and DNA

(3) Name any two major cell organelles of an Eukaryotic cell.

(4) State the chief function of following organelles :

(A) Mitochondria (B) Lysosomes (C) Golgi body

(D) Ribosomes (E) Chloroplast

(5) What is Plasmolysis ?

(6) State two main functions of cell wall.

(7) Draw labelled diagram :

(1) Structure of Chloroplast

(2) Structure of Mitochondria

3. Answer the following questions in detail :

(1) Who discovered cell ?

(2) How do CO_2 and water move in and out of the cell ?

(3) Why plasma membrane is called a selectively permeable membrane ?

(4) Why lysosome is known as suicide bag ?

(5) Which orgenelle is known as power house of the cell ? and why ?

(6) What is osmosis ?

7 Plant Tissues

7.1 Introduction

In the previous chapter you have studied the structure of the cell. Cell is a structural and functional unit of all living organisms. In the unicellular organisms, a single cell performs all basic functions but in multicellular organisms , different life functions are carried out by different groups of cells.

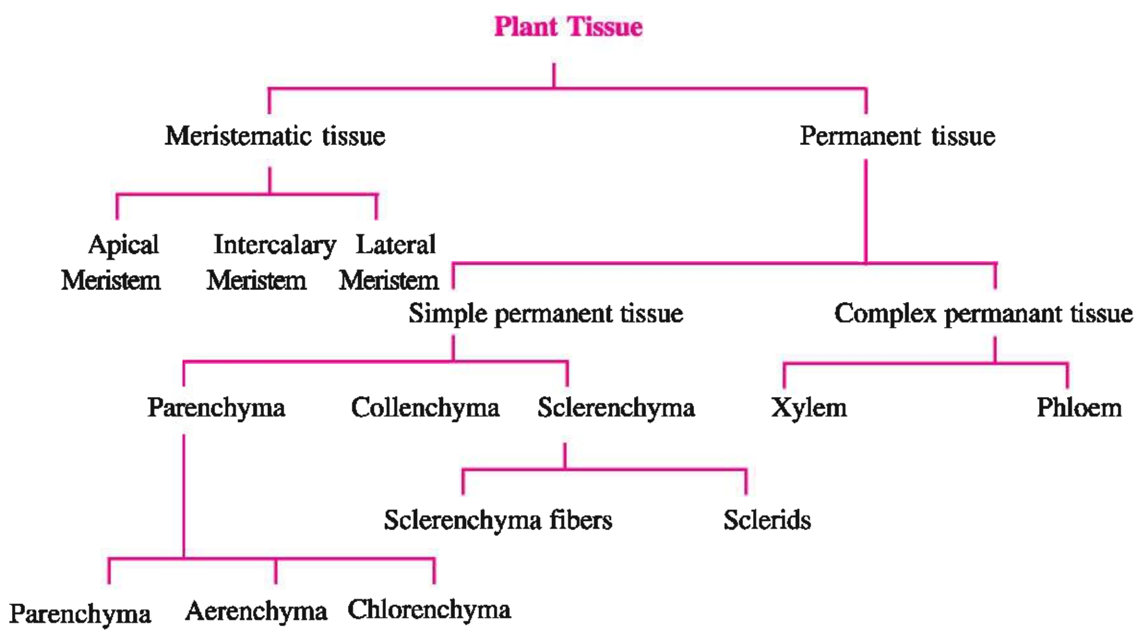
These cells are produced by the process of cell divisions.

Initially all the cells produced by the cell divisions are of the same type. Later on these cells start showing structural differentiation for different functions. Thus there commences tissue formation.

A group of cells that are similar in structure and work together to achieve a particular function forms a tissue. Tissues can be simple, consisting of a single cell type or complex, consisting of more than one cell type. The cells of a tissue are usually, though not necessarily, in physical contact with each other.

7.2 Plant Tissues

Plants are composed of three major organ groups: roots, stems and leaves. These organs are comprised of various types of tissues . On the basis of the ability of their cells to divide, tissues are classified into two types : (1) meristematic tissue and (2) permanent tissue. In this section, we will look at the various types of plant tissues along with their functions.



7.2.1 Meristematic tissues : Tissues where cells are constantly dividing are called meristems or meristematic tissues. These regions produce new cells. These new cells are generally small, spherical, oval or polygonal in shape.

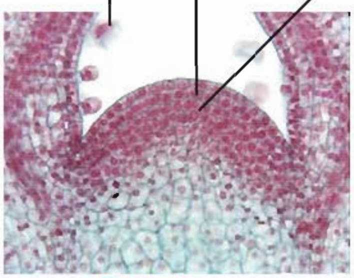
They are compactly arranged with no intercellular spaces. They possess abundant cytoplasm with large prominent nucleus. The vacuoles, if present in the cells, are quite small in size.

On the basis of their positions, the meristematic tissues are classified into three types

(1) Apical meristems (2) Lateral meristems

(3) Intercalary meristems

(1) Apical meristem : Apical meristems are located at the tips of roots and shoots. As new cells form in the meristems, the roots and shoots will increase in length. This vertical growth is also known as primary growth.



Shoot apex


Root apex

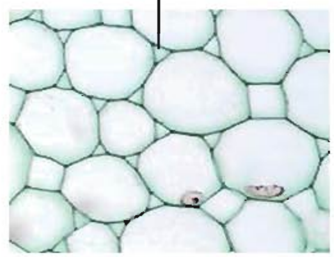
(2) Lateral meristems occupy lateral position in plant organs. They account for secondary growth in plants. Secondary growth is generally horizontal growth. A good example would be the growth of a tree trunk in girth.

(3) Intercalary meristems are internodal in their position and are found lying between masses of permanent tissues. This type of tissue is short lived and shows meristematic properties for short period and merges with the permanent tissues. This tissue can be distinctly seen in internodes and in sheathing leaf bases of grasses.

7.2.2 Permanent tissues : The permanent tissues are formed by cell divisions of meristematic tissues followed by their differentiation into definite types of tissue cells. These differentiated cells do not have ability to divide thereafter. They are classified into two types : (1) Simple permanent tissue and (2) Complex permanent tissue.

(1) Simple permanent tissues : Simple permanent tissues are made up of only one type of cells. There are three basic types of these tissues and they are named and classified on the basis of their structure and functions as follows :
(i) Parenchyma (ii) Collenchyma
(iii) Sclerenchyma.

(i) Parenchyma : This simple permanent tissue is made up of thin walled living cells and present in almost all the organs of plants. Cells are spherical, oval or elliptical, polygonal or elongated. Intercellular spaces are present between the cells. The cells possess large vacuoles in their cytoplasm. Parenchyma containing chloroplast with a green pigment chlorophyll is called chlorenchyma. It performs the function of photosynthesis. In aquatic plants, large air cavities are present in parenchyma to give buoyancy to the plants to help them to float. Such a parenchyma type is called aerenchyma.



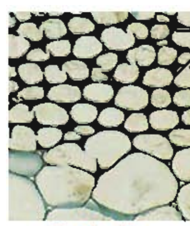
Parenchyma

This tissue provides support to plants and synthesizes food and stores it. The parenchyma of stem and root also stores nutrients and water.

The cells also store tannins, gum, various crystals, resin and some useful inorganic substances.

This tissue is found to fill up the spaces between different tissues and thus acts as a ground tissue or matrix.

(ii) Collenchyma : The cells of this simple permanent tissue are living with spherical, oval or polygonal shape. The cell wall is made up of cellulose which shows the deposition of pectin. Such deposition is more prominent in the angular regions of the cells where they come in contact with each other, hence the tissue is called chollenchyma. The cells are devoid of intercellular spaces. They are always found beneath the epidermis and hence, form hypodermis.

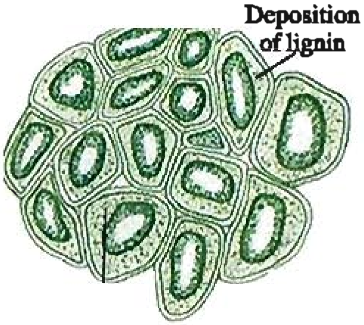


Collenchyma

Functions :

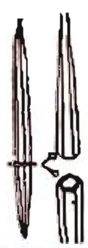
- The tissue provides mechanical strength to the organs and hence it is known as living mechanical tissue.
- The tissue also renders elasticity and flexibility to the organs. It allows easy bending in various parts of a plant (leaf, stem) without breaking.

(iii) Sclerenchyma : This simple permanent tissue makes the plant hard and stiff. The cells are dead. During the formation of this tissue the cytoplasm and nuclei disintegrate and the primary wall, made up of cellulose becomes thickened with lignin internally and forms a secondary wall. As a result the cell wall becomes thick and lumen of the cell gets reduced. Cells of the sclerenchyma are of two types : (a) Sclerenchyma fibres and (b) Sclerides or stone cells.

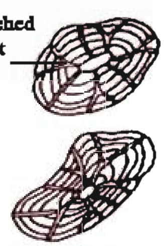


Sclerenchyma

(a) Sclerenchyma fibres : These are long , fibre like, narrow, fusiform and tapering at both the ends. The intercellular spaces in the tissue are almost absent and hence, cells appear to be polygonal in transverse section. They are found in stem around vascular bundles and in the veins of leaves.


Sclerenchyma fibres

(b) Sclerides or stone cells : They are somewhat isodiametric or variously shaped. They can be observed in the outer seed coat of bean, pea, green grams and nuts and pulp of chiku and pear.



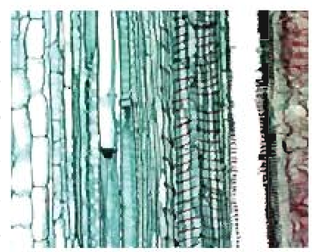
Sclerides

Functions :

They provide mechanical strength and rigidity to the plants and hence, they are known as dead mechanical tissues.

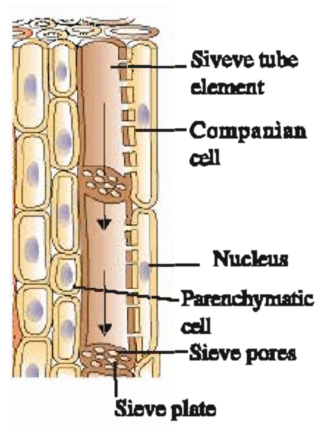
(3) Complex permanent tissue : Tissues composed of more than one cell type are generically referred to as complex tissues. Xylem and phloem are the two most important complex tissues in a plant. As they are associated with the transport of water, ions and soluble food substances, they are also known as conducting or vascular tissues.

(i) Xylem : The complex permanent tissue that conducts water and dissolved mineral salts upwards from root to leaves is called a xylem. Xylem consists of tracheids, vessels or tracheae, xylem parenchyma and xylem fibres. Tracheids are unicellular while tracheae are multicellular. The cells have thick walls, and many of them are dead cells. Tracheids and vessels are tubular structures and this allows them to transport water and minerals vertically. The parenchyma stores food and helps in the sideways conduction of water. Xylem fibres provide mechanical strength to the plants.


Xylem

(ii) Phloem : This complex tissue is concerned with translocation of organic food materials from leaves to the various plant organs. The phloem comprises, of sieve cells, sieve tubes, companion cells, phloem parenchyma and phloem fibres.

The sieve tube is an important component of phloem. The transverse walls of sieve tubes are perforated and are called sieve plates. Except the phloem fibres, phloem cells are living cells.



Phloem

What have you learnt ?

– A group of cells that are similar in structure and work together to achieve a particular function forms a tissue.

– On the basis of the ability of cell divisions, tissues are classified into two types : (i) Meristematic tissue and (ii) Permanent tissue.

– On the basis of positions, meristematic tissues are classified into (i) Apical meristem (ii) Lateral meristem (iii) Intercalary meristem.

– Permanent tissues are of two types :

(i) Simple permanent tissue and (ii) Complex permanent tissue.

– Simple permanent tissues, on the basis of their structure and functions, are classified in Parenchyma, Collenchyma and Sclerenchyma.

– Collenchyma is known as living mechanical tissue while Sclerenchyme is knownas dead mechanical tissue.

– Complex permanent tissues are Xylem and Phloem .

– Xylem conducts water and minerals upwards from root to leaves.

– Phleom translocates food from green parts of the body to different parts of plant.

EXERCISE

1. Select the proper choice from the given multiple choices :

(1) Tissue containing more than one type of cells are known as :

(A) Collenchyma (B) Simple tissue

(C) Parenchyma (D) Complex tissue

(2) Parenchyma which contains chlorophyll are known as :

(A) Sclerenchyma (B) Collenchyma

(C) Chlorenchyma (D) Aerenchyma

(3) Collenchyma mainly forms:

(A) Epidermis (B) Hypodermis

(C) Cortex (D) Xylem

(4) Main function of phloem in the plants is :

(A) Conduction of water (B) Transport of food

(C) Photosynthesis (D) Ascent of sap

(5) The living component of xylem is :

(A) Tracheid (B) Xylem fibre

(C) Xylem parenchyma (D) Tracheae

(6) The dead component of phloem is :

(A) Sieve tube (B) Sieve cell

(C) Phloem parenchyma (D) Phloem fibre

(7) Living mechanical tissue is :

(A) Parenchyma (B) Collenchyma

(C) Sclerenchyma (D) Chlorenchyma

2. Answer the following questions in short :

(1) Define : Tissue

(2) Give the names of three simple permanent tissue of plants.

(3) Name the various components of phloem.

(4) Name the various components of xylem.

(5) What is the function of phloem ?

(6) Which deposition is present in collenchyma cells ?

(7) What is the function of lateral meristem ?

(8) Write the characteristics of meristematic tissue.

3. Answer the following questions in detail :

(1) Give reason : Xylem is a complex tissue.

(2) Differentiate between collenchyma and chlorenchyma.

(3) Differentiate between xylem and phloem

(4) Differentiate between parenchyma and sclerenchyma

(5) Write the functions of parenchyma.

(6) Describe the structure and functions of xylem.

(7) Describe the structure and functions of phloem.

(8) Describe the types of meristematic tissues.

(9) Explain structure and functions of sclerenchyma.

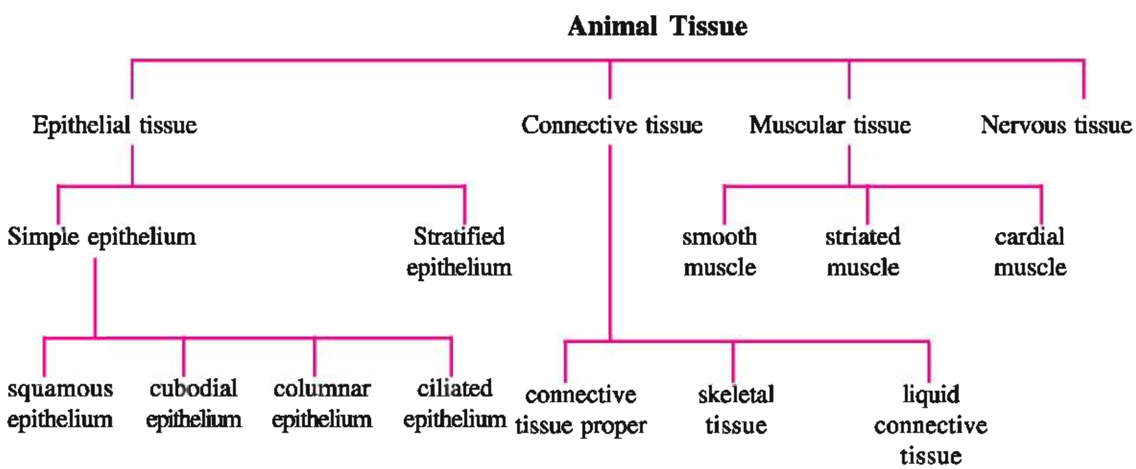
(10) Explain structure and functions of collenchymad

8 Animal Tissues

8.1 Introduction

Before studying various organs of human body, it is requisite to know the micro-structuring of such organs. The study of such micro-structure of organs is called Histology. All organs are made up of different types of tissues. These tissues are a group of cells performing particular functions of specific type, of similar shape, of common origin, structure and bearing specific properties. The origin of such cells are from specific embryonic layers. For example the origin of nervous tissue from embryonic ectoderm, connective tissues formed from embryonic mesoderm. The classification of body's tissues is taken out into four divisions :

1. Epithelial Tissue 2. Connective Tissue 3. Muscular Tissue 4. Nervous Tissue



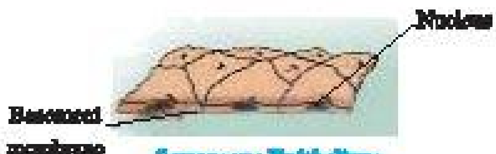
8.2. Epithelial Tissue

Epithelium is formed of covering cells so surrounding the entire body, at outer layer of the organs, internal layer of the alimentary canal and at the cavity of the glands epithelium layer is there. The epithelium layer surrounding the cavity of blood vessels is called endothelium.

The nomenclautre and classification of Epithelium tissue is done on the basis of shapes and the functions performed for example Columnar epithelium is so called as its shape is like a column. Whereas the cells of glandular epithelium posseses the functional properties of secretion. In the classification of epithelium mainly the functional properties and shape characteristics are not enough. There is no or very little intercellular substance is found between epithelium cells. So the walls of epithelium cells are strongly joined to one another. In addition to this, one cell layer on basement membrane which are made up of collagens substance of specific type. The simple epitheliums are made up of a series of one cell, whereas stratified epitheliums cells of this tissues are arranged in many layers simple epitheliums are mainly of four types based on their shape.

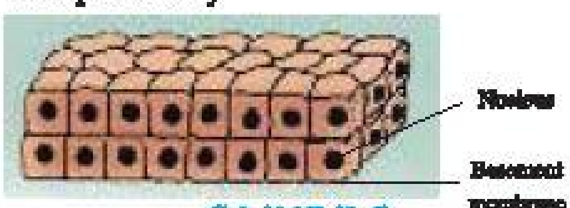
(1) Squamous Epithelium (2) Cuboidal Epithelium (3) Columnar Epithelium (4) Ciliated Epithelium

8.2.1 Squamous Epithelium : The cells appear to be thin, flat and hexagonal like a tile and the wall of every cell is connected to each other with cement like substance which becomes black while staining with silver nitrate. The squamous epithelium forms the layer of mouth, oesophagus, nose, alveoli sacs and blood vessels cavity and forms the coating outside the skin and tongue. The function of this tissue is to protect the chemicals of the body from entry of germs and mechanical injury.



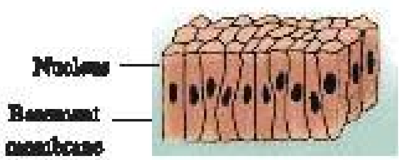
Squamous Epithelium

8.2.2 Cuboidal Epithelium : Cells appear to be a cube in section and round nucleus is found in the centre of the cell. From the free surface it appears polygonal. Cuboidal Epitheliums are found in Thyroid Vesicles, in liver tubules, Uriniferous tubules and in sweat glands. Its chief function is absorption, excretion and secretion. It gives mechanical support to the parts of body.



Cuboidal Epithelium

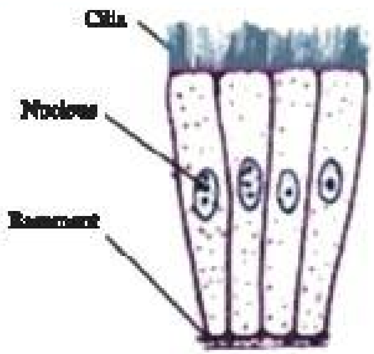
8.2.3 Columnar Epithelium : They are like cubodial Epithelium in many ways. But columnar Epithelium are much taller than the cubodial Epithelium. They are situated at the upper layer of basement membrane. The nucleus is long and the location of it in the cell is upper, lower or in the middle. The columnar epitheliums are found at the surrounding alimentary canal function. Cavity of alimentary canal and gonads and big tubes of some glands. The chief function of columnar epithelium is to absorb and secrete in stomach and intestine.



Columnar Epithelium

8.2.4 Ciliated Epithelium : These are one type of transformed columnar epithelium on the free ends of cells of Ciliated Epithelium, many delicate Cilia formed of cytoplasm are situated. All cilia originate from basal granules. Living epithelium cells rapidly move to one direction and come back again to the original condition. The movement done by Cilia is rythmic and wavy.

The comparison of which can be made with swaying grass or rice fields alongwith waves of winds. The function of Ciliated Epithelium is to create oscillatory movement and current in the fluid situated around it. The Ciliated Epitheliums are found in nasal cavity, bronchi and windpipe. The layer of Pharynx in frog is made up of Ciliated Epithelium. The Cilia of which work by pushing the food particles further entangling them into mucus push towards oesophagus.



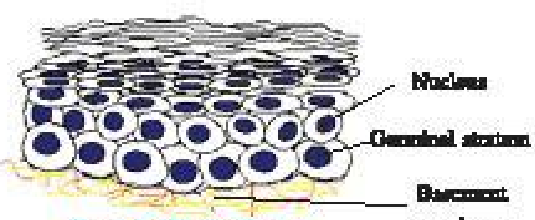
Ciliated Epithelium

Compound epithelium :

The surface of simple epithelium keep wet always. Moreover, they are situated on the location where these epitheliums need not take are tear on the secutrary the place were epithelium have to work deligently or face more friction, there is a need of new cells in place of dead cells. The result of this condition is the origin of stratified epithelium.

Stratified epithelium :

In the structure of stratified epithelium, there are layers of many cells. in which the layer situated above the basement layer is called germinal stratum. The cell of germinal layer divides permanently, and there is an increase in the layers of cells at upper side. Thus, there is a change found



Stratified Epithelium

in the shape of cells, as there is addition in the layers of cells. In this way the cells located at uppermost layers are flat and non - living bearing fibrous protein keratin. This uppermost dead layer- flexes away because of friction ultimately. The location of straitified epithelium in vertebrates is at external part of the skin and found in oesophagus. Its chief function is to protect internal parts.

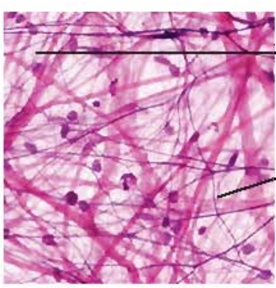
8.3 Connective Tissue

Most of the part of connective tissue is made up of matrix. The cells which are situated inside the connective tissue secrete the matrix. The chief function of connective tissue is to join various organs to make a packing around the organs to face the poisons entering in the body externally, to create new tissues in place of the dead tissues causing from the wounds. In addition to it, to create skeletal to give support to the body.

There are three types of Connective tissues : (1) Connective tissue proper (2) Skeletal tissue (3) Liquid connective tissue - Blood and lymph.

There are two types of connective Tissues Proper : (1) Aerolar tissue (2) Adipose tissue

8.3.1 Aerolar tissue : Aerolar tissue is a tissue which is found in many parts of the body. Its location is below the layer of the skin, in the packing between the muscles, mesentry peritonium and around the blood vessels entering the organs.

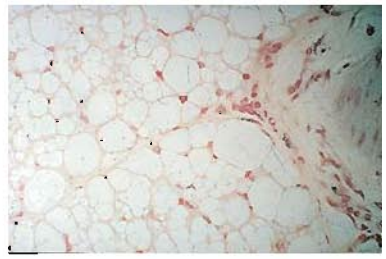


Aerolar Tissue

In the structure of tissue there is a matrix like collagens in which the fibres crossing over each other and from the cells found between them. There are two types of fibres like white fibres and yellow fibres. White fibres are found in group, wavy and without branch whereas yellow fibres are isolated somewhat thick and branched, of less numbers and not in groups, moreover, the branches of these fibres are joined together and form network white fibres are made up of collagens. In addition to it, in matrix there are various types of cells, from which chief are fibrocytes which are irregular in shapes and flat. Macrophages are of irregular shapes, round nucleus and white coloured which destroy the organisms and protects it from infection. In addition to it, Mast cells having big nucleus are there.

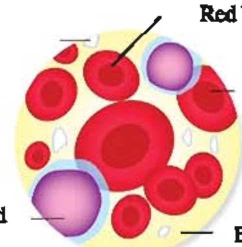
8.3.2 Adipose Tissue :

It is a transformation of general Areolar tissue in which an increasing number of connective tissue cells are found which are transformed into fat cells. In the fat cells neutral fat is stored and they are found in bigger size. The cell full of fat becomes round like sacs and lobulated. They get separated from the fibres made up of collagen and elastin. In frogs the adipose tissues are found in fat bodies whereas in mammals they are found below the layer of skin. The chief function of this tissue is to store fat.



Adipose Tissue

8.3.3 Blood fluid connective tissue :



Blood Tissue

Which is living, active and circulatory. In blood the live bloodcells are found flowing in matrix Almost 80% of the fluid of the matrix of this tissues of blood, along with pressure makes the part turgid and gives it support. The creation of matrix is not done by blood cells. In remaining 20% of the blood, blood cells are formed. Colourless fluid called as blood plasma (Matrix) in it different types of various blood Corpuscles or cells are found freely floating in blood plasma protein like fibrinogen, serum globulin, serum albumin and salts, hormones and antibodies are found.

Antibodies are one type of blood protein and their formation is made by antigen of blood plasma. Blood plasma has three types of blood cells, RBC,

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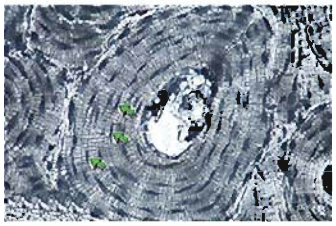
WBC and Platelets. Blood transports nutrients to body while, RBC carry oxygen and transport to living cells. Besides this they carry the excretory products and hormones. At the end blood clots at the part of the body and prevents blood flowing out of the body.

Skeletal tissue is connective tissue. It is of two types. Bone and Cartilage.

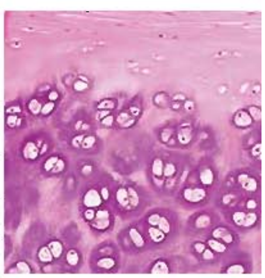
8.3.4 Bone : Bone is another example of connective tissue. Bones form skeleton that supports body. Osteocytes, salts of calcium and phosphates are found in solid matrix, Joint near two bones are connecting each other by ligaments.



Bone

Ligament is one type a connective tissue. This tissue is strong and elastic. Ligaments are having very little matrix. In ligaments network of irregularly arranged yellow elastic fibres bound by areolar tissue. Muscles are joined the bone by ligaments. Tendon is also one type a connective tissue. Tendon is fibrous tissue, it has great strength but its flexibility is limited. In tendon white fibres are running parallel to each other.

8.3.5 Cartilage : Cartilage is another type of connective tissue. Its matrix chondrin is solid which is made up of protein and sugars. Chondrin is formed by chondrocytes, they are found scattered near each other in matrix. Cartilage is tough, hard tissue but easily flexible. In the tissue no blood vessels or nerve is found. Cartilage acts as a shock absorber and functions sort of cushioning.



Cartilage

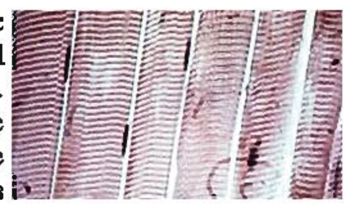
8.4 Muscular Tissue

Contraction and relaxation of muscle tissue is brought by the movement of different parts of animal body, muscle tissue is made up of specific type of long and contractile fibres. This unit is known as muscle fibre. There are three types of muscle tissue (i) smooth muscle (ii) striated muscle (iii) cardiac muscle. Structure innervation function, origin, and their location in body show variation in all the types of muscle tissues.

8.4.1 Smooth muscle : Smooth muscles are involuntary muscles. Their structure is simple as compared to other muscle. Smooth muscle fibres are spindle shaped, unicellular, flat, pointed at both the ends and broad in middle. In the centre of the cell there is single rounded nucleus which is surrounded by sarcoplasm. In the cell longitudinal myofibrlis are clearly seen. These are fibres contractile in nature hence muscles are contractile. In smooth muscle there is no striations as found in strineed muscle, and cardiac muscle. This muscles occur in the wall of alimentary canal except anterior and posterior end, ducts of glands, wall of the blood vessels muscle are made up of smooth muscle. Without help of our will the contraction of muscle is very slow, but can remain contracted for long time. The smooth muscle is innervated by autonomic nervous system.

Involuntary muscle

8.4.2 Striated muscle : Striated muscles are also called voluntary or skeletal muscles. Every one of the muscles is in the striped form and every of the muscle stripe is made up of specific type of cylindrical muscle fibres. Around every one of the muscle fibre thin sarcolemma is found. Inside the sarcolemma in sarcoplasm many oval nucleus are found. Thus, muscle fibre is called multinucleated cell. In sarcoplasm of every muscle fibres longtitudinal myofibrils are found parellel but separate from each other. By looking the muscle fibres through microscope, there are dark and light horizontal stripes like lines are found from this it is given the name of striated muscle, Striated muscle. fibres are found in limbs, body wall, tongue and pharynx. On response, the striated muscle has the property of



Striated muscles

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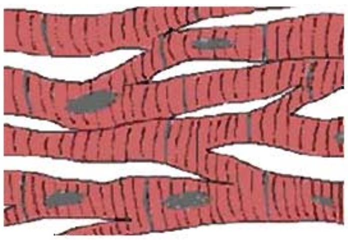
rapid contraction so they become tired and fatigued fast. The movement of these muscles is according to the will and so they are known as voluntary muscles.

8.4.3 Cardiac muscle : This muscle is found only in the wall of heart. Its structure is in between as compared to striated and unstriated muscle. At some point cardiac muscle fibre is also multi-nucleated like striated muscle. Like striated muscle, in cardiac muscle too dark horizontal stripes are found. Cardiac muscles are not made up of separate cells, but they are made up of fibres connected with the bridges formed by cytoplasm. That is why cardiac muscle fibres are seem in branches. Like striated muscle fibres, in cardiac muscles too. Nucleus, Sarcoplasm and myofibrils are there. Apart from this, in them thick and dark intercalated discs are there at certain distances. There is a property of rhythmic contraction found in these muscles. The cardiac muscles do not exhaust even after working for lifetime constantly without taking rest of a single moment and due to contraction and relaxation the heart works as a pump and distribute the blood to various parts of the body.

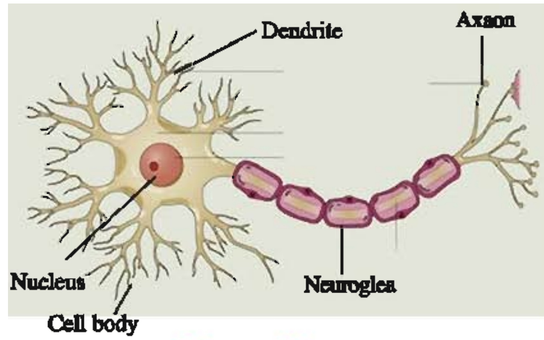


Cardiac muscle

Activity : Observe different kinds of muscles, tissues and make a comparative study of their shapes, number of nucleus and location.

8.5 Nervous Tissue

In the structure of nervous tissue, nerve cells and nerve fibres are found. The chief function of cytoplasm of nerve cell and nerve fibre is to receive stimuli and its transmission. In the structure of nervous tissue the unit is neuron which takes place by many small and large processes of cyton and branches come out of the walls. One process of these all processes is very long which is called axon. The remaining processes are generally short



Nervous Tissue

which are called dendrites, chief fibre is made up of axis cylinder and the covering is found around it. Around axon white coloured fatty myelin sheath is there and outside it thin flexible neurilemma are there. There is thin layer of cytoplasm between myelin sheath and neurilemma. These three parts are called schwan cells. The myelin sheath is not continuous but it is broken at interval by nodes of Ranvier. Thus, the part of nerve fibre without myelin sheath is known as Ranvier's node.

What have you learnt ?

- Tissue is the group of similar structure and functions.
- In animal tissue epithelium, connective, muscular and nerve tissues are included.
- In various types of connective tissues found in our body include areolar tissue, adipose tissue. Tendon, ligament, cartilage bones and blood.
- In muscular tissue striated, unstriated and cardiac muscles are three types.
- In nervous tissue, nerve cells are found which accepts stimuli and transmit it.

EXERCISE

1. Select the proper choice from the given multiple choices :

(1) In human being, muscle cells-

(A) Carry message from one part to another

(B) Contract and relax to cause movements

(C) Conduct food and water

(D) Transport of oxyen

(2) Bone is an example of

(A) Epithelium tissue (B) Muscular tissue

(C) Connective tissue (D) Nervous tissue

(3) Muscles contain special protein called.

(A) Globulin (B) Tubulin

(C) Contractile protein (D) Carrier protein

(4) White blood cells

(A) Help in the transport of oxygen (B) Help in blood clotting

(C) Act as soldiers (D) Are non-nucleated

2. Answer the following questions in short :

(1) State the location of tissue in living animal

(i) Areolar tissue (ii) Squamous Epithelium

(iii) Cardiac muscle (iv) Adipose tissue

(v) Glandular Epithelium

(2) Give the definition of following :

(i) Epithelium (ii) Blood

(iii) Tissue (iv) Organ

(3) Give only two differences :

(i) Bone and cartilage (ii) Osteocytes and white blood cell

(iii) RBC and WBC

(4) Give the important functions of epithelial tissue.

(5) Only draw the labbelled diagram :

(i) Neuron (ii) Striated muscle

(iii) Cardiac muscle

3. Answer the following questions in detail :

(1) What is tissue ?

(2) State main features of cardiac muscle ?

(3) State the functions of Areolar tissue ?

(4) What is specific function of cardiac muscle ?

(5) Give only the name of the following :

(i) Tissue which connects muscle to bone

(ii) Tissue present in the brain

(iii) Which tissue store fats in our body ?

(iv) Which tissue forms inner lining of our mouth ?

(6) Identify the type of tissue in the following :

(A) Bone (B) Skin

(C) Living of kidney tubules (D) Kidney

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9 Why do we fall ill ?

9.1 Introduction

In the previous chapter, we have learnt that cell is a basic unit of living being and cells are made of various substances like carbohydrates, proteins, lipids etc.

In organs or tissues of our body various specific kinds of activities go on. For example lungs respire, kidney filters blood and brain thinks.

All these activities are interrelated. For example if the kidneys do not form urine, poisonous substances will get collected in the body. In such a situation, the brain will not be able to think properly. To perform all these interrelated activities and to maintain the activities of the cell and tissues or organs the essential energy is obtained from food.

9.2 Health and Its Failure

We are familiar with the word 'health' which is used frequently all around us. We use the 'health' word often for ourselves and our family members. If health is not good then we say that health is not well. When the people meet each other first of all when they start conversation, ask about the well-being of health. Thus good health means physical, mental and social well-being.

9.3 Personal and Community Questions for Health

The health of every living being depends on the surrounding environment. For example during cyclone our health is at risk in many ways. It is more important that human beings live in society because for their individual health. Social environment is an important factor if we live in the society. We live in villages, towns or cities. In at such places even our physical environment is dead by our social environment.

Think, what would happen if no agency takes responsibility of collection and disposal of the garbage ? What would happen if no one take care of cleaning the drains and ensuring that water does not get collected in the streets or open spaces ? There are possibilities of getting the health spoiled if there is a dump of garbage thrown in our streets or there is open drain water lying stagnant around where we live. Therefore public cleanliness is very much important for the maintainence of indiviudal health.

Activity 1 : Find out which local organisation provide the facility of clean drinking water ? (Panchayat/Municipality)

Food is essential for health and it can be obtained by earning money. For this, it is necessary to get good job. For individual, health, good economic condition and jobs are nceessary. In the same way it is also important to be happy so that we can feel happy. In fact if we misbehave and stay in conflict with each other if then we cannot be happy or healthy. Social harmony and unity is necessary for individual health. We can also think of many other examples where there is some connection between community issues and individual health.

Activity 2 : Find out how your local authority manages the solid waste generated in your neighbourhood.

- Are these measures adequate ?
- If not, what improvement would you suggest ?
- What could your family do to reduce the amount of solid waste generated during a day/week ?

9.4 Distinction Between "Healthy" and "Disease-free".

In other words, disease means disturbed. The meaning of good health for a dancer means being able to stretch his/her body into a graceful position without difficulty. On the other hand for a musician it may mean having enough breathing capacity in his/her lungs. Because of these reasons, when we think of our disease, we should think of the people suffering from it.

9.5 Disease and Its Causes

9.5.1 How to Identify Diseases ? : Let us now think a bit more about diseases. Firstly how do we know that there is a disease ? When there is a disease, either the functioning or the appearance of one or more systems of the body will change for the worse. Due to this change, symptoms and signs of diseases originate. Symptoms such as not feeling well, having cough, having loose motion etc. show that disease has been caused, but they do not indicate what is the diseare. For e.g. a headache may be an examination stress, meningitis or any one from many others. Doctors diagnose the disease on the basis of signs and symptoms. These signs will give a little more definite indication of the presence of particular disease. Physicians will also get laboratory test done to pinpoint the disease further.

9.5.2 Acute and Chronic Disease :

Acute disease : We consider the disease like flu as acute disease because it affects start suddenly and they are fast on the body; for example cold. The effect of this disease is felt for a certain period, so there is not a long term bad effects of it on human body e.g. cough, cold, typhoid, cholera etc.

Chronic disease : These are long term diseases. The symptoms of such diseases are seen for months, years or even lifetime. The effects of these diseases on human body are strong and long term. e. g. Elephantiasis, TB, Cancer, Diabetes and Arthritis.

Activity 3 : Survey in your neighbourhood to find out.

(i) How many people suffered from acute diseases during the last three months ?

(ii) How many people developed chronic diseases during the same period ?

(iii) and finally, the total number of people suffering from chronic diseases in your neighbourhood ?

Are the answers to questions (i)and (ii) different ?

Are the answers to questions (ii) and (iii) different ?

What do you think could be the reason for these differences. What do you think would be the effect of these differences on the general health of the population ?

9.5.3 Chronic Diseases and Poor Health : Acute and chronic diseases have different effects on our health. The effect of chronic disease is greater on general health. For example think about cough and cold which we all have from time to time. We all get well within a week but it will not leave any bad effect on our body. We do not lose our weight, we don't feel difficulty in respiration, we do not feel tired because cough and cold will get over in a few days but if we get infected from a chronic disease like tuberculosis of lungs, then we feel tired all the time and lose our weight.

9.5.4 Causes of Disease : What are the causes of a disease? When we think of the reasons of disease, we should also consider that there are many levels of such causes. For example, a child is suffering from loose motion, then the main cause of this disease would be the infection with a virus. After that the immediate question is - where did the virus come from? Suppose we find that the virus has come from unclean drinking water. But this unclean drinking water is drunk by many children then why is it that one child developed loose motions while the others do not? One reason of it may be because the child is not healthy. Consequently, it may happen that the risk of disease in this child is great whereas other healthy children are not at risk. Why this child is not healthy ? Perhaps this child is not well-nourished. So the lack of good nourishment becomes a second level cause of the disease. There is a possibility of lack of proper public services in the area where this child lives. So lack of public services become third level cause. Now it is obvious that for all the diseases instead of one cause many other causes are there.

9.5.5 Infectious and Non-infectious disease :

Infectious disease : The reasons of infectious disease to take place are certain disease organisms like virus, bacteria, protozoans, worms, nematods, fungi etc. Infectious diseases are easily carried to other persons by some agents like physical contacts, water, air, food and microorganisms. They are spread from diseasesd person to a healthy one.

Non-Infectious diseases : Some diseases are not cansed by agents. For example cansed disease like cancer which is caused by genetic abnormalities. High blood pressure can be caused by excessive weight and lack of exercise. You can think of many other diseases where the immediate cause will not be infectious. In some cancers in some part of the body, there is an uncontrollable growth of tissues. Due to accident, one gets hurt or some physical harm takes place. How the disease gets spread and how its prervention and cure are taken up at general public level ? They are different for different diseases. It depends on whether the disease is infectious or non-infectious.

Activity 4 : Find out how many of you in your class had cold / cough / fever in the recent past.

- How long did the illness last ?
- How many of you took antibiotics ?
- How long were those who took antibiotics pills ?
- Is there a difference between these two groups ?
- If yes, why ? If not, why not ?

9.6 Infectious Diseases

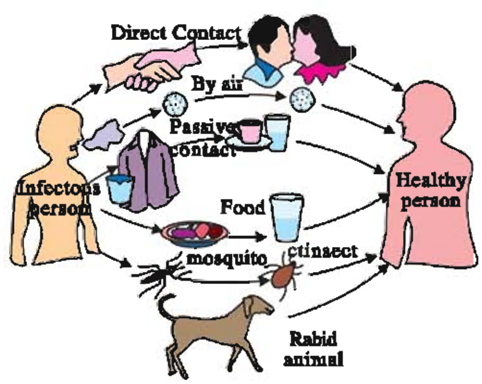
The disease caused by coming in contact with living beings is called infectious disease. Now let us study in detail about living beings responsible for infectious diseases, their spreading and how do they enter in to our body.

9.6.1 Infectious agents : Organisms that can cause disease are found in a wide range of categories of classification. Some of them are viruses, some are bacteria, some are fungi and some are unicellular protozoans. The causes of some diseases are multicellular organisms like various types of worms. Common cold, influenza, dengue and AIDS are caused by viruses. Typhoid, cholera, T.B. and anthrax are caused by bacteria. Some skin infections are causad by different types of fungi. Protozoans spread disease like malaria. Why do we think of these categories of infectious organisms ? The answer is that these categories are important factors in deciding what kind of treatment to take.

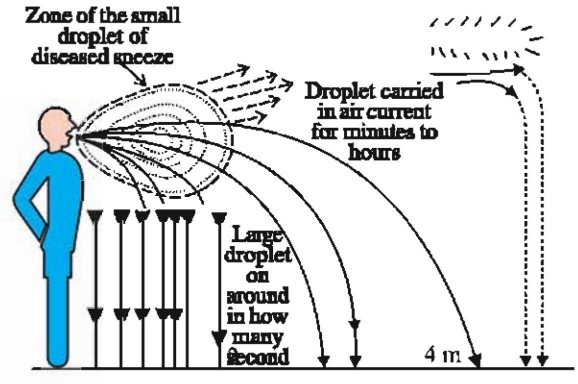
The medicines taken for curing the disease interrupt the biological activities of disease, causing organism and destroy take.

In bacteria and virus many varities are found. The medicine affecting the bacteria beloging to one group may not affect the bacteria of other group. Moreover, the medicine affacting the bacteria does not affect the virus. For example many bacteria make a cell wall to protect themselves. Antibiotic penicillin obstructs bacteria in constructing the cell wall consequently, the growing bacteria become unable to make cell walls and die easily. Human cells do not make a cell wall so penicil lin will not have any effect on their cells. But the virus does not use this biochemical pathways and so these antibiotics do not affect infective viruses.

9.6.2 Means of spread : How do infectious diseases spread ? Many agents generally transfer these disease from the infected person to healthy person. Disease spread takes place due to communication and thus they are called communicable disease. Microbes of such disease spread through air. This occurs through sneezing and coughing of an infected person or by standing close to such person. The diseases spread through air are tuberculosis, pneumonia, cough and cold. The diseases can also spread through water. If the excreta of infectious person suffering from cholera get mixed with water and if this water is used for drinking purpose, cholera spreads. During sexual intercourse the diseases like syphilis and AIDS spread. These diseases do not spread by casual physical contact such as hand shake, hug or by playing sports like wrestling or any otherway. AIDS can also be acquired by taking blood of an infected person. It also transmits from infected mother to her baby during breast feeding. Some diseases are transmitted through other animals like mosquitoes. Many species of female mosquitoes suck blood from other animals and spread disease like malaria.



Transmission of disease



Disease spread by air

9.6.3 How do microbes enter our body ? : The diseas causing microbes enter our body through different means. So, there are many possible places to enter into organs or tissues. If they enter from the air via nose they are likely to go to the lungs. This is seen in the bacteria causing tuberculosis. If they enter through the mouth, they can stay in gut lining like typhoid causing bacteria. Or they can go to the liver, like the viruses that cause jaundice. The virus of HIV generally entier through sexual organs of the body. The microbes responsible for malaria enter the body with biting of mosquito and go to the liver and then to the red blood cells. The virus causing brain fever will enter through a mosquito bite and infect the brain.

The signs and symptoms of a disease will depend on the tissue or the organ which the microbes target. If they have targeted the lungs, then cough, cold or breathlessness is felt. If they have targetted the liver then jaundice and if they have targetted the brain, headache, vomits and unconsciousness are felt. Against all these infections the immune system becomes active and destroys the microbe causing disease. During these processes certain local effects such as swelling, pain and fever etc. take place. In certain cases, tissue – specificity of the infection leads to general effects. For example in the HIV infection, the virus goes to the immune system and obstructs its function. Thus HIV infected body cannot fight against small infections that we face everyday. For example. Common cold will become pneumonia. In the same way, because of the small infections in intestine diarrhoea occurs and ultimately because of these other infections, HIV infected human being dies. It is also important to remember that severity of disease manifestation is based on the number of microbes entering the body. If the number of microbes is very small, the disease manifestation may be minor or unnoticeable. If the microbes found in great number, the severity increases and it is threatening to life. Immune system is the main factor and it has to determine the number of living microbes in the body

9.7 Diseases in Human Beings

Malaria : This disease is fatal for human beings. Every year approximately 2 lakh people die due to this disease. This disease is caused by protozoan *Plasmodium.* It is caused by biting of female anopheles mosquito. In malaria headache, muscular pain and fever are felt. The period of malaria attack is 6 to 10 hours and it has three stages. (1) In colder stage, much cold and shievering is felt. (2) In hotter stage much fever takes place. Respiration gets fast and heart beats faster. (3) Perspiration period – while perspiring, fever goes away and temperature gets normal. After getting cured from malaria patient feels weakness. Because of malaria there is turgidity in liver and spinal cord.

Jaundice : Jaundice is a disease of liver. It is a disease caused by Hepatitis viruses. In this disease hunger is not felt. Fever, headache, muscular pain, weakness, pain in joints, vomiting, yellow coloured urine, white coloured stool etc. are the symptoms of this disease. This disease is spread by contaminated food, water and Hepatitis virus.

Cholera : It is an acute infectious disease. This disease is generally spread at crowded places, fair, flood etc. This disease is spread very fast by flies, unclean water, contaminated food and absence of cleanliness. The bacteria of cholera gets multiplied very fast by entering into small intestine and epithelium cells of intestine. After the death of bacteria poisonous substances are released which cause swelling on intestinal wall. Due to which water and minerals go out of the body in great proportion.

Typhoid : Typhoid is a common disease in India. Typhoid is caused by *Salmonella typhi* bacteria. The flies coming in contact with typhoid infected people are responsible for this. After getting infected, the symptoms of this disease are found after 10 to 14 days. Headache, increasing or decreasing of fever, loose motion etc. are its symptoms

T.B. : Tuberculosis is an infectious disease. This disease is spread either directly or indirectly by *Mycobacterium tuberculosis*. Bacterium is responsible for this disease. It is called Tuberculi. The effects of T.B. are found on lungs, lymphoid glands, bones and intestine. Patient becomes weak and sick. Due to loss of apetite weight is lost. The infected organs of T.B. are lungs and lymphoid glands.

AIDS : It is a severe, infectious incurable and fatal disease. The full name of AIDS is Acquired Immuno Deficiency Syndrome. AIDS is caused by Human Immuno Deficiency Virus - HIV. It is the virus of Ritrovirus group. Because of the infection of this virus the immunity of the patient decreases. Because of lack of immunity it becomes difficult for the patient to get protected from various diseases. This disease is spread by homosexual or heterosexual intercourse, by intaking HIV infected blood, by using syringe or needle once used for an AIDS patient, by diseased mother to her foetus or by the AIDS infected mother to the baby through breast feeding.

Swine Flu (Primary Report) : Swine flu (swine influenza) is a respiratony disease, and spread through Influenza virus (H_1N_1). The symptoms of swine flu are fever, cough, infecting respiratory tract, decreased appetites, headache, muscular pain, vomiting etc. Swine flu symptoms are same in human and pig. Swine flu vaccines Tamiflues is discovered

Dengue : Dengue is acute febrile disease, which is transmitted by Aedis mosquito biting containing Dengue virus. During illness, there is strong headache, severe pain in muscle and joint and, scars on skin. Apart from this pain around the eyes, swelling on stomach. Pain in waist, vomiting sensation. Vomits and constant loose motion takes place. There is a decrease in the number of platelets and white blood cells. There is no vaccine discovered for Dengue virus. To control the disease the control of the mosquitoes is important.

Chikungunya : In chikungunya, along with illness there is a swelling on back, legs and skin. Joint pain is prolonged. Illness persists for two to four days, during which headache, much weakness, sleeplessness are felt. This disease is spread among human beings throgh biting of mosquitoes of chikungunya virus. Chloroquine medicine may give comfort. The control and the protection from chikunqunya virus is much important. Not any specific vaccine is discovered.

Conjuctivitis : It is an Infectious eye disease caused by virus. Acute pain in eye, eyes getting red, pricking in eye, continuous water falling. From eyes, swelling of eyes etc. are caused. It spreads from human to human. Eye drops may give comfort. Eyes should be kept clean.

9.7.1 Principles of Treatment : What steps are taken up by your family members when you fall sick ? Have you ever thought why you sometimes feel better if you sleep for sometimes ? When does the treatment involved medicines ? Infectious diseases are treated in two ways: one would be to reduce the effects of the disease and the other to kill (destroy) the cause of thie disease. In the first, we can provide treatment that will reduce the symptoms. The symptoms are usual because of inflammation for example we can take medicines that bring our fever down, reduce pain or loose motion. We conserve our energy in such conditions by taking rest. But this kind of symptoms - directed treatment will not destroy the infecting microbes and we do not feel disease free and hence we need to kill such microbes.

How shall we kill microbes ? One way is to use medicines that kill microbes. The classification of microbes is done into different categories. They are viruses, bacteria, fungi and protozoa. Each of these groups of organisms will have some essential biochemical life process which is peculiar to that group and absent in the other. The making of anti-bacterial medicines are comparatively easy than that of anti-viral medicines because the viruses have few biochemical mechanisms of their own. They enter our cells and use our machinery for their live processes. This means that there are relatively few virus specific targets to aim at. Inspite of these limitations, there are effective anti-viral drugs available now. For example the drugs that keep HIV infection under control.

9.7.2 Principles of prevention : For airborne microbes, we can prevent exposure by providing living conditions that are not overcrowded. For water-borne microbes, we can prevent exposure by providing safe drinking water. This can be done by treating water to kill any microbial contamination. For vector-borne infections we can provide clean environments. This would not allow mosquito breeding places. Thus, public hygiene is one fundamental key to the prevention of infectious diseases. Alongwith controlling the external disease factors, the immunity of the body should also be developed. For this balanced diet should be taken.

Vaccination : Accute disease can be controlled by vaccination. Vaccines are available against the disease like Tetanus, Diptheria, Measles, Polio, Rabies, Typhoid and Hipatitis. The children should be vaccinated as per prescribed time and dose.

Activity 5 : Visit your nearby primary health centre and get information about vaccination programme. Know from your doctor how the vaccine works in the body.

What have you learnt ?

- Heath is a state of being well enough to function well physically, mentally and socially.
- The health of an individual is dependent on various conditions.
- Diseases are classfied as acute or chronic, depending on their duration.
- Types of disease infectious and non-infectious.
- Infectious agents belong to different categories of organisms and may be unicellular and microscopic or multicellular.
- Infectious agents are spread through air, water, physical contact or vectors.
- The category to which a disease–causing organism belongs, decide the type of treatment.
- Prevention of disease is more desirable than its successful treatment.
- Infectious disease can be prevented by public health hygiene measures.
- Infectious disease can also be prevented by immunisation.
- Effective prevention of infectious disease in the community requires that every one should have access to public hygiene and immunisation.

EXERCISE

1. Select the proper choice from the given multiple choices :

(1) Which one is an infectious disease ?

(A) Cancer (B) Malaria

(C) Diabetes (D) Hypertention

(2) AIDS is caused by

(A) Virus (B) Fungus

(C) Bacteria (D) Protozoa

(3) Jaundice is disease of

(A) Kidney (B) Pancreas

(C) Liver (D) Intestine

(4) Causative agent of T. B. is

(A) Salmonella (B) Mycobacterium

(C) Streptococcus (D) Pneumococcus

(5) AIDS is spread by

(A) Homosexuality (B) Use of infected needle and syringe

(C) Immoral relationship (D) All the above

2. Answer the following questions in short :

(1) State any two conditions essential for being free from the diseases.

(2) What is acute disease ?

(3) What is chronic disease ?

(4) Give the reasons for disease.

(5) How do microbes enter the body ?

(6) Which of the following diseases are caused by bacteria ?

Cholera, Rabies, Typhoid, Influenza, T. B., AIDS, Swine Flu

(7) Which of the following diseases are caused by virus ?

Typhoid, Influenza, AIDS, Cholera, T. B., Swine Flu