

**2500+**

**NEW PATTERN**

**FOUNDATION EDGE SERIES**

- Assertion Reason
- Case Based
- Subjective
- Match the Columns
- MCQs

## **FOUNDATION EDGE SERIES**

Where Fundamentals Meet Thinking

**SCIENCE | MATHS | MAT | SST**

**Class IX**

✓ Aligned with NCERT Curriculum

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For Aspirants of

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**Concept-Based Learning**

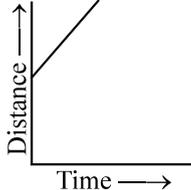


**Visual Explanations**

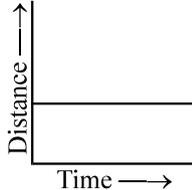


**Graded Practice**

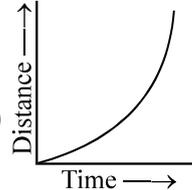


4. The symbol of kilometre is  
(A) kilo (B) km (C) kilo m (D) None of these
5. The symbols of all units are written in  
(A) plural (B) singular  
(C) both singular and plural (D) None of these
6. A speedometre records the speed directly in  
(A) m/s (B) km/s (C) km/h (D) m/min
7. A device that measures the distance by the vehicle is known as  
(A) a speedometre (B) an odometer (C) a barometer (D) None of these
8. Fig. shows the distance-time graph for the motion of two vehicles A and B. Which one of them is moving faster?  
(A) A  
(B) B  
(C) Both A and B are moving with same speed  
(D) None of these
9. Which of the following distance-time graphs shows a truck moving with speed which is not constant?
- 

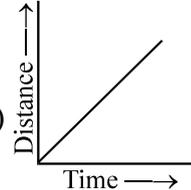
(A)



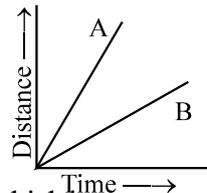
(B)



(C)



(D)
10. Motion of a pendulum is  
(A) Along a straight line (B) Circular  
(C) Periodic (D) None of these



## ANSWER KEY

- |      |      |      |      |       |
|------|------|------|------|-------|
| 1. B | 2. A | 3. C | 4. B | 5. B  |
| 6. C | 7. B | 8. A | 9. C | 10. C |

## 2. CONCEPT OF A POINT OBJECT, REST AND MOTION AND REFERENCE POINT

**Concept of a Point Object :** When the size of the object is much less in comparison to the distance covered by the object then the object is considered as a point object as :

Earth can be considered as a point object for studying its motion around the sun. Because length of the path covered by the earth in one revolution is very large in comparison to the size of earth.

### Examples:

- (i) Moving persons on earth as seen from a distant aircraft in space or a satellite are called point objects.
- (ii) Size of earth moving in space is taken as a point object w.r.t. large size of universe.
- (iii) Earth is treated as a point object during its revolution around the sun.

➤ **Frame of Reference :** A fixed point or a fixed object with respect to which the given body changes its position is known as reference point or origin as :

A convenient way to set up a frame of reference is to choose three mutually perpendicular axis and name them x-y-z axis. The co-ordinates (x, y, z) of the particle then specify the position of object w.r.t. that frame.



### Let's know

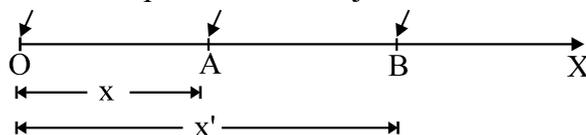
We need Frame of reference to define dimensions of motion.

- **Rest** : An object is said to be at rest, if it does not change its position with respect to the surroundings with the passage of time.
- **Motion** : An object is said to be in motion if it change its position with respect to the surroundings with the passage of time.
- **Note**: Rest and motion are relative terms. There is nothing like absolute rest. This means that an object can be at rest and also in motion at the same time e.g. all objects, which are stationary on earth, are said to be at rest with respect to each other, but with respect to the sun are making revolutions at  $30 \text{ kms}^{-1}$ . In order to study motion, therefore, we have to choose a fixed position or point with respect to which the motion has to be studied. Such a point or fixed position is called a **reference point** or the **origin**. In order to describe the motion of an object we need to keep in mind three things;
  1. The distance of the body from a reference point. This reference point is called the origin of the motion of the body.
  2. The direction of motion of the body.
  3. The time of motion.

### 3. MOTION IN DIMENSION

- (A) **Motion in one dimension** : An object moving along a straight line or path is said to have one-dimensional motion.

Suppose, an object moves in a particular direction then its position at any time can be described by knowing its distance from the starting point of the motion. It means, only one position coordinate (say  $x$ ) is required to describe the position of the object in one dimensional motion.



**Example:** Motion of a bus on a straight road and motion of a train on a straight track, an object dropped from a certain height above the ground etc.

- (B) **Motion in two dimension** : If two of the three co-ordinates specifying the position of object changes w.r.t. time, then the motion of object is called two dimensional. In such a motion the object moves in a plane.

**Example** : An insect crawling on the floor of the room, motion of object in horizontal and vertical circles etc., motion of planets around the sun, a car moving along a zig-zag path on a level road.

- (C) **Motion in three dimension** : If all the three co-ordinates specifying the position of object changes w.r.t. time, then the motion of object is called three dimensional. In such a motion the object moves in a space.

**Example** : An insect flying in the room, random motion of gas molecules, motion of an helicopter in sky.

- (D) **Linear motion (or translatory motion)** : The straight line motion is called linear motion as :  
The motion of a car moving on straight road, a running person, a stone being dropped, motion of a train on a straight track
- (E) **Rotational motion** : Motion of a body around a fix axis is called rotational motion as : The motion of an electric fan, motion of earth about its own axis.
- (F) **Oscillatory motion** : The to and fro periodic motion of a body around a fix point is called oscillatory motion as : The motion of a simple pendulum, a body suspended from a spring.



### Let's know

Motion along a straight line is called **translatory or rectilinear motion**.

## 4. UNIFORM AND NON-UNIFORM MOTION

### Uniform motion:

A body has a uniform motion if it travels equal distances in equal intervals of time as : Car running at a constant speed say, 10 metre per second, will cover equal distances of 10 metre every second, so its motion will be uniform, Distance-time graph for uniform motion is a straight line.

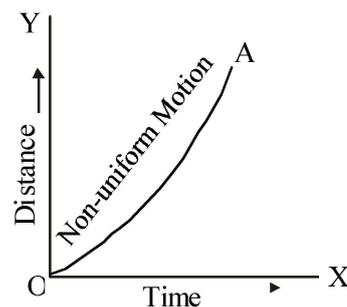
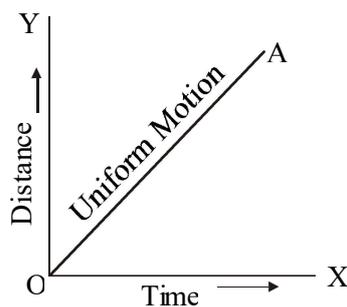
### Non-uniform motion:

A body has a non-uniform motion if it travels unequal distances in equal intervals of time as : If we drop a ball from the roof of a building, we will find that it covers unequal distances in equal intervals of time. It covers 4.9 metre in the 1st second, 14.7 metre in the 2nd second, 24.5 metre in the 3rd second, and so on. Distance-time graph for a body having non-uniform motion is a curved line. Non-uniform motion is also called accelerated motion.

## 5. SCALAR AND VECTOR QUANTITIES

Physical quantities may be divided into two groups according to their properties required for fully expressing them.

- (i) **Scalar Quantities** : Such physical quantities, as are completely represented only by their magnitude and unit are known as scalar quantities. Thus mass, time, distance, volume, temperature, etc. are scalar quantities. Scalar quantities may be positive or negative. These quantities obey the general algebraic rules of addition, subtraction, multiplication, division etc.
- (ii) **Vector Quantities** : The physical quantities which need the knowledge of direction also together with their magnitude and unit for their full representation, are known as Vector quantities. Thus, displacement, velocity, area, force, acceleration, momentum, torque, angular momentum, current density, etc. are Vector quantities.



### Let's know

**Remember** If Ram moves 100 m. eastward then the displacement of Ram is possible only in one direction. Hence, the displacement is a vector quantity.

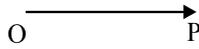
Similarly,

**Speed is a scalar quantity while velocity is a vector quantity. We can not distinguish between speed and velocity when a body moves along a straight line.**

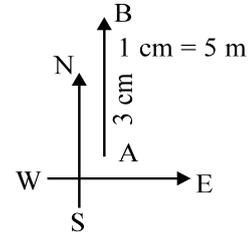
➤ **Representation of Vectors :**

A vector quantity is represented by a segment having an arrow at its end point.

In figure from where the arrow start 'O' is known as **initial point** (tail) and the point P where the arrow exits is known as the top (head) of the vector. The length of segment is proportional to the magnitude of vector taken in a proper scale. The direction of arrow represents the direction of vector quantity.



For example if a particle displaced by 15 metre in north direction then it can be represented proportionately as shown in figure. In this way the displacement 15 metre in north direction represented by vector  $\vec{AB}$  and the magnitude of the vector by  $|\vec{AB}|$  and it is also termed as modulus or mode of the vector. It is merely a number so the mode (magnitude) is a scalar quantity. In this way the vector  $\vec{AB}$  can be represent in magnitude and in direction as following.



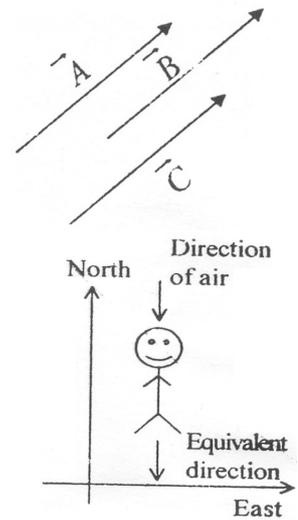
$$\vec{AB} = |\vec{AB}| \hat{n} \quad \text{or} \quad \hat{n} = \frac{\vec{AB}}{|\vec{AB}|}$$

➤ **Types of Vectors :**

The main type of vector quantities are as follow –

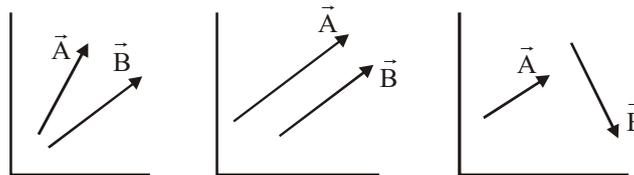
(1) **Equivalent Vector –**

If the magnitude, unit and direction of two or more than two vectors is same then they are termed as equal vectors. It is not necessary that the position of all equal vectors in space, to be same. In figure three vector  $\vec{A}$ ,  $\vec{B}$  and  $\vec{C}$  are shown. These vectors are of same length and parallel to each other also. Hence all of them are equal vectors. If a given vector is displaced parallel to it then it remains unchanged. For example if Rahim feels that the air is blowing from north direction then by parallel displacement the direction of air can be represented towards south as shown in figure.



(2) **Unequal Vector –**

If the magnitude or the direction or the both, are different for two vectors then they are termed as unequal vectors. In figure all the three states, both vector  $\vec{A}$  and  $\vec{B}$  are unequal vectors.



(3) **Unit Vector –**

Such a vector which has unit magnitude is known as unit vector. In general, the unit vector of vector  $\vec{A}$  is represented by  $\hat{A}$ . Hence

$$\hat{A} = \frac{\vec{A}}{|\vec{A}|} \quad \dots(i)$$

(4) **Opposite or Negative vector –**

If the magnitudes of two vectors are same but their directions are opposite to each other then they are termed as negative vector. As in figure if two vectors  $\vec{A}$  and  $\vec{B}$  are mutually opposite to each other than



**(5) Zero Vector –**

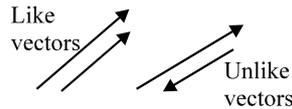
The vector which has zero magnitude and has no definite direction is known as zero vector and it is represented by zero (0).

**Remember –** (i) If we multiply a vector quantity with zero then the resultant which we get is a zero vector.

(ii) If  $\vec{A} = \vec{B}$  then difference  $(\vec{A} - \vec{B})$  will be the zero vector.

**(6) Collinear Vector –**

If two or more than two vectors are parallel to a straight line or opposite to each other are known as collinear vectors. In figure collinear vectors in two different states are shown.

**6. DISTANCE :**

The length of the actual path between initial and final position of a particle in a given interval of time is called distance covered by the particle. Distance is the actual length of the path. Distance between two points is path dependent.

**Let's know****Can you think why ?**

Distance cannot decrease?

**➤ Characteristics of Distance :**

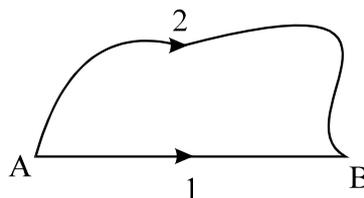
- (i) It is a scalar quantity
- (ii) It depends on the path
- (iii) It never reduces with time.
- (iv) Distance covered by a particle is always positive and can never be negative or zero.
- (v) Unit: In **C.G.S. centimeter (cm)**, in **S.I. system metre (m)**.

**7. DISPLACEMENT**

The shortest distance from the initial position to the final position of the particle is called displacement. The displacement of a particle is measured as the change in the position of the particle in a particular direction over a given time interval. It depends only on final and initial positions.

**➤ Characteristics of Displacement :**

- (i) It is a vector quantity.
- (ii) The displacement of a particle between any two points is equal to the shortest distance between them.



- (iii) The displacement of an object in a given time interval may be +ve, -ve or zero.
- (iv) The actual distance travelled by a particle in the given interval of time is always equal to or greater than the magnitude of the displacement and in no case, it is less than the magnitude of the displacement, i.e.  $\text{Distance} \geq |\text{Displacement}|$ .
- (v) Unit : In **C.G.S. centimeter (cm)**, In **S.I. system metre (m)**.

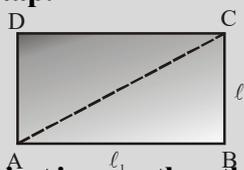


**Let's know**

**Displacement of an object is less than the distance travelled by the object.**

**Procedure :**

- (i) Ask a boy to go from corner A to corner C via corner B of a badminton court.
- (ii) Measure the distance AB and BC with a measuring tap.  
∴ Distance travelled by the body =  $l_1 + l_2$
- (iii) Now measure the distance between A and C = AC.



(which is the displacement of the body).

It is found that  $(l_1 + l_2) > AC$

This activity shows that the distance travelled by an object is more than the magnitude of the displacement.

**8. COMPARATIVE STUDY OF DISPLACEMENT AND DISTANCE**

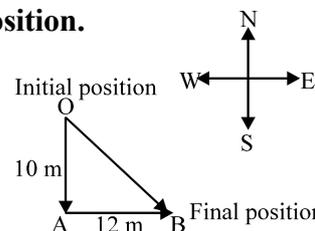
S.No.	Distance	Displacement
1.	It is defined as the actual path traversed by a body.	It is the shortest distance between two points between which the body moves
2.	It is a scalar quantity.	It is a vector quantity.
3.	It can never be negative or zero.	It can be negative, zero or positive.
4.	Distance can be equal to or greater than displacement.	Displacement can be equal to or less than distance.
5.	Distance travelled is not a unique path between two points.	Displacement is a unique path between two points.
6.	Distance between two points gives full information of the type of path followed by the body.	Displacement between two points does not give full information of the type of path followed by the body.
7.	Distance never decreases with time. For a moving body it is never zero.	Displacement can decrease with time. For a moving body it can be zero.
8.	Distance in SI is measured in metre.	Displacement in SI is measured in metre.

**EXAMPLES**

**Example: 1 :** A boy travels a distance of 10 m towards south, then he turns towards east and travels 12 m in that direction. Calculate (i) the total distance travelled by the boy and (ii) the displacement from his initial position.

**Solution :**

- (i) Total distance travelled  
= OA + AB = 10 + 12 = 22 m
- (ii) Displacement  
= OB =  $\sqrt{10^2 + 12^2} = \sqrt{100 + 144} = \sqrt{244}$  m



**Example: 2 :** An old person moves on a semi-circular track of radius 40.0 m during a morning walk. If he starts at one end of the track and reaches at the other end, find the distance covered and the displacement of the person.

**Solution**

The distance covered by the person equals the length of the track. It is equal to  $\pi R = \pi \times 40.0 \text{ m} = 126 \text{ m}$ . The displacement is equal to the diameter of the semi-circular track joining the two ends. It is  $2R = 2 \times 40.0 \text{ m} = 80 \text{ m}$ . The direction of this displacement is from the initial point to the final point.



## TRY YOURSELF

**Q.1** A body is moving along a circular path of radius  $r$ . What will be the distance and displacement of the body when it completes half a revolution?

**Ans.** Distance =  $\pi r$  ; Displacement =  $2r$ .

### 9. SPEED

Speed of an object is defined as the time rate of change of position of the object in any direction. It is measured by the distance travelled by the object in unit time in any direction. i.e.

$$\text{Speed} = \frac{\text{distance travelled}}{\text{time taken}} = \frac{s}{t}$$

- (i) It is a scalar quantity
- (ii) It gives no idea about the direction of motion of the objects.
- (iii) It can be zero or positive but never negative
- (iv) **Unit : C.G.S. cm/sec., S.I. m/sec.,**

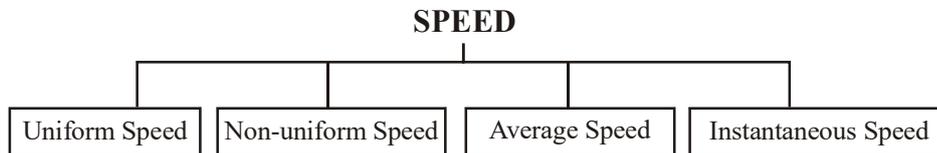
#### Let's know



$$1 \text{ km/h} = \frac{1000}{60 \times 60} = \frac{5}{18} \text{ m/s and } 1 \text{ m/s} = \frac{60 \times 60}{1000} = \frac{18}{5} \text{ Km/h}$$

**Info : - Light travels with a constant speed in a vacuum. The value of constant speed of light in vacuum is  $3 \times 10^8$  m/s**

#### ➤ Types of speed :



**9.1 Uniform speed :** An object is said to be moving with a uniform speed, if it covers equal distances in equal intervals of time, howsoever small these intervals may be. The uniform speed is shown by straight line in distance-time graph.

For example: suppose a train travels 1000 m., in 60 sec. The train is said to be moving with uniform speed, if it travels 500m, in 30 sec., 250 m. in 15 sec., 125 m. in 7.5 sec. and so on.

**9.2 Non-uniform speed :** An object is said to be moving with a variable speed if it covers equal distances in unequal intervals of time or unequal distances in equal intervals of time, howsoever small these intervals may be.

For example: suppose a train travels first 1000 m. in 60 sec., next 1000 m. in 120 sec. and next 1000 m. in 50 sec., then the train is moving with variable speed.

**9.3 Average speed :** When an object is moving with a variable speed, then the average speed of the object is that constant speed with which the object covers the same distance in a given time as it does while moving with variable speed during the given time. Average speed for the given motion is defined as the ratio of the total distance travelled by the object to the total time taken i.e..

$$\text{Average speed } \bar{v} = \frac{\text{total distance travelled}}{\text{total time taken}}$$

**Note :** If any car covers distance  $x_1, x_2, \dots$  in the time intervals  $t_1, t_2, \dots$  then.

$$\bar{v} = \frac{x_1 + x_2 + x_3 + \dots + x_n}{t_1 + t_2 + \dots + t_n}$$



### Let's know

#### Can you think why?

Is average speed defined for a time interval or at an instant?

**The average speed is defined for a time interval and the instantaneous speed is defined at a particular instant.**

**Special Case :** For a body moving along a circular path, the following points are worth noting ;

1. **If the body covers equal distances in equal intervals of time, then the speed of motion is said to be uniform.**
2. **When the body completes one revolution its distance travelled is equal to the circumference of the circular path whereas its displacement is zero.**

**9.4 Instantaneous Speed :** The speed of an object at any instant during its motion is called instantaneous speed.

The limiting value of average speed when the time interval approaches zero.

$$\text{Thus Instantaneous speed} = \lim_{\Delta t \rightarrow 0} \frac{\Delta s}{\Delta t} = \frac{ds}{dt}$$

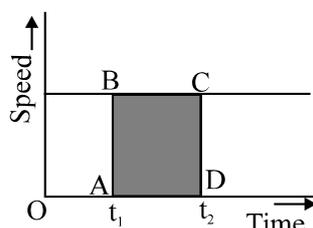
**Note :** Speedometer measures the instantaneous speed of a vehicle whereas odometer measures the distance travelled by the vehicle.

## 10. DISTANCE BY SPEED-TIME GRAPH

When the particle moves from time  $t_1$  to  $t_2$  with uniform speed  $V$  as shown in the graph.

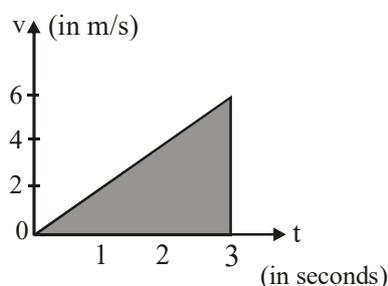
Then distance covered  $S = V(t_2 - t_1) = AB \times AD = \text{Area of ABCD}$

Total distance travelled by particle = Area of speed-time graph



## TRY YOURSELF

**Q.2** Figure shows the speed versus time graph for a particle. Find the distance travelled by the particle during the time  $t = 0$  to  $t = 3$  s.



**Sol.** The distance travelled by the particle in the time 0 to 3 s is equal to the area shaded in the figure. This is a right angled triangle with height = 6m/s and the base = 3s.

The area is  $\frac{1}{2}(\text{base})(\text{height}) = \frac{1}{2} \times (3\text{s})(6\text{ m/s}) = 9\text{m}$ . Thus, the particle covered a distance of 9m during the time 0 to 3s.

## 11. VELOCITY

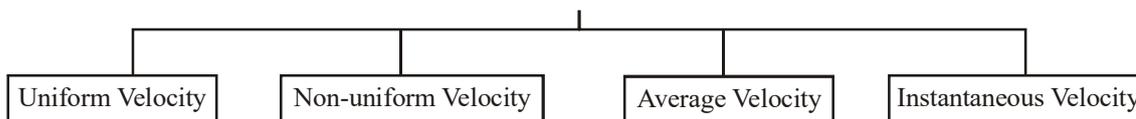
The rate of change of displacement of a particle with time is called the velocity of the particle.

$$\text{i.e., Velocity} = \frac{\text{Displacement}}{\text{Time interval}} = \frac{\bar{s}}{t}, \text{ unit of velocity} = \frac{\text{Unit of displacement}}{\text{Unit of time}} = \frac{\text{meter}}{\text{second}}$$

- (i) It is a vector quantity
- (ii) The velocity of an object can be positive, zero and negative
- (iii) Unit : C.G.S. cm/s ; S.I. m/s

### ➤ Types of Velocity :

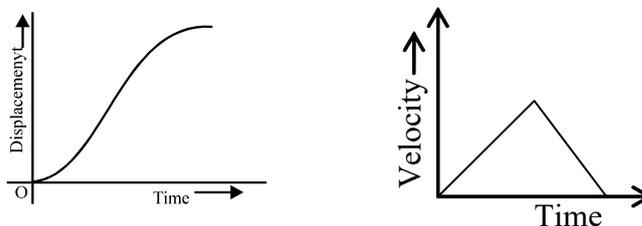
#### VELOCITY



**11.1 Uniform Velocity :** A body is said to move with uniform velocity, if it covers equal displacements in equal intervals of time, howsoever, small these intervals may be. When a body is moving with uniform velocity, then the magnitude and direction of the velocity of the body remain same at all points of its path.



**11.2 Non-uniform Velocity :** The particle is said to have non-uniform velocity if it covers unequal displacements in equal intervals of time, howsoever, small these intervals may be. In this type of motion velocity does not remain constant.



**11.3 Average Velocity :** The average velocity of an object is equal to the ratio of the displacement, to the time interval for which the motion takes place i.e.,

$$\text{Average velocity} = \frac{\text{displacement}}{\text{time taken}}$$

If the initial and final position of a particle are  $\vec{r}_1$  and  $\vec{r}_2$  at time  $t_1$  and  $t_2$  respectively,

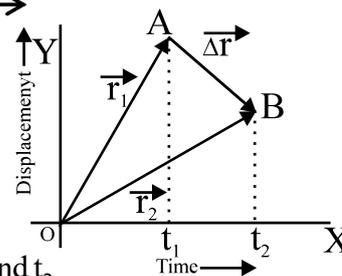
Then Displacement  $\Delta \vec{r} = \vec{r}_2 - \vec{r}_1$  and elapsed time  $\Delta t = t_2 - t_1$

$$\text{Average velocity } \vec{V}_{av} = \frac{\vec{r}_2 - \vec{r}_1}{t_2 - t_1} = \frac{\Delta \vec{r}}{\Delta t}$$

- (i) Uniform speed may be equal to uniform velocity in a linear motion because velocity = speed + direction.
- (ii) Moving body with uniform speed may have variable velocity. e.g. in uniform circular motion speed is constant but velocity is non-uniform.

### 11.4 Instantaneous Velocity :

The velocity of an object at a particular instant of time is called instantaneous velocity. It is equal to the limiting value of average velocity of the object when the time interval approaches zero.

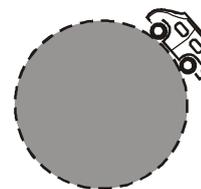


Thus Instantaneous velocity  $\vec{v} = \lim_{\Delta t \rightarrow 0} \frac{\Delta \vec{s}}{\Delta t} = \frac{d\vec{s}}{dt}$

It is a vector quantity.

➤ **Velocity of a body can be changed either :**

- (i) by changing the speed of the body while keeping the direction of motion of the body same.
- (ii) by changing the direction of motion of the body but keeping the speed of the body same.
- (iii) by changing both the speed and direction of motion of the body.



Car moving in a circular path.

**For example :**

1. The velocity of a ball dropped from the top of a building changes because its speed changes although its direction of motion is same.
2. The velocity of a car moving with a constant speed in a circular path changes because its direction of motion changes (figure)
3. The velocity of a car moving on a zig-zag road changes as its both speed and direction of motion change.

➤ **More about speed and velocity :**

- The instantaneous velocity in magnitude is equal to instantaneous speed.
- A particle may have constant speed but variable velocity. In uniform circular motion speed remains constant while velocity changes because of change in direction in motion.
- If particle is moving along a straight line without changing the direction, its average velocity will be equal to its average speed. Otherwise average velocity will be less than average speed

$$\left| \frac{\text{Average velocity}}{\text{average speed}} \right| \leq 1$$

## 12. COMPARATIVE STUDY OF SPEED AND VELOCITY

S.No.	Speed	Velocity
1.	It is defined as the rate of change of distance.	It is defined as the rate of change of displacement.
2.	It is a scalar quantity.	It is vector quantity.
3.	It can never be negative or zero.	It can be negative, zero or positive.
4.	Speed is velocity without direction.	Velocity is directed speed.
5.	Magnitude of speed may or may not be equal to velocity.	A body may possess different velocities but the same speed.
6.	Speed may decrease or increase with time. For a moving body it is never zero.	Velocity can decrease or increase with time. For a moving body it can be zero.
7.	Speed in SI is measured in $\text{ms}^{-1}$	Velocity in SI is measured in $\text{ms}^{-1}$

**Let's know****General Mistakes :**

**Average speed and average velocity :** Average speed is not the magnitude of average velocity. When Alexander Popov set a world record in 1994 by swimming 100.0 m in 46.74 s, his average speed was  $(100.0 \text{ m}) / (46.74 \text{ s}) = 2.139 \text{ m/s}$ . But because he swam two lengths in a 50-m pool, he started and ended at the same point and so had zero total displacement and zero average velocity! Both average speed and instantaneous speed are scalars, not vector, because these quantities contain no information about direction.

**EXAMPLES**

**Example: 3 :** A train covers half of its journey with a speed of 60 m/s and other half with a speed of 40 m/s. Calculate the average speed of the train during the whole journey.

**Solution :** Let the total distance =  $2x$  meter

$$\text{Time taken by the train during first half} = \frac{x}{60} \text{ sec.}$$

$$\text{Time taken by the train during other half} = \frac{x}{40} \text{ sec.}$$

$$\begin{aligned} \text{Average speed} &= \frac{\text{total distance}}{\text{total time}} = \frac{2x}{\frac{x}{60} + \frac{x}{40}} \\ &= \frac{2x}{\frac{4x + 6x}{240}} = 2x \times \frac{240}{10x} = 48 \text{ m/s} \end{aligned}$$

**Example: 4 :** A man walks at a speed of 6 km/hr for 1 km and 8 km/hr for the next 1 km. What is his average speed for the walk of 2 km ?

**Solution :** Distance travelled is 2 km.

$$\begin{aligned} \text{Time taken} &= \frac{1 \text{ km}}{6 \text{ km/hr}} + \frac{1 \text{ km}}{8 \text{ km/hr}} \\ &= \left( \frac{1}{6} + \frac{1}{8} \right) \text{ hr} = \frac{7}{24} \text{ hr.} \end{aligned}$$

$$\begin{aligned} \text{Average speed} &= \frac{2 \text{ km} \times 24}{7 \text{ hr}} = \frac{48}{7} \text{ km/hr} \\ &= 7 \text{ km/hr.} \end{aligned}$$

**Example: 5 :** The I.Sc. lecture theatre of a college is 40 ft wide and has a door at a corner. A teacher enters at 12.00 noon through the door and makes 10 rounds along the 40 ft wall back and forth during the period and finally leaves the class-room at 12.50 p.m. through the same door. Compute his average speed and average velocity.

**Solution.** Total distance travelled in 50 minutes = 800 ft.

$$\text{Average speed} = \frac{800}{50} \text{ ft/min} = 16 \text{ ft/min.}$$

At 12.00 noon he is at the door and at 12.50 pm he is again at the same door.

The displacement during the 50 min interval is zero.

Average velocity = zero.



## TRY YOURSELF

**Q.3** A scooterist moves from a place A to place B with a uniform speed of 30 km/h and returns from B to A with a uniform speed of 50 km/h. Find the average speed for the complete journey.

**Ans.** 37.5 km/h

### 13. ACCELERATION

The rate of change of velocity of an object with time is called acceleration of the object.

Let  $\vec{u}$  and  $\vec{v}$  be the velocity of the object at time  $t_1$  and  $t_2$  respectively, then acceleration of the body is given by:

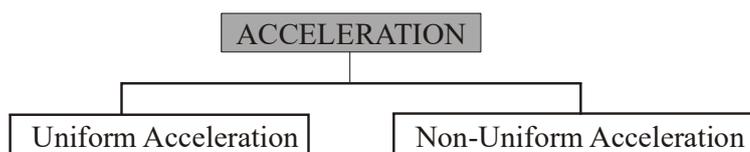
$$\text{Acceleration } (\vec{a}) = \frac{\text{Change in velocity}}{\text{Time interval}} = \frac{\vec{v} - \vec{u}}{t_2 - t_1}$$

- (i) Acceleration is a vector quantity.
- (ii) It is positive if the velocity is increasing and is negative if the velocity is decreasing.
- (iii) The negative acceleration is also called retardation or deceleration, which means velocity is decreasing with time.

(iv) Unit of acceleration =  $\frac{\text{Unit of velocity}}{\text{Unit of time}} = \frac{\text{ms}^{-1}}{\text{s}} = \text{ms}^{-2}$

(v) Dimension :  $[\text{M}^0\text{L}^1\text{T}^{-2}]$

#### ➤ Types of Acceleration :



- **Uniform acceleration :**  
An object is said to be moving with a uniform acceleration if its velocity changes by equal amounts in equal intervals of time.
- **Non Uniform acceleration :**  
An object is said to be moving with a variable acceleration if its velocity changes by unequal amounts in equal intervals of time.



#### Let's know

**Acceleration vs. velocity :** Be very careful not to confuse acceleration with velocity! Velocity describes how a body's position changes with time; it tells us how fast and in what direction the body moves. Acceleration describes how the velocity changes with time; it tells us how the speed and direction of motion are changing. It may help to remember the phrase "acceleration is to velocity as velocity is to position". It can also help to imagine yourself riding along with the moving body. If the body accelerates forward and gains speed, you would feel pushed backward in your seat; if it accelerates backward and loses speed, you would feel pushed forward. If the velocity is constant and there's no acceleration, you would feel no sensation about backwarding and forwarding.

Some students have misconception that acceleration of an object =  $\frac{\text{velocity of body}}{\text{time}}$

They should remember that acceleration of an object. =  $\frac{\text{change in velocity}}{\text{time}}$

If change in velocity of an object is zero or velocity of an object is constant, then acceleration of the object is zero.

**EXAMPLES**

**Example : 6** A car starts from rest and acquires velocity equal to 36 km h<sup>-1</sup> after 10 second. Calculate the acceleration of the car.

**Solution :** Here, u = 0 [∵ initially car is at rest]

$$v = 36 \text{ km h}^{-1} = \frac{36 \times 1000}{60 \times 60} \text{ ms}^{-1} = 10 \text{ ms}^{-1}$$

t = 10 sec.

Using,  $a = \frac{v-u}{t}$                       or                       $a = \frac{10 - 0 \text{ ms}^{-1}}{10 \text{ s}}$                       or                       $a = 1 \text{ ms}^{-2}$



**TRY YOURSELF**

**Q.4** A ship is moving at a speed of 56 km/h. One second later, it is moving at 58 km/h. What is acceleration?

**Ans.** 5/9 m/s<sup>2</sup>.

➤ **Some Relation between velocity, Position and time :**

**(i) Velocity-Time Relation : (v = u + at)**

Suppose a body is moving with uniform acceleration a, such that it has velocity v at time t and u at time t = 0. Then by the definition of acceleration we have  $a = \frac{v-u}{t}$ . Rewriting we have v – u = at

or

<p><b>1<sup>st</sup> equation of motion</b> <b>v = u + at.</b></p>
--

.....(i)

**(ii) Position-Time Relation : (S = ut +  $\frac{1}{2}$  at<sup>2</sup>) :**

The velocity of a body at two different times t and t = 0 is given by

$$v = u + at \quad \text{.....(1)}$$

Also average velocity is given by

$$v_{av} = \frac{v+u}{2} \quad \text{.....(2)}$$

But displacement travelled is given by

$$S = v_{av} \times t \quad \text{.....(3)}$$

Substituting equation 1 and 2 in equation 3 we have

$$S = \frac{v+u}{2} \times t = \left( \frac{u+at+u}{2} \right) \times t$$

or

$$S = \left( \frac{2u}{2} + \frac{at}{2} \right) \times t = ut + \frac{1}{2} at^2$$

Hence

<p><b>2<sup>nd</sup> equation of motion</b> <b>S = ut + <math>\frac{1}{2}</math> at<sup>2</sup></b></p>
---

.....(ii)

This gives the position time relation for a body moving with uniform acceleration ‘a’.

**(iii) Position-Velocity Relation : ( $v^2 - u^2 = 2aS$ ) :**

Consider a body having initial velocity 'u' moving with uniform acceleration 'a' for time 't' such that its final velocity is 'v' and 'S' be the displacement travelled. Now we know that

$$S = ut + \frac{1}{2} at^2 \quad \text{.....(1)} \quad \text{and}$$

$$v = u + at \quad \text{.....(2)}$$

Squaring equation 2 we have

$$(v)^2 = (u + at)^2 \Rightarrow v^2 = u^2 + 2uat + a^2t^2$$

Or  $v^2 - u^2 = 2a \left( ut + \frac{1}{2} at^2 \right)$  using equation 1 we have

<b>3<sup>rd</sup> equation of motion</b> $v^2 - u^2 = 2aS$	.....(iii)
---	------------

➤ **Graphs and Their use in studying motion :**

A graph is a line straight or curved showing the relation of two variable quantities in which one varies as a result of the change in the other. The quantity which is made to vary at will is called the **independent variable** and the other which varies as a result of this change, is called the **dependent variable**. for example the relation between the natural numbers and their squares can be shown by means of a graph. Graphs provide a convenient method to present basic information about a variety of events.

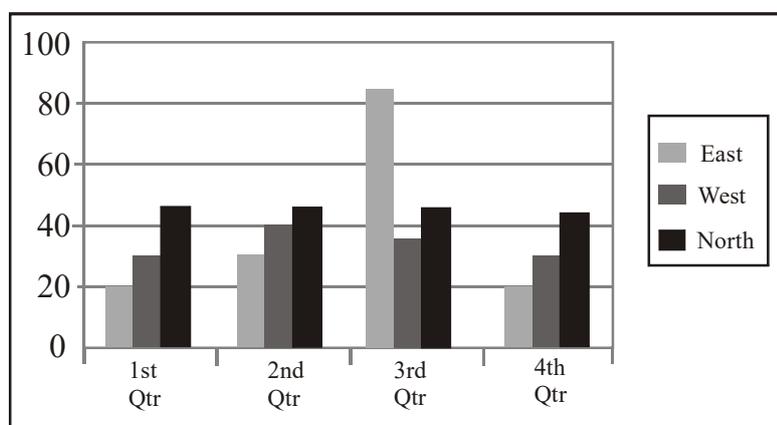


Figure : A bar graph showing the sales of a commodity in the four quarters of the year in three parts of a country.

A common example of a graph is the bar graphs which we see on a TV screen showing the sale of some commodities during the year in different parts of the country. Such a graph is as shown in figure.

➤ **Plotting a Graph :**

Graphs are usually plotted on paper ruled in millimetre or in squares. Following steps are involved while drawing a graph.

1. On a suitable graph paper two thick lines at right angles to each other are drawn at the bottom of the left hand side of the paper it indicate the two axes: X and Y axis.

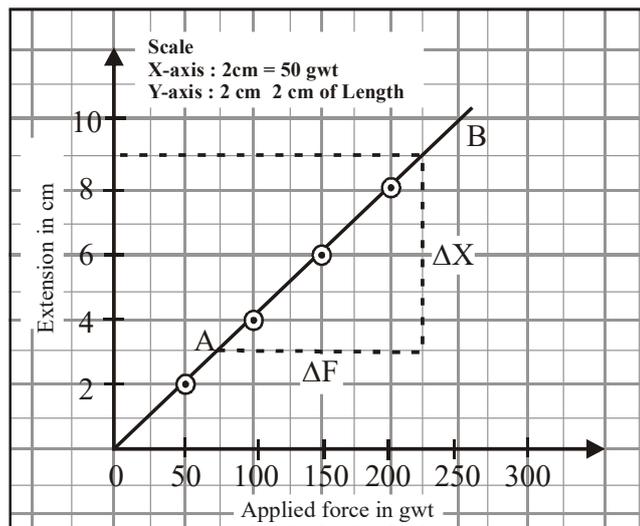


Figure : Graph showing the variation of extension with the applied force for a spring.

2. The independent quantity is then represented along the X-axis and the dependent quantity is represented along the Y-axis.
3. A convenient scale is chosen so as to accommodate the smallest as well as the largest observation.
4. Various points are then plotted for various pairs of observation by drawing a small circle around each of the points plotted.
5. A smooth curve is then drawn passing through maximum points plotted. If the graph seems to be a straight line draw a straight line passing through maximum of these plotted points.
6. Give a suitable name to the graph plotted.

### Graphs for uniform and non-uniform motion :

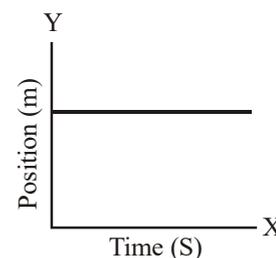
A graph is a pictorial representation of variation of one quantity with respect to another. The slope of a graph is the ratio of the quantity on the Y-axis to that on the X-axis.

Thus slope of the graph =  $\frac{\text{quantity on the Y-axis}}{\text{quantity on the X-axis}}$

## 14. DISTANCE TIME GRAPH

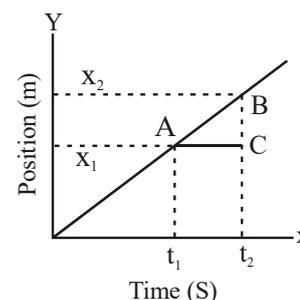
### ➤ CASE 1 : FOR A STATIONARY OBJECT

When the body is at rest or is stationary, the position-time graph is a straight line parallel to the time axis. This is so as there is no displacement in the body with the passage of time.



### ➤ CASE 2 : FOR UNIFORM VELOCITY

Since in uniform motion displacement has a linear dependence upon time therefore the position-time graph for such a motion is a straight line inclined towards the time axis as shown in figure. The position-time graph can have various orientations depending upon the sign of x and t.



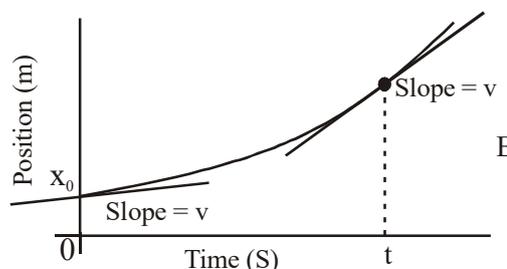
The position-time graph gives the value of the uniform velocity with which the body is travelling. **This is obtained by finding the slope of the graph.**

Suppose the particle starts from an initial position  $x = 0$  at  $t = 0$ . Consider two points A and B on the graph corresponding to time  $t_1$  and  $t_2$  and distance  $x_1$  and  $x_2$  as shown in figure. Now slope of graph

$$\text{slope} = \tan \theta = \frac{BC}{AC} = \frac{(x_2 - x_1)}{(t_2 - t_1)} = \text{velocity.}$$

### ➤ CASE 3 : FOR UNIFORM ACCELERATION

Position has quadratic dependence upon time. The position-time graph therefore, is a curve. This curve is called a parabola. This is depicted in figure. The slope of this graph gives the value of instantaneous velocity at that point. It should be noted that if the slope is negative it means that the body returning to its initial starting point. In case of retardation the parabola curves downwards.



### ➤ Activity-01

The following points are worth noting in case of a position-time graph.

1. The slope of the position-time graph gives the instantaneous velocity of a body.
2. In a  $x-t$  graph a straight line inclined to the time axis at an angle greater than  $90^\circ$  indicates negative velocity.
3. If a  $x-t$  graph has a continuously decreasing slope it indicates decreasing velocity i.e. retardation.
4. If a  $x-t$  graph has a continuously increasing slope it indicates increasing velocity i.e. acceleration.
5. In a  $x-t$  graph a line can never be perpendicular to the time axis.
6. In a  $x-t$  graph, straight line means uniform velocity.
7. The  $x-t$  graph for a particle moving with constant velocity is a straight line and that for an accelerated motion is a curve; parabola.
8. The distance-time graph cannot be below the time axis.
9. In  $x-t$  graph if straight line is parallel to the time axis then, body is at rest.

## Velocity-Time Graphs :

### ➤ CASE 1 : FOR UNIFORM VELOCITY

In uniform motion the velocity of the body remains constant with respect to time. Thus the velocity-time graph is a straight line parallel to the time axis as shown in figure.

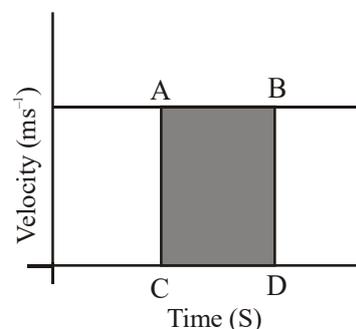
The displacement travelled by the body can be calculated from the velocity-time graph as follows. Consider two points A and B on the graph corresponding to times  $t_0$  and  $t$  respectively. Let  $v$  be the uniform velocity of the body. Now area of the rectangle ABCD is given by

$$\text{area of ABCD} = AC \times AB = v \times (t - t_0) = x - x_0$$

Since  $x - x_0$  is the displacement travelled by the body, therefore

**Area under  $v - t$  graph = displacement travelled by the body.**

If the body has negative velocity then the graph is drawn under the time axis. In such a situation the displacement is taken as negative.

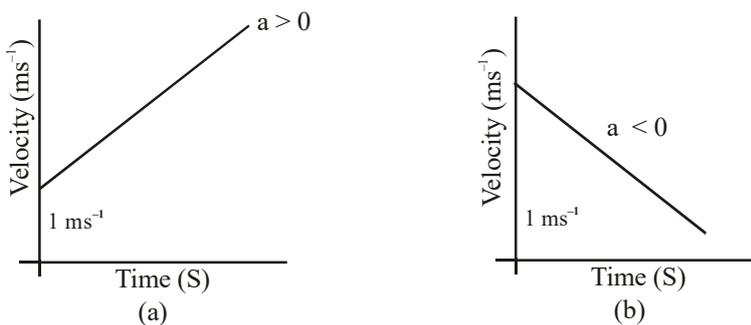


➤ **CASE 2 : FOR UNIFORM ACCELERATION AND RETARDATION**

The velocity-time relation of a body having uniformly acceleration motion is given by the expression  $v = u + at$ . Let the initial velocity and the acceleration of the body be  $u = 1 \text{ ms}^{-1}$  and  $1 \text{ ms}^{-2}$  respectively. Then the velocity of the body at different times can be obtained as

<b>Time in sec</b>	0	1	2	3
<b>Velocity in <math>\text{ms}^{-1}</math></b>	1	2	3	4

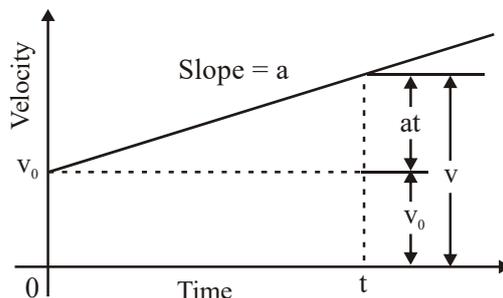
This show that the velocity increases linearly with time. Thus the velocity-time graph of a body in uniformly accelerated motion is a straight line inclined to the time axis if the body has uniform acceleration and it is inclined towards the velocity axis if the body has uniform retardation. This is as shown in figures 'a' and 'b'.



➤ **Activity-02**

**It is worth noting that the velocity-time graph gives us the following important result.**

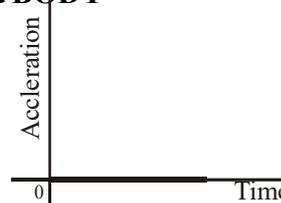
1. The graph is a straight line inclined towards the time axis for  $a > 0$ .
2. The graph is a straight line inclined towards the velocity axis for  $a < 0$ .
3. The area under the velocity-time graph gives the displacement/distance.  
For the distance the total area is added, for displacement area below the time axis is taken as negative.
4. A v-t graph can never be normal to the time axis, as this would indicate infinite velocity.
5. The slope of the velocity-time graph gives the acceleration of the object.  
The slope is positive if  $a > 0$  and negative if  $a < 0$ .
6. If the motion does not start from rest the velocity-time graph is as shown in figure.



**Acceleration Time Graphs :**

➤ **CASE-1: FOR A STATIONARY OR UNIFORM MOVING BODY**

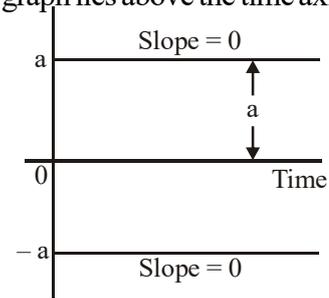
In this case the acceleration of the body is zero. It is so when the body moves with uniform velocity or is at rest. The acceleration-time graph for such a situation is a straight line coinciding with the time axis as shown in figure.



➤ **CASE-2: FOR A UNIFORMLY ACCELERATED OR RETARDED MOTION**

For a uniform motion body the acceleration is a constant and does not change with time. In this situation the acceleration-time graph is a straight line parallel to the time axis. This graph lies above the time axis.

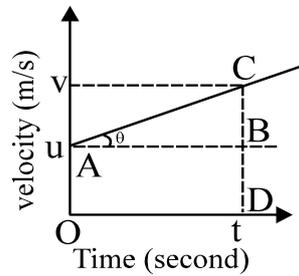
If the velocity of the body decreases uniformly with time, then the acceleration-time graph is again a straight line parallel to the time axis, but lies below the time axis. This indicates retardation. The two graphs are as shown in figure.



**Note:** For motion with uniform acceleration, x-t graph is a parabola while the v-t graph is a straight line inclined to the time axis.

**15. EQUATION OF MOTION BY GRAPHICAL METHOD**

In uniformly accelerated motion the change in velocity in equal time interval is same. Hence in uniformly accelerated motion the graph between velocity and time becomes a straight line. Its slope (tan θ) is equal to the acceleration. So



Slope =  $a = \tan \theta = \text{constant}$

In figure the velocity of a particle moving in uniform accelerated motion is shown by a graph in between velocity and time. At time  $t = 0$  (start of motion) the initial velocity of a particle is  $u$  and at time  $t$ , velocity of the particle is  $v$ .

Thus, slope of the graph =  $\frac{\text{quantity on the Y-axis}}{\text{quantity on the X-axis}} = \frac{BC}{AB}$

If 'a' is the acceleration, then from the graph we have.  $a = \frac{v-u}{t}$

Rewriting the above equation we have

$$v = u + at$$

or we can also state as slope of line AB is given by

$$\tan \theta = \frac{BC}{AB} = a = \text{constant}$$

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

**$v = u + at$  .....(i)**

**It is the first equation of motion.**

Again by a graph in velocity-time in uniform accelerated motion on time axis (In given time interval) the covered area is equal to the displacement of the particle. So, if the displacement in between time interval 0 to  $t$  is  $S$  then

$S = \text{Area of quadrilateral shape OACBD}$

or  $S = \text{Area of } \Delta ABC + \text{Area of rectangle OABD}$

or  $S = \frac{1}{2} AB \times BC + OA \times OD$

$$\text{or } S = \frac{1}{2} \times t(v-u) + u \times t$$

$$\text{or } S = \frac{1}{2} t(at) + ut$$

$$\text{or } \boxed{S = ut + \frac{1}{2} at^2} \quad \dots\dots\text{(ii)}$$

**It is the second equation of motion.**

Again from the first equation of motion

$$v^2 = (u + at)^2 = u^2 + a^2t^2 + 2uat$$

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

$$\text{or } \boxed{v^2 = u^2 + 2as} \quad \dots\dots\text{(iii)}$$

**It is the third equation of motion.**

➤ **Activity-03**

**Equations of motion of a body under uniform acceleration due to gravity :**

At a given place the earth pulls the objects with a uniform acceleration 'g'. Its average value is  $981 \text{ cms}^{-2}$  or  $9.81 \text{ ms}^{-2}$ . However, sometimes to make calculations easier. We take its value  $1000 \text{ cms}^{-2}$  or  $10 \text{ ms}^{-2}$ .

The acceleration due to gravity is always directed towards earth. It is taken as positive (+g), if the body is falling towards the earth. It is taken as negative (-g), if the body is moving away from the earth, i.e., projected in the upward direction.

Furthermore, the distance travelled by a freely falling body or by a body rising upward, is commonly called height. So, in the motion equations, if we substitute  $\pm g$  for 'a' and 'h' for 's', we can have following motion equations for the freely falling bodies,

$$v = u \pm gt \quad \dots\dots\text{(i)}$$

$$h = ut \pm \frac{1}{2} gt^2 \quad \dots\dots\text{(ii)}$$

$$v^2 - u^2 = \pm 2gh \quad \dots\dots\text{(iii)}$$

Amongst the sign  $\pm$  the sign plus is used when the body is falling freely towards the earth and the sign minus is used, when the body is projected upward.

➤ **Special cases when a freely falling body is initially at rest :**

When you drop something from a height, such as building or a mountain or a hovering helicopter, its initial velocity (u) is zero. Further the acceleration due to gravity (g) is positive. In such a situation

1. In the equation  
 $v = u + gt = 0 + gt$

$$\boxed{v = gt} \quad \dots\dots\text{(iv)}$$

As 'g' is a constant quantity at a given place, therefore

$$v \propto t$$

From the above relation it implies that final velocity of a body is directly proportional to the time of free fall. Furthermore, the ratio  $v/t$  is always equal to acceleration due to gravity.

2. In the equation

$$h = ut + \frac{1}{2} gt^2$$

$$\boxed{h = \frac{1}{2}gt^2} \quad \dots\dots (v) \quad [\because u = 0] \quad \text{i.e.} \quad \boxed{h \propto t^2}$$

$$\boxed{t = \sqrt{2h/g}} \quad \dots\dots (vi)$$

From equation (v) we can say that height (or distance) of free fall is directly proportional to square of time of free fall.

3. In the equation  
 $v^2 - u^2 = 2gh$   
 $v^2 = 2gh \dots\dots\dots(vii)$   
 or  $\boxed{v = \sqrt{2gh}} \dots\dots\dots(viii)$

➤ **Equations for the motion of body projected upwards :**

When a body is projected vertically upward, it has maximum initial velocity (u). However, as the body moves upward a constant negative acceleration due to gravity acts on the body such that its final velocity (v) is zero. If h is the height attained in time 't', then following motion equations are possible.

1. Time of ascent (upward journey)

$$\begin{aligned} v &= u + gt \\ \therefore 0 &= u - gt \\ \text{or } \boxed{t} &= \frac{u}{g} \dots\dots\dots(ix) \\ \text{or } \boxed{u} &= gt \dots\dots\dots(x) \end{aligned}$$

From equation (ix) it is clear, that 'g' is a constant quantity.

$$u \propto t,$$

Thus time of ascent (upward journey) is directly proportional to the initial velocity of body.

2. **Maximum height attained during ascent.**

$$\begin{aligned} \text{From } v^2 - u^2 &= 2gh \\ (0)^2 - u^2 &= -2gh \end{aligned}$$

$$\therefore \boxed{h = \frac{u^2}{2g} \text{ or } u = \sqrt{2gh}} \dots\dots\dots(xi)$$

From equation (xi) it implies that maximum height attained during ascent is directly proportional to square of initial velocity.

3. **Relation between time of ascent and time of descent.**

Let  $t_1$  and  $t_2$  be the time of ascent and descent of a body which is projected vertically upward with initial velocity u.

From equation (ix)

$$t_1 = \frac{u}{g} \dots\dots\dots (a)$$

From equation (vi)

$$\text{Time of descent } t_2 = \sqrt{\frac{2h}{g}}$$

From equation (xi)

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

$$\text{Substituting value of } h \text{ in } t_2 = \sqrt{\frac{2h}{g}}$$

$$t_2 = \sqrt{\frac{2u^2}{2g \times g}} = \sqrt{\frac{u^2}{g^2}}$$

$$t_2 = \frac{u}{g} \quad \dots\dots(b)$$

From equation (a) and (b), it is clear that. Time of ascent or descent of bodies under acceleration due to gravity is same.

### Time of Flight

When a body is projected upward it remains for sometime in air, before reaching the surface of earth. This time for which the body remains in air is called time of flight.

Time of flight = Time for ascent + Time for descent

As time for ascent is equal to time for descent

$$\therefore \text{Time of flight (t)} = t_1 + t_2$$

$$(t) = \frac{u}{g} + \frac{u}{g}.$$

$$\text{Time of flight (t)} = \frac{2u}{g}$$

### ➤ Displacement in n<sup>th</sup> second in a uniform accelerated motion :

Let the initial velocity of a particle in uniform acceleration motion is  $u$  and after  $n$  second is  $v$ , if the displacements of the particle in  $n$  and  $(n-1)$  second are  $s_n$  and  $s_{n-1}$  respectively then from second equation of motion

$$s_n = un + \frac{1}{2}an^2$$

and

$$s_{n-1} = u(n-1) + \frac{1}{2}a(n-1)^2$$

In this way the displacement in n<sup>th</sup> second is

$$\begin{aligned} d &= s_n - s_{n-1} \\ &= un + \frac{1}{2}an^2 - u(n-1) - \frac{1}{2}a(n-1)^2 \end{aligned}$$

Thus displacement in nth second with in interval of one second

$$d = u + \frac{a}{2}(2n-1)$$

## 💡 EXAMPLES 💡

**Example: 7 :** A stone is dropped from a height of 100 metre then find (1) time taken in fall of first 50 metre (2) time taken in fall of last 50 metre.

**Solution :** (i) If time taken in the fall of first 50 metres is  $t_1$  than by the second equation of motion

$$s = ut + \frac{1}{2}gt^2; \quad 50 = 0 + \frac{1}{2}g \times t_1^2$$

$$\text{or} \quad t_1 = \sqrt{\frac{100}{g}} = \sqrt{\frac{100}{10}} = \sqrt{10} \text{ sec}$$

(ii) If time taken in the fall of total 100 metre is say  $t$ , then by the second equation of motion.

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

$$100 = 0 + \frac{1}{2}gt^2 \Rightarrow t = \sqrt{\frac{200}{10}} = \sqrt{20} \text{ sec}$$

So the time taken in fall of last 50 metre.

$$t_2 = t - t_1 \text{ sec} = (\sqrt{20} - \sqrt{10}) \text{ sec.}$$



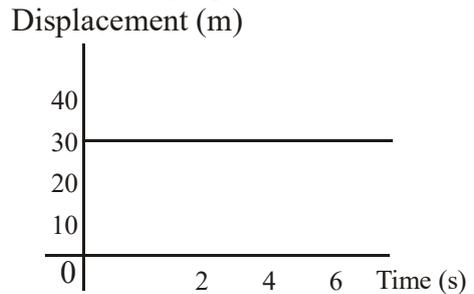
# TRY YOURSELF

- Q.5** (i) A car travels at constant acceleration of  $5 \text{ m/s}^2$  from rest. How far has it travelled by the time it reached the velocity of  $72 \text{ km/h}$  ( $20 \text{ m/s}$ )?  
 (ii) How long does it take for a car to change its velocity from  $10 \text{ m/s}$  to  $25 \text{ m/s}$  if the acceleration is  $5 \text{ m/s}^2$ ?

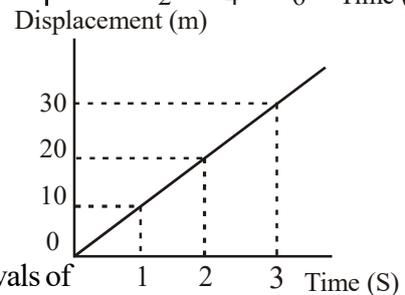
**Ans.** (i)  $s = 40 \text{ m}$ . (ii)  $t = 3 \text{ sec}$ .

➤ **Some Motion Graphs :** Some of the graphs usually encountered while studying motion are as follows.

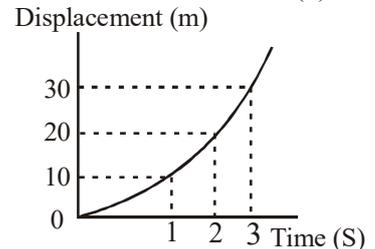
1. In graph the displacement of the body is not changing, though the time is increasing. Hence it represents a body which is not in motion or the one whose velocity is zero. Otherwise also, note that its slope is zero as the change along the vertical is zero. This again implies zero velocity.



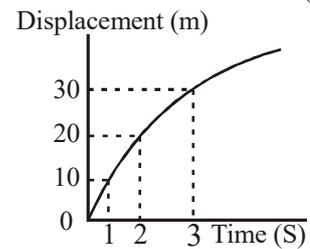
2. In graph equal displacement ( $10 \text{ m}$ ) are taking place in equal intervals of time ( $1 \text{ s}$ ). This graph thus represents a uniform motion i.e. a motion taking place with constant velocity of  $10 \text{ ms}^{-1}$ . Note that this graph is a straight line having a single slope. It implies a motion with zero acceleration.



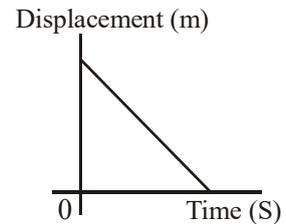
3. In graph greater displacements are taking place in equal intervals of time of  $1 \text{ s}$  each. This thus represents a body moving with an increasing velocity, or with an accelerated motion. You may also note by drawing tangents at various points of the curve that the slope of the curve is continuously increasing with time. This again implies a motion with an increasing velocity, or an accelerated motion.



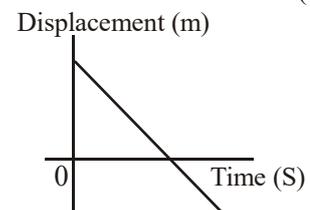
4. In graph decreasing displacements are taking place in equal intervals of time of  $1 \text{ s}$  each. This thus represents a body moving with decreasing velocity, or with retarded motion. You may also note by drawing tangents at various points of the curve that the slope of the curve is continuously decreasing with time. This again implies, motion with a decreasing velocity, or retarded motion.



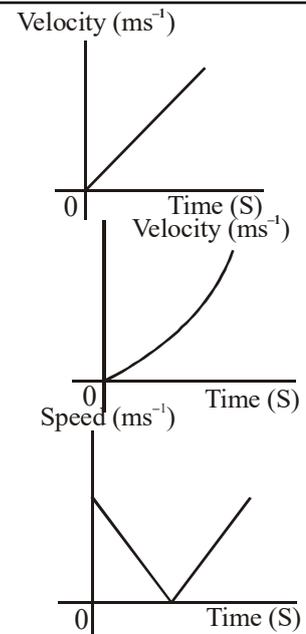
5. In figure the displacement of the body is decreasing as time is increasing. Ultimately the displacement becomes zero after a certain time. This implies that a body is returning back to its original position from where it had got displaced earlier. Note further that the motion is represented with a straight line with a negative slope. It implies that it has backward motion. Further it has a single slope therefore possesses uniform velocity. This entire means that the body is returning back to its original position with uniform velocity.



6. In graph, the body is having a negative displacement which is increasing in magnitude with time. This means that after returning back to the same point the body move in some other direction from there. This is done with uniform velocity.



7. In graph the straight line shows equal increases in velocity in equal intervals of time, and hence a body moving with uniform acceleration. Note that since the straight line is starting from a point from where  $v = 0$ , the initial velocity of the particle is zero. Note again that being a straight line, it represents a single slope, and hence a uniform acceleration.
8. In graph, greater changes are taking place in velocity in equal intervals of time. Hence it represents a motion with an increasing acceleration. This can also be seen by determining the slope of the graph at various points.
9. The graph, represents the case of a body projected upward. When a body is projected upwards, its speed keeps decreasing uniformly, till it attains a value equal to zero. During the return journey, its speed starts increasing uniformly, ultimately achieving the same value with which it is projected upwards.



## 16. CIRCULAR MOTION

Motion of an artificial satellite around earth, motion of a cyclist in circular path orbital motion of electron around nucleus etc. are the examples of circular motion. For the study of circular motion, it is necessary to understand the concepts of relevant quantities like angular displacement, angular velocity and angular acceleration.

or

**The motion of a body moving around a fixed point in a circular path is known as circular motion.**

### Examples of circular motion

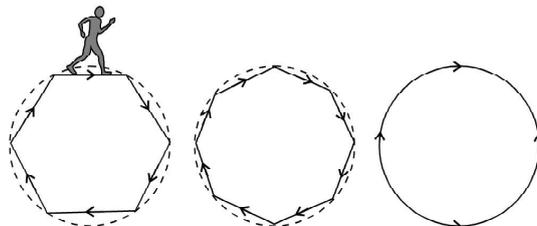
1. The motion of the blades of an electric fan around the axle.
2. The motion of the moon around the earth.
3. The motion of an electron around the nucleus of an atom.
4. The motion of planets around the sun is also approximately circular motion.
5. The motion of a satellite around the earth.
6. A stone tied at one end of the string and whirled above the head of a person in circular path.

### ➤ Uniform Circular motion :

If the body covers equal distances along the circumference of the circle in equal intervals of time, the motion is said to be a uniform circular motion.

- A uniform circular motion is a motion in which speed remains constant but direction of velocity changes continuously hence circular motion is known as accelerated motion as:

Motion of moon around the earth, Motion of satellite around its planet.

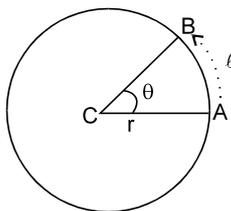


### Let's know

#### Boost your knowledge

- A body perform accelerated motion with uniform speed. The motion of the body is circular.

- **Radian:** It is the unit of plane angle. One radian is defined as the angle subtended at the centre of the circle by an arc equal in length to its radius.



$$\theta = \frac{l}{r} \text{ radians.} \quad [\text{For } l = r, \theta = 1 \text{ radian}]$$

Angle subtended by the circumference at the centre,  $\theta = \frac{2\pi r}{r} = 2\pi \text{ radians} \text{ \{or } 2\pi^{\circ}\}$

- **Relation between radian and degree :**

For complete circle at centre  $2\pi^{\circ} = 360^{\circ}$

$$\text{or } 1^{\circ} = \frac{360}{2\pi} = 57.3^{\circ}$$

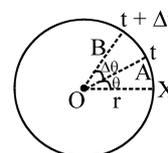
- **Angular Displacement ( $\theta$ ) :**

**It is an angle described by the body at the centre of its circular path while rotating**

Let a particle is moving in a circular path of radius 'r' and centre at 'O'. At any time 't' the particle is at position 'A', which is at the position of angle ' $\theta$ ' with reference to reference line 'OX'. If in time  $\Delta t$  the particle reaches point B where angular position

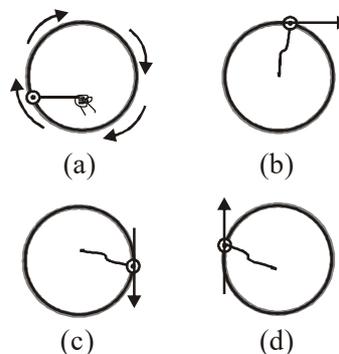
of the particle is  $\angle BOX = \theta + \Delta\theta$  then in the time interval  $\Delta t$  the angular displacement gained by the particle  $\Delta\theta = \angle BOA$  is obtained.

or We can say, it is the angle covered by a revolving particle. It is denoted by  $\theta$ .  
S. I. Unit of angular displacement is radian (rad.)



**Uniform circular motion is known as Accelerated Motion.**

When a body moves in a circular path with constant speed, its direction of motion changes continuously at every point in figure. This shows that the velocity of the body moving in a circular path changes continuously due to change in direction of its motion. It means, the body moves with changing velocity in a circular path. The change in velocity of the body with time gives rise to an acceleration. Thus, the uniform circular motion of a body is known as accelerated motion.



- **Angular Velocity ( $\omega$ ) :**

**It is define as the rate of change of angular displacement**

If in time interval  $\Delta t$ , angular displacement of a particle is  $\Delta\theta$  then the ratio of angular displacement  $\Delta\theta$  and time interval  $\Delta t$  is called average angular velocity, that is average angular velocity :

$$\vec{\omega}_{av} = \frac{\Delta \vec{\theta}}{\Delta t}$$

Under the limit  $\Delta t \rightarrow 0$  the average angular velocity becomes equivalent to instantaneous angular velocity.

$$\vec{\omega} = \lim_{\Delta t \rightarrow 0} \frac{\Delta \vec{\theta}}{\Delta t} = \frac{d\vec{\theta}}{dt}$$

S. I. unit of angular velocity is rad/s. It is a vector quantity whose direction is determined by the right hand screw rule.

If a particle is revolving in a circular path with constant angular velocity, then its angular displacement in time  $t$  will be  $\theta = \omega t$ .

Time 'T' taken in making one revolution by a particle in a circular path is called time period and number of revolutions 'n' completed in unit time is called frequency. Thus, relation between magnitude of angular velocity  $\omega$ , time period T and frequency n is as follows

$$\boxed{\omega = \frac{2\pi}{T} = 2\pi n} \quad \therefore n = \frac{1}{T}$$

**(iii) Angular Acceleration ( $\alpha$ ):** It is defined as the rate of change of angular velocity. It is denoted by  $\alpha$ . **The acceleration of a body moving in a circular path is known as centripetal acceleration. [centripetal means centre seeking.] The direction of its acceleration is always towards the**

**centre of the circle. The magnitude of the centripetal acceleration =  $\frac{v^2}{r}$ ,**

**where  $v$  = uniform speed of the body.**

**$r$  = radius of the circular path.**

**Linear speed of a body moving in a circular path of radius  $r$  in time  $t$  is given by**

$$\mathbf{u} = \frac{\text{distance}}{\text{time}} = \frac{\text{circumference of circular path}}{\text{time}} = \frac{2\pi r}{t}$$

### ➤ **RELATION BETWEEN LINEAR DISPLACEMENT AND ANGULAR DISPLACEMENT :**

Consider figure. Suppose a body is moving with uniform speed. It covers a distance S in a certain time  $t$ . By definition of angle we have

$$\boxed{\text{angle} = \frac{\text{arc}}{\text{radius}} \Rightarrow \theta = \frac{S}{r}}$$

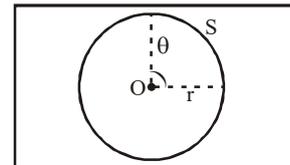


Figure for obtaining the relation between linear displacement and angular displacement.

**Or**

Thus linear displacement is equal to the angular displacement multiplied by radius of the circle.

### ➤ **RELATION BETWEEN LINEAR VELOCITY AND ANGULAR VELOCITY:**

Angular velocity is defined as the ratio of the angular displacement to the time taken. i.e.

$$\omega = \frac{\theta}{t}$$

But  $S = \theta r$ , substituting in the above relation we have.

$$\boxed{\omega = \frac{S}{rt} = \frac{v}{r}}$$

**Thus**

$$\mathbf{v = r \omega}$$

**EXAMPLES**

**Example: 8 :** A wheel completes 120 revolutions in one minute. Calculate its angular speed.

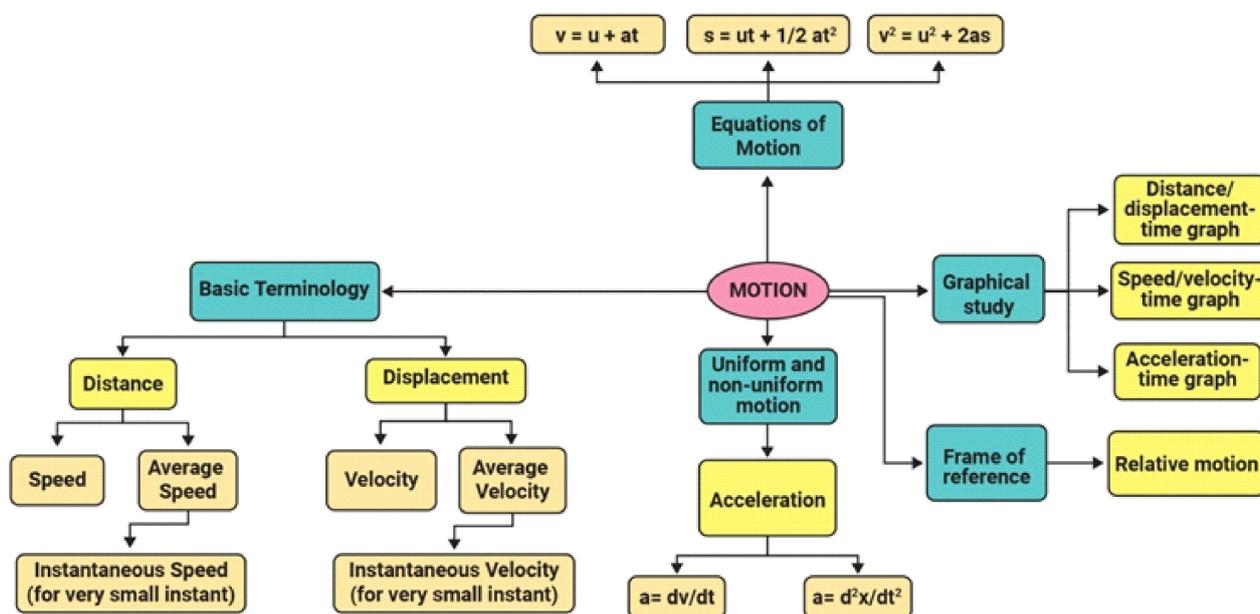
**Solution :**  $n = 120$  revolution per minute  $= \frac{120}{60} = 2$  revolution per second  
 $\therefore \omega = 2\pi n = 2\pi \times 2 = 4\pi \text{ rad s}^{-1}$

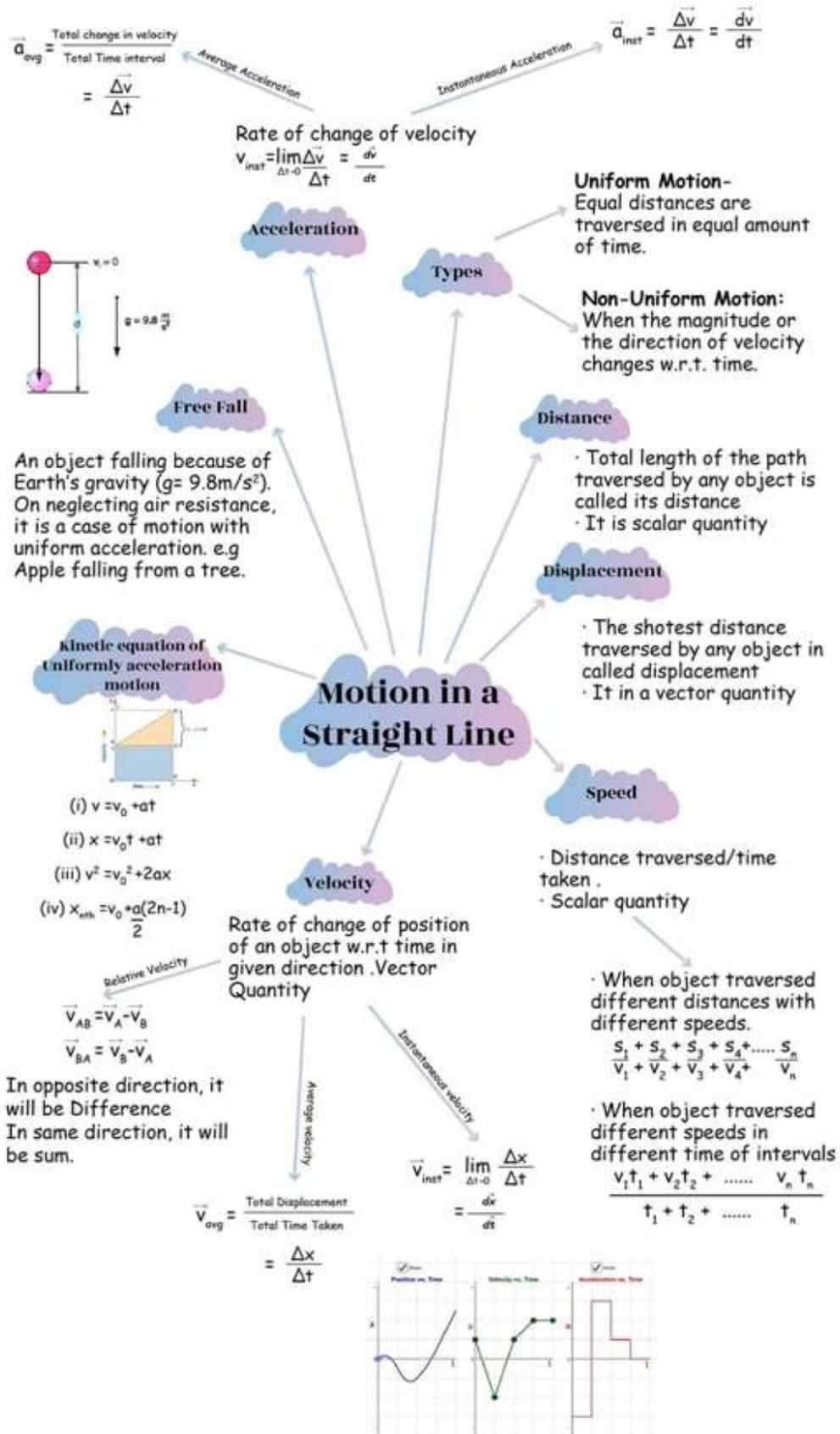
**Example: 9 :** A scooter goes round a circular track of radius 10 m with speed of  $30 \text{ ms}^{-1}$ . Calculate the angular speed of the scooter.

**Solution :**  $v = \omega r$  or  $\omega = \frac{v}{r}$   
 $\therefore \omega = \frac{30}{10} = 3 \text{ rad s}^{-1}$



**LET'S RECALL**





- **Motion** : An object which changes its position with respect to a fixed point is said to be in motion.
- **Motion is a relative term** : An object at rest with respect to one object may also be in motion with respect to another object.
- **Reference point** : A fixed point with respect to which an object changes its position is known as a reference point.

- **Distance** : The length of actual path between the initial position and the final position of a moving object or body is known as distance travelled by the particle.
- **Displacement** : The shortest distance between the initial and final positions of a moving object or body in a direction from initial to the final position of the particle is known as displacement of the particle.
- **Units of distance and displacement** : SI unit of distance and displacement is metre (m).
- **Distance** travelled by a body is always positive.
- **Displacement** of body may be **positive, negative** or **zero**.
- Ratio of the magnitude of displacement and the distance is equal to less than 1.
- **Uniform Motion** : The motion of a body is said to be uniform if (i) it moves along a straight line and (ii) it covers equal distance in equal intervals of time, how-so-ever, small these intervals may be.
- **Non-uniform motion** : The motion of a body is said to be non-uniform if it covers unequal distance in equal intervals of time.
- **Speed** : The distance travelled by a body in unit time is known as the speed of the body. That is

$$\text{Speed} = \frac{\text{Distance}}{\text{time}}$$

- **Unit of speed** : SI unit of speed is  $\text{ms}^{-1}$ .
- **Uniform speed** : If a moving body covers equal distances in equal intervals of time, the speed of the body is uniform.
- **Non-Uniform speed** : If a moving body covers unequal distances in equal intervals of time, the speed of the body is non-uniform.
- **Average speed** : The total distance travelled by a body during non-uniform motion divided by the time taken to travel this distance is called average speed.

$$\text{i.e. Average speed} = \frac{\text{Total distance travelled by body during non – uniform motion}}{\text{Total time taken}}$$

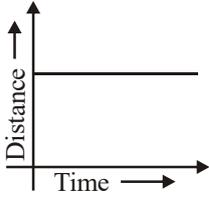
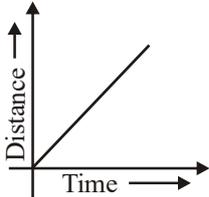
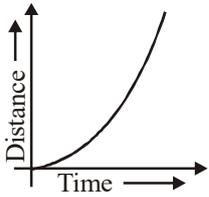
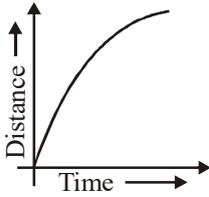
- **Velocity** : The displacement of the body per unit time is known as the velocity of the body. That is,

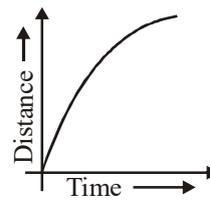
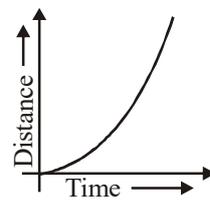
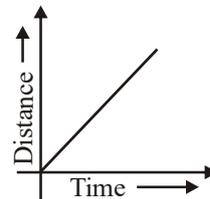
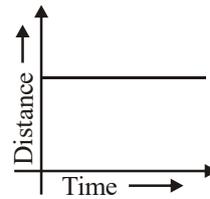
$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}}$$

- **Unit of velocity** : SI unit of velocity is  $\text{ms}^{-1}$ .
- **Uniform velocity** : Velocity of a body is said to be uniform velocity if it covers equal displacements in equal intervals of time.
- **Non-uniform velocity** : Velocity of a body is said to be non-uniform if it covers unequal displacement in equal intervals of time.
- **Average velocity** :  $\frac{\text{Total displacement of the body}}{\text{Total time taken}}$
- **Speed** is a scalar quantity, whereas velocity is a vector quantity.
- **Speed** of a body is always **positive**.

- **Velocity** of body can be **positive** as well as **negative**.
- **Acceleration** : Acceleration of a body is defined as the change in velocity per unit time.  
i.e. 
$$\text{Acceleration} = \frac{\text{Change in velocity}}{\text{Time}}$$
- **Positive acceleration** : When the velocity of a body increases with time, acceleration of body is said to be positive acceleration.  
Or When the change in velocity ( $\Delta v$ ) of a body takes place in the direction of the motion of the body, then the acceleration of the body positive.
- **Negative acceleration or retardation or deceleration** : If the velocity of the body decreases with time, then acceleration of body is negative acceleration of retardation.  
Or When the change in velocity ( $\Delta v$ ) of a body takes place in a direction opposite to the direction of motion of the body, then the acceleration of the body is negative.
- **S.I.** unit of acceleration is  $\text{m/s}^2$

### ➤ GRAPH

S.No.	State of object /body	Slope of Distance-time graph
1.	Rest or stationary	
2.	Uniform motion	
3.	Non-uniform motion (speed is increasing)	
4.	Non-uniform motion (speed is decreasing)	
5.	Slope or gradient of distance-time graph = speed of body.	
6.	Area under speed-time graph = distance travelled by a body.	

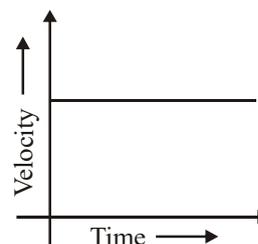
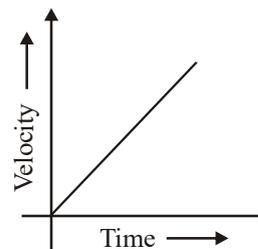
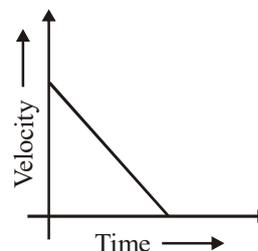


➤ **Velocity–time graph :**

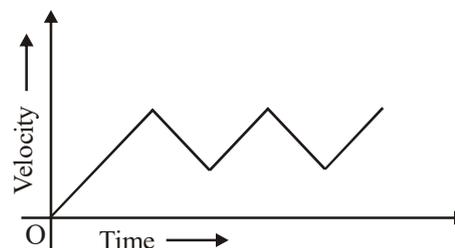
S.No.      State of object / body

Slope of Velocity-time graph

1.            Object is moving with constant velocity

2.            Object has uniform motion  
(Velocity is increasing at a constant rate)3.            Object has uniform motion  
(Velocity is decreasing at a constant rate)

4.            Object is moving with non-uniform velocity



➤ The slope of velocity–time graph = Acceleration of the body.

➤ Area under velocity–time graph = magnitude of the displacement of a body.

➤ **Equations of motion :**(i) Velocity of a uniform accelerated body after time  $t$  is given by

$$v = u + at$$

(ii) Distance travelled by a uniformly accelerated body after time  $t$  is given by

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

(iii)  $v^2 - u^2 = 2aS$ ➤ **Uniform circular motion :** The circular motion of a body having constant speed is known as uniform circular motion.

➤ Uniform circular motion is accelerated motion.

➤ **Activity-04**

Discuss whether the walls of your classroom are at rest or in motion.

**Explanation :** The walls of our classroom are at rest with respect to other houses on the Earth. But these walls share the earth's motion as it moves in space. Thus, when the classroom is seen outside the Earth, the walls are in motion.

➤ **Activity-05**

Have you ever experienced that the train in which you are sitting appears to move while it is at rest? Discuss and share your experience.

**Explanation :** Yes. When we are sitting in a train which is at rest, and the train on the adjoining track moves, we feel as if our train is also moving in the opposite direction. This is because the state of rest and of motion are relative.

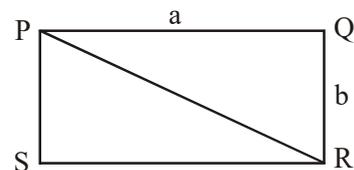
➤ **Activity-06**

Take a metre scale and a long rope.

- Walk from one corner of a basket-ball court to its opposite corner along its sides.
- Measure the distance covered by you and magnitude of the displacement.
- What difference would you notice between the two in this case?

**Explanation :** When we walk from one corner P of a basket ball court to its opposite corner R along its sides, distance covered = PQ + QR = a + b and displacement is given by the expression

$$PR = \sqrt{a^2 + b^2} .$$



We find that both displacement and distance are not same. The displacement is less than the distance.

➤ **Activity-07**

Automobiles are fitted with a device that shows the distance travelled. Such a device is known as an odometer. A car is driven from Bhuvaneshwar to New Delhi. The difference between the final reading and the initial reading of the odometer is 1850 km. Find the magnitude of the displacement between Bhuvaneshwar and New Delhi by using the Road Map of India.

**Explanation :** The odometer measures the actual travelled by the car in going from Bhuvaneshwar to New Delhi. It is 1850 km.

From the road map of India, locate Bhuvaneshwar and New Delhi. Measure the length of the line joining these two cities. Multiply this length with the chosen scale of distance on the road map. This would give us the displacement, i.e., shortest distance between the two stations. Obviously, it will be less than 1850 km. Thus, actual path length is greater than the displacement.

➤ **Activity-08**

The data regarding the motion of two different objects A and B are given in Table. Examine them carefully and state whether the motion of the objects is uniform or non-uniform.

Time	Distance travelled by object A in m	Distance travelled by object B in m
09.30 am	10	12
09.45 am	20	19
10.00 am	30	2
10.15 am	40	35
10.30 am	50	37
10.45 am	60	41
11.00 am	70	44

**Explanation :** From the table, we find that in equal intervals of time (= 15 minutes), object A travels equal distances, and object B travels unequal distances. Therefore, motion of object A is uniform and motion of object B is non-uniform.

➤ **Activity-09**

Measure the time taken by you to walk from your house to your bus stop or the school. If you consider that your average walking speed is  $4 \text{ km h}^{-1}$ , estimate the distance of the bus stop or school from your house.

**Explanation :** Suppose, we take 20 minutes to walk from our house to our bus stop or the school. Taking average walking speed be  $4 \text{ km h}^{-1}$ , distance of bus stop or school from our house is  
Distance = average speed  $\times$  time =  $4 \times 20/60 = 1.33 \text{ km}$ .

➤ **Activity-10**

At a time when it is cloudy, there may be frequent thunder and lightning. The sound of thunder takes some time to reach you after you see the lightning. Can you answer why this happens? Measure this time interval using a digital wrist watch or a stop watch. Calculate the distance of the nearest point of lightning. (Speed of sound in air =  $346 \text{ ms}^{-1}$ ).

**Explanation :** Lightning travels with the speed of light ( $3 \times 10^8 \text{ ms}^{-1}$ ) and thunder travels with the speed of sound in air =  $346 \text{ ms}^{-1}$ ). That is why sound of thunder reaches us sometime later than we see the lightning. Using a digital watch or a stop watch, we measure this time interval. Let it be 2 second.

As distance = speed  $\times$  time, distance =  $346 \times 2 = 692 \text{ m}$ .

Note that in calculating the distance of the nearest point of lightning, we have taken the speed of sound and multiplied it by the measured time interval. This is because speed of light is almost infinite and takes almost no time to reach us. The measured time interval is time taken by sound of thunder to reach us. Thus, Light travels much faster than sound.

➤ **Activity-11**

In your everyday life, you come across a range of motions in which

- acceleration is in the direction of motion.
- acceleration is against the direction of motion.
- acceleration is uniform.
- acceleration is non-uniform.

Can you identify one example each of the above type of motion?

**Explanation :**

- When speed of a car on a road increases, the acceleration of the car is in the direction of motion.
- When we apply brakes, the speed of the car decreases. Thus acceleration produced in the car is against the direction of motion.
- When a body is falling freely under the action of gravity, it has a uniform acceleration of  $9.8 \text{ ms}^{-2}$ , i.e. speed of the falling body is increasing at a constant rate.
- When a car is passing through the city limits on a highway, its acceleration/retardation is non-uniform depending on traffic.

➤ **Activity-12**

The times of arrival and departure of a train at three stations A, B and C and the distance of stations B & C and from A are given in table.

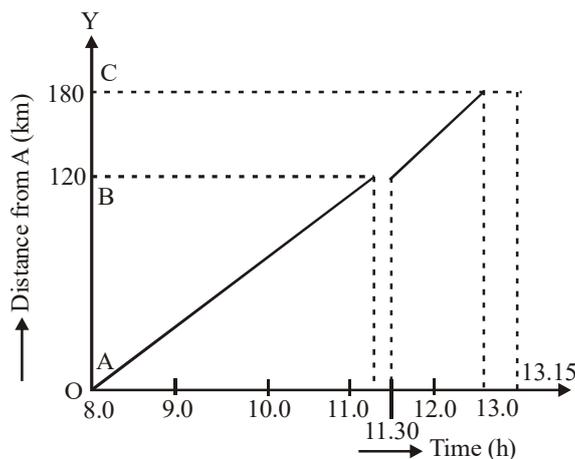
**Table : Distances of stations B and C from A and times of arrival and departure of the train.**

Station	Distance from A (km)	Time of arrival (hours)	Time of departure (hours)
A	0	08:00	08:15
B	120	11:15	11:30
C	180	13:00	13:15

Plot and interpret the distance-time graph for the train assuming that its motion between any two stations is uniform.

**Explanation :** The distance-time graph for the train is shown in figure. From 8.00 to 8.15, the train is standing on station (Let us say the origin O). From 8.15 to 11.15 the train moves with uniform speed and reaches station B at distance of 120 km from A. From 11.15 to 11.30, train is at rest at the station B. From 11.30 to 13.00, the train moves uniformly from station B to station C covering a distance of (180-120) km = 60 km. From 13.00 to 13.15 it is stationary at C.

The distance-time graph of the motion of the train is therefore as shown below.



The distance of 120 km from A to B is covered by the train in 3 hours with a uniform speed  $v_1$ , therefore,

$$\text{Uniform speed of the train is } v_1 = \frac{120}{3} = 40 \text{ kmh}^{-1}.$$

A distance of 60 km from B to C is covered in 1 h 30 min with uniform speed  $v_2$ , therefore,

Uniform speed of the train  $v_2 = \frac{60}{1.5} = 40 \text{ kmh}^{-1}$ . As  $v_1 = v_2$ , therefore, slope of distance-time graph of the two portions is the same. Thus the motion of the train is uniform motion.

➤ **Activity-13**

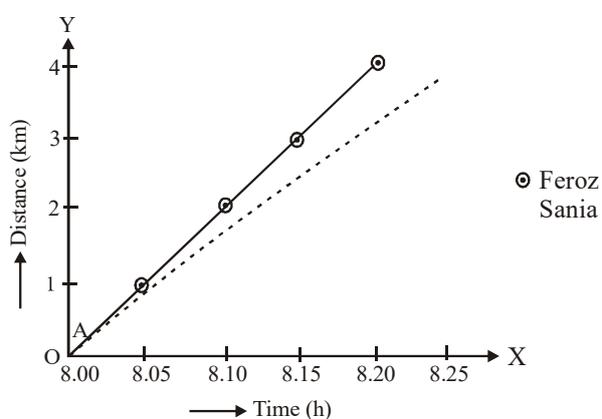
Feroz and his sister Sania go to school on their bicycles. Both of them start at the same time from their home, but take different times to reach the school although they follow the same route. Table shows the distance travelled by them in different times.

**Table : Distance covered by Feroz and Sania at different times on their bicycle.**

Time	Distance travelled by Feroz	Distance travelled by Sania
08:00:00 AM	0	0
08:05:00 AM	1.0	0.8
08:10:00 AM	1.9	1.6
08:15:00 AM	2.8	2.3
08:20:00 AM	3.6	3.0
08:25:00 AM	–	3.6

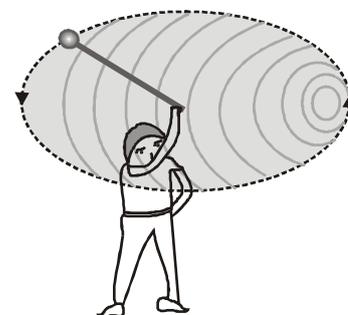
Plot the distance-time graph for their motions on the same scale and interpret.

**Explanation :** In the distance-time graph shown below, we have taken time along X-axis and distance along Y axis, choosing suitable scales. The distance-time graph of Feroz is shown by a bold line and distance-time graph of Sania is shown by a dashed line.



#### ➤ Activity-14

Take a piece of thread and tie a small piece of stone at one of its ends. Move the stone to describe a circular path with constant speed by holding the thread at the other end, as shown in figure.



Now, let the stone go by releasing the thread.

Can you tell the direction in which the stone moves after it is released?

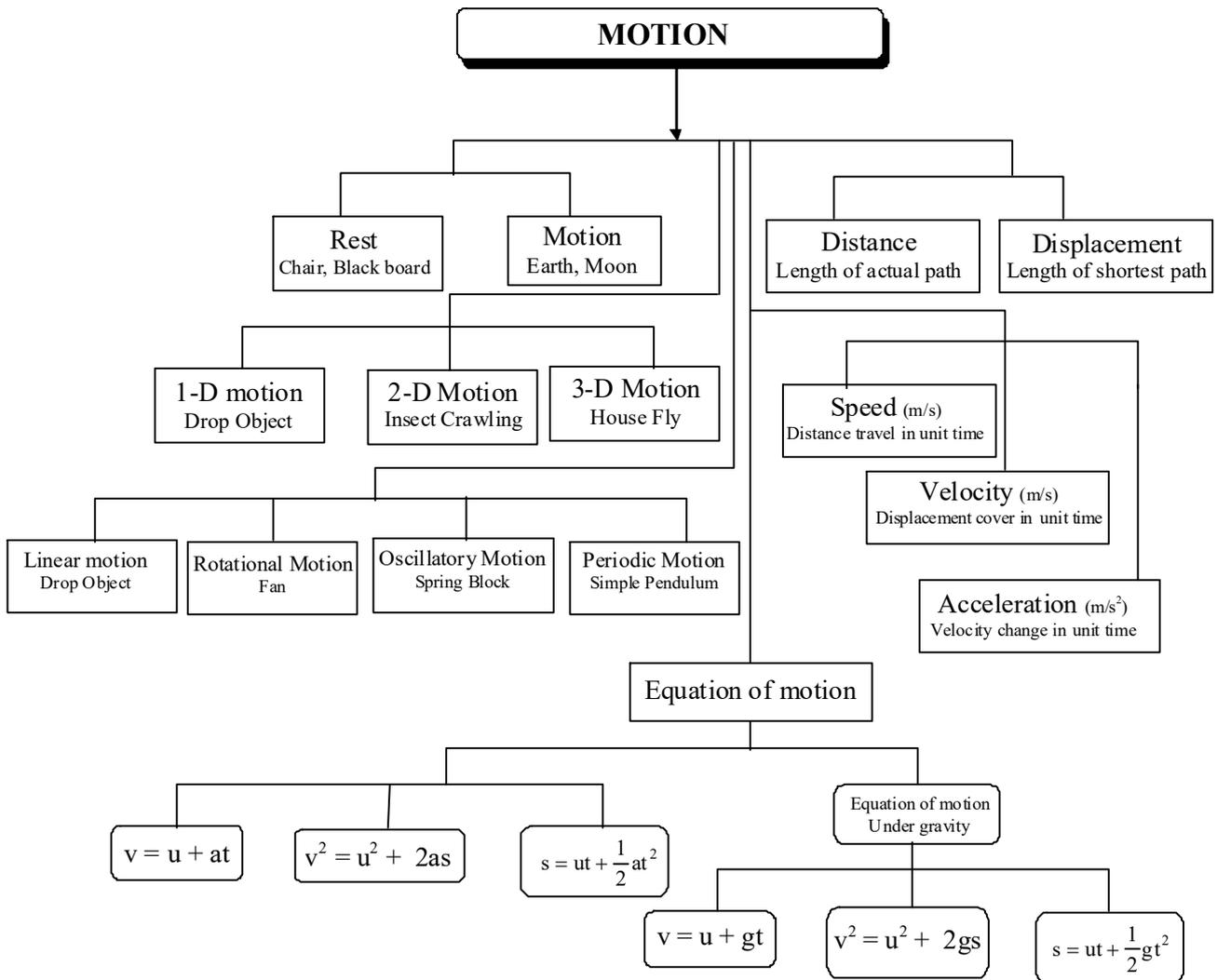
By repeating the activity for a few times and releasing the stone, at different positions of the circular path, check whether the direction in which the stone moves remains the same or not.

**Explanation :** When the stone is released, it will move along a tangent to the circular path at that particular moment. By releasing the stone at different positions of the circular path, we will find that direction in which the stone moves is always different, but it is always along the tangent to the circular path at that instant.

In fact, the stone is moving along a circular path due to centripetal force being provided by pull of our hand on the stone. When the stone is let off, centripetal force ceases to act. Due to inertia of direction, the stone moves along the straight line path, i.e., along the tangent to the circular path at that instant.



# MIND MAP



EXERCISE-I

NCERT Solutions



**Q.1** An athlete completes one round of a circular track of diameter 200 m in 40 s. What will be the distance covered and the displacement at the end of 2 minutes 20 s?

**Sol.** Given : Diameter of circular track,  $2r = 200\text{m}$   
Circumference of circular track

$$= 2\pi r = 2 \times \frac{22}{7} \times 100 = \frac{4400}{7} \text{ m.}$$

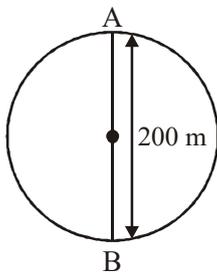
Time for completing one round = 40s.

Time for which athlete ran

= 2 min and 20 s = 140 s

Now distance covered by the athlete in 40 s

$$S = \frac{4400}{7} \text{ m}$$



(i) Distance covered by athlete in 140 s

$$S = \frac{4400}{7} \times \frac{140}{40} = 2200 \text{ m.}$$

(ii) As the athlete returns to the initial point in 40s, this displacement = 0

Now

Number of rounds in 40 seconds = 1

Hence number of rounds in 140 s is

$$= \frac{140}{40} = 3.5$$

For each complete round the displacement is zero. Therefore for 3 complete rounds, the displacement will be zero.

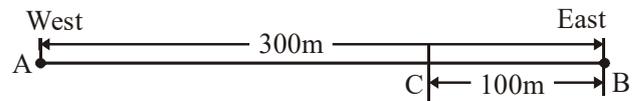
The final displacement will be due to half the round. In half round distance covered = half of circumference.

Thus, his displacement = diameter of circular track = 200 m

Displacement after 140 s = 200 m.

**Q.2** Joseph jogs from one end A to the other end B of a straight 300 m road in 2 minutes 30 seconds and then turns around and jogs 100 m back to point C in another 1 minute. What are Joseph's average speeds and velocities in Jogging.

**Sol.** The required figure is as shown :



Distance covered = 300 + 100 = 400 m and  
Time taken = 150 + 60 = 210 s.

Therefore average speed from A to C is

$$v_{av} = \frac{\text{distance covered}}{\text{time}} = \frac{400}{210} = 1.90 \text{ ms}^{-1}$$

Now displacement from A to C 200 m.

There average velocity from A to C is

$$v_{av} = \frac{\text{displacement}}{\text{time}} = \frac{200}{210} = 0.952 \text{ ms}^{-1}$$

**Q.3** Abdul while driving to school computes the average speed for his trip to be  $20 \text{ kmh}^{-1}$ . On his return trip along the same route, there is less traffic and the average speed is  $30 \text{ kmh}^{-1}$ . What is the average speed for Abdul's trip ?

**Sol.** Let one way distance for his trip be S. Let  $t_1$  be the time for his trip from home to school and  $t_2$  be the time for his return trip.

$$\text{Then } t_1 = \frac{S}{v_1} = \frac{S}{20} \text{ h and } t_2 = \frac{S}{v_2} = \frac{S}{30} \text{ h.}$$

Therefore total time of trip is

$$T = t_1 + t_2 = \frac{S}{20} + \frac{S}{30} = \frac{5S}{12} \text{ h}$$

Total distance covered = 2S

Therefore average speed of Abdul

$$v_{av} = \frac{\text{total distance}}{\text{total time}} = \frac{2S \times 12}{5S} = 24 \text{ kmh}^{-1}$$

**Q.4** A motorboat starting from rest on a lake accelerates in a straight line at a constant rate of  $3.0 \text{ ms}^{-2}$  for 8.0s. How far does the boat travel during this time ?

**Sol.** **Given :** Initial velocity of boat,  $u = 0$ ,  
Acceleration ,  $a = 3.0 \text{ ms}^{-2}$

Time,  $t = 8\text{s}$

Distance covered,  $S = ?$

Using the relation  $S = ut + \frac{1}{2} at^2$  we have

$$S = 0 \times 8 + \frac{1}{2} \times 3 \times (8)^2 = 96 \text{ m}$$

**Q.5** A driver of a car travelling at  $52 \text{ km h}^{-1}$  applies the brakes and accelerates uniformly in the opposite direction. The car stops in 5s. Another driver going at  $3 \text{ km h}^{-1}$  in another car applies his brakes slowly and stops in 10s. On the same graph paper plot the speed versus time graphs for the two cars. Which of the two cars travelled farther after the brakes were applied?

**Sol.** Since the speed of both the cars is decreasing with time, therefore both have a retarded motion.

Now initial velocity of the first car is  $u = 52$

$$\text{km h}^{-1} = 52 \times \frac{5}{18} = 14.4 \text{ ms}^{-1} .$$

Initial velocity of the first car is

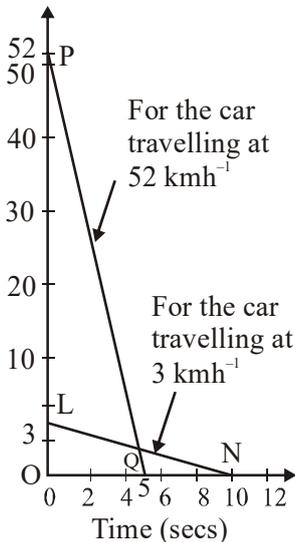
$$u = 3 \text{ kmh}^{-1} = 3 \times \frac{5}{18} = 0.83 \text{ ms}^{-1}$$

The speed time graphs of both the cars are shown below.

(i) Distance covered by car moving at  $14.4 \text{ ms}^{-1}$ .

$$= \text{area of PQO} = \frac{1}{2} \times \text{OQ} \times \text{PO}$$

$$= \frac{1}{2} \times 14.4 \times 5 = 36 \text{ m}$$



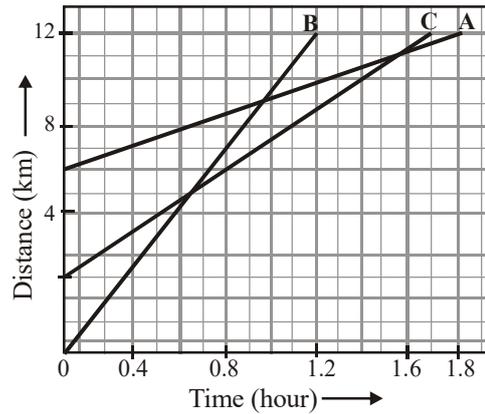
(ii) Distance covered by car moving at  $0.83 \text{ ms}^{-1}$ .

$$= \text{area of OLN}$$

$$= \frac{1}{2} \times \text{LO} \times \text{ON} = \frac{1}{2} \times 0.83 \times 10 = 4.15 \text{ m}.$$

The car moving at  $52 \text{ km h}^{-1}$  travels more distance on the application of brakes.

**Q.6** Figure below shown the distance-time graph of three objects A, B and C. Study the graph and answer the following questions.



- (a) Which of the three is travelling the fastest?
- (b) Are all three ever at the same point on the road?
- (c) How far has C travelled when B passes A?
- (d) How far has B travelled by the time it passes C?

**Sol.** (a) Speed of car A

$$v_A = \frac{S_{\text{final}} - S_{\text{initial}}}{\text{time}} = \frac{12 - 6}{1.8} = 3.34 \text{ km h}^{-1}$$

Speed of car B

$$v_B = \frac{S_{\text{final}} - S_{\text{initial}}}{\text{time}} = \frac{12 - 0}{1.4} = 8.57 \text{ km h}^{-1}$$

Speed of car C

$$v_C = \frac{S_{\text{final}} - S_{\text{initial}}}{\text{time}} = \frac{12 - 2}{1.76} = 5.68 \text{ km h}^{-1}$$

Car B is travelling the fastest.

- (b) No, they are never at the point because all the graphs of A, B and C do not intersect at one point.
- (c) When car B passes car A at point P, the distance covered by car C is 7 km.
- (d) Car B and C pass each other at point O. The distance travelled by B at that point is slightly more than 5 km.

**Q.7** A ball is gently dropped from a height of 20 m. If its velocity increases uniformly at the rate of  $10 \text{ ms}^{-2}$ , with what velocity will it strike the ground? After what time will it strike the ground?

**Sol.** **Given :** Initial velocity of ball,  $u = 0$  Final velocity of ball,  $v = ?$

Distance through which the ball falls,  $S = 20 \text{ m}$

Acceleration,  $a = 10 \text{ ms}^{-2}$

Time of fall,  $t = ?$

We know  $v^2 - u^2 = 2aS$

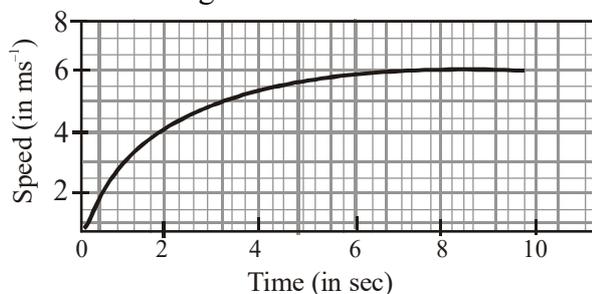
or  $v^2 - 0 = 2 \times 10 \times 20 = 400$

or  $v = 20 \text{ ms}^{-1}$

Now using  $v = u + at$  we have

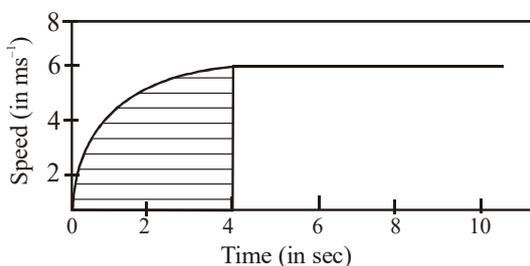
$20 = 0 + 10 \times t$  or  $t = 2\text{s}$

**Q.8** The speed-time graph for a car is shown below in figure.



- (a) Find how far does the car travel in the first 4 seconds. Shade the area on the graph that represents the distance travelled by the car during the period.
- (b) Which part of the graph represents uniform motion of the car?

**Sol.** (a) The car travels with a non-accelerated nature.



The distance travelled by the car in the first four second is given by the area enclosed by the speed-time graph and X-axis from  $t = 0$  to  $t = 4\text{s}$ .

To calculate the distance, in such cases, we actually count the number of squares in the shaded portion of the graph. This gives the distance travelled by the car in first four seconds as 17.80 m.

(b) The straight line portion of the graph represents uniform motion of the car.

**Q.9** State which of the following situations are possible and give an example for each of these

- (a) An object with a constant acceleration but with zero velocity.
- (b) An object moving in a certain direction with acceleration in the perpendicular direction.

**Sol.** (a) A body with a constant acceleration but with zero velocity is possible. For example, when a body is released, its initial velocity  $u = 0$ , but acceleration  $g = 10 \text{ ms}^{-2}$ .

(b) When a stone, tied to a string, is whirled in a circular path, the acceleration acting on it is always at right angles to the direction of motion of stone.

**Q.10** An artificial satellite is moving in a circular orbit of radius 42250 km. Calculate its speed if it takes 24 hours to revolve around the earth.

**Sol.** Distance covered by the satellite in 24 hours.

$$S = 2\pi r = 2 \times \frac{22}{7} \times 42250$$

$$= 265571.43 \text{ km}$$

Therefore speed of the satellite is

$$v = \frac{\text{distance travelled}}{\text{time}}$$

$$= \frac{265571.43}{24 \times 60 \times 60} = 3.07 \text{ km s}^{-1}$$

## EXERCISE-II

## Knowledge Vault



## MCQ BASED QUESTIONS:

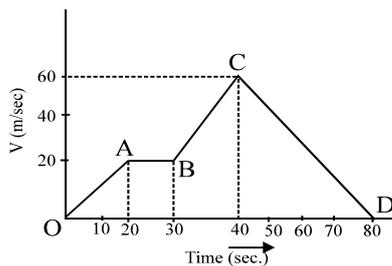
- Q.1** If the speed of car is increased to two times the breaking force to stop the car over the same distance will be :  
 (A) one fourth (B) half  
 (C) twice (D) four times
- Q.2** The numerical ratio of covering the distance is directly proportional to the square of the time. The acceleration of the body is  
 (A)  $< 1$  (B)  $= 1$   
 (C)  $> 1$  (D)  $\leq 1$
- Q.3** A moving body is covering the distance directly proportional to the square of the time. The acceleration of the body is :  
 (A) increasing (B) decreasing  
 (C) zero (D) constant
- Q.4** Distance travelled by a particle in a given interval of time is always  
 (A) zero (B) positive  
 (C) negative (D) -ve and +ve
- Q.5** Distance is a  
 (A) vector quantity (B) Scalar quantity  
 (C) both of them (D) none of these
- Q.6** Displacement is a  
 (A) vector quantity (B) Scalar quantity  
 (C) both of them (D) none of these
- Q.7** A bus moving on a crowded road is in  
 (A) uniform quantity  
 (B) non-uniform motion  
 (C) both of them  
 (D) none of these
- Q.8**  $1 \text{ km h}^{-1}$  is equal to  
 (A)  $\frac{5}{18} \text{ ms}^{-1}$  (B)  $\frac{18}{5} \text{ ms}^{-1}$   
 (C) both of them (D) none of these
- Q.9**  $1 \text{ km/h}^2$  is equal to  
 (A)  $\frac{1000\text{m}}{3600 \times 3600\text{s}^2}$  (B)  $\frac{1}{12960} \text{ m/s}^2$   
 (C) both A & B are equal  
 (D) none of these
- Q.10** 1 radian is equal to  
 (A)  $75.3^\circ$  (B)  $30.3^\circ$   
 (C)  $22.1^\circ$  (D)  $57.3^\circ$
- Q.11** When a moving body makes a round trip and returns back to its initial position then its displacement is  
 (A) +1 (B) -1  
 (C) 0 (D)  $\geq 1$
- Q.12** The position time ( $x-t$ ) graph for two children A and B returning from their school O to their homes P and Q respectively are shown in fig. choose the correct entries in the brackets below :
- 
- (A) (B) lives closer to the school than (A).  
 (B) (B) starts from the school earlier than (A).  
 (C) (A) walks faster than (B).  
 (D) (A/B) overtakes (B/A) on the road (once/twice)
- Q.13** A particle has a velocity towards east at  $t = 0$ . Its acceleration is towards west and is constant. Let  $x_A$  and  $x_B$  be the magnitude of displacements in the first 10 seconds and the next 10 seconds.  
 (A)  $x_A < x_B$   
 (B)  $x_A = x_B$   
 (C)  $x_A > x_B$   
 (D) the information is insufficient to decide the relation of  $x_A$  with  $x_B$ .
- Q.14** A person travelling on a straight line moves with a uniform velocity  $v_1$  for some time and with uniform velocity  $v_2$  for the next equal time. The average velocity  $v$  is given by : -  
 (A)  $v = \frac{v_1 + v_2}{2}$  (B)  $v = \sqrt{v_1 v_2}$   
 (C)  $\frac{2}{v} = \frac{1}{v_1} + \frac{1}{v_2}$  (D)  $\frac{1}{v} = \frac{1}{v_1} + \frac{1}{v_2}$
- Q.15** A stone is released from an elevator going up with an acceleration  $a$ . The acceleration of the stone after the release is:  
 (A)  $a$  upward (B)  $(g - a)$  upward  
 (C)  $(g - a)$  downward (D)  $g$  downward

- Q.16** A person standing near the edge of the top of a building throws two balls A and B. The ball A is thrown vertically upward and B is thrown vertically downward with the same speed. The ball A hits the ground with a speed  $v_A$  and the ball B hits the ground with a speed  $v_B$ . We have :
- (A)  $v_A > v_B$   
 (B)  $v_A < v_B$   
 (C)  $v_A = v_B$   
 (D) the relation between  $v_A$  and  $v_B$  depends on height of the building above the ground

- Q.17** A player throws a ball upwards with an initial speed of  $29.4 \text{ m s}^{-1}$ . The time taken by the ball to return to the player's hands is. (Take  $g = 9.8 \text{ m s}^{-2}$  and neglect air resistance).
- (A) 10 sec (B) 8 sec  
 (C) 12 sec (D) 6 sec

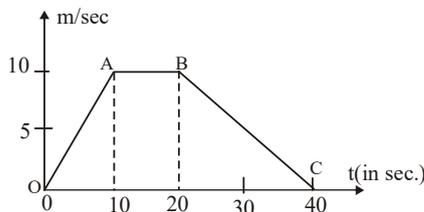
- Q.18** Ratio of displacement to distance is:
- (A) always  $< 1$  (B) always  $= 1$   
 (C) always  $> 1$  (D)  $=$  or  $< 1$

- Q.19** The following shows the time-velocity graph for a moving object. The maximum acceleration will be



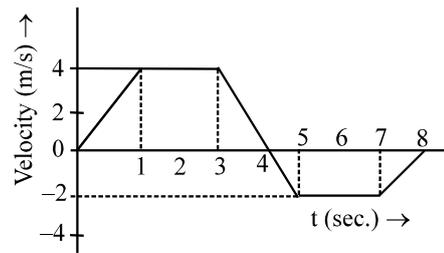
- (A)  $1 \text{ m/sec}^2$  (B)  $2 \text{ m/sec}^2$   
 (C)  $3 \text{ m/sec}^2$  (D)  $4 \text{ m/sec}^2$

- Q.20** The adjoining curve represents the velocity time graph of a particle, its acceleration values along OA, AB and BC in  $\text{m/sec}^2$ .



- are respectively-
- (A) 1, 0,  $-0.5$  (B) 1, 0,  $0.5$   
 (C) 1, 1,  $0.5$  (D) 1,  $0.5$ , 0

- Q.21** The v-t graph of a linear motion is shown in adjoining figure. The distance from origin after 8 sec. is-



- (A) 18 meters (B) 16 meters  
 (C) 8 meters (D) 6 meters

- Q.22** A motor car covers  $1/3$  part of total distance with  $v_1 = 10 \text{ km/hr}$ , second  $1/3$  part with  $v_2 = 20 \text{ km/hr}$  and rest  $1/3$  part with  $v_3 = 60 \text{ km/hr}$ . What is the average speed the car-
- (A)  $18 \text{ km/hr}$  (B)  $45 \text{ km/hr}$   
 (C)  $6 \text{ km/hr}$  (D)  $22.5 \text{ km/hr}$

- Q.23** A car covers a distance of 2 km. in 2.5 min. if it covers half of the distance with speed  $40 \text{ km/hr}$  the rest distance it will cover with speed-
- (A)  $56 \text{ km/hr}$  (B)  $60 \text{ km/hr}$   
 (C)  $50 \text{ km/hr}$  (D)  $48 \text{ km/hr}$

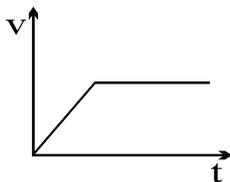
- Q.24** A cyclist moving on a circular track of radius 40 m completes half a revolution in 40 sec. Its average velocity is-
- (A) Zero (B)  $5 \text{ m/sec}$ .  
 (C)  $2 \text{ m/sec}$ . (D)  $3.5 \text{ m/sec}$ .

- Q.25** Which of the following statements is wrong about a ball thrown vertically up
- (a) It is moving with constant acceleration.  
 (b) It may have different velocities at the same position.  
 (c) It may have two positions at the same time.  
 (d) The angular momentum of the particle about origin remains conserved.
- (A) c only (B) c, d  
 (C) b, c, d (D) a, b, c and d

- Q.26** A bus accelerates uniformly from rest and acquires a speed of  $36 \text{ km/hour}$  in 10 seconds. The acceleration is :
- (A)  $1000 \text{ m/sec}^2$  (B)  $1 \text{ m/sec}^2$   
 (C)  $100 \text{ m/sec}^2$  (D)  $10 \text{ m/sec}^2$

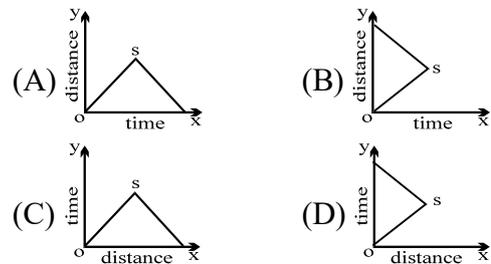
- Q.27** Acceleration of a particle changes when :
- (A) direction of velocity changes  
 (B) magnitude of velocity changes  
 (C) both of above  
 (D) speed changes

- Q.28** The book lying on the table is  
 (A) at rest  
 (B) in motion  
 (C) between rest and motion  
 (D) none of these
- Q.29** Which of the following is/are scalar quantity?  
 (A) acceleration (B) displacement  
 (C) distance (D) volume
- Q.30** Which of the following is/are vector quantity?  
 (A) acceleration (B) displacement  
 (C) area (D) volume
- Q.31**  $\text{ms}^{-1}$  is the SI unit of  
 (A) distance (B) speed  
 (C) velocity (D) acceleration
- Q.32** m is the unit of  
 (A) distance (B) displacement  
 (C) velocity (D) acceleration
- Q.33** Which of the following is correct in terms of motion  
 (A)  $v = u + at$  (B)  $v^2 = u^2 + 2as$   
 (C)  $s = ut + \frac{1}{2}at^2$  (D) none of these
- Q.34** Which is correct?  
 (A)  $\omega = \frac{\theta}{t}$  (B)  $\omega = \theta t$   
 (C)  $v = \frac{s}{t}$  (D)  $v = st$
- Q.35** Which is correct?  
 (A)  $\theta = \frac{1}{r}$  (B)  $\omega = \frac{\theta}{t}$   
 (C)  $\theta = \frac{s}{r}$  (D) none of these
- Q.36** Which of the following statements regarding the freely falling body is/are correct?



- (A) The body is uniformly accelerated  
 (B) The body is non-uniformly accelerated  
 (C) The distance travelled by the body in the first second, second second and third second are in the ratio of 1 : 3 : 5  
 (D) The distance travelled by the body in the first second, first two seconds and first three seconds are in the ratio of 1 : 4 : 9

- Q.37** The velocity time graph of an object is shown in figure.  
 Which of the following statement is/are correct?  
 (A) The slanted portion of the v-t graph represents constant acceleration.  
 (B) The horizontal portion represents constant velocity  
 (C) Area under v-t graph gives the momentum change.  
 (D) Area under v-t graph is equal to acceleration
- Q.38** In an examination, the students were asked to draw distance -time graph of a school boy going from home straight to school and starting back home immediately (without any time loss). The following graphs were drawn by four students. Which of these graphs do not depict the real situation?



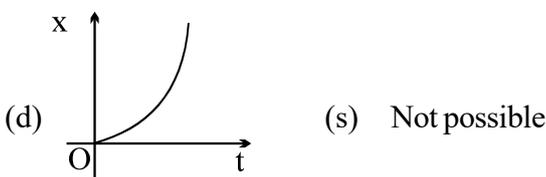
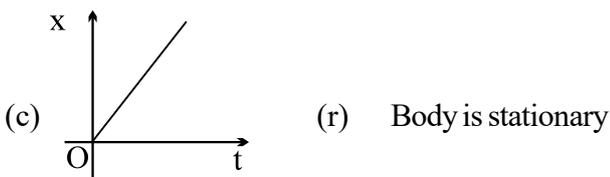
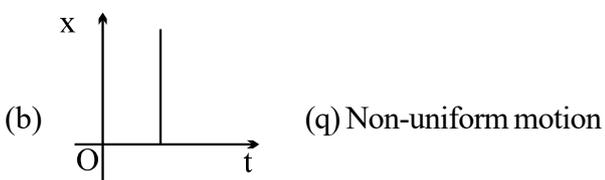
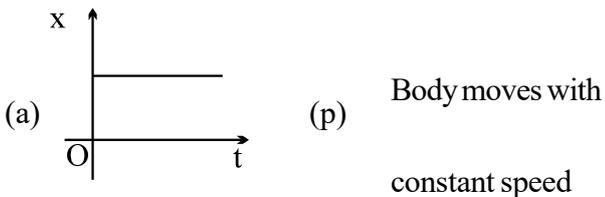
**FILL IN THE BLANKS:**

- Q.39** Displacement is a .....quantity.
- Q.40** .....is defined as the distance travelled by a body per unit time.
- Q.41** .....indicates the instantaneous speed of the vehicle.
- Q.42** Rate of change of velocity is called.....
- Q.43** Negative acceleration is called.....
- Q.44** Speed of a body is always .....
- Q.45** Velocity = speed  $\times$  .....
- Q.46** Speed is the magnitude of the .....
- Q.47** Acceleration is a .....quantity.
- Q.48** Acceleration of the body is increasing with passage of .....
- Q.49** In linear motion the body moves along a.....
- Q.50** In linear motion the direction of motion .....
- Q.51** 1 rad =.....

**MATCH THE COLUMN:**

**[A] [ONE TO ONE]:**  
**Column-I** and **column-II** contains **four** entries each. Entries of column-I are to be matched with some entries of column-II. Only One entries of column-I may have the matching with the some entries of column-II and one entry of column-II Only one matching with entries of column-I.

**Q.52 Column I (Distance time graph) Column II (Type of motion)**



- (A) (a)-(r), (b)-(s), (c)-(p), (d)-(q)
- (B) (a)-(q), (b)-(s), (c)-(p), (d)-(r)
- (C) (a)-(s), (b)-(r), (c)-(p), (d)-(q)
- (D) (a)-(p), (b)-(r), (c)-(s), (d)-(q)

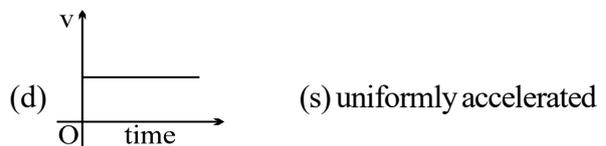
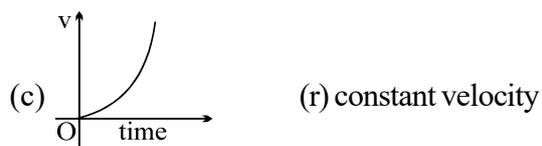
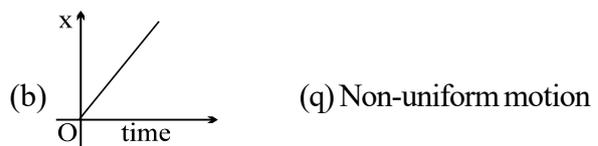
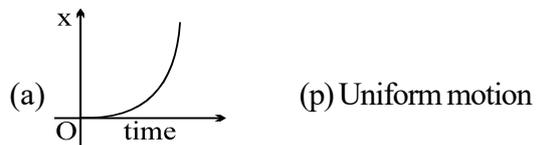
**Q.53 Column I (Type of motion) Column II (Nature of Acceleration)**

- (a) Circular Motion (p) Acceleration is along the direction of motion
- (b) Uniform Motion (q) Acceleration is along perpendicular direction of the motion.
- (c) Free Fall (r) Acceleration is in the opposite direction of motion
- (d) A stone thrown upward (s) Acceleration is Zero with initial velocity 'u'

- (A) (a)-(r), (b)-(p), (c)-(q), (d)-(s)
- (B) (a)-(q), (b)-(s), (c)-(p), (d)-(r)
- (C) (a)-(q), (b)-(s), (c)-(p), (d)-(r)
- (D) (a)-(p), (b)-(r), (c)-(s), (d)-(q)

**[B] [ONE TO MANY]:**  
**Column-I** and **column-II** contains **four** entries each. Entries of column-I are to be matched with some entries of column-II. One or more than one entries of column-I may have the matching with the some entries of column-II and one entry of column-II may have one or more than one matching with entries of column-I

**Q.54 Column I (Displacement time (x - t)/velocity-time graph (v - t) Column II (Type of motion)**



- (A) (a)-(r), (b)-(p), (c)-(q), (d)-(s)
- (B) (a)-(q,s), (b)-(p,r), (c)-(q), (d)-(p,r)
- (C) (a)-(s), (b)-(r), (c)-(p), (d)-(q)
- (D) (a)-(p), (b)-(r), (c)-(s), (d)-(q)

**ASSERTION & REASON TYPE QUESTIONS:**

Instructions: In the following questions as Assertion (A) is given followed by a Reason (R). Mark your responses from the following options.  
 (A) Both Assertion and Reason are true and Reason is the correct explanation of 'Assertion'.  
 (B) Both Assertion and Reason are true and Reason is not the correct explanation of 'Assertion'.  
 (C) Assertion is true but Reason is false.  
 (D) Assertion is false but Reason is true.

- Q.55 Assertion :** The  $v-t$  graph perpendicular to the time axis is not possible.  
**Reason :** If  $v-t$  graph is perpendicular to the time axis, then acceleration of the particle should be infinite.
- Q.56 Assertion :** Retardation is directed opposite to the velocity.  
**Reason :** Retardation is equal to the time rate of decrease of velocity.
- Q.57 Assertion :** Relative velocity when particles are moving on the same straight line path can be greater in magnitude than velocity of either particle.  
**Reason :** When the particles are moving with velocities  $v_1$  and  $v_2$  in opposite directions, then relative velocity  $= v_1 + v_2$ .
- Q.58 Assertion :** A body can have acceleration even if its velocity is zero at a given instant of time.  
**Reason :** A body is momentarily at rest when it reverses its direction of motion.
- Q.59 Assertion :** The velocity of a particle may vary even when its speed is constant.  
**Reason :** Such a body may move along a circular path.
- Q.60 Assertion :** The  $x-t$  graph for a body at rest is a straight line parallel to time axis.  
**Reason :** A body at rest does not change its position with the lapse of time.

**COMPREHENSIVE :**

A "sun yacht" is a spacecraft with a large sail that is pushed by sunlight. Although such a push is tiny in every day circumstances, it can be large enough to send the space craft outward from the Sun on a cost-free but slow trip. Suppose that the spacecraft has a mass of 900 kg and received a push of 20 N.

- Q.61** The magnitude of the resulting acceleration is :  
 (A)  $45 \text{ ms}^{-2}$  (B)  $18000 \text{ ms}^{-2}$   
 (C)  $\frac{1}{45} \text{ ms}^{-2}$  (D) None of these
- Q.62** If the craft starts from rest how far will it travel in 1 min :  
 (A) 40 m (B) 30 m  
 (C) 100 m (D) None of these
- Q.63** How fast will it then be moving :  
 (A)  $3/4 \text{ m/s}$  (B)  $4/3 \text{ m/s}$   
 (C)  $5/4 \text{ m/s}$  (D) None of these

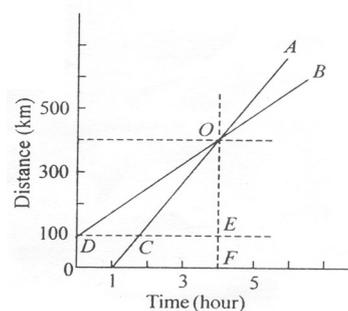
**CASE BASED / NUMERICAL TYPE QUE.:-**

- Q.64** Let an electron moves in circular path around the nucleus. If the radius of the path is  $r$  metre find the displacement and distance travelled by the electron in following situation :
- For one full revolution
  - For half revolution
  - For hundred revolutions

**Ans.**

- (i) In full revolution the initial and final positions are same hence the displacement of electron will be zero. While the distance travelled by the electron in one revolution equals to the circumference of the circular path i.e.  $= 2\pi r$  metre
- (ii) In half revolution the initial and final positions are opposite to each other, hence the displacement of the electron is equal to the diameter of the circular path i.e.  $2r$  metre while the distance travelled by the electron will be equal to  $\pi r$  metre
- (iii) For 100 revolutions the initial and final positions of the electron will remain same one hence its displacement will be zero. While the distance travelled by the electrons in 100 full revolutions will be equal to  $100 \times 2\pi r$ .

- Q.65** In figure time-distance graph for two cars is given. Then find out that
- Initially which car is ahead and how much?
  - Which car starts moving after and after how much time?
  - What is the speed of two cars?



- (iv) After how much time and at what distance the car moving faster will catch the second car.

**Ans.**

- (i) Initially at  $t = 0$  the car B was at a distance 100 km and the car A at  $t = 1$  hour was at zero km. Hence the car B is 100 km ahead of car A.
- (ii) The car A starts at  $t = 1$  hour and car B at  $t = 0$

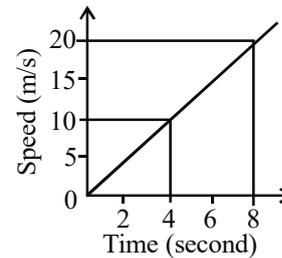
- (iii) (a) The speed of car  
 A = Slope of time graph  
 = Slope of line COA = OF/CF  
 =  $(400-0)/(4-1)$  km/hr  
 = 133.33 km/hour
- (b) Similarly the speed of car  
 B = Slope of line DOB = OE/DE  
 =  $(400-100)/(4-0)$  km/hour  
 = 75 km/hour
- (iv) The intersection of two lines will be the point of meeting of two cars. So the two cars will meet at a distance of 400 km. From the initial point and after 4 hours.

- Q.66** A student travels with a speed of 4 km/hour from his house to his school situated at a distance of 2 km. But seeing that school is closed, return home quickly with a speed of 6 km/hour then find out
- Average speed of the student
  - Average velocity of the student and
  - Average speed of the student for first 30 minute and first 50 minute

**Ans.**

- The time taken by the student to reach the school = distance/speed =  $2 \text{ km}/4 \text{ (km/hour)}$   
 Time taken in returning to home =  $2 \text{ km}/(6 \text{ km/hour}) = 1/3 \text{ h} = 20 \text{ minute}$   
 So, the total time taken by student in whole of the journey =  $30 + 20 = 50 \text{ minute} = 5/6 \text{ h}$   
 And the total distance travelled in that journey  
 Hence the average speed of the student =  $4/(5/6) = (4 \times 6)/5 = 4.8 \text{ km/h}$
- After starting from home as student returns back to the home. Since the resultant displacement is zero then velocity is also zero.
- In first 30 minutes (students reaches school) the distance travelled is 2km and time taken is 1/2 hour. So the average speed of the student is =  $2 \text{ km}/30 \text{ minute} = 4 \text{ km/h}$   
 In first 50 minutes students reaches school in first 30 minute and covers a distance of 2 km then in next 20 minute students returns home from the school speed with 6 km/h.  
 Hence the distance travelled by the student in 20 minutes when he returns to home =  $6 \times (1/3) = 2 \text{ km}$   
 So, the total distance travelled by the student in first 50 minutes  $(2 + 2) = 4 \text{ km}$   
 Hence, the average speed =  $4 \text{ km}/50 \text{ minute} = 4/5/6 = 4.8 \text{ km/hour}$

- Q.67** In given figure change in instantaneous speed of a particle with time is shown then find the acceleration and distance covered by the particle in first 8 seconds.



- Ans.** From figure the distance travelled by the particle = Area of speed – time graph with time axis =  $1/2 \times (8-0) \times (20-0) = 80 \text{ metre}$   
 Similarly,  
 Acceleration = Slope of the line =  $(20-0)/(8-0) = 2.5 \text{ metre/sec}^2$

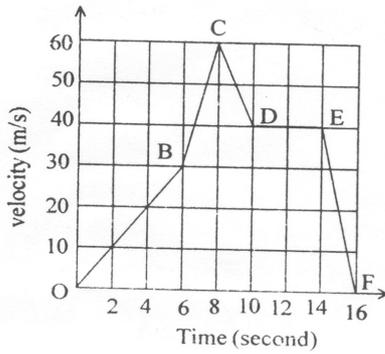
- Q.68** Truck 'A' is going on a road with velocity 10 m/s. The second truck 'B' is coming from its back and an another truck 'C' is coming from as front. The velocity of truck B and C is 15 m/s for each. When the distance AB and AC is 500 metre each. The driver of truck B thinks to cross the truck A before truck 'C'. In this position how much minimum acceleration required for truck B.

- Ans.** The relative velocity of truck 'C' with respect to truck 'A' = Velocity of truck 'C' – Velocity of truck 'A' =  $15 - (-10) = 25 \text{ m/s}$   
 and the distance of truck 'C' from truck 'A' = 500 metre  
 So the time taken by truck 'C' to cross truck 'A' =  $500/25 = 20 \text{ sec}$   
 Hence the time taken by truck 'B' to reach up to 'A' should be less than 20 sec.  
 Again the velocity of truck 'B' with respect to truck 'A' = Velocity of truck 'B' – Velocity of truck 'A' =  $15 - 10 = 5 \text{ m/s}$   
 If the minimum acceleration 'a' is required for truck 'B' to cover a distance of 500 metre with a relative velocity 5 m/s in 20 seconds then by the second equation of motion.  

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

$$500 = 5 \times 20 + \frac{1}{2} \times a \times 20 \times 20$$
 or  $a = (500-100)/200 = 2 \text{ m/s}^2$

- Q.69** In figure the velocity–time graph for a particle is shown. Then find out the following
- The average acceleration of the particle in between 6 to 8 seconds.
  - At what time interval the average acceleration of the particle becomes zero?
  - What will be the maximum acceleration?
  - What is the displacement of the particle in first 6 seconds?

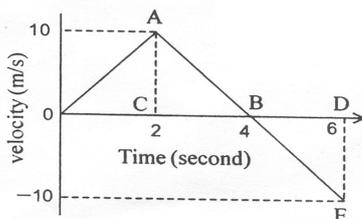


Ans.

- (i) Average acceleration of the particle in between 6 to 8 seconds = Slope of line BC =  $(60-30)/(8-6) = 30/2$  or  $a = 15 \text{ metre/sec}^2$
- (ii) For zero average acceleration the velocity-time graph should be parallel to time axis. In figure portion DE is parallel to the time axis. Hence for this portion the average acceleration will become zero. Where the time interval is in between 10 to 14 second.
- (iii) Retardation is a negative acceleration so the portion for which the velocity-time graph makes the smallest angle with the velocity axis, the retardation is the maximum. In figure the line EF has the maximum acceleration.
- (iv) displacement of the particle in first 6 seconds will be area under the velocity time graph for first 6 seconds. So, displacement = Area OBCO =  $\frac{1}{2} \times 6 \times 30 = 90 \text{ m}$

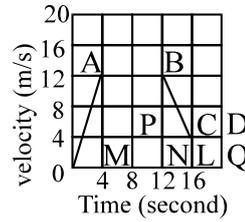
**Q.70** The velocity-time graph for a particle is according to figure. So, find the total displacement of the particle.

Ans. According to the figure the velocity of the particle for first 4 second will be in positive direction and from 4 to 6 seconds as the velocity of particle in opposite direction so the displacement of particle will be negative. So the total displacement.



$\Delta x = \text{Area of } \triangle OAB - \text{Areas of } \triangle BED$   
 $= \frac{1}{2} \times 4 \times 10 - \frac{1}{2} \times 2 \times 10 = 10 \text{ metre}$   
 So the displacement of the particle is 10 metre and will be in positive direction.

**Q.71** A runner races in straight line and his velocity time graph is shown in figure. Find the distance covered by the runner in 20 second and also the maximum instantaneous acceleration of the runner.



Ans.

Distance covered by the runner in 20 second = Area of graph in between velocity and time =  $\triangle OAM + \text{rectangle MABN} + \triangle BPC + \text{rectangle PDQN}$   
 $= \frac{1}{2} \times (4 \times 12) + (12 \times 8) + \frac{1}{2} \times (8 \times 4) + 4 \times 8$   
 $= 24 + 96 + 16 + 32 = 168 \text{ m}$   
 and the maximum acceleration =  $(12-0)/(4-0) = 3 \text{ metre/sec}^2$

**Q.72** If minute hand of a clock is 5 cm long. Find its angular velocity and linear velocity.

Ans. Since, minute hand of clock rotates and completes one rotation in 60 minutes. Therefore, angled described in 60 minutes =  $2\pi$  radian  
 Hence angular velocity of minute hand,

$$\omega = \frac{2\pi \text{ radian}}{60 \text{ minutes}} = \frac{2 \times 22 \text{ radian}}{7 \times 60 \times 60 \text{ sec}}$$

$$= \frac{11}{7 \times 900} = \frac{110}{63} \times 10^{-3} = 1.74 \times 10^{-3} \text{ rad / s}$$

Now, length of minute hand,  $l = r = 5 \text{ cm}$   
 Therefore, Linear velocity of minute hand,  
 $v = r\omega = 5 \times 1.74 \times 10^{-3} \text{ cm/s}$   
 $= 8.70 \times 10^{-3} \text{ cm/s}$

**Q.73** An aircraft completes a horizontal loop of radius 1 km with a uniform speed of 900 km/h. Find the angular velocity of the aircraft.

Ans. Given, radius of orbital of aircraft  
 $r = 1 \text{ km}$   
 and uniform linear speed  $V = 900 \text{ km/h}$   
 Now, linear speed,  
 $V = \text{radius } (r) \times \text{angular velocity } (\omega)$

$$\text{Angular velocity, } \omega = \frac{v}{r} = \frac{900 \text{ km / h}}{1 \text{ km}}$$

$$= 900 \text{ rad/h}$$

$$= \frac{900}{60 \times 60} \text{ rad / s} = 1/4 \text{ rad/s} = 0.25 \text{ rad/s}$$

**Q.74** A body covers a distance of 20m in the 7th second and 24m in the 9th second. How much distance shall it cover in 15th sec.

**Ans.**  $S_{7th} = u + \frac{a}{2}(2 \times 7 - 1)$  but

$S_{7th} = 20m$

$\therefore 20 = u + \frac{a}{2} \times 13 \Rightarrow 20 = u + \frac{13a}{2}$  .....(i)

also  $S_{9th} = 24$

$\therefore 24 = u + \frac{17a}{2}$  .....(ii)

from (i) equation  $u = 20 - \frac{13a}{2}$  .....(iii)

Substitute this value in (ii)

$24 = 20 - \frac{13a}{2} + \frac{17a}{2}$

$24 - 20 = \frac{17a}{2} - \frac{13a}{2}$

$4 = \frac{4a}{2} \Rightarrow 4 = 2a \Rightarrow a = \frac{4}{2} = 2m/s^2$

Use this value of (iii)  $u = 20 - \frac{13a}{2}$

$\therefore u = 20 - \frac{13 \times 2}{2} \Rightarrow u = 20 - 13$

$\therefore u = 7m/s$

Now,  $S_{15th} =$

$u + \frac{a}{2}(2 \times 15 - 1) = 7 + \frac{2}{2}(29) = 7 + 29 = 36m$

**Q.75** The driver of a train travelling at  $40\text{ ms}^{-1}$  applies the brakes as a train enters a station. The train slow down at a rate of  $2\text{ ms}^{-2}$ . The platform is 400 m long. Will the train stop in time?

**Ans.** Given  $u = 40\text{ ms}^{-1}$ ,  $v = 0$ ,  $a = -2\text{ ms}^{-2}$ ,  $S = ?$   
Using equation, we have  
 $0 = (40)^2 + 2(-2)S$  or  $4S = 1600$   
or  $S = 400\text{ m}$ .

Thus the train stops in 400 m. Since the platform is 400 m long, therefore, the train just stops in time.

**Q.76** A girl running a race accelerates at  $2.5\text{ ms}^{-2}$  for the first 4 s of the race. How far does she travel in time?

**Ans.** Given  $u = 0$ ,  $a = 2.5\text{ ms}^{-2}$ ,  $t = 4\text{ s}$  and  $S = ?$   
Substituting the values in equation

$S = ut + \frac{1}{2}at^2$ , we have  $S = 0 \times 4 + \frac{1}{2} \times 2.5 \times 4^2 = 20\text{m}$ .

**Q.77** Two trains A and B of length 400 m each are moving on two parallel tracks with uniform speed of  $72\text{ kmh}^{-1}$  in the same direction with A ahead of B. The driver of B decides to overtake A and accelerates by  $1\text{ ms}^{-2}$ . If after 50 s, the guard of B just passes the driver of A, what was the original distance between them?

**Ans.** Initial speed of each train,  
 $u = 72\text{ kmh}^{-1} = 20\text{ ms}^{-1}$   
Distance travelled by train A in 50 s =  $20 \times 50 = 1000\text{ m}$   
Distance travelled by train B in 50 s with an acceleration of  $1\text{ ms}^{-2}$  is

$20 \times 50 + \frac{1}{2}(1) \times (50)^2 = 2250\text{ m}$

(using  $S = ut + \frac{1}{2}at^2$ )

Therefore, the original distance between the trains is  $2250\text{ m} - 1000\text{ m} = 1250\text{ m}$ .

**Q.78** The velocity of a car is  $18\text{ ms}^{-1}$ . Express this velocity in  $\text{kmh}^{-1}$ .

**Ans.** Velocity =  $18 \times \frac{18}{5}\text{ km/h} = 64.8\text{ kmh}^{-1}$

**Q.79** An electric engine has a velocity of  $120\text{ kmh}^{-1}$ . How much distance will it travel in 30 s?

**Ans.** Velocity =  $\frac{\text{distance}}{\text{time}}$   
or distance = velocity  $\times$  time.

Therefore,  $S = \frac{120 \times 1000}{3600} \times 30 = 1000\text{ m}$ .

**Q.80** A car travels a certain distance with a speed of  $50\text{ kmh}^{-1}$  and returns with a speed of  $40\text{ kmh}^{-1}$ . Calculate the average speed for the entire journey?

**Ans.** Given  $v_1 = 50\text{ kmh}^{-1}$  and  $v_2 = 40\text{ kmh}^{-1}$   
Let S be the distance. Therefore, total distance travelled by the body =  $S + S = 2S$   
Now, time taken for the first motion

$t_1 = \frac{S}{v_1} = \frac{S}{50}$

Time taken for the second motion

$t_2 = \frac{S}{v_2} = \frac{S}{40}$

Total time taken

$t = t_1 + t_2 = \frac{S}{50} + \frac{S}{40}$

Hence, average speed

$$v_{av} = \frac{\text{total distance travelled}}{\text{total time taken}}$$

$$= \frac{2S}{t} = \frac{2S}{\frac{S}{40} + \frac{S}{50}} = 44.5 \text{ kmh}^{-1}.$$

**Q.81** The distance between two stations is 200 km. A train travels for the first 100 km at a speed of  $50 \text{ kmh}^{-1}$ . How fast should the train travel the next 100 km so as to average  $70 \text{ kmh}^{-1}$  for the whole journey?

**Ans.** Given total distance travelled = 200 km

Time taken for the first half

$$t_1 = \frac{S}{v_1} = \frac{100}{50} = 2 \text{ h}$$

Time taken for the second half

$$t_2 = \frac{S}{v_2} = \frac{100}{v_2}$$

Now,  $v_{av} = 70 \text{ kmh}^{-1}$

Therefore,  $v_{av} = \frac{\text{total distance travelled}}{\text{total time taken}}$

$$= \frac{S}{t_1 + t_2} = \frac{200}{\frac{100}{50} + \frac{100}{v_2}} = 70$$

Solving for  $v_2$ , we get  $116.6 \text{ kmh}^{-1}$ .

**Q.82** A train travels the first 15 km at a uniform speed of  $30 \text{ kmh}^{-1}$ , the next 75 km at a uniform speed of  $50 \text{ kmh}^{-1}$ , and the last 10 km at a uniform speed of  $20 \text{ kmh}^{-1}$ . Calculate the average speed for the entire train journey.

**Ans.** Given total distance travelled

$$= 15 + 75 + 10 = 100 \text{ km}$$

Time taken in the first part of motion

$$t_1 = \frac{S}{v_1} = \frac{15}{30}$$

Time taken in the second part of motion

$$t_2 = \frac{S}{v_2} = \frac{75}{50}$$

Time taken in the third part of motion

$$t_3 = \frac{S}{v_3} = \frac{10}{20}$$

Total time taken  $t = t_1 + t_2 + t_3$

$$t = \frac{15}{30} + \frac{75}{50} + \frac{10}{20} = 2.5 \text{ h.}$$

Therefore,  $v_{av} = \frac{\text{total distance travelled}}{\text{total time taken}}$

$$= \frac{100}{2.5} = 40 \text{ kmh}^{-1}.$$

**Q.83** Find the initial velocity of a car if it can be stopped in 10 sec by applying brakes which provide it a retardation of  $2.5 \text{ ms}^{-2}$ .

**Ans.** Given  $u = ?$ ,  $v = 0$ ,  $t = 10 \text{ s}$ ,  $a = -2.5 \text{ ms}^{-2}$

Using  $v = u + at$ , we have

$$0 = u - 2.5 \times 10, \text{ Therefore, } u = 25 \text{ ms}^{-1}.$$

**Q.84** A car acquires a velocity of  $72 \text{ kmh}^{-1}$  in 10 second after starting from rest. Find (a) the acceleration (b) the average velocity and (c) the distance travelled in the time.

**Ans.** Given  $v = 72 \text{ kmh}^{-1}$ ,  $t = 10 \text{ second}$ ,  $u = 0$ ,

$a = ?$ ,  $v_{av} = ?$ ,  $S = ?$ , also  $v = 72 \times \frac{5}{18} = 20 \text{ ms}^{-1}$ .

Using  $v = u + at$ , we have

$$20 = 0 + a \times 10, \text{ Therefore, } a = 2 \text{ ms}^{-2}$$

Using  $v^2 - u^2 = 2aS$ , we have

$$S = \frac{v^2 - u^2}{2a} = \frac{(20)^2 - 0}{2 \times 2} = \frac{400}{4} = 100 \text{ m}$$

$$\text{Also, } v_{av} = \frac{S}{t} = \frac{100}{10} = 10 \text{ ms}^{-1}$$

**Q.85** A bus starting from rest moves with a uniform acceleration of  $0.1 \text{ ms}^{-2}$  for 2 minutes. Find (a) the speed acquired, (b) the distance travelled.

**Ans.** Given: Initial speed of bus,  $u = 0 \text{ ms}^{-1}$

Final speed of bus,  $v = ?$

Acceleration,  $a = 0.1 \text{ ms}^{-2}$

Time,  $t = 2 \text{ min} = 120 \text{ s}$

Distance travelled,  $S = ?$

(i) We know,  $v = u + at$

$$\text{Or } v = 0 + 0.1 \times 120 = 12 \text{ ms}^{-1}$$

(ii) To find distance travelled, we use the equation

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

$$\text{Or } S = 0 \times 120 + \frac{1}{2} \times 0.1 \times (120)^2 = 720 \text{ m}$$

Therefore,

Final speed acquired =  $12 \text{ ms}^{-1}$

Distance travelled = 720 m.

**Q.86** A train is travelling at a speed of  $90 \text{ kmh}^{-1}$ . Brakes are applied so as to produce a uniform acceleration of  $-0.5 \text{ ms}^{-2}$ . Find how far the train will go before it is brought to rest.

**Ans.** Given Initial speed of train,  
 $u = 90 \text{ km h}^{-1} = 90 \times \frac{5}{18} = 25 \text{ ms}^{-1}$   
 Final speed,  $v = 0 \text{ ms}^{-1}$   
 Acceleration,  $a = -0.5 \text{ ms}^{-2}$   
 Distance covered,  $S = ?$   
 Using the relation  $v^2 - u^2 = 2aS$ , we have  

$$S = \frac{v^2 - u^2}{2a} = \frac{0 - (25)^2}{2 \times (-0.5)} = 625 \text{ m.}$$

**Q.87** A trolley, while going down an inclined plane, has an acceleration of  $2 \text{ cm/s}^{-2}$ . What will be its velocity 3 s after the start?

**Ans.** Given: Initial velocity,  $u = 0$   
 Final velocity,  $v = ?$   
 Time,  $t = 3 \text{ s}$   
 Acceleration,  $a = 2 \text{ cms}^{-2}$   
 We know that  $v = u + at$   
**Or**  $v = 0 + 2 \times 3 = 6 \text{ cms}^{-1}$

**Q.88** A racing car has uniform acceleration of  $4 \text{ ms}^{-2}$ . What distance will it cover in 10 s after start?

**Ans.** Given: Initial velocity,  $u = 0$   
 Acceleration,  $a = 4 \text{ ms}^{-2}$   
 Time,  $t = 10 \text{ s}$   
 Distance covered,  $S = ?$   
 We know ;  $S = ut + \frac{1}{2} at^2$   

$$S = 0 \times 10 + \frac{1}{2} \times 4 \times (10)^2$$

$$= 0 + 200 = 200 \text{ m}$$
 Therefore, distance covered = 200m.

**Q.89** A stone is thrown in a vertically upward direction with a velocity of  $5 \text{ ms}^{-1}$ . If the acceleration of the stone during its motion is  $10 \text{ ms}^{-2}$  in the downward direction, what will be the height attained by the stone and how much time will it take to reach there?

**Ans.** Given: Initial velocity,  $u = 5 \text{ ms}^{-1}$   
 Final velocity,  $v = 0$   
 Acceleration in the downward direction =  $10 \text{ ms}^{-2}$   
 Therefore acceleration in the upward direction  
 $a = -10 \text{ ms}^{-2}$

Height attained by stone,  $S = ?$

Time taken to attain height,  $t = ?$

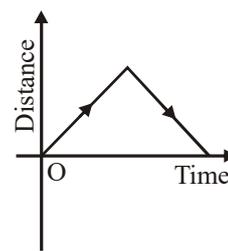
(i) Using the relation;  $v = u + at$

$$0 = 5 + (-10)t \Rightarrow t = \frac{5}{10} = 0.5 \text{ s}$$

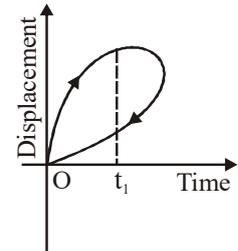
(ii) Using the relation;  $v^2 - u^2 = 2aS$ , we have

$$S = \frac{v^2 - u^2}{2a} = \frac{(0)^2 - (5)^2}{2 \times (-10)} = 1.25 \text{ m.}$$

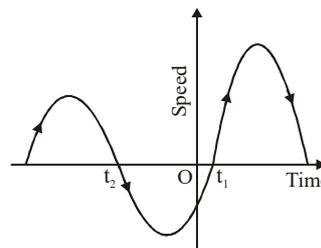
**Q.90** Explain with reason, which of the following graphs can possibly represent the motion of a particle observed in nature.



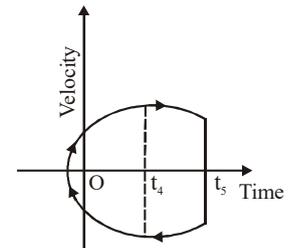
(i)



(ii)



(iii)

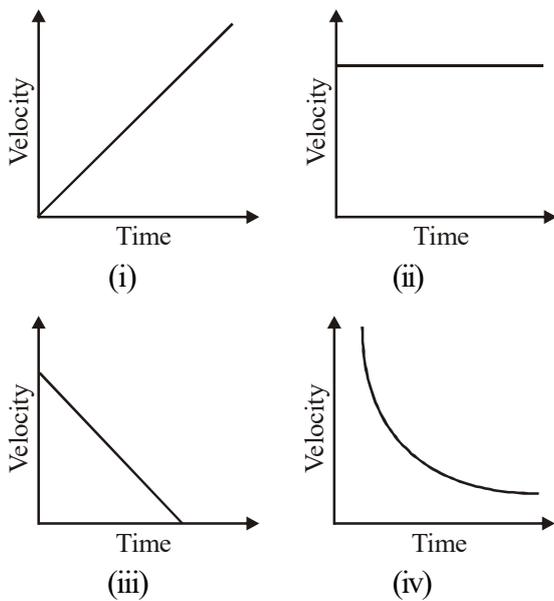


(iv)

**Ans.**

- (i) This graph shows that with increase in time, distance first increases and then decreases. However, distance can never decrease with time, so this graph is not possible.
- (ii) This graph shows that at a certain time  $t_1$  the body is present at two positions. It also shows that first time increases and then decreases. Since both these condition cannot be realized in practice, hence this graph is not possible.
- (iii) This graph shows that speed is negative for some interval of time. Since speed cannot be negative, this graph is also not possible.
- (iv) This graph show that at a given instant of time the particle has two velocities. Also it shows that at sometime it has infinite acceleration (graph parallel to the velocity axis). Both these conditions cannot be achieved in practice; therefore, this graph is also not possible.

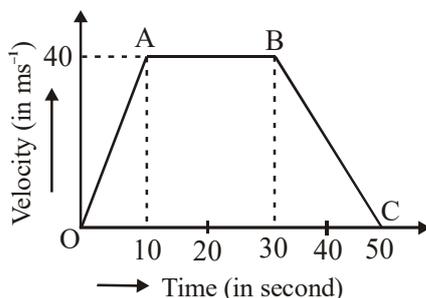
**Q.91** What type of motion is represented by the following graphs?



**Ans.**

- (i) Velocity-time graph is a straight line inclined equally towards the speed and time axis. Therefore, it represents uniformly accelerated motion.
- (ii) Velocity-time graph is a straight line parallel to the time axis. It represents uniform motion.
- (iii) Velocity-time graph is a straight line having a negative slope. It represents uniformly retarded motion.
- (iv) Velocity-time graph is a curve having a negative slope. It represents non-uniformly retarded motion.

**Q.92** Study the velocity graph of a car given alongside and answer the questions that follow :



- (i) What type of motion is represented by OA ?
- (ii) What type of motion is represented by AB ?
- (iii) What type of motion is represented by BC ?
- (iv) What is the acceleration of the car from O to A ?
- (v) What is the acceleration of the car from A to B?
- (vi) What is the retardation of the car from B to C?

**Ans.**

- (i) Velocity-time graph is a straight line inclined to the time axis from O to A. This represents a uniformly accelerated motion.
- (ii) Velocity-time graph is a straight line parallel to time axis from A to B. This represents uniform motion.
- (iii) The velocity-time graph is a straight line from B to C having a negative slope. This represents a uniformly retarded motion.
- (iv) Change in velocity =  $40 - 0 = 40^{-1}$   
Change in time =  $10 - 0 = 10$  s  
$$a = \frac{\text{change in velocity}}{\text{change in time}} = \frac{40}{10} = 4 \text{ ms}^{-2}$$
- (v) Since motion is uniform, therefore,  $a = 0$
- (vi) Change in velocity =  $0 - 40 = -40 \text{ ms}^{-1}$

Change in time =  $50 - 30 = 20$ s,

$$a = \frac{\text{change in velocity}}{\text{change in time}} = \frac{-40}{20} = -2 \text{ ms}^{-2}$$

**Q.93** In your everyday life, you come across a range of motions in which

- (i) acceleration is in the direction of motion.
- (ii) acceleration is against the direction of motion.
- (iii) acceleration is uniform.
- (iv) acceleration is non-uniform.

Can you identify one example each of the above type of motion.

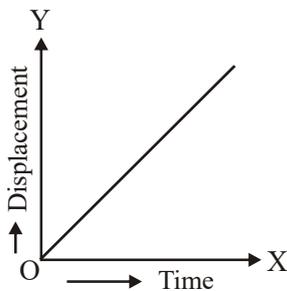
**Ans.**

- (i) When the speed of a car on a road increases, the acceleration of the car is in the direction of motion.
- (ii) When brakes are applied to a car in motion, its speed decreases. The acceleration produced in the car is against the direction of motion.
- (iii) When a body is falling freely under the action of gravity, it has a uniform  $g = 9.8 \text{ ms}^{-2}$ .
- (iv) When a car is passing through city limits on a highway, its acceleration/retardation is non-uniform depending on the volume of traffic.

**Q.94** Take a piece of thread and tie a small piece of stone at one of its ends. Move the stone to describe a circular path with constant speed by holding the thread at the other end. Now, let the stone go by releasing the thread. Can you tell the direction in which the stone moves after it is released?

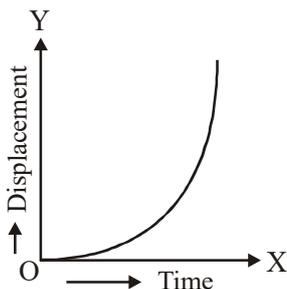
**Ans.** The moment the stone is released, it moves along the tangent to the circular path at that moment. By releasing the stone at different positions of the circular path, one will find that although the stone moves in different directions, but always tangent to the circular path at that instant. In fact, the stone is moving along a circular path due to centripetal force being provided by pull of our hand on the stone. When we let the stone go, centripetal force ceases to act. Due to inertia of direction, the stone moves along the straight line path, i.e., along the tangent to the circular path at that instant.

**Q.95** What conclusion can you draw from the displacement - time graph of a body shown below ?



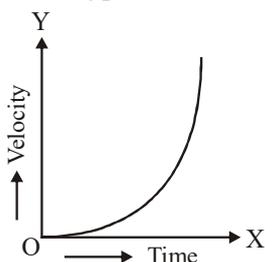
**Ans.** Since the graph is straight line, therefore, the body must be moving with a uniform velocity.

**Q.96** What conclusion can you draw from the displacement-time graph of a body as shown below?



**Ans.** A curved displacement-time graph represents non-uniform motion.

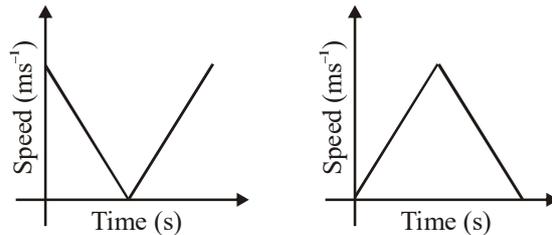
**Q.97** The velocity-time graph of a body is as shown. What type of motion does the body possess?



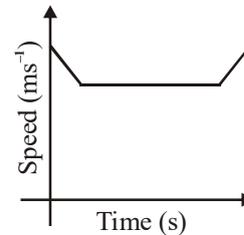
**Ans.** Since the velocity-time graph is a curved line, therefore, the body's velocity changes non-uniformly with time. Thus the body has variable acceleration.

**Q.98** Out of the three speed-time graphs shown below :

Identify the graph for the following cases :  
 Case (i) A ball thrown vertically upward and returning to the hand of the thrower.  
 Case (ii) A body decelerating to a constant speed and then accelerating



(a) (b)



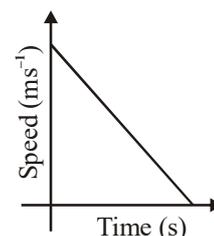
(c)

**Ans.**

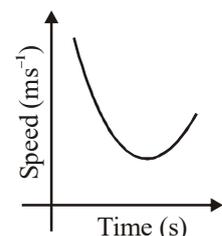
(i) Graph (a) shows that the speed of a body decreases with time becomes zero and then again starts increasing. This graph, therefore, represents the case of a ball thrown vertically upward and then caught by the thrower. Initially the ball is thrown with some speed. As the ball rises up its speed decreases at a constant rate and becomes zero at maximum height. The ball then falls with a uniform acceleration till its speed becomes equal to speed of projection.

(ii) Graph (c) represents deceleration of the body to some constant speed, and then accelerating after sometime.

**Q.99** Identify what do the graphs shown below indicate?



(i)

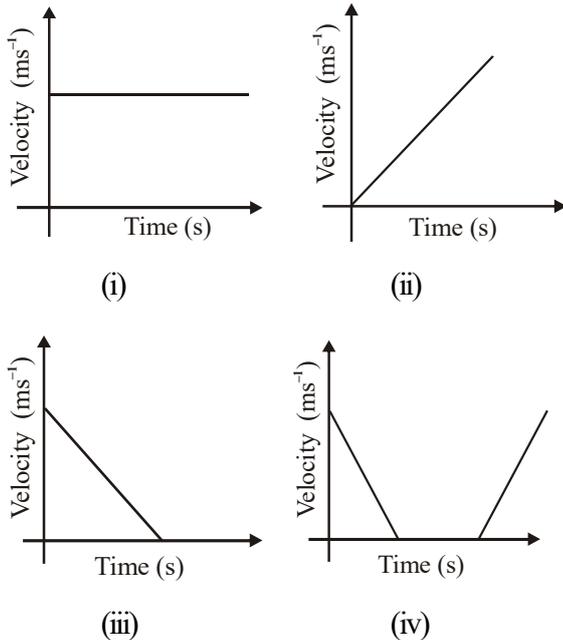


(ii)

**Ans.** Graph (i) show that speed decreases continuously with time. This therefore shows constant retardation.

Graph (ii) show that speed first decreases and then increases. Thus the body show non-uniform retardation first and then non-uniform acceleration.

**Q.100** What can we conclude about the motion of a body depicted by following velocity-time graphs ?



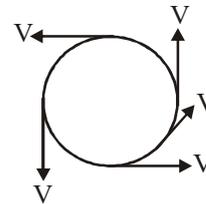
- Ans.**
- (i) It represents a body moving with uniform velocity.
  - (ii) It represents a body moving with uniform acceleration.
  - (iii) It represents a body moving with uniform retardation.
  - (iv) It represents a body first retarding uniformly, remaining at rest for sometime, and then accelerated uniformly.

**Q.101** What does the slope of a displacement-time graph represent ? Can displacement-time sketch be parallel to be displacement axis ? Give reason to your answer.

**Ans.** The slope of a displacement-time graph gives the velocity. The displacement-time graph can never be a straight line, parallel to the displacement axis because it would mean that the distance covered by the body in a certain direction is increasing without any increase in time i.e., the velocity of the body is infinite which is impossible.

**Q.102** Draw a diagram to show the motion of a body whose speed remains constant but velocity continuously changes.

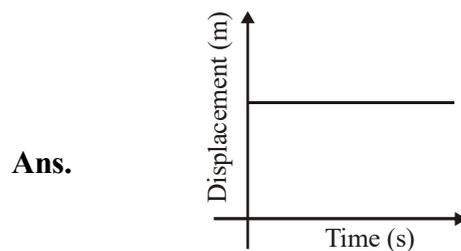
**Ans.** Uniform circular motion is an example of the motion where speed remains constant but the velocity changes continuously.



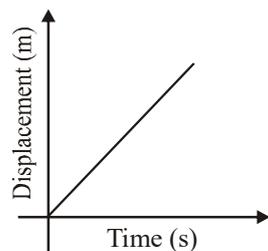
The motion is represented by the diagram given below.

**Q.103** Draw displacement-time graphs for the following situations.

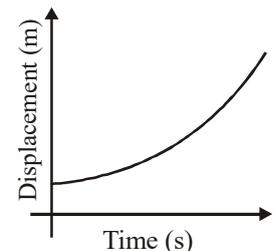
- (i) When body is stationary
- (ii) When body is moving with uniform velocity.
- (iii) When body is moving with variable velocity.



(i) For a stationary body.



(ii) For a body moving with moving with variable velocity.

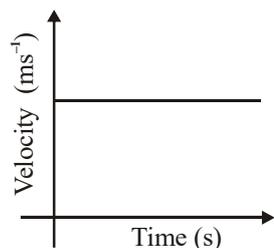


(iii) For a body uniform velocity

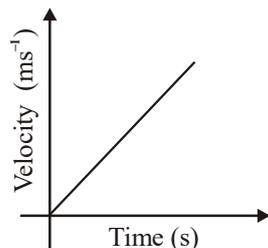
**Q.104** Draw velocity-time graphs for the following situations :

- (i) When body is moving with uniform velocity.
- (ii) When body is moving with variable velocity, but uniform acceleration.
- (iii) When body is moving with variable velocity, but uniform retardation.
- (iv) When body is moving with a variable velocity and variable acceleration.

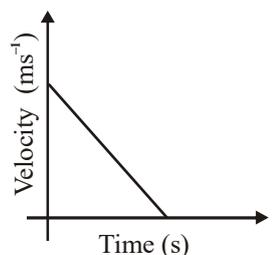
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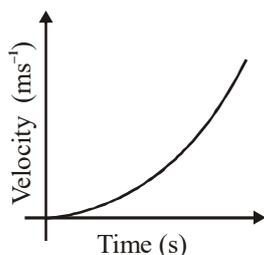
(i)



(ii)

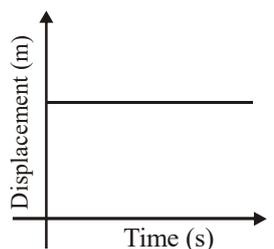


(iii)

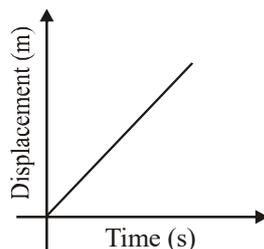


(iv)

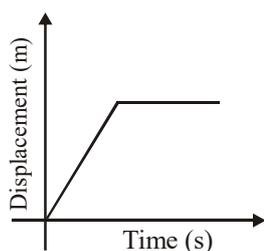
**Q.105** Can you suggest about the kind of motion of a body from following displacement-time graphs?



(i)



(ii)

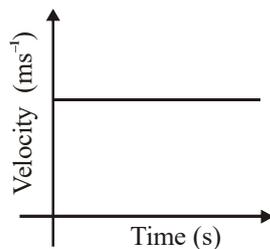


(iii)

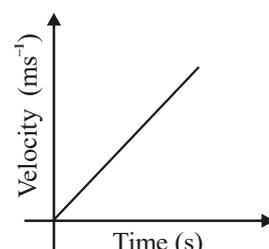
**Ans.**

- (i) Body is stationary.
- (ii) Body is moving with uniform velocity.
- (iii) Initially the body moves with uniform velocity and then stops suddenly.

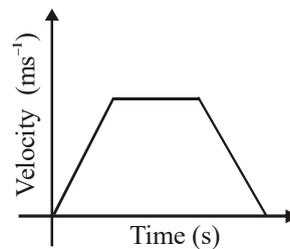
**Q.106** Can you suggest real life examples about the motion of a body from the following velocity-time graphs?



(i)



(ii)



(iii)

**Ans.**

- (i) A car moving with uniform velocity.
- (ii) A freely falling body under the action of gravity.
- (iii) A train starts from rest, picks up velocity, moves with uniform velocity for sometime and then retards.

**Q.107** Figure (i) below shows the displacement-time graph for the motion of a body. Draw the velocity-time graph in figure (ii) for it.

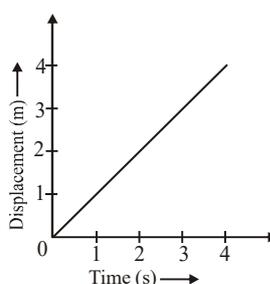


Fig (i)

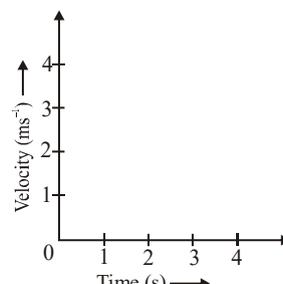
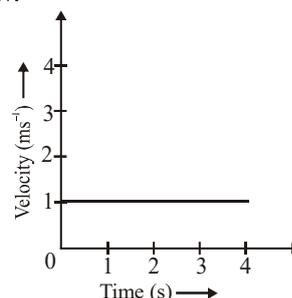


Fig (ii)

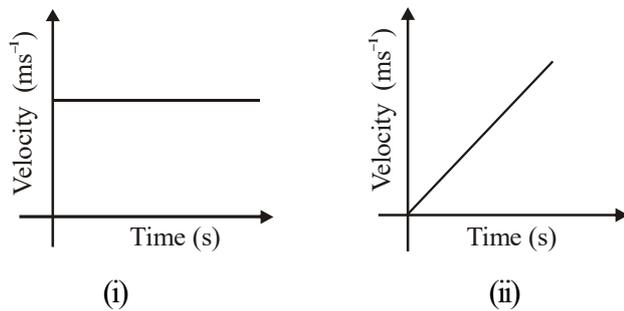
**Ans.**

The displacement-time graph shows that the object has a uniform velocity. From the graph, we find that this velocity is  $1\text{ms}^{-1}$ . The velocity-time graph therefore is as shown below.



**Q.108** Sketch the shape of the velocity-time graph for a body moving with (i) uniform velocity  
(ii) uniform acceleration.

**Ans.**

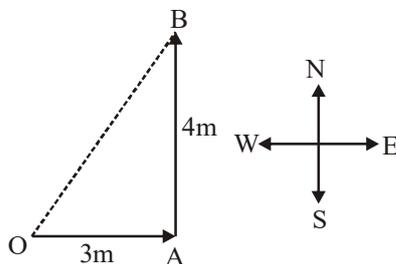


**Q.109** A particle moves through a distance of 3m due east and then 4m due north.

- (a) How much is the net distance traversed?
- (b) What is the magnitude of the net displacement?

**Ans.** The situation is shown in figure. The particle starts from O. It moves through a distance of 3m due east to reach A and then through a distance of 4m due north to reach B.

- (a) The total distance moved is 3m + 4m = 7m.
- (b) The magnitude of the net displacement is OB. In the right angled triangle OAB,



$$OB^2 = OA^2 + AB^2$$

$$= (3m)^2 + (4m)^2$$

$$= 9m^2 + 16m^2 = 25m^2$$

or  $OB = 5m.$

**Q.110** A car covers 30 km in 30 minutes and the next 30 km in 40 minutes. Calculate the average speed for the entire journey.

**Ans.** As given, the total time taken is 30 min + 40 min = 70 min =  $\frac{70}{60}$  h, and the total distance traversed is 30 km + 30 km = 60km. The average speed is

$$v_{av} = \frac{60 \text{ km}}{70 \text{ min}} = \frac{60 \text{ km}}{\left(\frac{70}{60}\right) \text{ h}}$$

$$= \frac{3600}{70} \text{ km/h} \approx 51.4 \text{ km/h}$$

**Q.111** A car covers 30 km at a uniform speed of 30 km/h. What should be its speed for the next 90 km if the average speed for the entire journey is 60 km/h?

**Ans.** The total distance = 30 km + 90 km = 120 km.  
The average speed for the entire journey = 60 km/h.

$$\text{Using } s = vt, t = \frac{s}{v} = \frac{120 \text{ km}}{60 \text{ km/h}} = 2 \text{ h.}$$

Thus, it takes 2 hours to complete the journey. The first 30 km is covered at a speed of 30 km/h. Suppose the time taken to cover the first 30 km is  $t_1$ . Using  $s = vt$ ,

$$t_1 = \frac{30 \text{ km}}{30 \text{ km/h}} = 1 \text{ h.}$$

Thus, the remaining 90 km must be covered in  $(2 \text{ h} - 1 \text{ h}) = 1 \text{ h}$ . The speed during this 90 km should be

$$v = \frac{s}{t} = \frac{90 \text{ km}}{1 \text{ h}} = 90 \text{ km/h.}$$

**Q.112** A body runs for 10 min at a uniform speed of 9 km/h. At what speed should he run for the next 20 min so that the average speed comes to 12 km/h?

**Ans.** Total time = 10 min + 20 min = 30 min.  
The average speed is 12 km/h. Using  $s = vt$ , the total distance covered in 30 min is

$$12 \text{ km/h} \times 30 \text{ min} = 12 \frac{\text{km}}{\text{h}} \times \frac{1}{2} \text{ h} = 6 \text{ km}$$

The distance covered in the first 10 min is

$$9 \text{ km/h} \times 10 \text{ min} = 9 \frac{\text{km}}{\text{h}} \times \frac{1}{6} \text{ h} = 1.5 \text{ km.}$$

Thus, he has to cover 6 km – 1.5 km = 4.5 km in the next 20 min. The speed required is

$$\frac{4.5 \text{ km}}{20 \text{ min}} = \frac{4.5 \text{ km}}{\left(\frac{20}{60}\right) \text{ h}} = 13.5 \text{ km/h.}$$

**Q.113** A particle was at rest from 9.00 a.m. to 9.30 a.m. It moved at a uniform speed of 10 km/h from 9.30 a.m. to 10.00 a.m. Find the average speed between

- (a) 9.00 a.m. and 10.00 a.m.
- (b) 9.15 a.m. and 10.00 a.m.

**Ans.**

(a) The distance moved by the particle between 9.30 a.m. and 10.00 a.m. is

$$s = vt = 10 \frac{\text{km}}{\text{h}} \times \frac{1}{2} \text{ h} = 5 \text{ km.}$$

This is also the distance moved between 9.00 a.m. and 10.00 a.m. Thus, the average speed during this interval is

$$v_{av} = \frac{s}{t} = \frac{5\text{km}}{1\text{h}} = 5\text{km/h.}$$

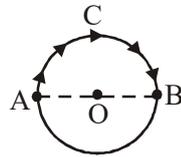
- (b) The distance moved between 9.30 a.m. and 10.00 a.m. is 5 km. This is also the distance moved in the interval 9.15 a.m. to 10.00 a.m. The average speed during this interval is

$$v_{av} = \frac{s}{t} = \frac{5\text{km}}{45\text{min}} = \frac{5\text{km}}{\left(\frac{45}{60}\right)\text{h}}$$

$$= \frac{5 \times 60}{45} \text{ km/h} \approx 6.67 \text{ km/h.}$$

**Q.114** An insect moves along a circular path of radius 10 cm with a constant speed. If it takes 1 minute to move from a point on the path to the diametrically opposite point, find

- (a) the distance covered,  
 (b) the speed,  
 (c) the displacement, and  
 (d) the average velocity.



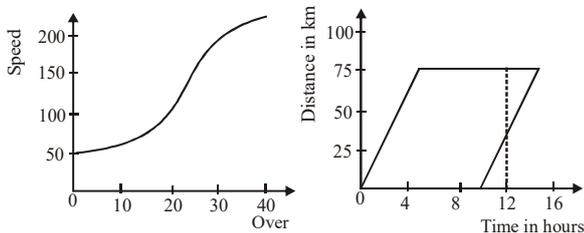
**Ans.** Suppose the insect was at A initially, and it moved along ACB to reach the diametrically opposite point B in 1 minute.

- (a) The distance moved in 1 minute =  $\pi r = 3.14 \times 10 \text{ cm} = 31.4 \text{ cm.}$   
 (b) The speed is  $\frac{31.4\text{cm.}}{1\text{min}} = 31.4 \text{ cm/min.}$   
 (c) The displacement is  $AB = 2r = 20 \text{ cm}$  in the direction A to B.  
 (d) The average velocity is

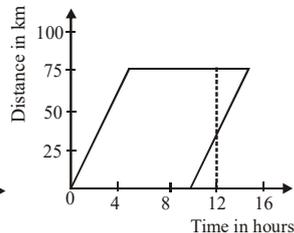
$$v_{av} = \frac{\text{displacement}}{\text{time}} = \frac{20\text{cm}}{1\text{min}} = 20 \text{ cm/min}$$

in the direction A to B.

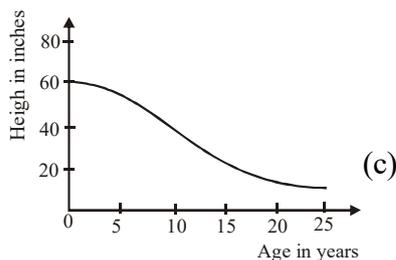
**Q.115** What is wrong with the following graphs ?



(a)



(b)



(c)

- (a) Score-over graph in a one-day  
 (b) Distance-time graph for an object cricket match  
 (c) Height-age graph for a person

**Ans.**

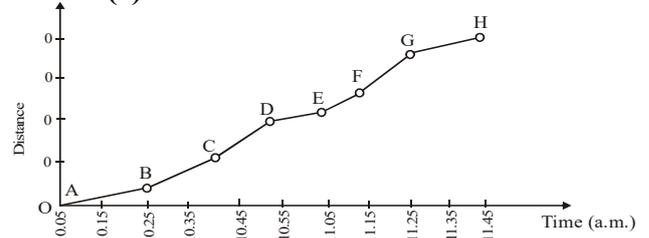
- (a) 50 runs are shown at the end of the 0th over, i.e., at the beginning. This is not possible in a one-day cricket match under the present rules.  
 (b) If we draw a perpendicular on the time-axis at the point corresponding to 12 hours, it cuts the graph at two points. One corresponds to 25 km and the other corresponds to 75 km. Thus according to the graph, the distance travelled in 12 hours is 25 km as well as 75 km, which is not possible.  
 (c) According to the graph, the height of a person gradually decreases as his age increases. Such a thing does not happen.

**Q.116** The distance-time table for a car is given. Assuming that the car moves with uniform speed between the indicated times, answer the following questions.

- (a) Plot the graph of the distance travelled with time.  
 (b) During which period was the car travelling at the greatest speed?  
 (c) During which period was the car moving with the least speed?  
 (d) What is the average speed of the car between 10.05 a.m. and 11.00 a.m.?  
 (e) What is the average speed of the car for the entire journey?

Time	Distance in km
10.05 am	0
10.25 am	5
10.40 am	12
10.50 am	22
11.00 am	23
11.10 am	28
11.25 am	38
11.40 am	42

**Ans.**



The graph is shown in figure. The consecutive points are joined by straight lines. This is because we have assumed that the car moves with uniform speed in each interval.

- (b) The greatest inclination (slope) with the time-axis occurs in the part CD of the graph. Thus, the speed is the greatest in this part, i.e., between 10.40 a.m. and 10.50 a.m.
- (c) The least inclination with the time-axis occurs in the part EF. Thus, the speed is the least in this part, i.e., between 11.00 a.m. and 11.10 a.m.
- (d) The distance travelled between 10.05 a.m. and 11.00 a.m. is 26 km. The time interval is 55 min. The average speed is

$$v = \frac{26\text{km}}{55\text{min}} = \frac{26\text{km}}{\left(\frac{55}{60}\right)\text{h}}$$

$$= \frac{26 \times 60}{55} \text{ km/h} \approx 28.4 \text{ km/h.}$$

- (e) The total distance travelled is 42 km and the total time taken is 1 h 35 min. The average speed is

$$v = \frac{42\text{km}}{1\text{h}35\text{min}} = \frac{42\text{km}}{\left(1 + \frac{35}{60}\right)\text{h}}$$

$$= \frac{42 \times 60}{95} \text{ km/h} \approx 26.5 \text{ km/h.}$$

- Q.117** A train is moving at a speed of 40 km/h at 10.00 a.m. and at 50 km/h at 10.02 a.m. Assuming that the train moves along a straight track and the acceleration is constant, find the value of the acceleration.

**Ans.** The acceleration is

$$a = \frac{v - u}{t} = \frac{50\text{km/h} - 40\text{km/h}}{2\text{min}}$$

$$= \frac{10\text{km/h}}{\left(\frac{2}{60}\right)\text{h}} = \frac{10 \times 60}{2} \text{ km/h}^2 = 300 \text{ km/h}^2.$$

- Q.118** A particle with a velocity of 2 m/s at  $t = 0$  moves along a straight line with a constant acceleration of  $0.2 \text{ m/s}^2$ . Find the displacement of the particle in 10 s.

**Ans.**

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

$$= (2\text{m/s})(10\text{s}) + \frac{1}{2} (0.2 \text{ m/s}^2)(10\text{s})^2$$

$$= 20\text{m} + 10\text{m} = 30\text{m.}$$

- Q.119** A particle is pushed along a horizontal surface in such a way that it starts with a velocity of 12 m/s. Its velocity decreases at a rate of  $0.5 \text{ m/s}^2$ . (a) Find the time it will take to come to rest. (b) Find the distance covered by it before coming to rest.

**Ans.**

- (a) Initial velocity  $u = 12 \text{ m/s}$   
 Acceleration  $a = -0.5 \text{ m/s}^2$  (as the velocity is decreasing)  
 Final velocity  $v = 0$  (as it comes to rest)  
 We have  $v = u + at$   
 or  $0 = (12 \text{ m/s}) + (-0.5 \text{ m/s}^2)t$   
 or  $(0.5 \text{ m/s}^2)t = 12 \text{ m/s}$

$$\text{or } t = \frac{12\text{m/s}}{0.5\text{m/s}^2} = \frac{12}{0.5} \frac{\text{m}}{\text{s}} \times \frac{\text{s}^2}{\text{m}} = 24 \text{ s}$$

So the particle takes 24 s to stop.

- (b) We have  $v^2 = u^2 + 2aS$ .  
 or  $0 = (12 \text{ m/s})^2 + 2(-0.5 \text{ m/s}^2)S$   
 or  $(1 \text{ m/s}^2)S = 144 \text{ m}^2/\text{s}^2$

$$\text{or } S = \frac{144 \text{ m}^2/\text{s}^2}{1 \text{ m/s}^2} = 144 \text{ m.}$$

So the particle covers 144 m before stopping.

- Q.120** A train accelerates from 20 km/h to 80 km/h in 4 minutes. How much distance does it cover in this period? Assume that the tracks are straight.

**Ans.** We will first find the acceleration and then the distance.

At  $t = 0$ , the velocity is  $u = 20 \text{ km/h}$

$$\text{At } t = 4 \text{ min} = \frac{1}{15} \text{ h,}$$

the velocity is  $v = 80 \text{ km/h}$ .

Using  $v = u + at$ ,

$$a = \frac{v - u}{t} = \frac{80\text{km/h} - 20\text{km/h}}{\left(\frac{1}{15}\right)\text{h}}$$

$$= 60 \text{ km/h}^2 \times 15 = 900 \text{ km/h}^2.$$

The distance covered is

$$x = ut + \frac{1}{2} at^2 = (20 \text{ km/h}) \times \left(\frac{1}{15} \text{ h}\right) + \frac{1}{2}$$

$$(900 \text{ km/h}^2) \times \left(\frac{1}{15} \text{ h}\right)^2$$

$$= \frac{20}{15} \text{ km} + 2 \text{ km} = \frac{10}{3} \text{ km.}$$

**Q.121** A car moving along a straight line at a speed of 54 km/h stops in 5 seconds after the brakes are applied.

- (a) Find the acceleration, assuming it to be constant.
- (b) Plot the graph of speed versus time.
- (c) Using the graph, find the distance covered by the car after the brakes are applied.

**Ans.** (a) The initial velocity is

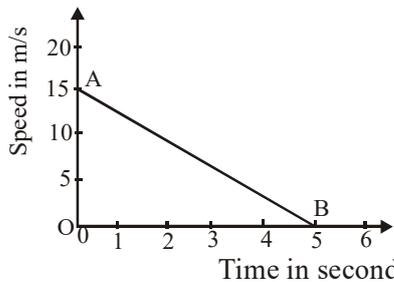
$$u = 54 \text{ km/h} = \frac{54 \text{ km}}{1 \text{ h}} = \frac{54 \times 1000 \text{ m}}{3600 \text{ s}} = 15 \text{ m/s}$$

The velocity  $v$  at  $t = 5 \text{ s}$  is zero.

The acceleration is

$$a = \frac{v - u}{t} = \frac{0 - 15 \text{ m/s}}{5 \text{ s}} = -3 \text{ m/s}^2$$

Since the sign of the acceleration is opposite to that of the velocity, the car is decelerating. At  $t = 0$ , the speed is 15 m/s, and at  $t = 5 \text{ s}$ , it is 0. Thus, we get two point A and B on the graph (figure).



The acceleration is constant and the car moves in a fixed direction, the speed-time graph should be a straight line. Therefore we join the points A and B by a straight line to get the required graph.

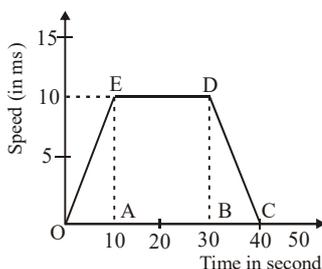
- (c) The distance covered between 0 and 5 s is equal to the area under the graph, i.e., the area of the triangle OAB.

$$\text{It is } \frac{1}{2} \times \text{height} \times \text{base}$$

$$= \frac{1}{2} \times (15 \text{ m/s}) \times (5 \text{ s}) = 37.5 \text{ m.}$$

**Q.122** Figure shows the speed-time graph of a particle.

Find the distance travelled in the time interval 0 to 40s.



**Ans.** The distance travelled is equal to the area under the graph. From figure, this area is equal to the area of the triangle OAE + the area of the rectangle ABDE + the area of the triangle BCD.

The areas of the triangle OAE is

$$A_1 = \frac{1}{2} \times \text{OA} \times \text{AE}$$

$$= \frac{1}{2} \times (10 \text{ s}) \times (10 \text{ m/s}) = 50 \text{ m.}$$

The area of the rectangle ABDE is

$$A_2 = \text{AE} \times \text{AB} = (10 \text{ m/s}) \times (20 \text{ s}) = 200 \text{ m.}$$

The area of the triangle BCD is

$$A_3 = \frac{1}{2} \times \text{BC} \times \text{BD}$$

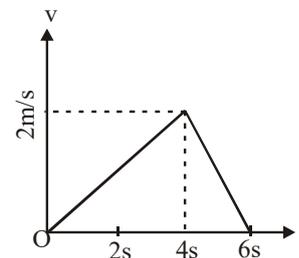
$$= \frac{1}{2} \times (10 \text{ s}) \times (10 \text{ m/s}) = 50 \text{ m.}$$

The total area is  $A_1 + A_2 + A_3$

$$= 50 \text{ m} + 200 \text{ m} + 50 \text{ m} = 300 \text{ m.}$$

The total distance covered is 300 m.

**Q.123** The velocity-time graph of a particle moving along a straight line is



shown in figure.

- (a) Is the motion uniform ?
- (b) Is the acceleration uniform?
- (c) Does the particle change its direction of motion?
- (d) Find the distances covered from 0 to 4s and from 4 to 6s.

**Ans.**

- (a) The velocity is changing with time. So the motion is not uniform.
- (b) The acceleration is given by the slope of the velocity-time graph. The slope are different before and after  $t = 4 \text{ s}$ . So the acceleration is not uniform for the entire time shown. It is uniform between 0 and 4 s and also between 4 and 6 s as the slope does not change in these periods.

- (c) The velocity always remains positive. It means that the particle keeps moving in the positive direction. In other words, it does not change direction.
- (d) The displacement during the period 0–4 s is equal to the area under the velocity-time graph for this period. This area is in the shape of a triangle.

$$\text{Area of the triangle} = \frac{1}{2} \times \text{base} \times \text{height}$$

$$= \frac{1}{2} \times 4\text{ s} \times (2 \text{ m/s}) = 4 \text{ m.}$$

As the particle moves in the same direction, this is also the distance moved.

For the period 4–6s, the area is

$$\frac{1}{2} (2\text{ s}) \times 2 \left( \frac{\text{m}}{\text{s}} \right) = 2\text{ m.}$$

So the particle moves 2m in this period.

**EXERCISE -III**

**Subjective Stuff**



**VERY SHORT TYPE QUESTIONS:**

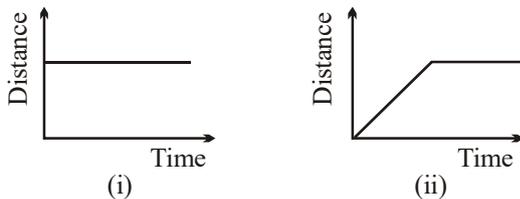
**Q.1** Name a physical quantity that essentially changes as a body moves.

**Ans.** Distance.

**Q.2** Give an expression for the speed of an athlete if he takes time 't' to go around a circular track, of radius r.

**Ans.**  $v = \frac{2\pi r}{t}$

**Q.3** What kind of motion of a body is represented by the graphs given below ?



**Ans.** (i) object is at rest.  
(ii) Object has non-uniform motion.

**Q.4** Which of the following is true for displacement ? (a) It cannot be zero. (b) Its magnitude is greater than the distance travelled by the object.

**Ans.** None of the statement (a) or (b) is true for displacement.

**Q.5** What does the path of an object look like when it is in uniform motion ?

**Ans.** The path of an object will be a straight line.

**Q.6** Mention the nature of motion of a body if its displacement-time graph is a straight line parallel to time axis.

**Ans.** No motion.

**Q.7** Under what condition will the magnitude of the displacement be equal to the distance travelled by an object ?

**Ans.** When the object moves along a straight line.

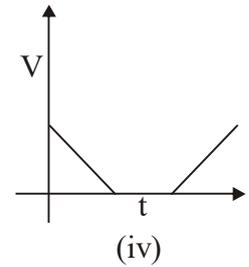
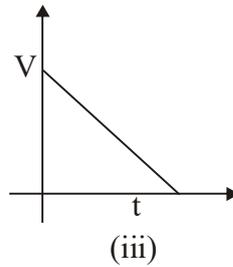
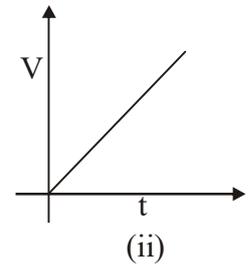
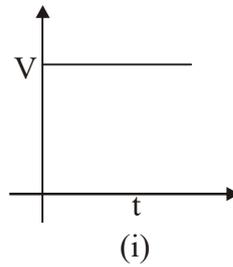
**Q.8** A bus covers equal distance in equal intervals of time. What type of motion does the bus exhibit ?

**Ans.** Uniform motion.

**Q.9** Name the physical quantity which corresponds to the rate of change of momentum.

**Ans.** Force.

**Q.10** What can we conclude about the motion of a body depicted by following velocity-time graphs ?



**Ans.** (i) It represents a body moving with uniform velocity.  
(ii) It represents a body moving with uniform acceleration.  
(iii) It represents a body moving with uniform retardation  
(iv) It represents a body first retarding uniformly, remaining at rest for some time, and then accelerating uniformly

**SHORT TYPE QUESTIONS :**

**Q.11** Which of the following is true for displacement ? Justify your answer for the true statement.

- (i) It can be zero.
- (ii) Its magnitude is greater than the distance travelled by the object.

**Ans.** (i) True, e.g., if an object returns back to its original position.  
(ii) False. Magnitude of displacement can be equal to or less than the distance travelled.

**Q.12** What is the relation between distance and time:

- (i) when body is moving with uniform velocity?
- (ii) body is moving with variable velocity ?

**Ans.** (i) The distance covered by the body is directly proportional to time.  
(ii) The distance covered by the body not directly proportional to time.

**Q.13** When is the acceleration :

- (i) positive
- (ii) negative ?

**Ans.** (i) If the velocity of a body is increasing with respect to time, the acceleration is said to be positive.  
 (ii) If the velocity of a body is decreasing with respect to time, the acceleration is said to be negative.

**Q.14** Differentiate between distance and displacement.

Any three differences.

S.No.	Distance	Displacement
1.	It is defined as the actual path traversed by a body.	It is the shortest distance between two points between which the body moves
2.	It is a scalar quantity.	It is a vector quantity.
3.	It can never be negative or zero.	It can be negative, zero or positive.
4.	Distance can be equal to or greater than displacement.	Displacement can be equal to or less than distance.
5.	Distance travelled is not a unique path between two points.	Displacement is a unique path between two points.
6.	Distance between two points gives full information of the type of path followed by the body.	Displacement between two points does not give full information of the type of path followed by the body.
7.	Distance never decreases with time. For a moving body it is never zero.	Displacement can decrease with time. For a moving body it can be zero.
8.	Distance in SI is measured in metre.	Displacement in SI is measured in metre.

**Q.15** A fireworks shell is accelerated from rest to a velocity of  $50 \text{ m s}^{-1}$  over a distance of 0.250 m. Calculate the acceleration. How long did the acceleration last ?

**Ans.** Given  $u = 0$ ,  $v = 50 \text{ m s}^{-1}$ ,  
 $S = 0.250 \text{ m}$ ,  $a = ?$ ,  $t = ?$

Using

$$a = \frac{(v^2 - u^2)}{2S} = \frac{(50)^2 - (0)^2}{2 \times 0.250}$$

$$= 5000 \text{ m s}^{-2}$$

$$\text{and } t = \frac{(v - u)}{a} = \frac{(50 - 0)}{5000} = 0.01 \text{ s}$$

**Q.16** Give one example for each of the type of motion when:

- (i) acceleration is in the direction of motion.
- (ii) acceleration is against the direction of motion.
- (iii) acceleration is uniform.

**Ans.**

- (i) The motion of a car when it starts from rest and increases its velocity at a constant rate in a particular interval of time.
- (ii) The motion of a train when it slows down while approaching a station.
- (iii) The motion of a ball falling down freely.

**Q.17** A bus is moving to the left (has a negative velocity) slows down and then comes to a stop:

- (i) What is the direction of its acceleration? Is the acceleration positive or negative?
- (ii) What is the sign of acceleration that reduces the magnitude of a positive velocity?

**Ans.** (i) To the right side. The acceleration is negative.  
 (ii) Negative.

**Q.18** (a) A body thrown vertically upwards reaches a maximum height  $h$ . It then returns to ground. Calculate the distance travelled and its displacement.

(b) In a long distance race, the athletes were expected to take four rounds of the track such that the line of finish was same as the line of start. Suppose the length of the track was 200 m.

- (i) What is the total distance to be covered by the athletes ?  
 (ii) What is the displacement of the athletes when they touch the finish line?  
 (iii) Is the motion of the athletes' uniform or non-uniform?

**Ans.** (a) Here, Distance travelled =  $h + h = 2h$   
 Displacement = 0  
 (b) Length of the track = 200 m.  
 (i) Total distance to be covered by the athletes in four rounds =  $200 \times 4 = 800$  m.  
 (ii) Displacement of the athletes when they touch the finish line = 0.  
 (iii) Non-uniform.

**Q.19** A cheetah can accelerate from rest at the rate of  $4 \text{ m s}^{-2}$ .

- (i) What will be the velocity attained by it in 10s ?  
 (ii) How far will it travel in this duration?

**Ans.** Given,  $u = 0$ ,  $a = 4 \text{ m s}^{-2}$   
 (i) From the first equation of motion,  
 $v = u + at = 0 + 4 \times 10 = 40 \text{ m s}^{-1}$   
 (ii) From the second equation of motion,  
 $S = ut + \frac{1}{2}at^2 = 0 \times 10 + \frac{1}{2} \times 4 \times (10)^2$   
 $= 200 \text{ m}.$

**Q.20** State which of the following situations are possible and give an example of each of these :

- (a) A body moving with constant acceleration but with zero velocity.  
 (b) A body moving horizontally with an acceleration in vertical direction.  
 (c) A body moving with a constant speed in an accelerated motion.

**Ans.**  
 (a) Yes, at the highest point of a body thrown vertically upwards. At the highest point the body's velocity is zero but it has an acceleration of  $9.8 \text{ m s}^{-2}$  in the downward direction.  
 (b) Yes, a projectile fired at an angle has a uniform velocity along the horizontal, but its motion along the vertical is uniformly accelerated.  
 (c) Yes, when a body moves along a circular path with constant speed. In this situation, the speed is constant but due to change in direction the body possesses acceleration.

**Q.21** Explain the following type of motion with one example of each :

- (i) Acceleration is positive.  
 (ii) Acceleration is negative.  
 (iii) Acceleration is zero.

**Ans.** (i) Here, the motion is accelerated motion.  
 Ex. A car moving on a road with increasing velocity.  
 (ii) Here, the motion is retarded motion. Ex. Brakes applied to a moving car.  
 (iii) Here, the motion is uniform motion. Ex. Motion of the second's hand of a clock.

**Q.22** Answer the following questions :

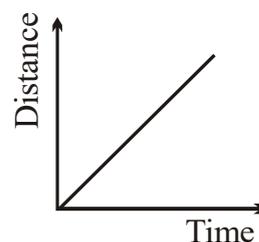
- (i) State the type of motion shown by a freely falling stone.  
 (ii) When a stone is thrown vertically upwards its velocity is continuously decreased. Why?  
 (iii) Give an example of a motion in which average velocity is zero, but the average speed is not zero.

**Ans.** (i) Accelerated motion  
 (ii) The stone is continuously being attracted by the earth, this causes retardation in the stone's motion, hence its velocity goes on decreasing continuously.  
 (iii) Uniform circular motion.

**Q.23** (a) When will You say a body is in:

- (i) uniform motion ?  
 (ii) non-uniform motion ?  
 (b) Show the path of an object when it is in uniform motion with the help of a graph.

**Ans.** (a)  
 (i) When it covers equal displacements in equal intervals of time.  
 (ii) When it does not covers equal displacements in equal intervals of time.  
 (b) The distance-time graph is as shown. For uniform motion.



**Q.24** An electric engine has a velocity of 120 km h<sup>-1</sup>. How much distance will it travel in 30 s ?

**Ans.**  $\text{Velocity} = \frac{\text{distance}}{\text{time}}$

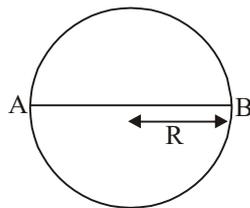
Distance = velocity × time ,

Therefore,  $S = \frac{120 \times 1000}{3600} \times 30 = 1000\text{m}$

**Q.25** A person is running along a circular path in a park.

- (a) At what point he changes his direction while running ?
- (b) If he covered half of the circular path, what will be his displacement ? Draw a diagram showing it.

**Ans.** (a) At each and every point.  
(b) Displacement = Diameter of the circle.



**Q.26** An object is moving with uniform speed in a circle of radius 7 m. Calculate the distance and displacement when it completes half the circle. What type of motion does the object possess ?

**Ans.** When it completes half cycle, then

Distance =  $\pi R = \frac{22}{7} \times 7 = 22\text{m}$

Displacement = 14 m

It posses uniform circular motion.

**Q.27** A cyclist goes once around a circular track of diameter 105 metre in 5 minutes. Calculate his speed.

**Ans.** Given, D = 105 m, R = 105/2 = 52.5 m,  
t = 5 × 60 = 300s

Now, speed =  $\frac{\text{distance}}{\text{time}}$

=  $\frac{2 \times 3.14 \times 52.5}{300} = 1.1\text{ms}^{-1}$

**Q.28** A train is travelling at a speed of 90 km h<sup>-1</sup>. Breaks are applied so as to -0.5 ms<sup>-2</sup>. Find how far the train will go before it is brought to rest.

**Ans.** Given, u = 90 km h<sup>-1</sup> =  $90 \times \frac{5}{18} = 25 \text{ m s}^{-1}$ ,

v = 0, a = - 0.5 m s<sup>-2</sup>, S = ?

Using

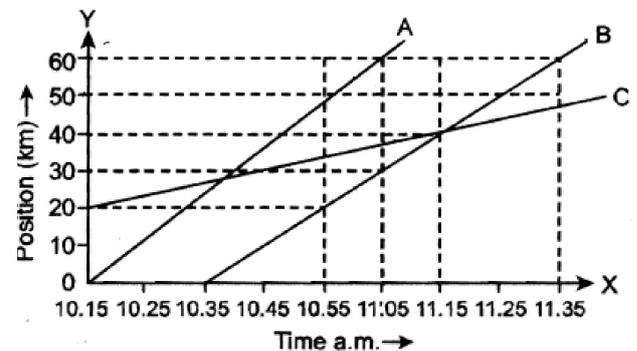
$v^2 - u^2 = 2aS$

$0 - (25)^2 = 2 \times - 0.5 \times S$

or S = 625 m

**LONG TYPE QUESTIONS:**

**Q.29** The position-time graph of three objects A, Band C in motion is shown below :



- (i) Which of the three is travelling fastest?
- (ii) Do any of the three objects meet at the same point on the road?
- (iii) How far has C travelled at 11:15 a.m.?
- (iv) Calculate the average speed of object B between 10:15 to 11:35 a.m.
- (v) How much is A ahead of B at 10:55 a.m.?

**Ans.** (i) A is travelling fastest.  
(ii) Yes, firstly A and C meet at the same point on the road at 10:35 a.m., then B and C meet at another point on the road at 11 :15 a.m.

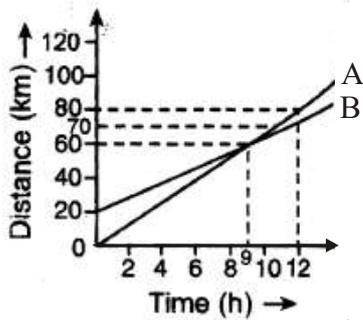
(iii) 20 km.

(iv) Total distance travelled by B between 10: 15 to 11 :35 a.m. = 60 km

Average speed =  $\frac{60 \text{ km}}{80 \text{ min}} = \frac{60 \times 60}{80} = 45\text{km h}^{-1}$

(v) 50 km – 20 km = 30 km.

**Q.30** Distance -time graph represents the motion of two buses A and B:



- (i) What is the distance by which bus B was ahead of bus A initially?
- (ii) Do they ever meet each other? If so, when?
- (iii) What is the distance travelled by bus A when it overtakes bus B?
- (iv) Find out the distance by which bus A was ahead of bus B at  $t=12$  h.
- (v) Which one of them is moving faster? Give reason.

**Ans.**

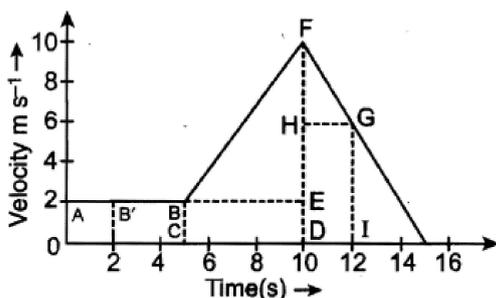
- (i) 20 km.
- (ii) Yes, they meet after 9 hour.
- (iii) 60 km
- (iv)  $80 - 70 = 10$  km.
- (v) A moves faster as its slope is higher than that of B.

**Q.31** A body moves with a velocity of  $2 \text{ m s}^{-1}$  for 5 s, then its velocity increases uniformly to  $10 \text{ m s}^{-1}$  in next 5s. Thereafter, its velocity begins to decrease at a uniform rate until it comes to rest after 5 s.

- (i) Plot a velocity-time graph for the motion of the body.
- (ii) From the graph, find the total distance covered by the body after 2 s and 12 s.

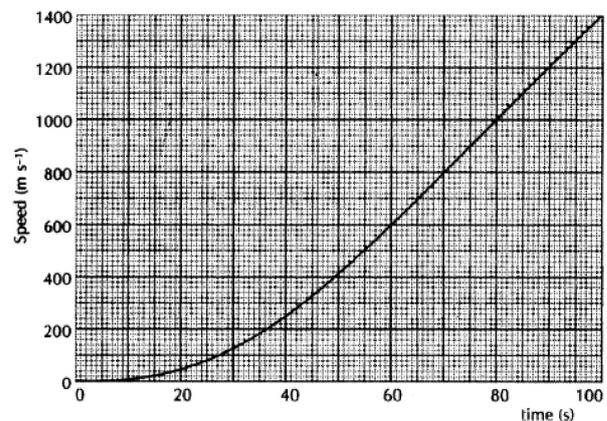
**Ans.**

(i) The velocity-time graph is as shown :



(ii) According to the graph :  
 Distance moved by the body after 2s = Area OAB'C' =  $2 \times 2 = 4$  m  
 Distance covered by the body after 12s = Area OAED + Area BEF + Area of DHGI + Area of FHG =  $2 \times 10 + \frac{1}{2} \times 5 \times 8 + 6 \times 2 + \frac{1}{2} \times 2 \times 4 = 56$  m

**Q.32** Following figure is the speed-time graph for a rocket from the moment when the fuel starts to burn, i.e., at time  $t=0$ .



- (a) State the acceleration of the rocket at  $t=0$
- (b) State what happens to the acceleration of the rocket between  $t=5$  s and  $t=60$  s.
- (c) Calculate the acceleration of the rocket at  $t=80$  s. Give reason for your answer.
- (d) The total mass of the rocket at  $t=80$ s is  $1.6 \times 10^6$  kg. Calculate the resultant force on the rocket at this time. Give reason for your answer.

**Ans.**

- (a) No net acceleration,
- (b) Increases after 10 sec. till  $t=50$  sec. after  $t=50$  s acceleration is constant till  $t=100$  s
- (c) Zero,  $a = \frac{\Delta v}{\Delta t} = \frac{1400 - 400}{50} = \frac{1000}{50} = 20 \text{ m/s}^2$   
 $t=80$ s,  $a = 20 \text{ m/s}^2$
- (d) Zero as it is moving with constant velocity.  
 $F = 1.6 \times 10^6 \times 20$   
 $F = 32 \times 10^6 \text{ N}$

EXERCISE-IV

Competitive Edge



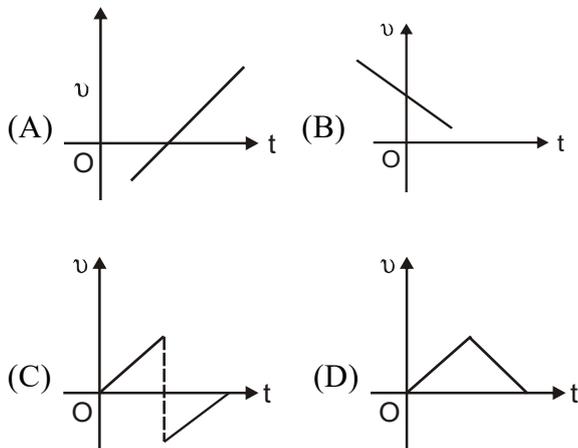
**Q.1** A student starts with a velocity 40 km/hr for school at 4 km away from his house. Due to closing of school he returns soon to his house with a velocity of 60 km/hr. His average velocity will be:

(Raj./NTSE Stage-I/2007)

- (A) zero
- (B) 10 km/hr
- (C) 48 km/hr
- (D) 50 km/hr

**Q.2** The velocity-time graph of a body falling rest under gravity and rebounding from a solid surface is represented by :

(Raj./NTSE Stage-I/2014)

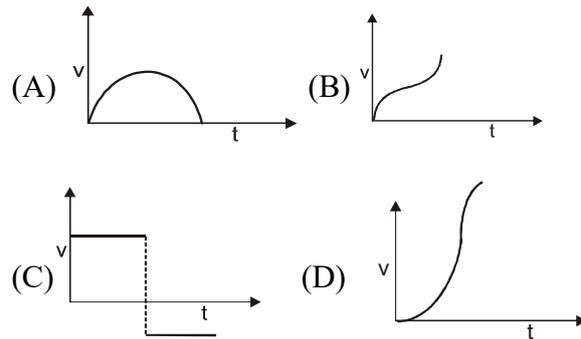
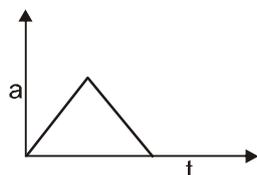


**Q.3** A bullet of mass 10 g travelling horizontally with a velocity of  $160 \text{ ms}^{-1}$  strikes a stationary wooden block and comes to rest in 0.02 s. The distance of penetration of the bullet into the block will be :

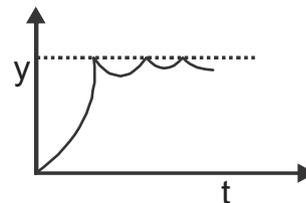
(Raj./NTSE Stage-I/2014)

- (A) 1.20 m
- (B) 1.60 m
- (C) 2.00 m
- (D) 2.40 m

**Q.4** The acceleration versus time graph of an object is as shown in figure. The corresponding velocity-time graph of the object is : (Raj./NTSE Stage-I/2014)



**Q.5** The graph below describe the motion of a ball rebounding from a horizontal surface being released from a point above the surface. (Haryana/NTSE Stage-I/2014)



The quantity represented in the y-axis is the ball's

- (A) displacement
- (B) velocity
- (C) acceleration
- (D) momentum

**Q.6** Value of one Fermi is :

(M.P./NTSE Stage-I/2014)

- (A)  $10^{-13}$  metre
- (B)  $10^{-14}$  metre
- (C)  $10^{-15}$  metre
- (D)  $10^{-16}$  metre

**Q.7** Correct relation is .....

(M.P./NTSE Stage-I/2015)

- (A)  $v^2 = u^2 + 2a^2s^2$
- (B)  $v^2 = u^2 - 2a^2s^2$
- (C)  $v^2 = u^2 + 2as$
- (D)  $v^2 = u^2 + 2a^2s$

**Q.8** A ball hits a wall horizontally with a velocity of  $6.0 \text{ ms}^{-1}$ . After hitting wall it rebounds horizontally with a velocity of  $4.4 \text{ ms}^{-1}$ . If the ball remains in the contact with wall for 0.040 sec. the acceleration of ball would be:

(Uttarakhand/NTSE Stage-I/2015)

- (A)  $-260 \text{ m/s}^2$
- (B)  $+260 \text{ m/s}^2$
- (C)  $-26 \text{ m/s}^2$
- (D)  $+26 \text{ m/s}^2$

**Q.9** The speed of a train decreases from 80 km/hour to 60 km/hr in 5 seconds. In this process, find out the acceleration of the train : **(Uttarakhand/NTSE Stage-I/2015)**  
 (A) 2.22 m/sec<sup>2</sup> (B) -2.22 m/sec<sup>2</sup>  
 (C) -1.11 m/sec<sup>2</sup> (D) 1.11 m/sec<sup>2</sup>

**Q.10** A ball thrown vertically upward returns to the thrower after 6s. The ball is 5m below the highest point at t=2s. The time at which the body will be at same position, (take g = 10 m/s<sup>2</sup>)  
**(Delhi/NTSE Stage-I/2015)**

- (A) 2.5 s (B) 3 s  
 (C) 4 s (D) 5 s

**Q.11** A particle starts its motion from rest under the action of a constant force. If the distance covered in first 10 s is S<sub>1</sub> and that covered in first 20s is S<sub>2</sub> then :

**(Delhi/NTSE Stage-I/2015)**

- (A) S<sub>2</sub> = S<sub>1</sub> (B) S<sub>2</sub> = 2S<sub>1</sub>  
 (C) S<sub>2</sub> = 3S<sub>1</sub> (D) S<sub>2</sub> = 4 S<sub>1</sub>

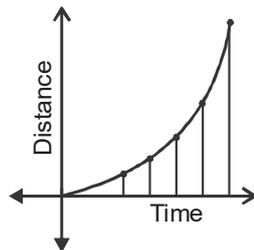
**Q.12** A car travels 40 km at an average speed of 80 km/h and then travels 40 km at an average speed of 40 km/h. The average speed of the car for this 80 km trip is :

**(Raj./NTSE Stage-I/2015)**

- (A) 40 km/h (B) 45 km/h  
 (C) 48 km/h (D) 53 km/h

**Q.13** Which motion does the graph of distance and time shows for accelerated motion ?

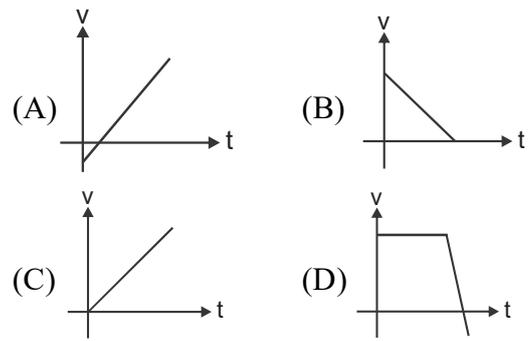
**(Gujrat/NTSE Stage-I/2015)**



- (A) non uniformly accelerated  
 (B) constant velocity  
 (C) uniformly accelerated  
 (D) uniformly retarded motion

**Q.14** A body is dropped from certain height from a uniformly ascending balloon. The correct graph showing variation of velocity with time for body is

**(Haryana/NTSE Stage-I/2015)**



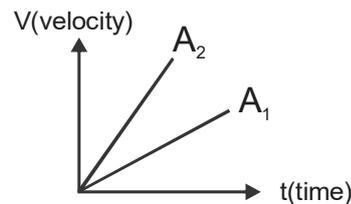
**Q.15** A stone is dropped from the top of a tower. Its velocity after it has fallen 20 m is (take g = 10 m/s<sup>2</sup>)

**(Bihar/NTSE Stage-I/2015)**

- (A) -10 m/s (B) 10 m/s  
 (C) -20 m/s (D) 20 m/s

**Q.16** In the adjacent V -T diagram what is the relation between acceleration A<sub>1</sub> and A<sub>2</sub> ?

**(West Bengal/NTSE Stage-I/2015)**



- (A) A<sub>2</sub> = A<sub>1</sub> (B) A<sub>2</sub> > A<sub>1</sub>  
 (C) A<sub>2</sub> < A<sub>1</sub> (D) Cannot be predicted

**Q.17** A car covers 30 km at a uniform speed of 60 km/hr and the next 30 km at a uniform speed of 40 km/hr. The total time taken is :

**(M.P./NTSE Stage-I/2017)**

- (A) 30 min (B) 45 min  
 (C) 75 min (D) 120 min

**Q.18** Tripling the speed of a motor car multiplies the distance needed for stopping it by :

**(Haryana/NTSE Stage-I/2017)**

- (A) 3 (B) 6  
 (C) 9 (D) 12

**Q.19** Two particles of masses m<sub>1</sub> and m<sub>2</sub> are allowed to fall freely from height h<sub>1</sub> and h<sub>2</sub>. They reach the ground at time t<sub>1</sub> and t<sub>2</sub> respectively. Then

**(West Bengal/NTSE Stage-I/2017)**

- (A)  $\frac{t_1}{t_2} = \sqrt{\frac{h_1}{h_2}}$  (B)  $\frac{t_1}{t_2} = \sqrt{\frac{h_2}{h_1}}$   
 (C)  $\frac{t_2}{t_1} = \frac{h_2}{h_1} c$  (D)  $\frac{t_2}{t_1} = \frac{h_1}{h_2}$

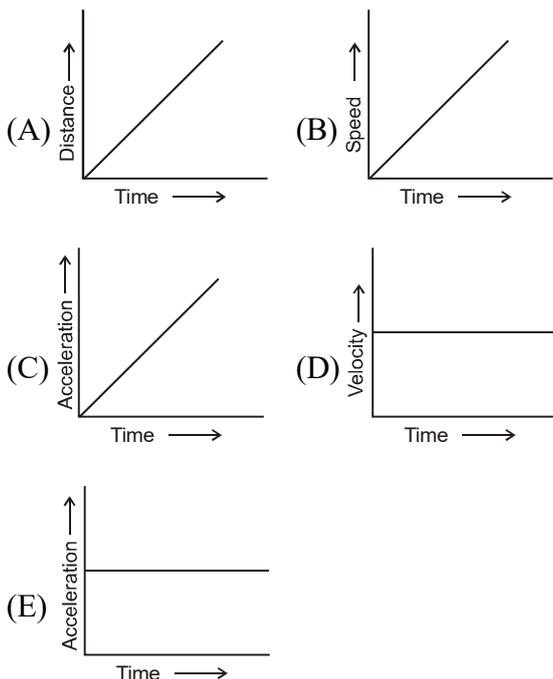
**Q.20** Position of a particle moving along x-axis is given by  $x = 3t - 4t^2 + t^3$ , where x is in metre and t is in second. Find the average velocity of the particle in the time interval from  $t = 2$  second to  $t = 4$  second.

(West Bengal/NTSE Stage-I/2017)

- (A) 7 m/s (B) 1 m/s  
(C) 13 m/s (D) 5 m/s

**Q.21** Consider the following five graphs (note the axes carefully) Which of the following represents motion at constant speed?

(Raj./NTSE Stage-I/2018)



- (A) D only (B) D and E  
(C) A, B and C (D) A, B and D

**Q.22** A ball is shot vertically upward with a given initial velocity. It reaches a maximum height of 100 m. If on second shot, the initial velocity is doubled then the ball will reach a maximum height of

(Raj./NTSE Stage-I/2018)

- (A) 70.7 m (B) 141.4 m  
(C) 200 m (D) 400 m

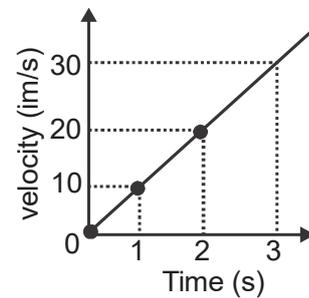
**Q.23** A body falls freely from a tower and travels a distance of 40 m in its last two second. The height of the tower is (take  $g = 10 \text{ m/s}^2$ ):

(Delhi/NTSE Stage-I/2018)

- (A) 54 m (B) 45 m  
(C) 80 m (D) 65 m

**Q.24** Velocity-time graph of a boyd moving with uniform acceleration is shown in the diagram. The distance travelled by the body in 3 seconds is :

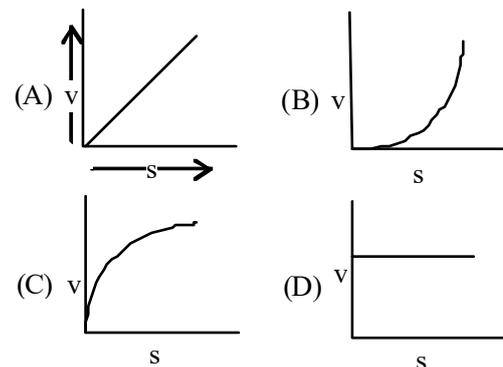
(Raj./NTSE Stage-I/2019)



- (A) 90 m (B) 45 m  
(C) zero (D) 10 m

**Q.25** A body is dropped from rest. Its velocity varies with displacement covered as :

(Haryana /NTSE Stage - I/2019)



**Q.26** The initial velocity of a particle is 10 m/s. It is moving with an acceleration of  $4 \text{ m/s}^2$ . The distance covered by the particle after 2s is

(Raj./NTSE Stage-I/2019)

- (A) 6 m (B) 18 m  
(C) 22 m (D) 28 m

**Q.27** Two steel balls of mass 1 kg and 2 kg and a lead ball of 10 kgs are released together from the top of tower 30 m high. Assuming the path to be in vacuum ?

(UP/NTSE Stage - I/2019)

- (A) the lead ball reaches the ground earlier.  
(B) the 1 kg iron ball reaches the ground earlier.  
(C) all the balls reach the ground simultaneously.  
(D) the 2 kgs steel ball reaches the ground earlier.

**Q.28** The distance-time graph of a particle makes an angle  $45^\circ$  with the time axis. After 1 second it makes an angle  $60^\circ$  with the time axis. What is the average acceleration of the particle during this time interval?

(West Bengal/NTSE Stage - I/2019)

- (A)  $(\sqrt{3} - 1)$  unit      (B)  $(\sqrt{3} + 1)$  unit  
(C)  $(\sqrt{3})$  unit      (D) (A) unit

**Q.29** Parsec is the unit of :

(Bihar/NTSE Stage - I/2019)

- (A) distance      (B) time  
(C) velocity      (D) angle

**Q.30** The ratio of displacement to distance of a moving object is

(Chhattisgarh/NTSE Stage - I/2020)

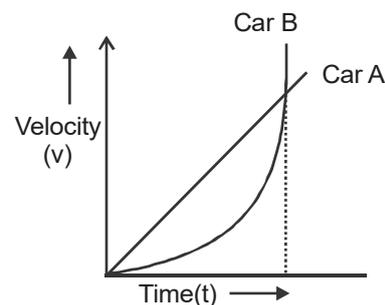
- (A) More than 1  
(B) Less than 1  
(C) Equal to or less than 1  
(D) Equal to or more than 1

**Q.31** Two bodies of masses  $m_a$  &  $m_b$  ( $m_a > m_b$ ) are dropped from height 'a' & 'b' respectively. The ratio of velocities with which they reach ground is:

(Haryana/NTSE Stage - I/2020)

- (A)  $m_a/m_b$       (B)  $a/b$   
(C)  $\sqrt{(am_a/bm_b)}$       (D)  $\sqrt{(a/b)}$

**Q.32** An object is moving in a straight line. The velocity time graph is as shown below. Then (Delhi/NTSE Stage - I/2020)



- (A) In part OA acceleration is increasing  
(B) In part AB acceleration is increasing  
(C) In OA acceleration is decreasing  
(D) In part AB acceleration is decreasing

**Q.33** A car moving along straight line covers  $1/5^{\text{th}}$  of total distance  $v_1$  and remaining part of distance with speed  $v_2$ . The average speed of car over entire distance is.

(Delhi/NTSE Stage - I/2021)

- (A)  $\frac{5v_1v_2}{v_2 + 4v_1}$       (B)  $\frac{4v_1v_2}{5v_1 + v_2}$   
(C)  $\frac{5v_1v_2}{4v_2 + v_1}$       (D)  $\frac{4v_1v_2}{4v_1 + v_2}$

## ANSWER KEY

## EXERCISE-II

## MCQ BASED QUESTIONS :

Q.1	D	Q.2	D	Q.3	D	Q.4	B	Q.5	B	Q.6	A	Q.7	B
Q.8	A	Q.9	C	Q.10	D	Q.11	C	Q.12	D	Q.13	D	Q.14	A
Q.15	D	Q.16	C	Q.17	D	Q.18	D	Q.19	D	Q.20	A	Q.21	A
Q.22	A	Q.23	B	Q.24	C	Q.25	A	Q.26	B	Q.27	C	Q.28	A,B
Q.29	C,D	Q.30	A,B	Q.31	B,C	Q.32	A,B	Q.33	A,B,C	Q.34	A,C	Q.35	A,B,C
Q.36	A,C,D	Q.37	A,B	Q.38	ABCD								

## FILL IN THE BLANKS :

Q.39	Vector	Q.40	Speed	Q.41	Speedometer	Q.42	Acceleration.
Q.43	Retardation	Q.44	Positive	Q.45	Direction of motion	Q.46	Velocity
Q.47	Vector	Q.48	Time	Q.49	Straight line	Q.50	Does not change
Q.51	57.3°						

## MATCH THE COLUMN :

Q.52	A	Q.53	C	Q.54	B
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## ASSERTION &amp; REASON TYPE QUESTIONS:

Q.55	B	Q.56	A	Q.57	A	Q.58	A	Q.59	B	Q.60	A
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## COMPREHENSIVE :

Q.61	C	Q.62	A	Q.63	B
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## EXERCISE-IV

Q.1	A	Q.2	C	Q.3	B	Q.4	D	Q.5	A	Q.6	C	Q.7	C
Q.8	A	Q.9	C	Q.10	C	Q.11	D	Q.12	D	Q.13	C	Q.14	A
Q.15	D	Q.16	B	Q.17	C	Q.18	C	Q.19	A	Q.20	A	Q.21	D
Q.22	D	Q.23	B	Q.24	B	Q.25	C	Q.26	D	Q.27	C	Q.28	A
Q.29	A	Q.30	C	Q.31	D	Q.32	D	Q.33	D				

# 1 Matter in Our Surrounding

## 1. INTRODUCTION

If we look at our surroundings, we see a large number of things of different sizes, shapes, appearances and texture. Everything in this universe is made up of material which in scientific terms is called **matter**. The air we breathe, the food we eat, the clothes we wear, the houses where we live in, the paper on which we write, the link with which we write, wood, salt, steel, plants, animals, clouds, stars, even a drop of water or a particle of sand, each thing is made up of matter. In fact, everything in this universe is made up of matter. All these things can be felt with the help of any one of our five senses, i.g., sight, touch, smell, hearing and taste.

If we now look at all the objects mentioned above a little more carefully, we find that all of them have two things in common, i.e., they occupy space (or have volume) and have a definite amount of mass. Thus,

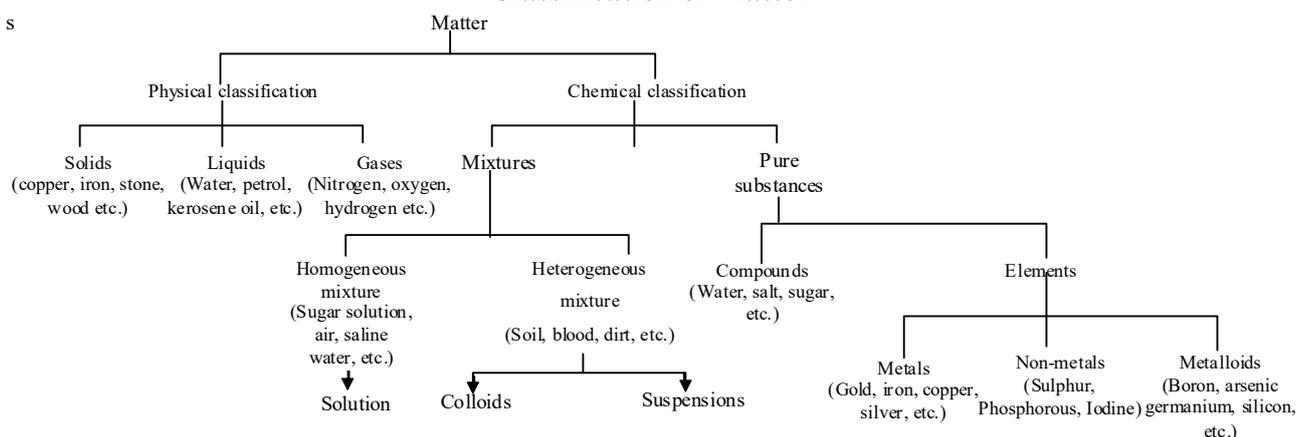
**Matter may be defined as anything that occupies space, possesses mass and the presence of which can be felt by any one or more of our five senses.**

## 2. CLASSIFICATION OF MATTER

The matter can be classified into the following two types on the basis of their properties -

- (i) **Physical Classification :** On the basis of physical properties, matter has been classified as solids, liquids and gases.
- (ii) **Chemical Classification :** On the basis of chemical properties, matter has been classified as elements, compounds and mixture.
  - Air, water , sugar , sand, metals are different kinds of matter.
  - The perception of joy, love , hot, cold, pain , thought are not considered as matter.

### Classification of Matter



## 3. PHYSICAL NATURE OF MATTER

For a long time there were two views about the physical nature of matter :

- (i) **Continuous nature** , like a block of wood or sheet of glass.
- (ii) **Particulate nature**, that matter is made up of particles like that of sand.

To understand whether the matter is continuous or particulate in nature, hold a sheet of glass in your hand, it appears continuous. Now throw it on the floor, it breaks into very small or tiny particles. In fact, all matter in this universe is made up of small particles. These particles, which make up all the matter around us are either atoms or molecules however these particles differ from one kind of matter to the other.

**Matter is made up of particles**

The particle nature of matter can be demonstrated by a simple activity :

➤ **ACTIVITY 1**

**Aim :** To show the particle nature of matter.

**Method**

- Take about 50 ml water in 100 ml beaker.
- Mark the level of water.
- Add some salt to the beaker.
- Stir with the help of a glass rod.

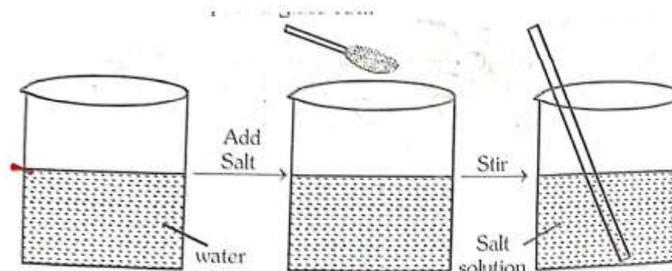


Fig.2 Dissolution of salt in water.

On the basis of your observation try to answer the following question

- What happened to the common salt initially ?
- What happened to the common salt on stirring?
- What happened to the level of water in the beaker after the activity is over ?
- Where does the common salt disappear ?

**Conclusion :**

- The common salt settled at the base of the beaker, as if it a continuous form of matter.
- On stirring, the common salt disappeared, i.e., it dissolved in water. This dissolving or disappearance of common salt in water suggests that common salt is not one continuous state of matter. Instead, it is made of extremely small particles. The water breaks down the common salt into so small particles that they are no longer visible to the eye.
- The level of water in the beaker dose not rise or fall. This suggests that particles of common salt got dispersed in water. This also suggests that there must be some hollow spaces in the water. This implies that water by itself is not continuous, but is made of extremely small particles, which are not visible to the eye.
- The extremely small particles of common salt positioned themselves in the small spaces between the particles of water. This also accounts for the fact that level of water dose not rise. because the particles of common salt do not displace it but occupy the small spaces in between the particles of water.

**4. CHARACTERISTICS OF PARTICLES OF MATTER**

The particles of matter have the following four characteristics :

**4.1 The particles of matter are very, small :**

- The Matter is composed of small particles. To understand particle nature, let us perform one experiment.

➤ **ACTIVITY 2**

**Aim :** To show that the constituent particle of matter are very small.

**Method :**

- Take a 250 ml beaker and add 100 ml water to it.
- Now add 2-3 crystals of potassium peramanganate ( $\text{KMnO}_4$ ) and stir with a glass rod in order to dissolve the crystals.
- Take 10 ml of this diluted solution and add to 90 ml of water taken in another beaker.
- Repeat this process 2 more times. Observe the colour of the solution in the last beaker.

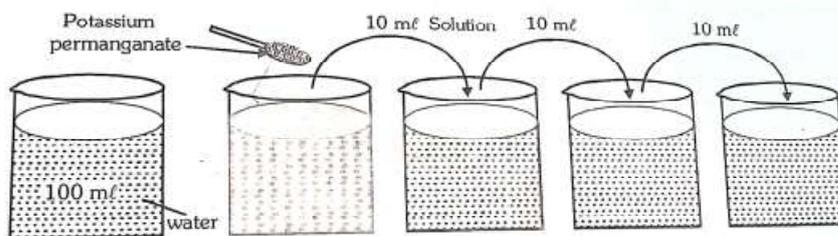


Fig.3 Potassium permanganate colour fades on dilution with water.

### Conclusion :

- This experiment shows that just a few crystals of potassium permanganate can colour a large volume of water. So we conclude that there must be millions of tiny particles in just one crystal of potassium permanganate which keep on dividing themselves into smaller and smaller particles with each dilution there by making the colour lighter and lighter.
- The same experiment can also be carried out by using 2 mL of dettol instead of potassium permanganate. With each dilution, the small becomes less and less intense but can still be detected.
- From the above two experiments, we conclude that **the matter is made up of extremely small particles which cannot be seen even with a powerful microscope. What we actually see is an aggregate of tiny particles.** For example, even a drop of water contains about  $10^{21}$  molecules of water.

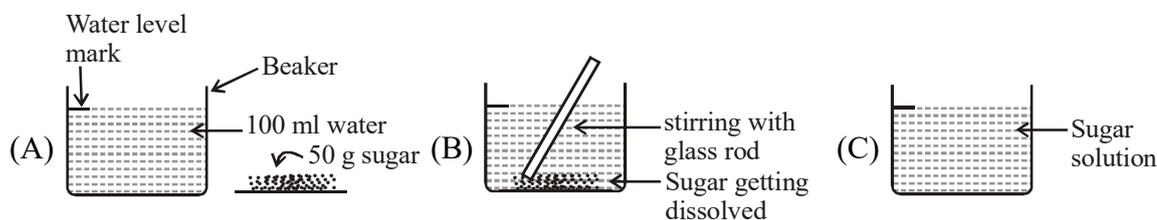
The particles of matter are very small, they are small beyond our imagination !!

### 4.2 The particles of matter have spaces between them :

There are spaces present in between the particles of matter. To understand it , let us perform an experiment.

#### ➤ ACTIVITY 3

**Aim :** We take about 100 ml of water in a beaker and mark the level of water. We will also take 50 g of sugar. Now we will dissolve the sugar by stirring and we get a sugar solution.



### Method :

When we dissolve sugar in water, there is no change in volume of water.

### Conclusion :

- The level of sugar solution in the beaker is at the same mark where water level was initially in the beaker.
- It shows that particles of sugar go into the spaces between various molecules of water due to which there is no change in the volume. Thus, from this experiment it can be concluded that, the molecules in water are not tightly packed, they have spaces between them.

## 💡 EXAMPLES 💡

**Example: 1 :** The Diver is able to cut through water in a swimming pool. Why ?

**Solution :** The diver is able to cut through water in the swimming pool because matter is not continuous, but it is made up of particles which have vacant spaces between them. Moreover , the attractive forces between molecules of water are not very strong. the diver can easily cut through water by applying force to displace water and occupy its place.

### 4.3 The particles of matter are constantly moving :

This property can be explained by diffusion and Brownian motion.

**Diffusion :** “Intermixing of particles of two different types of matter on their own is called diffusion.”

It is the phenomenon in which the movement of molecules or particles occur from their higher concentration towards their lower concentration.

- Diffusion is very commonly observed in our day-to-day life.
- **E.g. :** When a perfume bottle is opened in one corner of a room, its fragrance spreads in the whole room quickly. This happens because the particles of perfume move rapidly in all directions and mix with the moving particles of air in the room.

**Diffusion in gases :** Diffusion is fastest in gases.

#### ➤ ACTIVITY 4

**Aim :** To prove that the particles of matter are in a state of continuous motion.

**Materials required :**

A fresh agarbatti (incense stick), a stand to hold agarbatti, a matchstick.

**Method :**

- (a) Take out a fresh incense stick and hold it in a stand.
- (b) Place the stand in the corner of a room. You will be able to smell its perfume. Now slowly move away from the incense stick. You will notice that you cannot smell the perfume.
- (c) Now light the incense sticks and leave the room for a few minutes. On entering the room, you will be able to smell the perfume everywhere in the room.

**Let us try to answer the following questions**

- (i) Why can you smell the perfume of the incense stick when you were close to the stick ?
- (ii) Why can you not smell perfume at a short distance when the incense stick is not lighted ?
- (ii) Why does the smell of perfume of the incense stick fill the whole room in few minutes, when lighted ?

**Conclusion :**

1. The particles of perfume (matter) are not stationary, but are continuously moving. They drift through the air and hence we can smell the perfume.
2. The particles of perfume (matter) do not have sufficient energy to drift through the air. Thus, a few steps away from the incense stick, we cannot smell it.

#### ➤ ACTIVITY 5

**Aim :** To demonstrate that the Kinetic Energy of particles increases with increase in temperature.

**Method :**

- (a) Take two beakers. To one beaker add 100 ml of cold water and to the other beaker add 100 ml of hot water.
- (b) Now add a crystal of potassium permanganate to both the beakers

**Conclusion :**

It is observed that purple colour of potassium permanganate starts spreading and after sometime the entire solution becomes purple. The rate of mixing is faster in case of hot water. This experiment demonstrates that the particles of matter possess motion and that the kinetic energy of the particles increases with increase in temperature.

**Diffusion in liquids** Diffusion in liquids is slower than that in gases.

**For examples:**

- The spreading of purple colour of potassium permanganate into water, on its own, is due to the diffusion of potassium permanganate particles into water.
- The spreading of blue colour of copper sulphate into water, on its own, is due to the diffusion of copper sulphate particles into water.
- The rate of diffusion in liquids is much faster than that in solids because the particles in a liquid move much more freely, and have greater spaces between them as compared to particles in the solids.

➤ **ACTIVITY 6**

**Aim :** To understand different rates of diffusion by different substances.

**Method :**

- (a) Take two glasses filled with water.
- (b) Put a drop of blue or red ink slowly and carefully along the sides of the first glass and honey in the same way in the second glass.
- (c) Leave them undisturbed. Record your observations.

**Let us try to answer the following questions**

- (i) What do you observe immediately after adding the ink drop?
- (ii) What do you observe immediately after adding a drop of honey?
- (iii) How many hours or days does it take for the colour of ink to spread evenly throughout the water?

**Conclusion**

1. As the drop of ink trickles along the sides of the beaker, the blue colour of the ink starts diffusing in water, which appears like wavy blue streaks in water.
2. The honey drop continues travelling along the side of beaker and there is no visible diffusion of it in water.
3. The ink spreads evenly in the water in about two hours.

**Therefore.**

- Rate of diffusion depends upon the nature of substances.
- More viscous substances which have particles with less kinetic energy, takes more time to get diffused.
- From these activities it is observed that when two different forms of matter are brought in contact, they intermix spontaneously. This intermixing is possible due to motion of the particles of matter and also due to the spaces between them. The intermixing takes place due to movement of particles of one form into the spaces between the particles of the other form of matter.

“This spontaneous intermixing of particles of two or more different substances is called diffusion”  
The rate of diffusion becomes faster with increase in temperature because at higher temperature, the particles have more energy and hence move faster.

➤ **Diffusion in solids :** Diffusion in solids is a very , very slow process.

**For example :**

- If we write something on a blackboard and leave it uncleaned for a considerable period of time, we will find that it becomes quite difficult to clean the blackboard afterwards. This is due to the fact that some of the particles of chalk have diffused into the surface of blackboard.
- If two metal blocks are bound together tightly and kept undisturbed for a few years, then the particles of one metal are found to have diffused into the other metal.

**Diffusion is ,**

- (i) Fastest between two different gases.
- (ii) Slower between two different liquids or a solid and a liquid.
- (iii) Slowest (or almost negligible) in case of two different solids.

**4.4 Brownian motion :** Zig-zag motion (in a very irregular way) of particles is known as Brownian motion. It is also known as Pedesis. Sometimes, when a beam of light enters a room, we can see tiny dust particles suspended in air which are moving rapidly in a very random way. This is an example of Brownian motion in gases. The tiny dust particles move here and there because they are constantly hit by the fast moving particles of air.

**Conclusion :** Water is made up of tiny particles which are moving very fast (The water molecules themselves are invisible under the microscope because they are very, very small). The pollen grains move on the surface of water because they are constantly being hit by the fast moving particles of water. So, through the water particles (or water molecules) are too small to be seen, but their effect on the pollen grains can be seen clearly. The random motion of visible particles (pollen grains) caused by the much smaller invisible particles of water is an example of Brownian motion (after the name of the scientist Robert Brown who first observed this phenomenon).

➤ **The existence of Brownian motion gives two conclusions.**

- Matter is made up of tiny particles.
- Particles of matter are constantly moving.



**Let's know**

The best evidence for the existence and movement of particles in liquids was given by

Robert Brown in 1827. Robert Brown suspended extremely small pollen grains in water. On looking through the microscope, it was found that the pollen grains were moving rapidly throughout water in a very irregular manner (or zig-zag way)

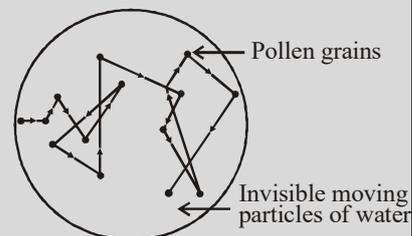


Figure : Brownian Motion

**EXAMPLES**

**Example: 2 :** (a) What happens to the sugar when it dissolves in water?

(b) Where does the sugar go?

(c) What information do you get about the nature of matter from the dissolution of sugar in water?

- Solution :**
- When sugar dissolves in water, its tiny particles break off from the solid 'sugar crystals'
  - The sugar particles go into the space between the particles of water and mix with them (to form sugar solution)
  - The dissolution of sugar tells us that :
    - The matter (here sugar and water) is made up of small particles.
    - The particles of matter (here water) have space between them.

**Example: 3 :** We can get smell perfume sitting several meters away, why ?

**Solution :** This is because perfumes contain volatile solvent which carries pleasant smelling vapours. They diffuse quite fast and can reach to people sitting several meters away.

**Example: 4 :** Give example of each type of diffusion.

- (i) Solid in liquid      (ii) Liquid in liquid      (iii) Gas in liquid  
(iv) Gas in gas      (v) Solid in gas

- Solution :**
- Solid in liquid → Sugar in water
  - Liquid in liquid → Milk in water
  - Gas in liquid → Oxygen in water
  - Gas in gas → Oxygen in air
  - Solid in gas → Dust particles in air

**Example: 5 :** A bottle of scent when opened in a room, its smell spreads out. Explain why?

**Solution :** This is because of diffusion of gas particles. As soon as the bottle is opened, the scent particles come out and get diffuse with air very soon and reach from one place to another place.

**4.5 The particles of matter attract each other :**

There are some forces of attraction between the particles of matter which bind them together.

- Cohesive force :** The force of attraction between the particles of same substances is called Cohesive Force.
- Adhesive force :** The force of attraction between the particles of different substances is called Adhesive Force.

**For e.g. :** If we take a piece of chalk, a cube of ice and an iron nail and beat them with a hammer.

**Observation :**

- Chalk will easily break into smaller pieces.
- More force is required to break a cube of ice. Iron nail does not break.

**Conclusion :**

- Force of attraction is quite weak in between the chalk particles.
- Force of attraction in between the particles of ice cube is a bit stronger.
- Force of attraction in between the particles of iron is very, very strong.

➤ **ACTIVITY 7**

**Aim :** To demonstrate the strength of attractive forces between particles of different kinds of matter.

**Method :**

Play this game in the field. Make four groups and form human chains as suggested.

- (a) The first group should hold each other from the back and lock arms like Bihu dancers.
- (b) The second group should hold hands to form a human chain.
- (c) The third group should form a chain by touching each other with only their finger tips.
- (d) Now, the fourth group of students should run around and try to break the three human chains one by one into as many small groups as possible.

**Let us try to answer the following questions**

- (i) Which group was the easiest to break ? Why ?
- (ii) If we consider each student as a particle of matter, then in which group the particles held each other with the maximum force ?

**Conclusion :**

- (i) Third group, because they were weakly bonded with each other.
- (ii) 1<sup>st</sup> group  
If particles are bonded tightly it is difficult to separate them.

➤ **ACTIVITY 8**

**Aim :** To show that particles of different matter have different force of attraction.

**Method :**

- (a) Take a piece of Iron wire, a piece of chalk and a rubber band.
- (b) Try to break them by hammering, cutting or stretching.

**Let us try to answer the following question**

In which of the above three substance do you think the particles are held together with greater force ?

**Conclusion :**

It is observed that the piece of iron wire is most difficult to break. This indicates that particles in iron wire are held by stronger force of attraction as compared to particles in piece of chalk or rubber band.

➤ **ACTIVITY 9**

**Aim :** To show that particles of matter attract each other

**Method :** Open a water tap , try breaking the stream of water with your fingers.

**Let us try to answer the following questions**

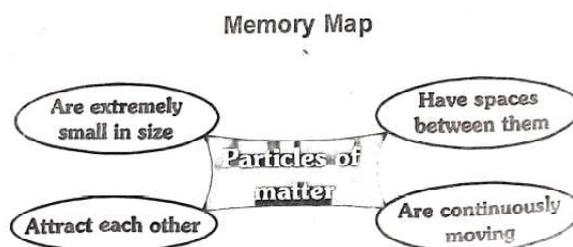
- (a) Were you able to cut the stream of water.
- (b) What could be the reason behind the stream of water remaining together ?

**Observations :**

- (a) Yes, stream of water can be cut.
- (b) Water molecules exerts a force of attraction on each other. Therefore as soon as we remove fingers, they will try to unite again and will remain together forming a continuous stream again.

**Conclusion :**

Since energy is required to break crystal of matter into particles. It indicates that particles in matter are held by some attractive forces, the strength of these attractive forces varies from one matter to another.

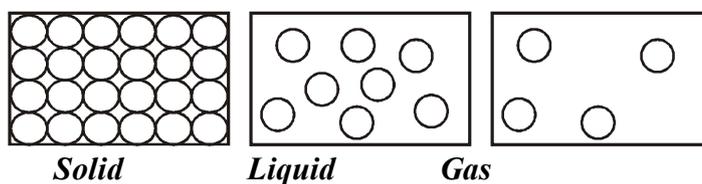


## 5. STATES OF MATTER

### ➤ Classification of Matter based on Physical State :

Under normal conditions of temperature and pressure, matter can exist in any one of the following three states:

- (i) **Solids** : A solid has a definite shape and definite volume. Examples are iron, copper, sugar, wood, rock, ice, etc.
- (ii) **Liquid** : A liquid has a definite volume but not no definite shape. Examples are milk, water, oil, petrol, kerosene, alcohol etc.
- (iii) **Gases** : A gas has neither a definite shape nor a definite volume. It takes the shape and volume of the containing vessel. Examples are steam, oxygen, nitrogen, carbon dioxide, chlorine etc.

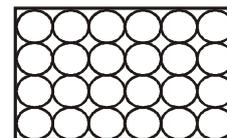


### ➤ THE SOLID STATE

Solids are known for their hardness and rigid nature.

#### • Characteristics of the solid state

- (i) **Solids have fixed shapes** : Solids generally have fixed shapes. They do not change their shape even when put in different containers.



**Figure : Arrangement of molecules in a solid**

For example, blue crystals of copper sulphate have needle like shape which they retain whether kept in a beaker or in a china dish or place on the palm of our hand.

- (ii) **Some solids can change their shape** under force but regain the same when the applied force is removed. For example, a sponge on pressing changes its shape, but regains it after force is removed.
- (iii) **Solids keep their volume** which means that they have fixed volume. For example a sponge on pressing changes its shape, but regains it after force is removed. Volume is the space occupied by a substance. The solids have fixed volume. Actually in the solid state, the constituents are very closely packed in space and interparticle forces are strong. As a result, the solids keep their volume.
- (iv) **Solids can be hardly compressed on applying pressure.**  
It is very difficult to compress a solid on applying pressure. For example, we cannot press a piece of stone by applying pressure with our hands. Actually, the constituent particles are so closely packed in a solid that they either do not come closer or do so only slightly when a high pressure is applied. However, there are some exceptions.
- (v) **Solids have negligible kinetic energy of the particles.** The kinetic energy is linked with movement of the particles from one place to the other. Since the constituents in the solid state are very closely packed, they have negligible kinetic energy. That is why solids do not flow.
- (vi) **Solids do not have the property of diffusion.** Due to the absence of kinetic energy in the particles of a solid, there is hardly any diffusion. For example, let us keep pieces of metals like copper and silver side by side. They may touch each other but will not mix.  
**Example :** Table, chair, common salt, silver, ice, diamond, stone, sugar etc.

**Note :-**

In certain cases of solids, diffusion is noticed when the two solids are kept in contact for a long time. For example, if we try to rub something written on the black board by a chalk after a gap of about a week or so, it becomes rather difficult to rub the same. Probably some particles of chalk in the form of dust have diffused in the pores of the black board which is normally made from some wooden material.


**EXAMPLES**

**Example: 6 : A rubber band changes its shape on stretching, then why do we call it a solid?**

**Solution :** A rubber band is considered a solid because it changes shape under the action of force, and when the force is removed the rubber band regains its original shape. Like all other solids, if rubber band is stretched with a large force it breaks.

**Example: 7 : If salt and sugar do not appear to have a fixed shape, then why do we call them solids?**

**Solution :** Actually, this problem arises because salt and sugar have very tiny crystals. Salt and sugar are considered to be solids because the shape of individual crystals of salt and sugar remain fixed even when they are put in jars of different shapes.

**Example: 8 : A sponge can be compressed easily, so why do we call sponge a solid?**

**Solution :** This can be explained as follow: A sponge is considered to be a solid because its compressibility is due to the presence of minute pores in it which are filled with air. When we press the sponge air is expelled from its holes making it highly compressible.

➤ **ACTIVITY 10**

**Aim :** To study the properties of solids.

**Method :** Collect the following articles : a pen, a book, a needle and a wooden stick.

**Let us try to answer the following question**

- (i) Do all these have a definite shape, distinct boundaries and a wooden stick.
- (ii) Are these capable of diffusing into each other?
- (iii) Try compressing them by applying force. Are you able to compress them?

**Ans. (i). Yes (ii). No (iii). No**

**Let's know**➤ **Types of Solids**

Solids can be classified as crystalline or amorphous on the basis of the nature of order present in the arrangement of their constituent particles.

- (a) A crystalline solid usually consists of a large number of small crystals, each of them having a definite characteristic geometrical shape. In a crystal, the arrangement of constituent particles (atoms, molecules or ions) are ordered. Sodium chloride and quartz are typical examples of crystalline solids.
- (b) An amorphous solid consists of particles of irregular shape. The arrangement of constituent particles in such a solid has only short range order. In such an arrangement a regular and periodically repeating pattern is observed over short distances only. The structure of amorphous solid is similar to that of liquids. Glass, rubber, plastic are typical examples of amorphous solids.

### Distinction between crystalline and Amorphous Solids

Property	Crystalline solids	Amorphous solids
Shape	Definite characteristic geometrical shape	Irregular shape
Melting point	Melt at a sharp and characteristic temperature	Gradually soften over a range of temperature
Cleavage property	When cut with a sharp edged tool, they split into two pieces and the newly generated surfaces are plain and smooth	When cut with a sharp edged tool, they cut into two pieces with irregular surfaces
Heat of fusion	They have a definite and characteristic heat of fusion	They do not have definite heat of fusion
Nature	True solids	Pseudo solids or super cooled liquids
Order in arrangement of constituent particles	Long range order	Only short range order

#### ➤ THE LIQUID STATE :

The liquids are less rigid than the solids and the molecular motion is also comparatively more. Both these characteristics in the liquid

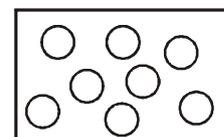
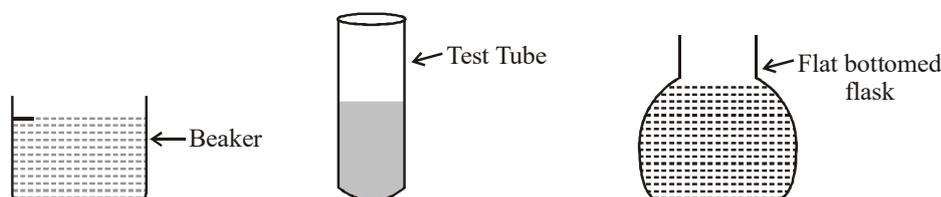


Figure : Arrangement of molecules in a liquid.

state are because of the presence of weaker interparticle forces.

- **Liquids are quite often called fluids. We generally suffer from dehydration in extreme hot weather due to excessive loss of fluids.**



- **Characteristics of the liquid state :**

#### (i) Liquids do not have fixed shapes.

Liquids do not have fixed shapes and take up the shapes of any container in which these are put.

#### ➤ ACTIVITY 11

**Aim :** To show that liquids take the shape of the container.

**Method :** Take a known volume of a liquids (say water ) first in a glass beaker

- Then transfer water into a conical flask
- And finally into a flat bottomed flask

#### Observation

We observe that the water has acquired the shape of all the three containers.

#### (ii) Liquids occupy definite volume or keep their volume.

Though the liquids do not have definite shape, but they do have definite volume. This means that like a solid, a liquid cannot be compressed on applying pressure. Actually, the intermolecular forces in the liquids are so strong that the pressure which is applied is not in a position to overcome these. The liquids therefore keep their volume.

**(iii) Liquid have fluidity and not rigidity.****➤ ACTIVITY 12****Aim :** To show that liquid flow.**Method :** Collect the following

- (a) Water, cooking oil, milk, juice, a cold drink
- (b) Containers of different shapes.

**Let us try to answer the following questions**

When you pour the liquid from one container into another, does it flow easily ?

**Conclusion**

We observe that liquids flow and change shape, so they are not rigid but can be called fluid.

Unlike solids, the liquids have fluidity not rigidity i.e., they have tendency to flow. This is due to lesser interparticle or intermolecular forces that are present in the liquid state as compared to the solid state. However, the liquids differ in their relative fluidity. For example, water flows at a faster rate than honey because in honey, the particles are heavier and also more closely packed.

**Let's know**Usually density of solids is more than liquids, but in case of  $H_2O$ , ice floats on water. Because the structure of ice is more porous as compared to that of water. Therefore, for a given mass, the volume of the ice is more than that of water and its density is comparatively less. As a result, ice floats over water.**(iv) Liquids have lesser density as compared to solids.**

As compared to solids, liquids are generally light. This is on account of greater number of interparticle spaces in the liquid state as compared to the solid state of the same substance.

**(v) The kinetic energy of the particles in the liquid state is more than in the solid state**

The particles in the liquid state are less closely packed as compared to the solid state. As a result, the interparticle forces are weaker. Therefore, the kinetic energy of the particles in the liquid state of a substance is more than in solid state. It further increases with the rise in temperature.

**(vi) Particles in the liquid state can easily diffuse.****➤ ACTIVITY 13****Aim :** To study diffusion of gases in water.**Materials required :** 200 cc beakers half filled with tap water, wire gauze, tripod stand, spirit lamp or Bunsen burner.**Method :** Place the wire gauze over tripod stand and then the beaker containing water. Heat the beaker by a spirit lamp or a Bunsen burner on low flame. Do not allow the water to boil. Make your observation as the water is being heated.**Let us try to answer the following questions**

- (i) What do you observe on the sides of glass beaker ?
- (ii) Give an explanation to your above observation.

**Conclusion**

- (i) Tiny bubbles of gas cling to the sides of beaker.
- (ii) The tiny bubbles are of air (especially carbon dioxide and oxygen) which got dissolved in water naturally. These gases are expelled out when water is warmed.

The gases like oxygen and carbon dioxide diffuse and hence dissolve in water. The dissolved oxygen in water is essential for the respiration of water animals. The dissolved carbon dioxide helps the water plant to synthesize their food by the process of photosynthesis.

Due to lesser interparticle forces of attraction, the particles in a liquid state can diffuse more readily than the solid state of a substance. This also helps in the intermixing of certain liquids. For example, water and alcohol are both liquids and can easily mix to form a liquid mixture or solution.



### Let's know

Osmosis should not be confused with diffusion. Osmosis takes place between a pure liquid (generally water) and the dilute solution of some salt/sugar prepared in water. When the two are separated by some semi-permeable membrane such as parchment membrane, the particles of the solvent (water) pass through the membrane into solution. This is called osmosis. Thus, osmosis may be regarded as a special case of diffusion which occurs only in liquids that are separated by a semi-permeable membrane.

### ➤ GASEOUS STATE :

#### CHECK YOUR ANSWER 1.2

1. Salt or sugar takes the shape of containing vessel, but does not change its individual shape. For example, sugar crystals are cubical and they remain cubical in any vessel.

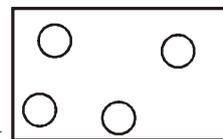


Figure : Arrangements of Molecule in Gas.

2. Sponge has very small holes throughout its structure. These holes are filled with air. When it is compressed, the air in the holes is squeezed out. Thus, we are able to compress it.

### ➤ Gaseous state

Out of the three states of matter, the interparticle spaces are the maximum in the gaseous state. The interparticle forces which hold the different particles in the gaseous state together are the minimum. As a result, rigidity is the minimum while fluidity is the maximum.

### ➤ Characteristics of gaseous state

#### (i) Gases do not have fixed shape.

Gases do not have any shape of their own. They acquire the shape of the container in which they are filled or kept.

#### (ii) Gases have maximum fluidity and least rigidity.

Since the interparticle spaces are the maximum in the gaseous state, the attractive forces are the least. As a result, the fluidity is very large while rigidity is negligible.

#### (iii) Gases do not have fixed volume and are highly compressible.

Since the interparticle distance in the gaseous state are very large, they can be changed (increased or decreased) by altering the pressure. Thus, a gas can be compressed to a large extent on applying pressure. This means that change in pressure can bring a change in volume or we can say that gases do not keep their volume.

#### (iv) Density of gases is very less.

Due to large interparticle spaces. Particles of gas are far separated and volume of a given mass of a given mass of a gas is quite large. Therefore, density becomes less and gases are thus, light.

#### (v) The kinetic energy of the particles in the gaseous state is very high.

The interparticle forces are very weak. As a result, the particles or the molecules of a gas can move quite freely from one place to the other. This means that their translational motion is large and kinetic energy is quite high. It can further increase when the temperature of the gas is increased.

#### (vi) Gases exert pressure.

Since particles in a gas have high kinetic energy, they strike the walls of the container with force. As a result, they exert pressure.

Please note that greater the number of hits recorded per unit area of the wall of the container, more will be the pressure of the gas. Which depends on the energy of particles.

#### (vii) Gases diffuse very rapidly.

Since the interparticle spaces are very large and interparticle forces are quite weak, the particles of one gas can readily move into the empty spaces of another gas.

Please note that even the heavier gases can rise upwards and lighter gases can move downwards. This means that the diffusion of the gases is not influenced by gravity. For example, invert a cylinder containing hydrogen gas (colourless) over a cylinder containing nitrogen dioxide (reddish brown) and separate the two cylinders by a lid. Now, remove the lid. What will you observe? Both the cylinders will acquire the same colour i.e., light brown. This means that hydrogen gas has moved downwards and nitrogen dioxide upwards. Both the cylinders contain a uniform mixture of these two gases and are light brown in colour.

**Example :** Air is the common example of the gaseous state. It is a mixture of number of gases like nitrogen, oxygen, carbon dioxide, inert gases etc. A few other examples are hydrogen, ammonia, sulphur dioxide, chlorine etc.

**More Example**

- (i) CNG (compressed Natural gas) is used as fuel in internal combustion engines.
- (ii) Oxygen in compressed form is supplied to hospitals for serious patients in cylinders.
- (iii) LPG (liquefied petroleum gas) which is used in home for cooking.

➤ **ACTIVITY 14**

**Aim :** To study the compressibility of solids, liquids & gases.

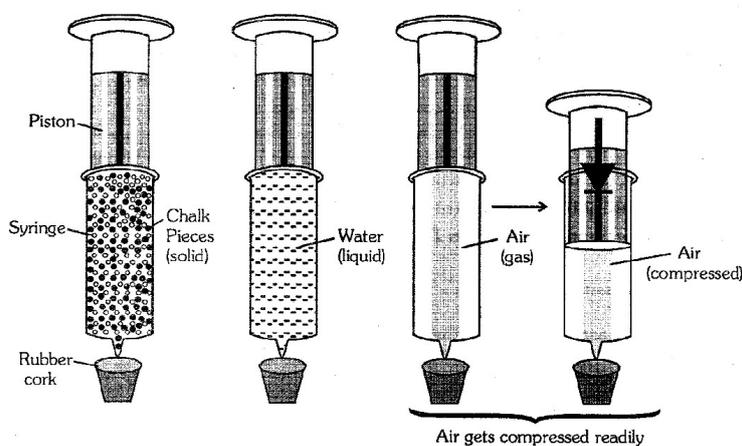
**Method :**

- (a) Take three 100 ml syringes and close their nozzles by inserting them in a rubber cork. Remove the pistons from all the syringes.
- (b) Fill chalk pieces in the first, water in the second and leave third syringe as such. It already contains air.
- (c) Insert the pistons back into the syringes.
- (d) Compress all the syringes by pushing the pistons.

**Observation**

It is observed that when the syringe containing air, is compressed by applying pressure, the piston can move downward easily and it can be compressed to a larger extent. But when the second syringe containing water is compressed, it is compressed not easily and it can be compressed to much lesser extent than that of air. The first syringe containing chalk pieces (solid) is compressed with most difficulty.

**Conclusion :** This shows that gases are more compressible than solids & liquids.



**Figure.** Study the compressibility of solid, liquid and gas.

**Comparison of some important characteristics of solid, liquid and gas**

**EXAMPLES**

**Example: 9 :** Explain why a gas fills completely the vessel, in which it is kept?

**Solution :** The molecules of a gas have large intermolecular space and kinetic energy, but extremely small intermolecular forces. Thus, the molecules of the gas spread in the entire space of the containing vessel on the account of high kinetic energy and practically low intermolecular force, hence, fill entire space of the vessel.

S.No	Characteristics	Solid	Liquid	Gas
1.	Shape and Volume	Solids have fixed shape and definite volume.	Liquids have fixed volume but no definite shape.	Gases have no fixed volume and shape.
2.	Density	Solids have high density.	Liquids have high density but less than solids.	Gases have low density.
3.	Expansion on heating	Solids show only slight expansion on heating.	Liquids show slight expansion on heating but more than solids.	Gases expand considerably on heating.
4.	Compressibility	They have slight or no compressibility.	They have slight compressibility but more than solids.	They have high compressibility.
5.	Fluidity	Solids do not flow.	Liquid generally flow easily.	Gases flow freely.
6.	Melting and boiling point	They have their melting and boiling points above room temperature.	They have their melting point below room temperature.	They have their melting and boiling points both below room temperature.
7.	Intermolecular forces	Intermolecular forces are very strong and constituent particles are closely packed.	Intermolecular forces are strong enough to keep the particles together but not strong enough to keep them in fixed position.	Intermolecular forces are very weak and the particles are free to move.
8.	Filling a container	Solids cannot fill the container	Liquids fill container according to the volume of liquid	Gases fill entire space of a container
9.	Kinetic energy	Molecules of solid has least K.E.	Molecules of liquid has more K.E. than solids	Molecules of gases have maximum K.E.

### **EXAMPLES**

**Example: 10 : Cycle tubes burst during summer.**

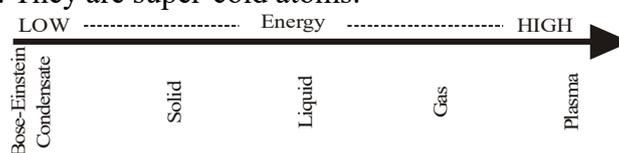
**Solution :** This is because during summer the kinetic energy of the gaseous molecules increases. So they exert pressure on the walls of tube. So if the tube is weak, it bursts.

➤ **Another states of matter**

➤ **Plasma** is the fourth state of matter which exists only at very high temperature about  $10^7$  K which is found only in the interior of the star. At this temperature basic units of the matter, atoms, are completely ionized. Such a state of matter consists of base nuclei and electrons is called **plasma**. You won't find plasmas just anywhere. However, there may be some in front of you. Think about a fluorescent light bulb. They are not like regular light bulbs. Inside the long tube is a gas. Electricity flows through the tube when the light is turned on. The electricity acts as that special energy and charges up the gas. This charging and exciting of the atoms creates glowing plasma inside the bulb.

➤ **Bose Einstein condensate (BEC):** in 1920 an Indian Scientist Satyendra Nath Bose did some calculation for the fifth state of matter. On the basis of these calculations, Albert Einstein predicted the existence of a new state of matter called Bose–Einstein condensate. It is achieved by cooling a gas of extremely low density (about one hundred thousandth the density of normal air) to super low temperature.

If plasmas are super hot and super excited atoms, the atoms in a Bose-Einstein condensate (BEC) are total opposites. They are super-cold atoms.



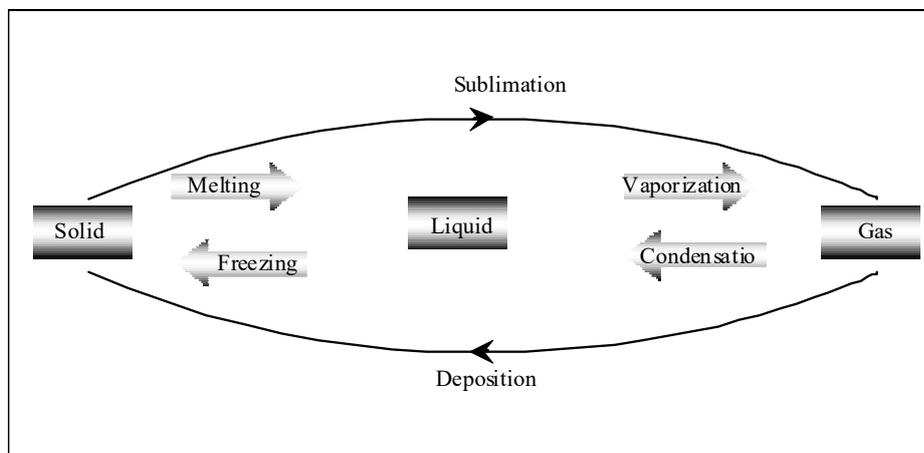
## 6. INTERCONVERSION OF PHYSICAL STATE

### (i) Inter conversion of states of matter

One state of a substance can be converted into another by changing interparticle spaces and interparticle forces of attraction. This is known as interconversion of states of matter and this can be brought about by 2 ways :-

(i) By changing the temperature

(ii) By changing the pressure



### Let's know

Temperature affects the phase of matter by breaking the bonds between the molecules of a substance, leading it to change its state.

#### ➤ Effect of change of temperature

The effect of temperature on three states of matter could be seen by performing the following activity.

#### ➤ ACTIVITY 15

**Aim :** To show that temperature remains constant during the change of state.

#### **Method :**

- Take a piece of about 100-150g of ice in a beaker.
- Hang a thermometer in it so that its bulb is in contact with ice.
- Start heating the beaker slowly on a low flame.
- Note down the temperature when ice starts changing to water & ice has been converted to water.
- Record all observation for the conversion of solid ice into liquid water.
- Now, place a glass rod in the beaker and slowly heat the beaker with constant stirring with help of a glass rod.
- Note the temperature when water starts changing into water vapour.
- Record all observation for the conversion of water in the liquid state to vapour state.

#### **Observation :**

It is observed that as temperature increases, the ice starts changing into water. This change is called "Melting". The temperature remains same till all the ice change into water. The thermometer shows  $0^{\circ}\text{C}$  until all the ice has melted.

On further heating, the temperature starts rising. At  $373\text{ K}$  (or  $100^{\circ}\text{C}$ ) water starts boiling. As the water continues boiling the temperature remains almost constant.

#### ➤ Explanation about interconversion of different states of matter :-

Ice is a solid, the particles are tightly packed together. When we heat a solid, its particles become more energetic and kinetic energy of the particles increases. Due to the increase in kinetic energy, the particles start vibrating more strongly with greater speed. The energy supplied by heat overcomes the intermolecular forces of attraction between the particles. As a result, the particles leave their mean position and break away from each other. After this solid melts and a liquid is formed.





### Let's know

In general low boiling liquids such as ether (b.p. 308 K), acetone (b.p. 329 K), methyl alcohol (b.p. 338 K), chloroform (b.p. 334 K), alcohol (b.p. 351 K), benzene (b.p. 353 K), petrol etc. have weak forces of attraction, *such liquids are called volatile liquids.*

**Latent heat of vaporization.** Again, it is observed that during the change of state from liquid to gaseous, the temperature of the system remains constant till the entire amount of liquid is converted into vapours even though heat is continuously being supplied. *This heat is actually used up in overcoming the forces of attraction between the particles of a liquid during the change of state from liquid to gas without increasing their kinetic energy.* Since the kinetic energy of the particles does not increase, therefore, the temperature of the liquid does not rise during the change of state. Since this heat is absorbed without showing any rise in temperature, therefore, it is called **latent heat of vaporisation.** Thus,

*The amount of heat energy that is required to change 1 kg of a liquid into vapour at atmospheric pressure at its boiling point is called latent heat of vaporization.*

### EXAMPLES

**Example: 10 : Steam is more effective than boiling water for heating purposes. Why ?**

**Solution :** The latent heat of vaporization of water is  $22.59 \times 10^5$  J/kg or 540 kcal/kg. This means that  $22.59 \times 10^5$  joules of heat is required to change 1 kg of water at its boiling point 373 K (100°C) into steam at the same temperature 373 K (100°C). Thus, at 100°C, both water and steam exist together. But the particles of steam at 100°C have more energy as compared to particles of water at the same temperature since during the change of state from water to steam, heat energy equal to latent heat of vaporization has been absorbed. So steam is more effective than boiling water for heating purposes.

**Example: 10 : Why cooking food takes longer time on mountains and lesser in pressure cookers ?**

**Solution :** The boiling point of a liquid depends upon the pressure acting on it. It increases, if the pressure is increased or decreases if the pressure acting on it is decreased. For example, water boils at 373 K at sea level where the pressure is 1 atmosphere. However, on mountains, it boils at a lower temperature where the pressure is less than 1 atmosphere. Conversely, in a pressure cooker it boils at a higher temperature where the pressure is more than one atmosphere. It is because of this reason that cooking of food takes longer time on mountains and lesser time in pressure cookers.



### Let's know

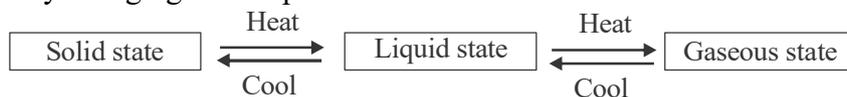
*Impurities Increase the boiling point of liquids.*

(iv) **Change of gaseous to liquid state condensation**

When a gas or vapour is cooled by lowering its temperature, the kinetic energy of their constituent particles decreases. Due to a decrease in the kinetic energy, the particles start moving slowly. As the temperature is further lowered, the attractive forces pull the particles close together and the gas or vapour condenses, i.e., gas or vapour changes into liquid. Thus, the process of changing a gas (or vapour) to a liquid by cooling is called condensation.

**Condensation is reverse of boiling (or vaporization).** For example, the boiling point of water is 373 K (100°C) and temperature of condensation of steam is also 373 K (100°C).

- From the above discussion, we conclude that one state of matter can be changed into another or *vice-versa* by changing the temperature.





### Let's know

Burns caused by steam are much more severe than those caused by boiling water though both of them are at the same temperature of  $100^{\circ}\text{C}$ . This is due to the reason that steam at  $100^{\circ}\text{C}$  has more heat (equal to heat of vaporization, i.e.,  $22.59 \times 10^5 \text{ J/kg}$ ) than boiling water at  $100^{\circ}\text{C}$ . So when steam at  $100^{\circ}\text{C}$  falls on our skin and condenses to form water, it gives out  $22.59 \times 10^5 \text{ J/kg}$  more heat than boiling water at  $100^{\circ}\text{C}$  and hence cause severe burns.

#### ➤ Sublimation

We have discussed above that most of the substances around us change their state first from solid to liquid and then from liquid to gaseous state by absorption of heat. However, there are some substances known which on heating directly change their state from solid to gaseous and *vice-versa* on cooling without passing through the intervening liquid state. This process is called sublimation.

The process of conversion of a solid into gas or viceversa without undergoing into liquid state is known as sublimation. Sometimes the sublimation of gaseous state into solid is known as deposition or desublimation.

**Example :** Ammonium chloride, camphor, iodine, naphthalene, solid carbon dioxide (dry ice), anthracene undergoes sublimation.

- **Sublime :** A gaseous form, directly formed from a solid on heating, is known as sublime.
- **Sublimate :** A solid state of matter formed directly from its gaseous state on cooling, is called sublimate.

#### ➤ ACTIVITY 15

**Aim :** To demonstrate the process of sublimation.

#### Method

- (a) Take some camphor or ammonium chloride.
- (b) Powder it and put in a china dish.
- (c) Place an inverted funnel over the china dish.
- (d) Put a cotton plug on the stem of the funnel.
- (e) Heat the china dish slowly.

#### Observation

We observe that solid camphor on heating gets converted into vapour which gets condensed on the funnel.

Solid state is directly converted into gaseous state. This experiment shows sublimation process.

More examples of sublimation

- (i) In very cold places, that snow does not melt but sublimates directly to vapours.
- (ii) In frost-free refrigerators, ice on the walls of the freezer sublimates when warm air is circulated through the compartment during the defrost cycle.

### **EXAMPLES**

**Example: 10 :** Naphthalene balls disappear with time without leaving any solid why?

**Solution :** Naphthalene is a volatile solid and has a tendency to sublime, therefore, it changes into vapours completely which disappear into the air and no solid is left.

#### ➤ Effect of Change of Pressure :

To convert a gas into a liquid or to convert a liquid into a solid, the interparticle distances must be decreased and the interparticle forces of attraction must be made stronger. This can be done in the following ways :

- (i) By applying pressure
- (ii) By lowering temperature or
- (iii) By combination of both the factors discussed above.

**(i) By applying pressure**

Gases are compressible because on applying pressure, the spaces between the gaseous particles decrease. Therefore gases can be compressed readily.

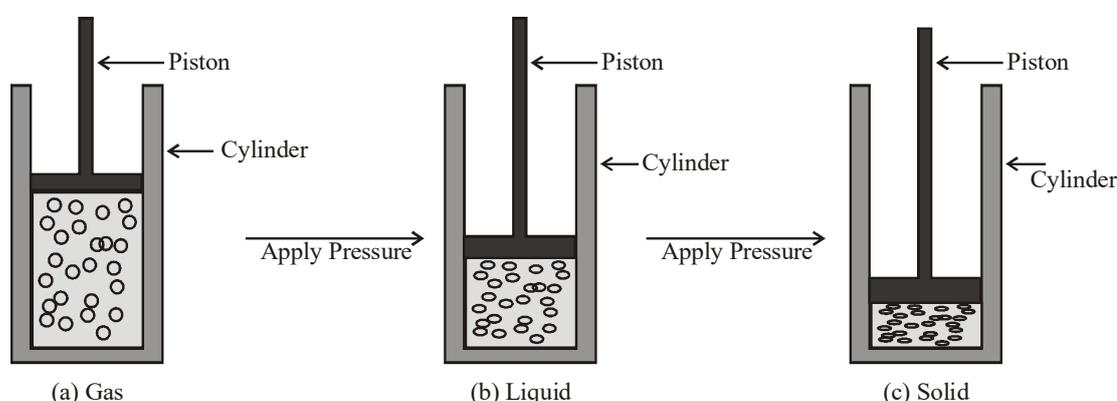
Take a certain volume of a gas in a cylinder provided with a piston. Now compress the gas by pushing in the piston. If enough pressure is applied to the piston, the gas compresses to a small volume. Consequently, interparticle distances decrease, and the gas particles come so close that they start attracting one another strongly to form a liquid. In other words, *the gas gets liquefied by application of pressure.*

**(ii) By lowering temperature**

If we cool the gas, the kinetic energy decreases and the particles slow down. As a result, interparticle distance decrease and interparticle forces of attraction increases which pull the gas particles close to form a liquid.

**(iii) By combination of both the factors discussed above**

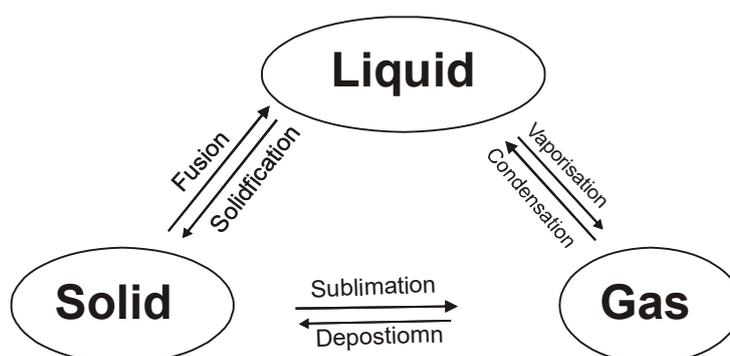
From the above discussion, it is evident that a gas can be liquefied either by increasing the pressure or by lowering the temperature. However, in most of cases, a combination of both these factors is used to liquify the gases. If the pressure on the liquefied gas is further increased and the temperature further lowered the liquefied gas may change into the solid state.



**Figure : By applying pressure, particles of a gas come close together to first get liquefied and then solidified**

Gases like ammonia, sulphur dioxide, carbon dioxide, etc. can be liquefied easily either by applying pressure at room temperature or by cooling at atmospheric pressure. If, however, carbon dioxide is cooled under high pressure, it can be directly converted into solid carbon dioxide called **dry ice**. Dry ice is stored under high pressure. If the pressure on dry ice is decreased to one atmosphere, it sublimates, *i.e.*, it directly gets converted into the gaseous state (*i.e.*, *carbon dioxide gas*) without passing through the intervening liquid state. As a result, unlike ordinary ice, dry ice does not wet the surface on which it is kept. *It is because of this reason that solid carbon dioxide is called dry ice.* It is used as a refrigerant under the name **dricold**.

Thus, we can say that pressure and temperature determine the state of a substance, whether it will be solid, liquid or gas





### Let's know

**Impurities decreases the freezing point and increases boiling point of liquids.  
Three conditions of temperature and pressure which decide the state of matter.**

If the melting point of a substance is above the room temperature at the atmospheric pressure, it is called solid.

If the boiling point of substance is above room temperature under atmospheric pressure, it is classified as liquid.

If the boiling point of the substance is below the room temperature at the atmospheric pressure, it is called gas.

### ➤ Evaporation

During the study of change of states of matter, we have seen that a liquid can be converted into gaseous state either by heating or by decreasing the pressure. Sometimes, this conversion can take place on its own. For example, you must have seen in your day today life that when water is left uncovered in a dish, it slowly changes into vapours without reaching its boiling point. Similarly, when wet clothes are spread in air, they get dried up, *i.e.*, water gets converted into vapours which escape into the air. This process is called **evaporation**. Thus, ***the phenomenon of change of a liquid into vapour at any temperature below its boiling point is called evaporation.***

We know that particles of a liquid are constantly moving in different directions. As a result of this random motion, they collide with one another. Due to these collisions, the particles of a liquid are moving with different speeds and thus have different amounts of kinetic energy. At any given temperature, the kinetic energy of some of the particles on the surface of the liquid may be so high that they overcome the forces of attraction by the neighbouring particles and may leave the liquid and get converted into vapours. This process is called **evaporation**.



### Let's know

**Evaporation is an endothermic process while condensation is an exothermic process.  
Factors affecting evaporation**

#### (i) Nature of the liquid

Different liquids have different rates of evaporation. A liquid having weaker interparticle forces evaporates at faster rate because less energy is required to overcome the attractive forces.

#### Example :

For example, alcohol with a boiling point of 351 K evaporates much more quickly than water with a boiling point of 373 K. This is due to the reason that interparticle forces of attraction are weaker in alcohol than in water.

In general, *lesser is the boiling point, more is the tendency of the liquid to evaporate or to change into vapours.*

#### (ii) Surface area of the liquid

Evaporation is a surface phenomenon, *i.e.*, only the particles on the surface of the liquid get converted into vapours. Thus, *greater is the surface area, more is the rate of evaporation.*

#### Example :

- (a) The rate of evaporation increases when we put kerosene or petrol in an open china dish than in a test tube.
- (b) Clothes dry faster when they are well spread because the surface area for evaporation increases.

#### (iii) Increase in Temperature

Rate of evaporation increases with increase in temperature. This is because with the increase in temperature more number of particles get enough kinetic energy to go into the vapour state (or gaseous state).

**Example :** Clothes dry faster in summers than in winters.

**(iv) Humidity in the air**

The air around us contains water vapour or moisture. The amount of water present in the air is referred to as humidity. The air cannot hold more than a definite amount of water vapour at a given temperature. If the humidity is more, the rate of vaporization decreases. The rate of evaporation is more if the air is dry.

**Example :** Clothes do not dry easily during rainy season because the rate of evaporation is less due to high moisture content (humidity) in the air.

**(v) Wind speed**

The rate of evaporation also increases with increase in speed of the wind. This is because with increase in speed of wind, the particles of water vapour move away with wind thereby decreasing the amount of vapour in the atmosphere.

**Example :**

**(a)** Clothes dry faster on a windy day.

**(b)** In a desert cooler an exhaust fan sucks the moist air from the cooler chamber which results in greater rate of evaporation of water and hence greater cooling.

➤ **ACTIVITY 16**

**AIM :** To study the factors affecting evaporation

**Method**

- Take 5 mL of water in a test tube and keep it near a window or under a fan.
- Take 5 mL of water in an open china dish and keep it near a window or under a fan.
- Take 5 mL of water in an open china dish and keep it inside a cupboard or on a shelf in your class.
- Record the room temperature.
- Record the time of days taken for the evaporation process in the above cases.
- Repeat the above three steps of activity on a rainy day and record your observations. What do you infer about the effect of temperature, surface area and wind velocity (speed) on evaporation?

**Conclusion**

There are five factors which affect the rate of evaporation.


**EXAMPLES**


**Example: 10 :** How does evaporation cause cooling?

**Solution :** During evaporation, only the liquid particles having high kinetic energy leave the surface of the liquid and get converted into vapour. As a result, the average kinetic energy of the remaining particles of the liquid decreases and hence the temperature falls. Thus, *evaporation causes cooling*.

If we place some water in an open vessel, it keeps on evaporating. For evaporation to occur, heat energy is taken from the water. The particles of the water, in turn, absorb energy from the surroundings to regain the energy lost during evaporation. This absorption of energy from the surroundings makes the surroundings cold.

➤ **Some examples of cooling caused by evaporation from daily life :**

- Why do we sprinkle water on the roof or open ground in summer?** During the hot summer evenings, people often sprinkle water on the roof of the house or open ground in front of their house. The water evaporates by absorbing the large latent heat of vaporisation of water from the ground and the surrounding air. By losing heat, the ground becomes cool and comfortable. Similarly, on hot sunny days, water evaporating from the leaves of the trees keeps the surroundings cool.
- Pouring of acetone on palm.** If you pour some acetone (nail polish remover) on your palm, you feel cool. The reason being that the energy needed for evaporation is taken from the palm. By losing heat, the palm feels cooling.

3. **Why do we wear cotton clothes in summer ?** During summer, we prefer to wear cotton clothes to keep ourselves cool. The reason being that during summer, we sweat or perspire a lot. Now cotton is a good absorber of water. Therefore, it absorbs sweat from the body and exposes it to the air (atmosphere). Due to increase in surface area, sweat evaporates by taking large latent heat of vaporization of water from the body and the cotton clothes. As a result, our body feels cool and comfortable. On the other hand,, synthetic clothes (made up of polyester, nylon, etc.) do not absorb much of sweat and hence fail to cool our body in summer.
4. **perspiration keeps our body cold.** On a hot summer day or after doing heavy exercise, the temperature of our body tends to rise. Due to increase in temperature, our body gives out sweat. When the sweat evaporates, it takes heat equal to large latent heat of vaporization of water from our body. By losing heat, our body feels cool.
5. **Why do we see water droplets on the outer surface of a glass tumbler containing ice - cold water ?**  
This is due to the reason that the water vapours present in air, on coming in contact with the cold surface of the glass, lose energy and get condensed or get converted into the liquid state, which we see as water droplets.
6. **Why surgeons often spray some ether on skin before performing minor surgery ?** Surgeons quite often spray ether on a portion of skin before performing minor surgery. The reason being that ether has very low boiling point (308 K). Therefore, it evaporates quite rapidly. As a result, the temperature of the skin becomes so low that it almost becomes numb. Due to this numbness, the patient does not feel much pain when a minor cut is made in the skin in order to perform the surgery.
7. **Why is ice rubbed on a burnt part of the skin ?** When a finger or some other part of our body gets burnt, we rub the burnt portion with an ice cube. The reason being that due to burning, the temperature of the injured skin increases. When ice is rubbed, the excess heat from the skin is taken by large latent heat of fusion of water. As a result, the temperature of the injured skin decreases and we feel less pain.

#### Differences between evaporation and boiling

	Evaporation	Boiling
1.	Evaporation process takes place spontaneously at all temperature.	Boiling takes place only at definite temperature (boiling point) at which the vapour pressure of the liquid is equal to atmospheric pressure.
2.	Evaporation takes place only at the surface phenomenon.	Boiling takes place even below the surface of the liquid in the form of bubbles . Boiling is bulk phenomenon.
3.	It always causes cooling	No cooling

**SUMMARY**

1. Anything that occupies space and has mass is known as matter.
2. Matter is not continuous but rather consists of large number of particles.
3. Characteristics of Particle
  - Large number of particles constitutes matter.
  - Particles of matter are very small in size.
  - Particles of matter have spaces between them
  - Particles of matter are continuously moving
4. Solids have definite shape, distinct boundaries and fixed volume
5. Liquids have fixed volume but no fixed shape.
6. Gases neither have fixed shape nor volume.
7. Solids possess least compressibility.
8. Liquids possess higher compressibility than solids.
9. Gases possess highest compressibility as compared to solids and liquids.
10. The process in which a solid changes to liquid state by absorbing heat at constant temperature is called fusion.
11. The temperature at which a solid melts to become a liquid at the atmospheric pressure is called as melting point.
12. SI unit of temperature is Kelvin.  $T(K) = T(^{\circ}C) + 273$
13. The hidden heat which breaks the force of attraction between the molecules during change of state is called latent heat.
14. Latent heat of fusion is the amount of heat energy required to change 1kg of solid into liquid at its melting point.
15. The melting point of a solid is an indication of the strength of the force of attraction between its particles.
16. The temperature at which a liquid changes to solid by giving out heat at atmospheric pressure is called freezing point.
17. The temperature at which a liquid starts boiling at the atmospheric pressure is known as boiling point.
18. Latent heat of vaporisation is the heat energy required to change 1kg of liquid to gas at atmospheric pressure at its boiling point.
19. Boiling is a bulk phenomenon.
20. The phenomenon of change of a liquid into its gaseous state at any temperature below its boiling point is known as evaporation.
21. In evaporation, the conversion of liquid to gaseous state occurs at a much slower rate, compared to boiling.
22. Evaporation takes place only at the surface of the liquid while boiling can take place in all parts of the liquid.
23. Evaporation is surface phenomenon.
24. Boiling is a bulk phenomena.
25. The amount of water vapour present in the air is called humidity.
26. Evaporation is a continuous or ongoing process.
27. Evaporation causes cooling.

28. The process of evaporation of water from the aerial parts of plants especially leaves is known as transpiration.
29. The rate of evaporation is affected by the surface area exposed to atmosphere, temperature, humidity and wind speed.
30. Since evaporation is a surface phenomenon, therefore, it increases with an increase in surface area.
31. Evaporation increases with an increase in temperature.
32. Evaporation decreases with an increase in humidity.
33. Evaporation increases with the increase in wind speed.
34. The process in which a gas changes into liquid state by giving out heat at constant temperature is called condensation.

\*\*\*\*\*

## EXERCISE-I

## NCERT Solutions



**Q.1** Which of the following are matter?  
Chair, air, love, smell, hate, almonds, thought, cold, cold drink, smell of perfume.

**Sol.** Anything that occupies space and has mass is called matter. Matter can exist in three physical states—solid, liquid, and gaseous. Chair and almond are forms of matter in the solid state.

Cold drink is a liquid state of matter.

Air and smell of perfume are gaseous states of matter.

**Note :** The sense of smell is not matter. However, the smell or odour of a substance is classified as matter. The smell of any substance (say, perfume) is the gaseous form of that substance which our olfactory system can detect (even at very low concentrations). Hence, smell of perfume is matter.

**Q.2** Give reasons for the following observation :  
The smell of hot sizzling food reaches you several metres away, but to get the smell from cold food you have to go close.

**Sol.** Solids diffuse at a very slow rate. But, if the temperature of the solid is increased, then the rate of diffusion of the solid particles into air increases. This is due to an increase in the kinetic energy of solid particles. Hence, the smell of hot sizzling food reaches us even at a distance, but to get the smell from cold food we have to go close.

**Q.6** (a) Tabulate the differences in the characteristics of states of matter.

(b) Comment upon the following: rigidity, compressibility, fluidity, filling a gas container, shape, kinetic energy, and density.

**Sol.** (a) The differences in the characteristics of states of matter are given in the following table.

S. No.	Solid state	Liquid state	Gaseous state
1	Definite shape and volume.	No definite shape. Liquids attain the shape of the vessel in which they are kept.	Gases have neither a definite shape nor a definite volume.
2	Incompressible	Compressible to a small extent.	Highly compressible
3	There is little space between the particles of a solid.	These particles have a greater space between them.	The space between gas particles is the greatest.
4	These particles attract each other very strongly.	The force of attraction between liquid particles is less than solid particles.	The force of attraction is least between gaseous particles.
5	Particles of solid cannot move freely.	These particles move freely.	Gaseous particles are in a continuous, random motion.

**Q.3** A diver is able to cut through water in a swimming pool. Which property of matter does this observation show?

**Sol.** The diver is able to cut through water in the swimming pool because matter is not continuous. but it is made up of particles which have vacant spaces between them. Moreover , the attractive forces between molecules of water are not very strong. the diver can easily cut through water by applying force to displace water and occupy its place.

**Q.4** What are the characteristics of particles of matter?

**Sol.** The characteristics of particles of matter are :

- (i) Particles of matter have spaces between them.
- (ii) Particles of matter are continuously moving.
- (iii) Particles of matter attract each other.

**Q.5** The mass per unit volume of a substance is called density (density = mass/volume). Arrange the following in order of increasing density - air, exhaust from chimney, honey, water, chalk, cotton, and iron.

**Sol.** The given substances in the increasing order of their densities can be represented as :  
Air < Exhaust from chimney < Cotton < Water < Honey < Chalk < Iron

- (b) • Rigidity can be expressed as the tendency of matter to resist a change in shape.  
 • Compressibility is the ability to be reduced to a lower volume when force is applied.  
 • Fluidity is the ability to flow.  
 • By filling a gas container we mean the attainment of shape of the container by gas.  
 • Shape defines a definite boundary.  
 • Kinetic energy is the energy possessed by a particle due to its motion.  
 • Density is mass per unit volume.

**Q.7** Give reasons :

- (a) A gas fills completely the vessel in which it is kept.  
 (b) A gas exerts pressure on the walls of the container.  
 (c) A wooden table should be called a solid.  
 (d) We can easily move our hand in air, but to do the same through a solid block of wood, we need a karate expert.

- Sol.** (a) There is little attraction between particles of gas. Thus, gas particles move freely in all directions. Therefore, gas completely fills the vessel in which it is kept.  
 (b) Particles of gas move randomly in all directions at high speed. As a result, the particles hit each other and also hit the walls of the container with a force. Therefore, gas exerts pressure on the walls of the container.  
 (c) A wooden table has a definite shape and volume. It is very rigid and cannot be compressed i.e., it has the characteristics of a solid. Hence, a wooden table should be called a solid.  
 (d) We can easily move our hand in air since the force of attraction between the particles of a gas, i.e., air are very weak and hence can be easily overcome for the movement of the hand. In contrast, the particles of a solid are closely packed and hence the interparticle forces of attraction are very strong. As a result, they cannot be easily overcome for movement of the hand. In other words, we need a karate expert with almost incredible power to separate these particles apart.

**Q.8** Liquids generally have lower density as compared to solids. But you must have observed that ice floats on water. Find out why.

**Sol.** The mass per unit volume of a substance is called density (density = mass/volume). As the volume of a substance increases, its density decreases. Though ice is a solid, it has large number of empty spaces between its particles. These spaces are larger as compared to the spaces present between the particles of water. Thus, the volume of ice is greater than that of water. Hence, the density of ice is less than that of water. A substance with lower density than water can float on water. Therefore, ice floats on water.

**Q.9** Convert the following temperature to Celsius scale :

- (a) 300 K  
 (b) 573 K

**Sol.** (a)  $300\text{ K} = (300 - 273)^{\circ}\text{C} = 27^{\circ}\text{C}$   
 (b)  $573\text{ K} = (573 - 273)^{\circ}\text{C} = 300^{\circ}\text{C}$

**Q.10** What is the physical state of water at :

- (a)  $250^{\circ}\text{C}$   
 (b)  $100^{\circ}\text{C}$

**Sol.** (a) Water at  $250^{\circ}\text{C}$  exists in gaseous state.  
 (b) At  $100^{\circ}\text{C}$ , water can exist in both liquid and gaseous form. At this temperature, after getting the heat equal to the latent heat of vaporization, water starts changing from liquid state to gaseous state.

**Q.11** For any substance, why does the temperature remain constant during the change of state?

**Sol.** During a change of state of a substance at its melting point or boiling point, the temperature remains constant because all the heat supplied to a substance is utilised in changing the state by overcoming the forces of attraction without increasing kinetic energy between the particles. Therefore, this heat does not contribute in increasing the temperature of the substance.

**Q.12** Suggest a method to liquefy atmospheric gases.

**Sol.** By applying pressure and reducing the temperature, atmospheric gases can be liquefied.

**Q.13** Why does a desert cooler cool better on a hot dry day?

**Sol.** When a liquid evaporates, the particles of the liquid absorb energy from the surroundings to compensate the loss of energy during evaporation. This makes the surroundings cool.

In a desert cooler, the water inside it is made to evaporate. This leads to absorption of energy from the surroundings, thereby cooling the surroundings. Again, we know that evaporation depends on the amount of water vapour present in air (humidity). If the amount of water vapour present in air is less, then evaporation is more. On a hot dry day, the amount of water vapour present in air is less. Thus, water present inside the desert cooler evaporates more, thereby cooling the surroundings more.

That is why a desert cooler cools better on a hot dry day.

**Q.14** How does water kept in an earthen pot (matka) become cool during summers?

**Sol.** There are some pores in an earthen pot through which the liquid inside the pot evaporates. This evaporation makes the water inside the pot cool. In this way, water kept in an earthen pot becomes cool during summers.

**Q.15** Why does our palm feel cold when we put some acetone or petrol or perfume on it?

**Sol.** When we put some acetone or petrol or perfume on our palm, it evaporates. During evaporation, particles of the liquid absorb energy from the surrounding or the surface of the palm to compensate for the loss of energy, making the surroundings cool. Hence, our palm feels cold when we put some acetone or petrol or perfume on it.

**Q.16** Why are we able to sip hot tea or milk faster from a saucer than a cup?

**Sol.** A liquid has a larger surface area in a saucer than in a cup. Thus, it evaporates faster and cools faster in a saucer than in a cup. For this reason, we are able to sip hot tea or milk faster from a saucer than a cup.

**Q.17** What type of clothes should we wear in summers?

**Sol.** We should wear cotton clothes in summers. During summers, we sweat more. On the other hand, cotton is a good absorber of water. Thus, it absorbs sweat from our body and exposes the liquid to the atmosphere, making evaporation faster. During this evaporation, particles on the surface of the liquid gain energy from our body surface, making the body cool.

### Exercise Questions :

**Q.1** Convert the following temperatures to Celsius scale.

- (a) 293 K  
(b) 470 K

**Sol.** Kelvin is an SI unit of temperature, where  $0^{\circ}\text{C} = 273.16\text{ K}$  (approximately 273 K)

- (a)  $293\text{ K} = (293 - 273)^{\circ}\text{C} = 20^{\circ}\text{C}$   
(b)  $470\text{ K} = (470 - 273)^{\circ}\text{C} = 197^{\circ}\text{C}$

**Q.2** Convert the following temperatures to Kelvin scale.

- (a)  $25^{\circ}\text{C}$   
(b)  $373^{\circ}\text{C}$

**Sol.** Kelvin is an SI unit of temperature, where  $0^{\circ}\text{C} = 273.16\text{ K}$  (approximately 273 K)

- (a)  $25^{\circ}\text{C} = (25 + 273)\text{ K} = 298\text{ K}$   
(b)  $373^{\circ}\text{C} = (373 + 273)\text{ K} = 646\text{ K}$

**Q.3** Give reason for the following observations.

- (a) Naphthalene balls disappear with time without leaving any solid.  
(b) We can get the smell of perfume sitting several metres away.

**Sol.** (a) Naphthalene is volatile solid and has a tendency to sublime, therefore, it changes into vapours completely which disappear into the air and no solid is left.  
(b) This is because perfumes contain volatile solvent which carries pleasant smelling vapours.

They diffuse quite fast and can reach to people sitting several meters away.

**Q.4** Arrange the following substances in increasing order of forces of attraction between particles :- water, sugar, oxygen.

**Sol.** These forces of attraction are the strongest in solids, followed by liquids and weakest in gases. Since sugar is a solid, water a liquid and oxygen a gas, therefore, the forces of attraction between particles increase in the order : oxygen < water < sugar.

**Q.5** What is the physical state of water at –

- (a) 25°C      (b) 0°C      (c) 100°C

**Sol.** (a) Water at 25°C is present in the liquid state.

(b) At 0 °C, water can exist as both solid and liquid. At this temperature, after getting the heat equal to the latent heat of fusion, the solid form of water i.e., ice starts changing into its liquid form i.e., water.

(c) At 100 °C, water can exist as both liquid and gas. At this temperature, after getting the heat equal to the latent heat of vaporization, water starts changing from its liquid state to its gaseous state, i.e., water vapours.

**Q.6** Give two reasons to justify –

- (a) water at room temperature is a liquid.  
 (b) an iron almirah is a solid at room temperature.

**Sol.** (a) At room temperature (25°C), water is a liquid because it has the following characteristic of liquid:

(i) At room temperature, water has no shape but has a fixed volume that is, it occupies the shape of the container in which it is kept.

(ii) At room temperature, water flows.

(b) An iron almirah is a solid at room temperature (25°C) because:

(i) It has a definite shape and volume like a solid at room temperature.

(ii) It is rigid as solid at room temperature.

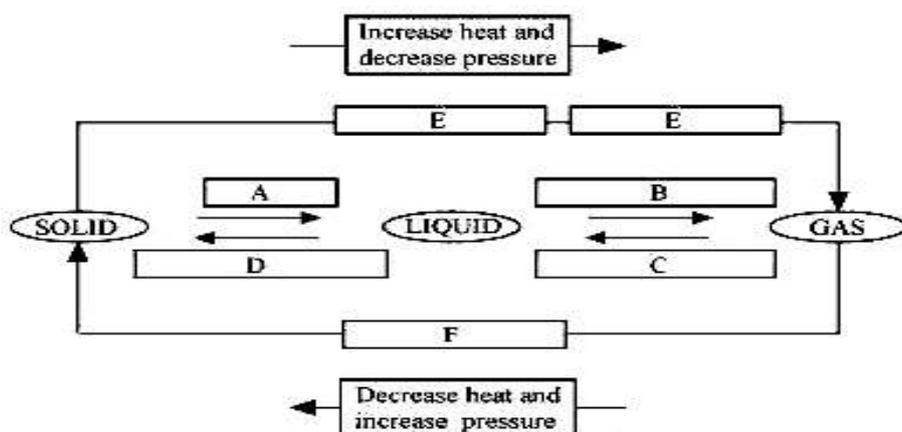
**Q.7** Why is ice at 273 K more effective in cooling than water at the same temperature?

**Sol.** When ice at 273 K melts to form water at 273 K, it absorbs heat energy equal to the latent heat of fusion from the surrounding. This, ice at 273 K has less heat energy than water at 273 K and hence ice is more effective in cooling than water at the same temperature.

**Q.8** What produces more severe burns, boiling water or steam?

**Sol.** Steam has more energy than boiling water. It possesses the additional latent heat of vaporization. Therefore, burns produced by steam are more severe than those produced by boiling water.

**Q.9** Name A, B, C, D, E and F in the following diagram showing change in its state.



**Sol.**

(A) Fusion

(B) Vaporisation

(C) Condensation

(D) Solidification

(E) Sublimation

(F) Desublimation or Deposition

## EXERCISE-II

## Knowledge Vault



## MCQ BASED QUESTIONS:

- Q.1** The chemical substance used to keep within the clothes to protect from the insects and moths are  
 (A) sodium chloride.  
 (B) naphthalene.  
 (C) iodine.  
 (D) ammonium chloride.
- Q.2** The fifth state of matter is formed by  
 (A) condensation of water vapours.  
 (B) evaporation of liquids.  
 (C) sublimation of substance.  
 (D) cooling of gas at super low temperature
- Q.3** The temperature at which celsius and fahrenheit scales shows the same reading is  
 (A)  $40^{\circ}\text{K}$  (B)  $100^{\circ}\text{F}$   
 (C)  $-40^{\circ}\text{C}$  (D)  $-100^{\circ}\text{C}$
- Q.4** The super energetic particle is  
 (A) Solid (B) Plasma  
 (C) Liquid (D) Gas
- Q.5** The more effective in cooling is  
 (A) water at  $0^{\circ}\text{C}$  (B) water at  $100^{\circ}\text{C}$   
 (C) ice at  $0^{\circ}\text{C}$  (D) gas at  $0^{\circ}\text{C}$
- Q.6** The sponge has a  
 (A) lesser mass than the gold.  
 (B) lesser volume than the gold.  
 (C) larger mass than the gold.  
 (D) larger volume than the gold.
- Q.7** Plasticine is a  
 (A) solid  
 (B) highly viscous solid  
 (C) highly viscous liquid  
 (D) gas
- Q.8** The liquid is  
 (A) Honey. (B) Cotton wool.  
 (C) Flour. (D) Plasticine.
- Q.9** The type of clothes that are comfortable for us in summer is  
 (A) Silk clothes (B) Cotton clothes  
 (C) Leather clothes (D) Rayon clothes
- Q.10** The following which has definite shape and volume is  
 (A) Water. (B) Ice.  
 (C) Oxygen. (D) Steam.
- Q.11** The following which uses compressed air is  
 (A) tyres of a bullock cart.  
 (B) juice cans.  
 (C) air guns.  
 (D) balloons.
- Q.12**  $250\text{ mL milk} + 770\text{ cubic meter milk} =$   
 (A)  $1020\text{ mL}$   
 (B)  $1020\text{ cubic meters}$   
 (C)  $250.00077\text{ mL}$   
 (D)  $770.00025\text{ cubic meters}$
- Q.13** The following which diffuses faster is  
 (A) a drop of ink in water.  
 (B) Oxygen in nitrogen.  
 (C) milk in water.  
 (D) sugar in salt.
- Q.14** Anne filled  $1\text{L}$  of air in a jar of capacity  $750\text{ mL}$ . Volume of air in the jar is  
 (A)  $1000\text{ mL}$ . (B)  $875\text{ mL}$ .  
 (C)  $750\text{ mL}$ . (D)  $250\text{ mL}$ .
- Q.15** The following that determines the state of the matter is  
 (A) pressure and temperature.  
 (B) pressure and volume.  
 (C) volume and temperature.  
 (D) temperature.
- Q.16** Energy of particles in steam at  $373\text{ K}$   
 (A)  $>$  Energy of particles in water at  $373\text{K}$ .  
 (B)  $<$  Energy of particles in water at  $373\text{ K}$ .  
 (C)  $=$  Energy of particles in water at  $373\text{ K}$ .  
 (D) Energies cannot be compared.
- Q.17** The following that sublimates on heating is  
 (A) Ice. (B) Dry ice.  
 (C) Water. (D) Water vapours.
- Q.18** Melting points of four solids A, B, C & D are  $773^{\circ}\text{C}$ ,  $826^{\circ}\text{C}$ ,  $932^{\circ}\text{C}$  and  $1238^{\circ}\text{C}$  respectively. The one which has strongest force of attraction between its particles is  
 (A) A. (B) B. (C) C. (D) D.
- Q.19** The normal atmospheric pressure is  
 (A)  $1\text{ atmosphere}$ . (B)  $1.01 \times 10\text{ Pa}$ .  
 (C)  $1\text{ bar}$ . (D)  $1\text{ torr}$ .
- Q.20** Rate of evaporation is highest in  
 (A) an open vessel of diameter  $25\text{ cm}$ .  
 (B) an open vessel of diameter  $30\text{ cm}$ .  
 (C) an open vessel of diameter  $27.5\text{ cm}$ .  
 (D) an open vessel of radius  $26\text{ cm}$ .

- Q.21** The liquid which has the highest rate of evaporation is :  
 (A) Petrol (B) Nail-polish remover  
 (C) Water (D) Alcohol
- Q.22** A gas which obeys the gas laws is known as :  
 (A) An ideal gas (B) A heavier gas  
 (C) A lighter gas (D) A real gas
- Q.23** Diffusion is a property of matter, based on  
 (A) Motion of its particles  
 (B) Size of its particles  
 (C) Pressure (D) Temperature
- Q.24** The process of changing liquid into solid is called  
 (A) Evaporation (B) Freezing  
 (C) Condensation (D) Sublimation
- Q.25** The tendency of non-reacting gases to mix with each other is called as  
 (A) Chemical reaction (B) Diffusion  
 (C) Effusion (D) Explosion
- Q.26** By which property are gases and liquids different from solid ?  
 (A) Volume (B) Mass  
 (C) Conductivity (D) Fluidity
- Q.27** Ice is floating on water in a beaker when ice completely melts then level of water in beaker :  
 (A) Increases  
 (B) Decreases  
 (C) remains the same  
 (D) First increases decreases
- Q.28** The boiling point of a gas is  $-80^{\circ}\text{C}$ . This temperature is equivalent to  
 (A)  $-193\text{ K}$  (B)  $193\text{ K}$   
 (C)  $353\text{ K}$  (D)  $-353\text{ K}$
- Q.29** When the solid melts, its temperature :  
 (A) increases (B) decreases  
 (C) remain constant  
 (D) first increases then decrease
- Q.30** A drop each of two non-corrosive and non-irritating liquids A and B at a temperature of  $22^{\circ}\text{C}$  are placed on the skin. Liquid A gives a more cooling sensation than liquid B. Which of the following can be said about the liquids A and B?  
 (A) Liquid A has higher boiling point than that of liquid B.  
 (B) Liquid A has higher latent heat of vaporisation than that of liquid B.  
 (C) Liquid A has lower latent heat of vaporisation than that of liquid B.  
 (D) The boiling points of liquid A and B are equal.

**MATCH THE COLUMN:****Q.31 Column I (principle)**

- (a) Evaporation  
 (b) filtration  
 (c) Sublimation

**Column II ( Procedure)**

- (p) Purification of drinking water which contains suspended matter  
 (q) Earthen pots  
 (r) Odonil used in washroom  
 (A) (a)-(p), (b)-(r), (c)-(q)  
 (B) (a)-(r), (b)-(p), (c)-(q)  
 (C) (a)-(r), (b)-(q), (c)-(p)  
 (D) (a)-(q), (b)-(p), (c)-(r)

**Q.32 Column I**

- (a) Dry ice  
 (b) LPG  
 (c) Marsh gas  
 (d) Super cooled liquid

**Column II**

- (p) Domestic gas  
 (q) Solid carbon dioxide  
 (r) Methane  
 (s) Water  
 (A) (a)-(r), (b)-(q), (c)-(s), (d)-(s)  
 (B) (a)-(s), (b)-(r), (c)-(q), (d)-(p)  
 (C) (a)-(q), (b)-(p), (c)-(r), (d)-(s)  
 (D) (a)-(q), (b)-(r), (c)-(s), (d)-(p)

**Q.33 Column I**

- (a) Smell of hot food reaches far away  
 (b) Ice floats on water  
 (c) Temperature remains constant during the change of state  
 (d) Desert cool better on a hot dry day

**Column II**

- (p) There are vacant spaces between water molecules in ice.  
 (q) matter uses latent heat to change the state.  
 (r) High temperature and low humidity causes increased evaporation.  
 (s) Hot particles diffuse faster in air  
 (A) (a)-(s), (b)-(p), (c)-(q), (d)-(r)  
 (B) (a)-(s), (b)-(r), (c)-(q), (d)-(p)  
 (C) (a)-(q), (b)-(p), (c)-(r), (d)-(s)  
 (D) (a)-(q), (b)-(r), (c)-(s), (d)-(p)

**Q.34 Column I**

- (a) Diffusion
- (b) Naphthalene
- (c) Evaporation
- (d) Intensive

**Column II**

- (p) Sublime
- (q) The free mixing of molecules.
- (r) Independent
- (s) Liquid into vapours

- (A) (a)-(r), (b)-(q), (c)-(s), (d)-(p)
- (B) (a)-(q), (b)-(p), (c)-(s), (d)-(r)
- (C) (a)-(q), (b)-(p), (c)-(r), (d)-(s)
- (D) (a)-(q), (b)-(r), (c)-(s), (d)-(p)

**Q.35 Column I**

- (a) Pressure
- (b) Temperature
- (c) Density
- (d) Mass
- (e) Volume

**Column II**

- (p) Cubic metre
- (q) Kilogram
- (r) Pascal
- (s) Kelvin
- (t) Kilogram per cubic metre

- (A) (a)-(r), (b)-(s), (c)-(t), (d)-(q), (e)-(p)
- (B) (a)-(q), (b)-(p), (c)-(s), (d)-(r), (e)-(t)
- (C) (a)-(q), (b)-(p), (c)-(r), (d)-(s), (e)-(t)
- (D) (a)-(t), (b)-(r), (c)-(s), (d)-(p), (e)-(q)

**ASSERTION & REASON TYPE QUESTIONS:**

**Q.36 Assertion (A) :** Dogs stretch out their tongues in summer.

**Reason (R) :** Evaporation leads to cooling.

- (A) Both A and R are true and R is the correct explanation for A.
- (B) Both A and R are true but R is not the correct explanation for A.
- (C) A is true and R is false.
- (D) A is false and R is true.

**Q.37 Assertion (A) :** Rate of evaporation is less in rainy season.

**Reason (R) :** Rate of evaporation is directly proportional to humidity.

- (A) Both A and R are true and R is the correct explanation for A.
- (B) Both A and R are true but R is not the correct explanation for A.
- (C) A is true and R is false.
- (D) A is false and R is true.

**Q.38 Assertion (A) :** Baking soda ( $\text{NaHCO}_3$ ) is a compound.

**Reason (R) :** Properties of  $\text{NaHCO}_3$  are absolutely different from sodium, carbon, hydrogen and oxygen.

- (A) Both A and R are true and R is the correct explanation for A.
- (B) Both A and R are true but R is not the correct explanation for A.
- (C) A is true and R is false.
- (D) A is false and R is true.

**Q.39 Assertion (A) :** Carbonated drinks produce a hiss sound when opened.

**Reason (R) :** Carbonated drinks are prepared by the diffusion of gas in water and when opened, the gases come out of the pressurized bottles causing a hissing sound.

- (A) Both A and R are true and R is the correct explanation for A.
- (B) Both A and R are true but R is not the correct explanation for A.
- (C) A is true and R is false.
- (D) A is false and R is true.

**Q.40 Assertion (A) :** The temperature remains constant during change of state.

**Reason (R) :** Heat is used to overcome the forces of attraction.

- (A) Both A and R are true and R is the correct explanation for A.
- (B) Both A and R are true but R is not the correct explanation for A.
- (C) A is true and R is false.
- (D) A is false and R is true.

**EXERCISE -III****Subjective Stuff****VERY SHORT TYPE QUESTIONS :**

- Q.1** Name the property of gases that helps aquatic plants and animals to survive in water.
- Q.2** What is the common between three states of matter?
- Q.3** Why evaporation is called a surface phenomenon ?
- Q.4** It is hot summer day, Priyanshi and Ali are wearing cotton and nylon clothes respectively. Who do you think would be more comfortable and why ?
- Q.5** A doctor advises to use ice pad on forehead to bring high fever down instead of using water at 0°C. Why?

**SHORT TYPE QUESTIONS:**

- Q.6** (a) Explain why temperature remains constant during interconversion of states of matter.  
(b) "Sublimation does not require heating." Is this statement true ? Justify your answer.
- Q.7** (a) Why does the smell of hot cooked food reach you several metres away within seconds ?  
(b) What is the effect of the following on the rate of diffusion :  
(i) Temperature (ii) Density of liquid ?
- Q.8** (a) When common salt is dissolved in water, what will be the change in volume and why ? (b) What property of matter is exhibited by this ?  
(c) Write any one similarity between three states of matter.
- Q.9** (a) List out three differences between evaporation and boiling.  
(b) Why perspiration keeps our body cool ?
- Q.10** Why do solids have a regular geometrical shape ?

**LONG TYPE QUESTIONS:**

- Q.11** Is there any similarity in materials ?
- Q.12** Name the process which occurs when a drop of Dettol is added to water.
- Q.13** Define density and give its SI unit.
- Q.14** Which of the following diffuses faster ?  
Water vapour, wax or ethyl alcohol.
- Q.15** Can materials exist in all the three states

**EXERCISE-IV****Competitive Edge**

- Q.1** Sudden decrease in the intermolecular forces of attraction occurs most efficiently in  
[IJSO-Stage-1/2011-12]  
(A) evaporation (B) melting  
(C) condensation (D) sublimation
- Q.2** Mixture of ethyl alcohol and water can be easily separated by using  
[IJSO-Stage-1/2011-12]  
(A) separating funnel  
(B) fractional distillation.  
(C) filter paper  
(D) None of the above
- Q.3** Charring of sugar in concentrated Sulphuric acid is due to [IJSO-Stage-1/2012-13]  
(A) Oxidation of sugar  
(B) Reduction of sugar  
(C) Hydrolysis of sugar  
(D) Dehydration of sugar
- Q.4** Cheese is a colloidal system of  
[IJSO-Stage-1/2012-13]  
(A) Gas in solid (B) Gas in liquid  
(C) Liquid in gas (D) Liquid in solid
- Q.5** Green house effect is related to  
[IJSO-Stage-1/2012-13]  
(A) Ozone layer depletion  
(B) Carbon dioxide emission and absorption  
(C) Nitrogen radiation  
(D) Oxygen radiation
- Q.6** The method that cannot be used for removing permanent hardness of water is  
[IJSO-Stage-1/2013-14]  
(A) adding sodium carbonate  
(B) distillation  
(C) adding caustic soda  
(D) boiling
- Q.7** Which properties of plastics make their disposal difficult : (I) PVC produces harmful combustion products ; (II) polyalkenes are highly flammable ; (III) Polyalkenes non-biodegradable [IJSO-Stage-1/2013-14]  
(A) I and II only (B) I and III only  
(C) II and III only (D) I, II, III
- Q.8** Melting point of a substance is  $10^{\circ}\text{C}$ . What does this mean ? [IJSO-Stage-1/2016-17]  
(A) The substance is a liquid at  $10^{\circ}\text{C}$ .  
(B) The substance is a solid at  $10^{\circ}\text{C}$ .  
(C) There is an equilibrium between solid phase and liquid phase at  $10^{\circ}\text{C}$ .  
(D) The substance is 50% solid and 50% liquid at  $10^{\circ}\text{C}$ .

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**ANSWER KEY**

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**EXERCISE-II**

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**MULTIPLE CHOICE QUESTIONS:**

<b>Q.1</b>	B	<b>Q.2</b>	D	<b>Q.3</b>	C	<b>Q.4</b>	B	<b>Q.5</b>	C	<b>Q.6</b>	D	<b>Q.7</b>	A
<b>Q.8</b>	A	<b>Q.9</b>	B	<b>Q.10</b>	B	<b>Q.11</b>	C	<b>Q.12</b>	D	<b>Q.13</b>	C	<b>Q.14</b>	C
<b>Q.15</b>	A	<b>Q.16</b>	A	<b>Q.17</b>	B	<b>Q.18</b>	D	<b>Q.19</b>	A	<b>Q.20</b>	B	<b>Q.21</b>	A
<b>Q.22</b>	A	<b>Q.23</b>	A	<b>Q.24</b>	B	<b>Q.25</b>	B	<b>Q.26</b>	D	<b>Q.27</b>	C	<b>Q.28</b>	B
<b>Q.29</b>	C	<b>Q.30</b>	C										

**MATCH THE COLUMN :**

<b>Q.31</b>	D	<b>Q.32</b>	C	<b>Q.33</b>	A	<b>Q.34</b>	B	<b>Q.35</b>	B
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**ASSERTION & REASON :**

<b>Q.36</b>	A	<b>Q.37</b>	C	<b>Q.38</b>	A	<b>Q.39</b>	A	<b>Q.40</b>	A
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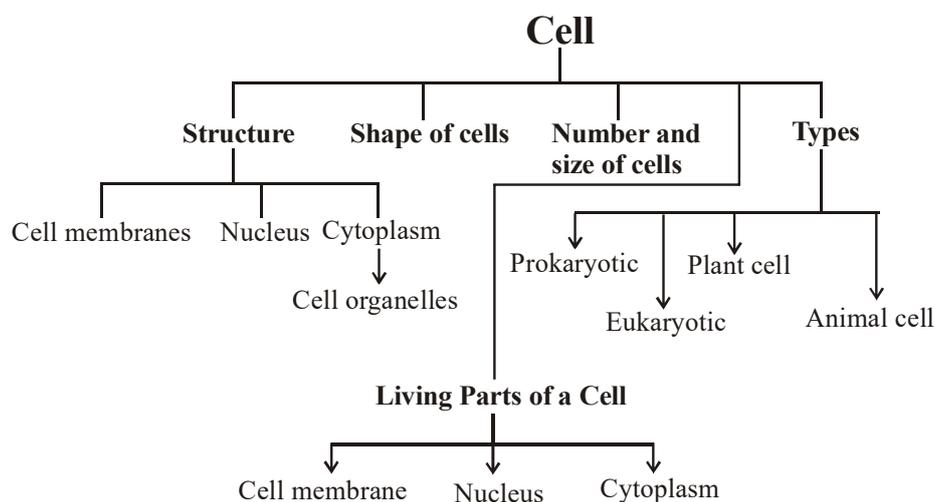
**EXERCISE-IV**

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<b>Q.1</b>	D	<b>Q.2</b>	B	<b>Q.3</b>	D	<b>Q.4</b>	D	<b>Q.5</b>	B	<b>Q.6</b>	D	<b>Q.7</b>	D
<b>Q.8</b>	C												

# 1 Fundamental Unit of Life

## 1. INTRODUCTION



- **Cell is the structural and functional unit of all life forms.**
- A single cell organism such as **bacteria, Amoeba and Chlamydomonas** are also a type of life forms.
- **The microscopic study of cell is called Cytology.**
- **A cell may be defined as a unit of protoplasm surrounded by a membrane.**

## 2. HISTORY

- **A.V. Leeuwenhoek (1632 – 1723)**, a first person to construct a microscope. He discovered the minute forms of life such as bacteria and single-celled animals like **Infusoria** in a drop of water.
- Cells were first discovered by **Robert Hooke (1665)**, in a cork slice. He gave details about cell in his book “**Micrographia**” and described cell as honey comb lattice.
- **Leeuwenhoek (1674)** with the improved microscope, discovered the free cells of bacteria for the first time.
- **Robert Brown in 1831**, discovered the **nucleus** in the cell.
- **J.E. Purkinje in 1839** gave the term ‘**protoplasm**’ for the **living fluid substance of the cell**.
- The cell theory was presented by two German biologists, **M.Schleiden (1838) and T. Schwann (1839)**.
- In 1855, **Rudolf Virchow** said, “**Omnis cellulae cellula**”, (cells arise from pre-existing cells).

## 3. CELL THEORY

- Two biologists, “**Schleiden and Schwann**” gave the “**Cell theory**” which was later on expanded by “**Rudolf Virchow**”. Cell theory states that
  - (i) All plants and animals are composed of cells.
  - (ii) Cell is the basic unit of life.
  - (iii) All cells arise from pre-existing cells.



### Let's know

Viruses are the exceptions of cell theory.

## 4. TYPES OF CELL & ORGANISM

### I. On the Basis of Number of Cells, Organisms can be categorized as :

- (A) **Unicellular organisms** : These are organisms which are made up of single cell only. This single cell Performs all the vital body functions of an organism. e.g. Amoeba.
- (B) **Multicellular organisms** : These are the organisms which are made up of numerous cells. These cells then combine to form an organ and group of organs performing different functions forms an organ system which further forms an organism. e.g. plants and animals.
- (C) **On the basis of type of organization, cells are of two types :**
- (i) **Prokaryotic cells** : These are primitive and incomplete cells. They have less developed nucleus without nuclear membrane & nucleolus. e.g. Bacteria.
- (ii) **Eukaryotic cells** : These are well developed cells. They have advanced nucleus with unclear membrane and nucleolus. e.g. Plants & animals.

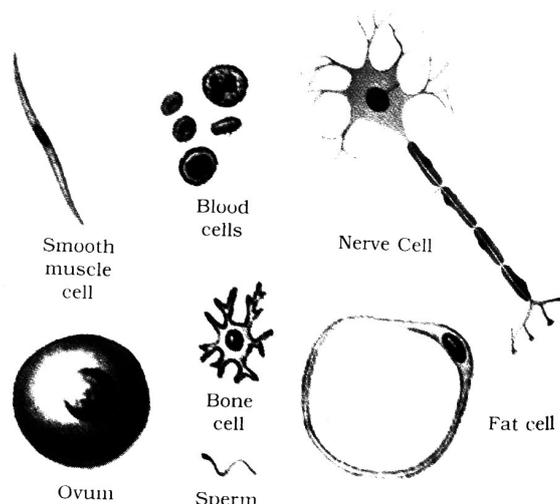
## 5. CELL STRUCTURE, SHAPE, SIZE AND NUMBER

### I. Structure of Cell :

- All cells have three major functional regions, viz. plasma membrane, nucleus and cytoplasm.
- The **cytologists** divide the cell into two major components – the nucleus and the cytoplasm, with the development of electron microscope, whose magnifying power is of the order  $16 \times 10^5$ .

### II. Shape of Cell :

- There is a great variation in the shape of cells. The shape of cell is usually related to its function.



### III. Size of Cells :

- The smallest cells ( $0.1 - 0.2 \mu\text{m}$ ) are found as bacteria and **pleuropneumonia-like organisms (PPLO)**, eg. **Mycoplasma galliseptum**.
- The largest cell is the egg of an Ostrich which measures about 180 mm in diameter.
- The largest human cell is the female ovum (0.01 mm in diameter).
- The smallest human cell is the red blood cell ( $0.0075 \text{ mm}$  or  $7.5 \mu\text{m}$ ).



### Let's know

Cells are measured in micrometres. A micrometer is one thousandth of a millimetre.

### IV. Number of Cells :

- The number of cells in living organisms also varies greatly. In unicellular organisms, a single cell constitutes its body eg. **Chlamydomonas, Amoeba and Paramecium (Protist Organisms)**.
- On the other hand, in human body, the estimated number of cells is about 26 trillion.

## 6. MICROSCOPE

- A Microscope is an instrument which magnifies the object seen through it.
- The 1st compound microscope was built by F. Janssen and Z. Janssen (1590).

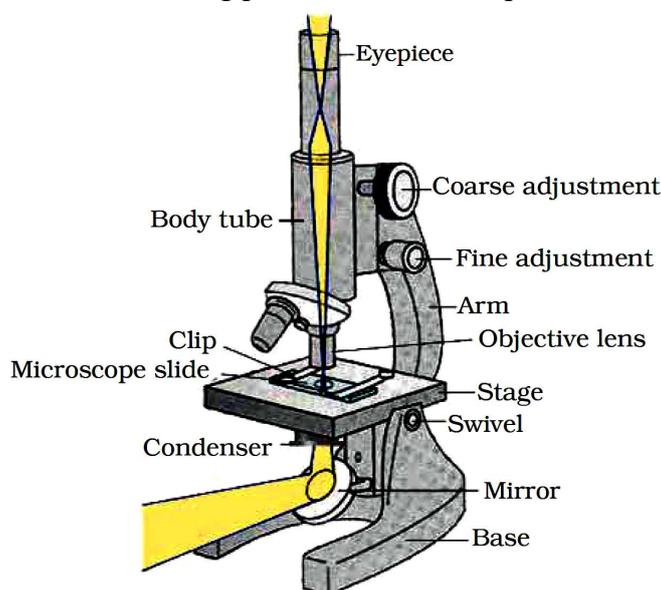
The microscope used in schools is called **compound microscope**. A compound microscope has following parts:

**Base :** It is the basal, metallic, horse-shoe shaped structure. It bears the whole weight of microscope.

- **Handle :** It is the curved part to hold the microscope. It is also called as arm.
- **Stage :** It is a strong metallic, rectangular, horizontal plate fixed to the handle.
- **Stage Clips :** Two clips are attached to stage used for holding the slide in position.
- **Condenser :** Below the stage is present a condenser for concentrating the light rays.
- **Body tube :** It is wide, hollow tube attached to the upper part of the arm. To this tube lenses are attached

### ➤ Adjustment screw :

- **Coarse adjustment :** It is bigger sized screw used to move the body tube up and down.
- **Fine adjustment :** It is a smaller sized screw for fine focussing.
- **Reflecting mirror :** It is meant for reflecting the light rays, so that light passes through the object which is to be seen.
- **Resolving Power of a Microscope :** In addition to magnifying a specimen, microscope must produce a clear image of the closely spaced parts. The ability to provide such an image is called the resolving power of a microscope.



## 7. PARTS OF A CELL :

### I. Plasma membrane or Cell membrane

### II. Nucleus :

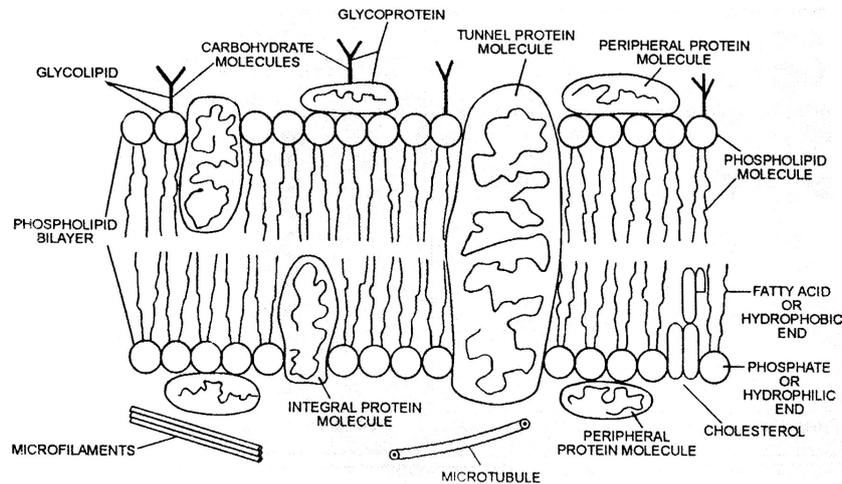
- |                      |                        |
|----------------------|------------------------|
| (A) Nuclear membrane | (B) Nucleolus          |
| (C) Nucleoplasm      | (D) Chromatin material |

### III. Cytoplasm : Contain various cell organelles :

- |                               |                           |              |
|-------------------------------|---------------------------|--------------|
| (A) Endoplasmic Reticulum     | (B) Golgi Complex         | (C) Lysosome |
| (D) Mitochondria              | (E) Plastid (plants only) | (F) Ribosome |
| (G) Centrosome (animals only) |                           |              |

### I. Plasma membrane or Cell Membrane :

- Every living cell is externally covered by a thin, transparent, elastic, selectively-permeable membrane called- **plasma membrane** or **cell membrane**.
- **Plasma membrane** name was given by **Nageli**.
- Present on both prokaryotic and eukaryotic cells.
- Made up of protein and phospholipids.
- Fluid-Mosaic model of plasma membrane is most acceptable. It was proposed by **Singer** and **Nicholson**.
- It helps in exchange of gases i.e.  $\text{CO}_2$ ,  $\text{O}_2$  by the process of **diffusion**.



**DIFFUSION** - It the movement of molecules from the region of high concentration to the region of low concentration.

### EXAMPLES

#### ➤ Example - 1

- If the perfume bottle is opened in one corner of the room, then the fragrance of the perfume can be smelled on the other corner soon.
- It happens because the fragrance molecules are more concentrated in the perfume bottle.
- The fragrance molecules are nil in the air present in the room.
- The fragrance molecules spread in the air present in the room from the opened perfume bottle just by diffusion.

#### ➤ Example - 2

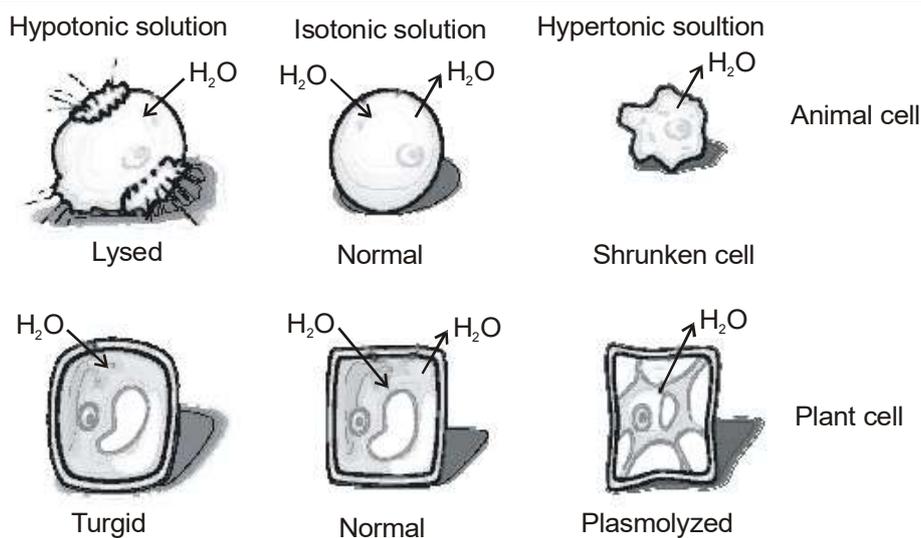
- If a drop of ink is added to the beaker containing water, then the ink slowly spreads in the water.
- It occurs because of diffusion.
- Movement of water takes place by the process of **osmosis** through it.

#### ➤ OSMOSIS

- *It is the process of movement of solvent molecules from the region of low concentration to the region of high concentration through semi-permeable membrane.*

#### ➤ Types of solution on the basis of concentration :

- Isotonic solution:** When the concentration of the solution outside is equal to the concentration of cytoplasm of the cell, it is called as isotonic solution.
- Hypertonic solution:** When the concentration of the solution outside the cell is more than that inside the cell, it is called hypertonic. Due to this cell loses water and becomes plasmolysed.
- Hypotonic solution:** When the concentration of the solution outside the cell is lesser than that of cytoplasm of cell, it is called hypotonic solution due to this cell swells up and bursts.



### Movement of water in a cell in different types of solution

#### ➤ Functions of Cell membrane :

- It regulates the movement of molecules in and out of the cells.
- It allows selective molecules to pass through it, so called selectively permeable.
- Selective permeability allows the passage of solvent molecules i.e. water. On the basis of this property, cell shows change in its shape according to concentration of surrounding solutions, which are :
  - In isotonic solution, has the same concentration of water and solutes as inside a cell. Cell shows no change in its shape.
  - In hypotonic solution, has lower solute concentration than inside the cell. Cell becomes turgid.
  - In hypertonic solution, has higher solute concentration than inside the cell. Cell becomes flaccid.

**TABLE : DIFFERENCES BETWEEN DIFFUSION AND OSMOSIS**

S.no.	Diffusion	Osmosis
1.	Diffusion can occur in any medium	It occurs only in liquid medium
2.	The diffusing molecules may be solids, liquids or gases	It involves movement of solvent molecules only
3.	Semipermeable membrane is not required	Semipermeable membrane is required
4.	It is dependent upon the free energy of the molecules of diffusing substance only ; presence of other substance in the system is of no importance	Though it is the diffusion of solvent molecules only, yet influenced by the presence of other substances (solutes) in the system.

#### ➤ Cell wall :

- Outer most, rigid, dead, protective and supportive layer found on all plant cells, bacteria, cyanobacteria and some protists but not found on animal cells.
- Discovered by **Robert Hooke (1666)**.

#### ➤ Function of Cell wall :

- It lies outside the plasma membrane.
- Provide shape and rigidity to cell.
- In plants, it is made up of cellulose, a polymer of glucose.
- In Fungi, it is made up of chitin, a polymer of acetylglucosamine.
- In prokaryotes, it is made up of peptidoglycan, a combination of non-cellulose polysaccharides and amino acids.

- Helps in withstanding hypotonic external media without bursting the cell. In such condition cell absorb water by osmosis, swells up and exerts a pressure on cell wall. It is called turgor pressure (TP). At the same time cell wall exert an equal pressure on Plasma membrane, called wall pressure (WP). In fully turgid cell WP is always equal to TP. Thus, due to cell wall, cell can withstand greater changes in surrounding medium.

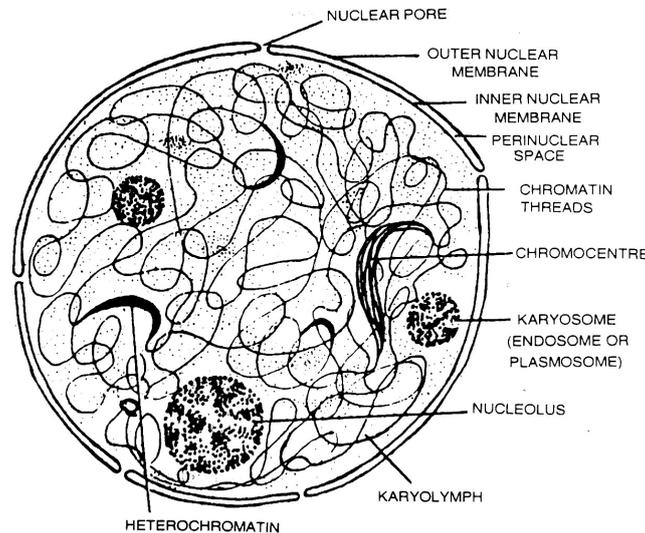


### Let's know

Plasmodesmata are microscopic channels which transverse the cell walls of adjacent plant cells to maintain communication between them.

## II. Nucleus :

- Important and essential part of the cell is present in cytoplasm and is called 'nucleus'.
- It shows variation in shape and number.
- Most cells are monokaryotic with (single nucleus) but RBCs of mammals are enucleate, **Paramoecium** is binucleate, **Opalina** is multinucleate.
- **Robert Brown (1831)** described it for the first time.
- In prokaryotic cells well defined nucleus is absent due to the absence of nuclear membrane. Such undefined nuclear region is called **nucleoid** or **genophore**.



### ➤ Structure :

- It is generally spherical or oval in shape.
- It is formed of four components.

#### (A) Nuclear Membrane :

- It is bilayered, also called nuclear envelope or nucleolemma.
- Has nuclear pores that allow exchange of substances between nucleus and cytoplasm.

#### (B) Nucleolus :

- 1<sup>st</sup> observed by **Fontana (1781)**.
- It is most prominent in non dividing cell.
- It is a store house of RNA. Helps in synthesis of ribosomes.
- Nucleolus is known as the factory of ribosome.

#### (C) Nucleoplasm :

- Transparent, homogenous, semifluid substance, has chromatin material and nucleolus. Has water, sugar, minerals and various enzymes.

**(D) Chromatin material :**

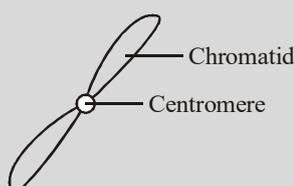
- First reported by **W. Flemming** (1882).
- Made up of DNA with genes.
- Genes are linearly arranged on DNA.
- Change in DNA produce variations.
- Since DNA can be coloured (stained) and is in the form of net-work, it is also called chromatin network.
- By coiling (or condensation), chromatin material can form chromosomes.

**➤ Chromosome :**

- Appear only at the time of cell division inside the nucleus.
- Appear by coiling and condensation of DNA.
- DNA coil around the histone proteins, so chromosomes are said to be made of nucleoproteins (since DNA is a nucleic acid).
- *Chroma* means colour or stain or dye and *soma* means body.
- Since chromosomes can be coloured or stained, these are given the name 'chromosomes'.
- The term chromosome was used for the first time by **Waldeyer**.
- Chromosomes appear as rod or thread shaped structures.
- Since DNA has genes on it, DNA is called '**genetic material**'.
- Since chromosome are made of DNA, that in turn has genes, chromosomes carry genetic information from one generation to the next generation.
- Thus the chromosomes are called '**the vehicles of heredity**'.

**Let's know**

Structure of a typical chromosome :



On the basis of the position of centromere on the chromosome, chromosomes are of following types.

- |                                |   |  |
|--------------------------------|---|--|
| 1. Metacentric or V-shaped     | → |  |
| 2. Sub-metacentric or L-shaped | → |  |
| 3. Acrocentric or j-shaped     | → |  |
| 4. Telocentric or i-shaped     | → |  |
| 5. Acentric                    | → |  |

**➤ Functions of Nucleus:**

- Controls all cellular activities.
- Chromosome contains hereditary informations of the cell and transfer the genetic information from one generation to another.
- Plays central role in cellular reproduction. It determines the way in which cell will develop.

**III. Cytoplasm :**

- Part of cell present outside the nucleus and inside the cell membrane is called **cytoplasm**. Has various organelles to perform various activities of cell like digestion, synthesis, release of energy etc.
- Cytoplasm is an aqueous jelly with H<sub>2</sub>O, Oxygen, Carbohydrates, lipids, proteins, amino acids etc.
- Organelles are primitive in Prokaryotic cells.



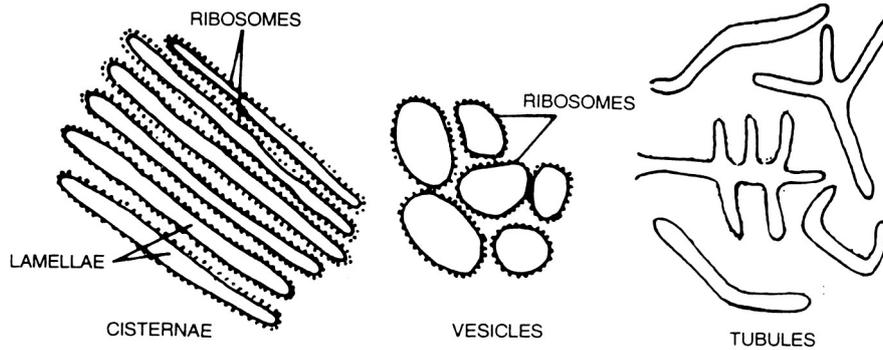
**Let's know**

On the basis of membranous covering, cell organelles are divided into three types :

- (i) **Membrane less organelles** – Example : Ribosomes.
- (ii) **Single membrane bound organelles** – Example : Endoplasmic reticulum, Golgi bodies, Lysosomes, Vacuoles.
- (iii) **Double membrane bound organelles** – Example : Mitochondria and plastids.

➤ **CELL ORGANELLES FOUND IN EUKARYOTIC CELLS**

(A) **Endoplasmic Reticulum (ER)**



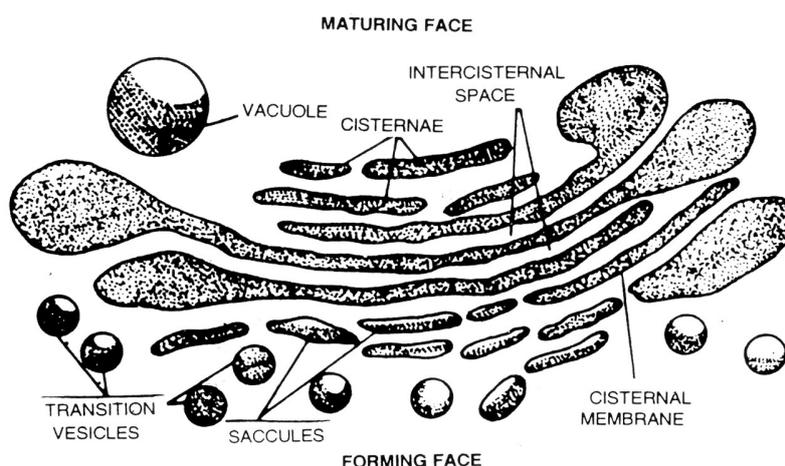
- First observed by **Garnier (1897)**, then ER the term was given by **Porter (1952)**.
- Membranous network, enclosing a fluid-filled lumen present through out the cytoplasm.
- Absent in prokaryotes.
- Made up of three types of elements i.e. Cisternae, Vesicles and Tubules.
- On the basis of presence or absence of ribosomes, ER is of two types
  - (i) Smooth or agranular endoplasmic reticulum (SER)
  - (ii) Rough or granular endoplasmic reticulum (RER).

**TABLE : DIFFERENCES BETWEEN SMOOTH AND ROUGH ENDOPLASMIC RETICULUM**

S.NO.	Character	SER	RER
1.	Components	Made of tubules mainly.	Made of cisternae & vesicles.
2.	Ribosomes	Absent	Present
3.	Position	Mainly present near cell membranes	Mainly present near the nucleus
4.	Functions	Helps in steroid, lipids & polysaccharide synthesis.	Helps in protein synthesis.
		Helps in membrane biogenesis and detoxification	
5.	Occurrence	Mainly found in lipid forming cells like adipocytes (Fat cells)	Mainly found in protein forming cells like Nissl's granules of nerve cells.

➤ **Function :**

Helps in transportation of materials between various regions of the cytoplasm or between the cytoplasm and the nucleus.  
 Act as cytoskeleton and provide mechanical support and shape to cell.  
 RER helps in synthesis of proteins which are sent to various places in the cell depending on need. SER helps in lipid synthesis.  
 Some proteins and lipids synthesized in ER are used for producing cell membrane the process is called **membrane biogenesis**.  
 Some proteins and lipids synthesized by ER also work as hormones and enzymes.  
 ER forms cytoplasmic frame work and provide surface for biochemical activities.  
 In liver cells of vertebrates, SER helps in detoxifying many poisons and drugs.

**(B) Golgi Apparatus :**

- First described by **Camilo Golgi (1898)**, by using black reaction staining technique.
- In animal cells it lies above the nucleus. In plant cells, it is scattered in the cytoplasm and is called **dictyosomes**.
- It is absent in Prokaryotes, mammalian RBCs.
- It consist of set of smooth, flattened cisternae, vacuoles, vesicles.
- Its membrane is connected with membrane of ER and make another cellular membrane system.

➤ **Function :**

Golgi apparatus helps in packing and dispatching various materials synthesized near ER to inside and outside the cell.

It helps in storage, modification and packaging of products in vesicles.

Some time it may form complex sugar from simple sugar.

Also forms lysosomes, by converting proteins into enzymes.

**(C) Lysosomes :(Lyso-Digestive, Some-Body)**

- Discovered by **de Duve (1955)**.
- Single membrane-bound vesicles formed by SER or golgi apparatus.
- Contain strong hydrolytic enzyme capable of digesting or breaking down all organic materials, these enzymes are synthesized by RER.

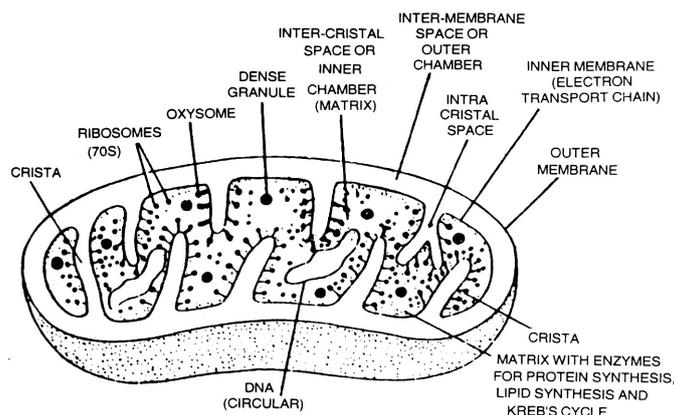
➤ **Function :**

Helps in intracellular digestion, so called **digestive bags**.

Destroy any foreign material inside cell such as bacteria etc.

Also remove the worn-out and poorly working cell organelles by digesting them. Hence, make a waste disposal system of the cell and keep the cell clean.

During disturbance in cellular metabolism, Lysosomes get burst and its enzyme digest their own cell. Thus, Lysosomes are also called **suicidal bags** of cell.

**(D) Mitochondria :**

- It was first observed by **Altman** and was later explained by **Kollikar**.
- Name mitochondria was given by **Benda (1897-98)**.
- Rod-shaped, double membranous cell organelles, called **power-house of cell**.
- Outer membrane is smooth and porous but inner one is folded into finger like cristae, for ATP generating reactions.
- On cristae oxysomes are present, which are the main site of ATP generation.

**➤ Function :**

Main cell organelles that help in aerobic respiration.

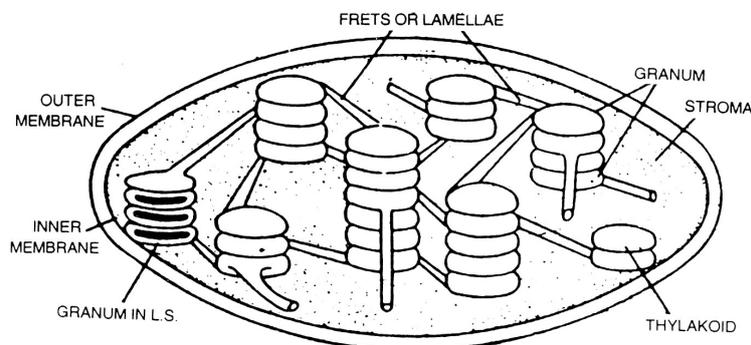
Release energy required in the form of ATP (Adenosine triphosphate). ATP is called **energy currency**.

ATP is used for making new chemical compounds and for mechanical works.

Mitochondria have their own circular DNA and ribosomes. So, regarded as **semi-autonomous** and **self-replicating cell organelles**.

**Let's know**

ATP = Adenosine Triphosphate. ATP is known as energy currency of the cell. It is a common cellular fuel that drives many energy-requiring processes of the cell.

**(E) Plastids :**

- Term plastid was given by **Haeckel (1866)**.
- Found in all plant cells and some protists.
- These are double-membranous and have their own DNA.
- In photosynthetic prokaryotic bacteria chlorophyll is associated with membranous vesicles (but not with plastids).

- **Schimper** used the term plastid for the first time in 1885 and classified plastids as :
  - Leucoplasts** : Colourless plastids that store starch, oil and proteins.
  - Chromoplasts** : Coloured plastids other than green. Contain several pigments and provide colour to petals, fruits etc.
  - Chloroplast** : Green coloured plastids, found in leaf and other green parts of plants. Help in photosynthesis to prepare carbohydrates. So, are called **kitchen of the cell**.
- Two membranes of chloroplast surround colourless, proteinaceous matrix called **stroma**, containing DNA, ribosomes and enzymes etc. In stroma dark reaction of photosynthesis takes place.
- Stroma contain flat, membranous disc like structures called **thylakoids**, and their group forms granum.
- Grana are connected by stroma lamellae.
- In side grana chlorophyll molecules are present. So, in grana light reaction of photosynthesis occurs.



### Let's know

- Granum is the site of light reaction during photosynthesis while stroma is the site of dark reaction during photosynthesis.
- Mitochondria and chloroplasts are called semi autonomous organelles because of the following reasons:
  - They have their own DNA which can replicate independently.
  - Its matrix possesses its own ribosomes.
  - It synthesizes some of its own proteins.
  - For the synthesis of some proteins it depends on nuclear DNA.

### (F) Ribosome :

- First observed by **Claude (1941)** through electron microscope and called **microsome**.
- Name ribosome was given by **Palade (1955)**.
- Smallest cell organelle found in both prokaryotic and eukaryotic cells.
- Not surrounded by membrane.
- Are of two types on the basis of size and Swedberg unit or sedimentation coefficient i.e.
  - 70S ribosomes** : Found in prokaryotes and have two sub units (i.e. 50S and 30S).
  - 80S ribosomes** : Found in eukaryotes and have two sub units (that is 60S and 40S).
- Centrally placed in plant cells and may occupy 50-90% of the cell volume.

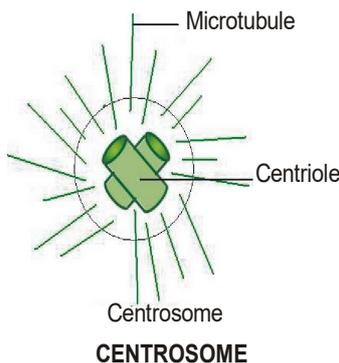


### Function :

Main site of protein synthesis so called “**Protein Factory of the cell**”.

### (G) Centrosome :

- Formed by two granules called **centrioles**, surrounded by transparent area called **centrosphere**.
- Found in all animal cells except mature RBC and nerve cell. Also found in most of protists, motile plant cells.



➤ **Function :**

Forms asters during cell division of animal cells.  
Forms basal-bodies of cilia and flagella.

**(H) Peroxisomes :**

- Small, membrane bound sacs and contain powerful oxidative enzymes.
- Mostly found in kidney and liver cells.

➤ **Function :**

In plants, help in photorespiration.  
Carrying out some oxidative reactions and help in removal of toxic substances.

**(I) Vacuoles :**

- These are uni-membranous sacs for storage of solid or liquid, nutrients
- Outer membrane is called **tonoplast**.
- Small and few in animal cells but large and well developed in plant cells.
- Centrally placed in plant cells and may occupy 50-90% of the cell volume.

➤ **Function :**

Store some proteins, amino acids, sugars, various organic acids etc., that are essential for plant cells.

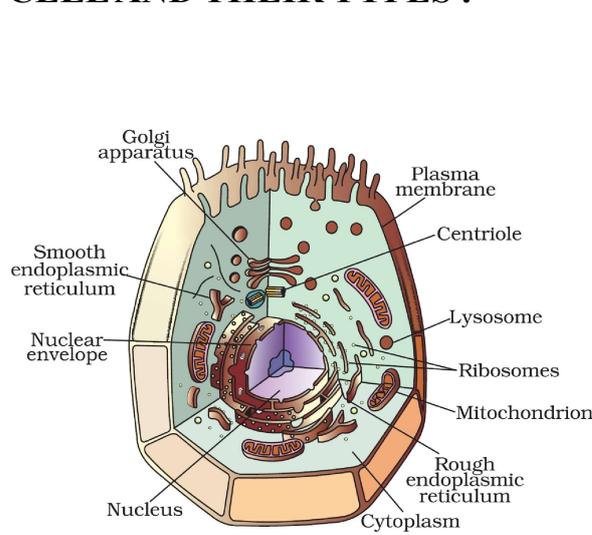
In amoeba, store food called and so are called **food vacuoles**.

In some unicellular, aquatic organisms vacuole helps in expelling excess water and some wastes from the cell and are called **contractile vacuole (CV)**.

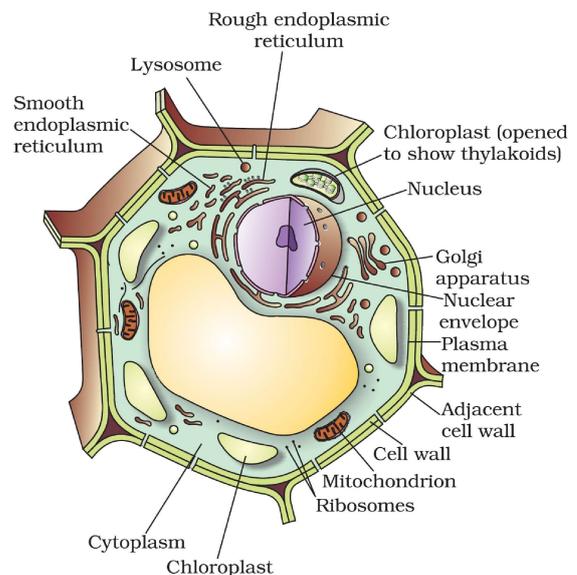
**(J) Cell Inclusions :**

- On the basis of nature, cell inclusions are classified as :
  - Reserve product: Carbohydrates, fats and oils, yolk (in animals), proteins.
  - Secretory Products: Enzymes, pigments, nectar (in plants).
  - Waste products (in plants): Mineral crystals, gums and resins, latex, alkaloids (e.g. nicotine, morphine, quinine), tannin and essential oils.

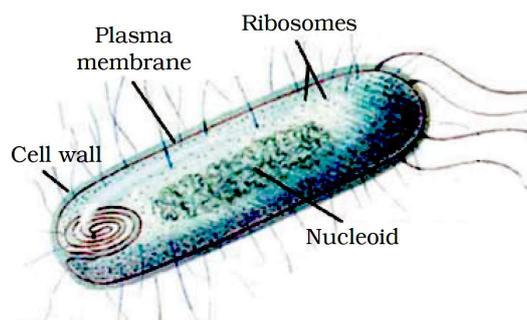
**8. CELL AND THEIR TYPES :**



**Animal Cell**



**Plant cell**



Bacterial Cell

## Differences between prokaryotic and eukaryotic cell

Prokaryotic Cell	Eukaryotic Cell
1. Size is generally small (1 – 10 $\mu\text{m}$ )	1. Size is generally large (5 – 100 $\mu\text{m}$ )
2. Protoplasm is relatively rigid, usually non-vacuolate.	2. Protoplasm is typically more fluid like, generally vacuolate.
<b>3. True nucleus absent, i.e. nuclear membrane and nucleolus are absent.</b>	<b>3. True nucleus present, i.e. nuclear membrane and nucleolus are present.</b>
4. DNA scattered in the protoplasm and without histone proteins.	4. DNA organized with histone proteins to form chromosomes.
5. Membrane-bound cell organelles like plastids, mitochondria, Golgi bodies, E.R. are absent.	5. Membrane-bound cell organelles like plastids mitochondria, Golgi bodies, E.R. are present.
<b>6. Ribosomes are of 70S type.</b>	<b>6. Ribosomes are of 70S and 80S type.</b>
7. <b>Examples :</b> Bacteria, blue-green algae, mycoplasma.	7. <b>Examples:</b> Cells of all higher organisms

## Differences between plant and animal cells

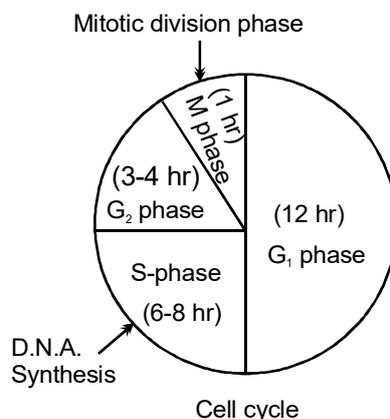
Plant cell	Animal cell
1. Plant cells are usually larger than animal cells.	Animal cells are generally small in size.
2. The plasma membrane of a plant cell is surround by a rigid cell wall.	Cell wall is absent.
3. Plastids (leucoplasts, chloroplasts, chromoplasts) are present in plant cells.	Plastids are absent.
4. Vacuoles are present in abundance. They are larger in size.	Vacuoles are less in number and smaller in size.
5. Plant cells have many simpler units of Golgi complex, called dictyosomes.	Animal cells have a single highly elaborate Golgi complex.
6. Centrioles have not been found in plant cells (except in a few lower plants).	Animal cells possess centrioles.
7. Cytokinesis takes place by cell-plate formation.	Cytokinesis takes place by constriction during cell division.
8. Plant cells usually have a regular shape.	Animal cells are usually irregular in shape.

## 9. CELL DIVISION :

Cell division was first observed by Nageli in plant cell (1842) and it was first studied by Prevost and Dumas in the fertilized egg of frog.

**Cell Cycle :** It is a series of programmed cyclic changes by which the cell duplicates its contents and divides into two daughter cells. Cell cycle was discovered by Howard and Pelc. It is divided into two phases :

1. Long non dividing (I – phase) or interphase.
2. Short dividing M – phase or mitotic phase



1. **Long non dividing (I – phase) or interphase or preparatory phase :** Interphase divided in the following steps.

- $G_1$  (First growth phase),
- S (Synthesis phase),
- $G_2$  (Second growth phase)

2. **Short dividing M – phase :**

It is the phase of cell division. It consists of karyokinesis (nuclear division) and cytokinesis (cytoplasmic division). It is of three types:

### I. Mitosis :

- Term mitosis was given by Flemming.
- It is also called as somatic division as it occurs during formation of body cells.
- It is an equational division in which a parent cell divides into two identical daughter cells, each of them contains the same number of chromosomes as are present in parent cell.

➤ It occurs in two steps :

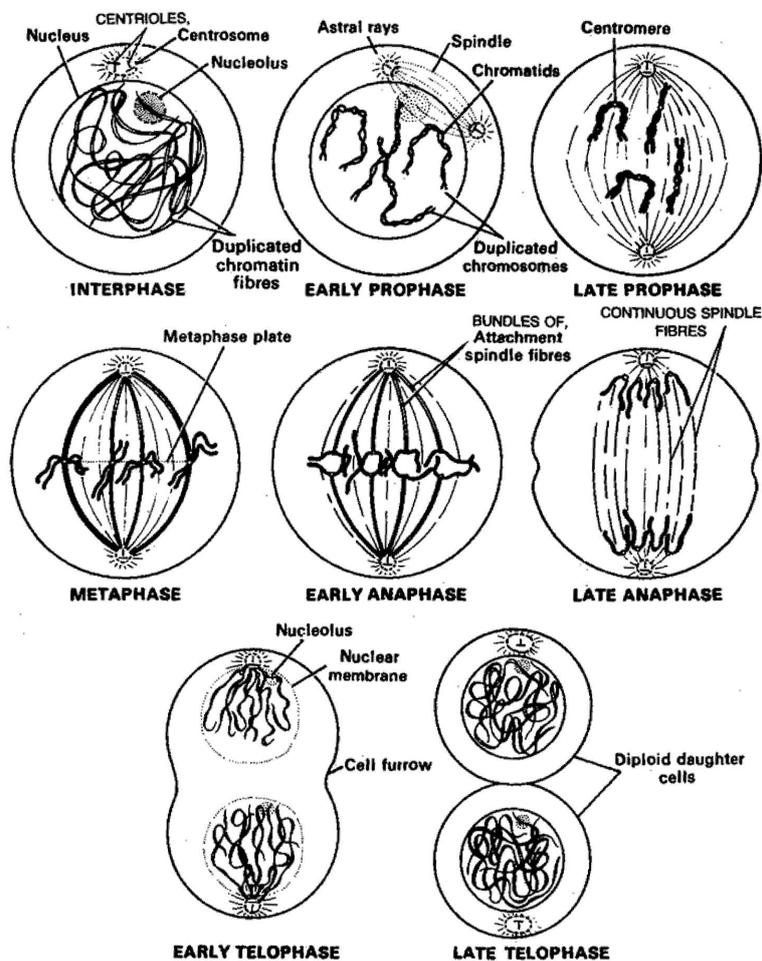
- (A) Karyokinesis (Division of Nucleus)
- (B) Cytokinesis (Division of Cytoplasm)

- (A) **Karyokinesis :** Division of nucleus. It is divided in four steps :

- (i) **Prophase :** Longest phase of cell division. In this chromatin condensed into chromosomes and nuclear membrane disappears.
- (ii) **Metaphase :** Chromosomes are arranged at the equator & forming a metaphase plate. Chromosomes are shortest and thickest in this stage. This phase is most suitable for study of chromosomes.
- (iii) **Anaphase :** Shortest phase of cell division.
  - Chromosomes are appeared in different shapes.
  - V – Shaped (Metacentric)
  - L – Shaped (Submetacentric)
  - J – Shaped (Acrocentric)
  - I – Shaped (Telocentric)
- (iv) **Telophase :** It is reverse of prophase

- (B) **Cytokinesis** : It is referred to the division of cytoplasm.  
**In animals it occurs by formation of cleavage furrow in the middle by constriction in plasma membrane. In plants it occurs by cell plate formation.**

**Note** : Colchicine is a mitotic poison. It blocks the completion of metaphase.



Various stages of mitosis

## II. Meiosis :

- It occurs only once in the life cycle of organism.
- It is a double division in which a diploid cell divides twice to form four haploid cells.
- It can be studied in anthers of unopened flowers in plants and in testis of grasshopper in animals. It consists of two phases :

(A) **Interphase** : Size of nucleus increases to three times. It also involves  $G_1 - S -$  phase in meiosis-I and  $G_1 - G_2$  in meiosis-II.

(B) **M - phase** : It occurs in two steps

(i) Meiosis - I,                      (ii) Meiosis - II

(i) **Meiosis - I** : Also called as reduction division. Diploid stage changes to haploid stage. It occurs in four steps.

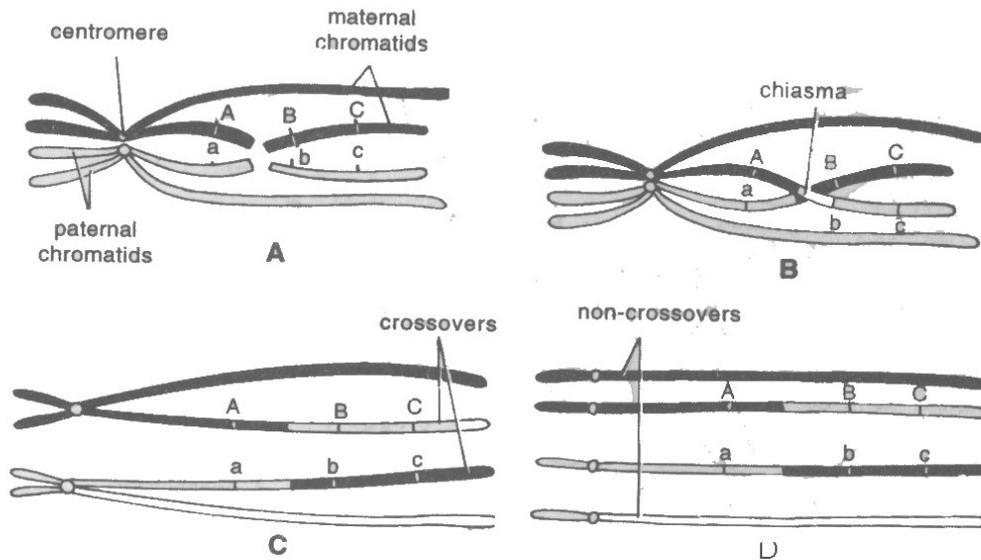
**Prophase - I** : It is the longest phase of meiosis. It has following stages :

**Leptotene** : Chromatin fibres condense to form chromosomes. There are two chromosomes of each type which are diploid and are called as "homologous chromosomes".

**Zygotene** : Synaptonemal complex is formed between two homologous chromosomes.

**Pachytene** : The exchange of segments between non sister chromatids of chromosome is called as crossing over.

**Diplotene** : Synaptonemal complex is dissolved, tetrads are cleared. At some places nonsister chromatids of two homologous chromosomes remain attached to form a chiasmata.



Genes or chromatid exchange between homologous chromosomes during meiosis

**Diakinesis** : Chiasmata shifts towards ends, nucleolus degenerates.

**Metaphase – I** : Spindles are formed and bivalents form a double whorl or double metaphase plate.

**Anaphase – I** : Chiasmata disappears, homologous chromosomes separate by disjunction forming dyads. They move towards poles and form two groups of haploid chromosomes.

**Telophase–I** : Chromosomes elongate, nucleoplasm & nuclear envelope reappears.

- (ii) **Meiosis – II** : It is also called as equational division and maintains the haploid number of chromosomes. No replication of DNA occurs in this stage (It is similar to mitosis)
  - Prophase – II
  - Metaphase – II
  - Anaphase – II
  - Telophase – II

**Differences between mitotic and meiotic cell division**

Mitosis	Meiosis
It occurs in all somatic cells.	It occurs in reproductive cells (germ cells)
In the resultant daughter cells, the number of chromosomes remains the same (i.e., diploid), hence, called equational division.	In resultant daughter cells, the number of chromosomes reduces to half (i.e., haploid), hence, called reductional division.
By mitosis two daughter cells are produced	By meiosis four daughter cells are produced.
During mitosis no crossing over takes place	During meiosis crossing over takes place.
Daughter cells have identical chromosomes which are also identical to that of parent cell (i.e. remains constant)	Chromosomes of the daughter cells are with combined components (genes) of both parents (i.e., genetic variability occurs)

- **Significance of mitosis** : It is essential for growth, repair, differentiation, maintenance of chromosome number etc.
- **Significance of meiosis** : It produces variations and essential for sexual reproduction. It maintains the chromosome number in each generation of living organisms.



## LET'S RECALL

1. In 1665, Robert Hooke first discovered and named the cells.
2. Cell is the structural and functional unit of all living organisms.
3. Organisms may be unicellular or multi-cellular. A single cell constitutes the unicellular organism whereas many cells coordinately function in case of multi-cellular organism.
4. The size, shape and volume of the cell are related to the specific function that they perform.
5. A cell generally shows plasma membrane, nucleus and cytoplasm.
6. Plasma membrane is a thin, selectively permeable membrane, covering the cell and is made up of lipids and proteins.
7. Functions of plasma membrane :
  - (i) It separates the contents of a cell from its outside environment.
  - (ii) It regulates the flow of substances to and from the cell through diffusion, facilitated diffusion, active transport and endocytosis.
8. Osmosis is diffusion of water through a selectively permeable membrane.
9. A cell will gain water when placed in hypotonic solution and lose water when placed in hypertonic solution. When placed in isotonic solution, cells will neither lose nor gain water.

Can be written more specifically as :

  - (i) Hypotonic solution : A cell placed in it will gain water.
  - (ii) Hypertonic solution : A cell placed in it will lose water : Also known as plasmolysis.
  - (iii) Isotonic solution: A cell placed in it will neither gain nor lose water.
10. In addition to plasma membrane, the cells of plants, fungi and bacteria have another rigid, non-living, outer covering called cell wall, composed mainly of cellulose.

Can be written more specifically as

Cells of Plants, fungi & bacteria: Contain both plasma membrane & cell wall.

Cell wall is rigid, non-living & outer most covering, composed mainly of cellulose.
11. When placed in hypertonic solution, a living plant cell shows plasmolysis.
12. Cell wall provides mechanical strength to the cell. It permits the cell to withstand huge changes in the surrounding medium.
13. Nucleus is an important, spherical, usually centrally located constituent of the cell and is bounded by double layered nuclear envelope.
14. The nucleus of a dividing cell shows rod-shaped chromosomes, made up of DNA and proteins. In a non-dividing cell, the chromosomes elongate and take the form of thread-like chromatin.
15. DNA molecules are responsible for transmitting hereditary information from one generation to the next.
16. Nucleus controls all metabolic activities of the cell.
17. Depending on the presence or absence of nucleus, cells may be prokaryotic or eukaryotic.
  - (i) Prokaryotic cells lack a well-defined nucleus and instead show nucleoid, an undefined nuclear region containing the genetic material.
  - (ii) Eukaryotic cells possess a proper nucleus with nuclear membrane.
18. Cytoplasm is the fluid content of the cell, occurring between nucleus and plasma membrane. It stores several vital chemicals and is the site of certain important metabolic pathways.

19. Several specialized cell organelles are present in the cytoplasm. These organelles perform different kinds of metabolic activities and are kept separate from each other.
20. The various cell organelles include endoplasmic reticulum, Golgi apparatus, lysosomes, mitochondria, plastids, vacuoles and centrosome.
21. Endoplasmic reticulum (ER) is an extensive, interconnected, membrane bound network of tubes and sheets.
22. Ribosomes are attached to the surface of Rough Endoplasmic Reticulum (RER) and are absent in Smooth Endoplasmic Reticulum (SER).
23. Functions of ER :
  - (i) It synthesizes important proteins (RER) and lipids (SER).
  - (ii) It provides a pathway for intracellular transport of materials.
  - (iii) SER of liver cells is important for detoxification.
24. Golgi apparatus is a network of stacked, flattened, membrane bound sacs and vesicles.
25. Golgi apparatus carries out the storage, modification and packaging of substances manufactured in the cell and is also involved in lysosome formation.
26. The spherical, sac-like lysosomes contain powerful digestive enzymes and form the waste disposal system of the cell. They are also known as ‘suicide bags’.
27. Mitochondria and plastids are each covered by 2 membranes and possess their own DNA and ribosomes.
28. Mitochondria are the ‘power houses of the cell’, providing energy for various metabolic activities.
29. Chromoplasts and leucoplasts are the 2 types of plastids present in plant cells.
30. Chloroplasts are chromoplasts containing chlorophyll and carry out photosynthesis in plants.
31. Leucoplasts store starch, oil and protein granules.
32. The large central vacuole of mature plant cells provides turgidity to the cell and also stores important substances.
33. In unicellular organisms, vacuoles play important roles in nutrition and osmoregulation.
34. Ribosomes are sites of protein synthesis.
35. Centrosome is found only in animal cells and consists of 2 centrioles. Centrosome helps in cell division.
36. The membrane-bound cell organelles are absent in prokaryotic cells.
37. Differences between plant cell and animal cell.

	<b>Plant cell</b>	<b>Animal cell</b>
1.	Plant cells are generally large in size.	Animal cells are smaller than plant cells.
2.	Plant cells possess plastids.	Animal cells lack plastids.
3.	Cell wall is present	Cell wall is absent.
4.	Mature plant cells possess a large, central and permanent vacuole.	Animal cells possess many small and temporary vacuoles.
5.	Centrosome and centrioles are absent in plant cells.	Centrosome and centrioles are present in animal cells.

38. The basic structural organization of the cell helps it to perform important functions like respiration, nutrition, excretion and protein synthesis.

## EXERCISE-I

## NCERT Solutions



- Q.1** Who discovered cell and how ?  
**Sol.** Robert Hooke discovered cells with the help of his self-designed microscope. In 1665, Robert Hooke was examining a thin slice of cork and he saw that the cork resembled the structure of a honeycomb consisting of many compartments.
- Q.2** Why are cells called the structural and functional unit of life?  
**Sol.** Each living cell has the capacity to perform certain basic functions that are characteristic of all living forms. Each living cell has got certain specific components within it known as cell organelles. Each kind of cell organelle performs a special function, such as making new material in the cell, clearing up the waste material from the cell and so on. A cell is able to live and perform all its functions because of these organelles. These organelles together constitute the basic unit called the cell.
- Q.3** How do substances like  $\text{CO}_2$  and water move in and out of the cell ?  
**Sol.** Substances like  $\text{CO}_2$  (which is cellular waste and requires to be excreted out by the cell) accumulate in high concentrations inside the cell. In the cell's external environment, the concentration of  $\text{CO}_2$  is low as compared to that inside the cell. As soon as there is a difference of concentration of  $\text{CO}_2$  inside and outside a cell,  $\text{CO}_2$  moves out of the cell, from a region of low concentration outside the cell by the process of diffusion.
- Q.4** Why is the plasma membrane called a selectively permeable membrane ?  
**Sol.** The plasma membrane allows or permits the entry and exit of some materials in and out of the cell. It also prevents movement of some other materials. The cell membrane, therefore, is called a selectively permeable membrane.
- Q.5** Can you name the two organelles we have studied that contain their own genetic material?  
**Sol.** Mitochondrion and Plastid.
- Q.6** If the organisation of a cell is destroyed due to some physical or chemical influence, what will happen?  
**Sol.** Each living cell has the capacity to perform certain basic functions due to its cell organelles which are responsible for its organisation. If this organisation of a cell is destroyed, then the cell will not be able to perform certain basic functions and ultimately it will die soon.
- Q.7** Why are lysosomes known as suicide bags ?  
**Sol.** Lysosomes contain powerful digestive enzymes capable of breaking down all organic material whenever there is disturbance in the cellular metabolism, i.e., when the cell gets damaged, then these lysosomes may burst and the enzymes digest their own cell. Therefore, lysosomes are also known as the 'suicide bags' of a cell.
- Q.8** Where are proteins synthesised inside the cell ?  
**Sol.** Ribosomes (which are attached to the surface of Rough Endoplasmic Reticulum) are the sites of protein manufacture inside the cell.
- Q.9** What would happen if the plasma membrane ruptures or breaks down ?  
**Sol.** If the plasma membrane ruptures or breaks down, then the following things may happen :  
 (i) There will be no difference between the contents of the cell and its external environment.  
 (ii) Since the plasma membrane is selectively permeable and allows only useful substances to enter inside the cell. When it may get ruptured, then all the useful substances will also move out of the cell.  
 (iii) The cell will lose its shape.  
 Ultimately all the metabolic activities of the cell will get affected and the cell may die even.
- Q.10** What would happen to the life of a cell if there was no Golgi apparatus ?  
**Sol.** The following things may happen in the cell if there was no Golgi apparatus :  
 (i) There will be an effect on the packaging and dispatching of different types of proteins to various targets inside and outside the cell.  
 (ii) The products of the cell cannot be stored and modified further.  
 (iii) The formation of complex sugars from simple sugars cannot take place.

**Q.11** Which organelle is known as the power house of the cell? Why?

**Sol.** Mitochondria are known as the power house of the cell. These organelles contain many oxidative enzymes which oxidise the food and convert it into energy currency of the cell in the form of ATP (Adenosine tri phosphate). This energy (in the form of ATP) is used by body for making new chemical compounds and for doing mechanical work. Due to this reason, mitochondria are generally referred to as 'power house of the cell'.

**Q.12** Where do the lipids and proteins constituting the cell membrane get synthesised?

**Sol.** Lipids are synthesised in Smooth Endoplasmic Reticulum (SER) while proteins are synthesised in the ribosomes which are attached to the Rough Endoplasmic Reticulum (RER).

**Q.13** How does an Amoeba obtain its food?

**Sol.** Amoeba acquires its food through the process of endocytosis. This process takes place due to the flexible nature of cell membrane which forms the structure of amoeba. The flexible nature of cell membrane enables the amoeba to engulf in food and other material from its external environment.

**Q.14** What is osmosis?

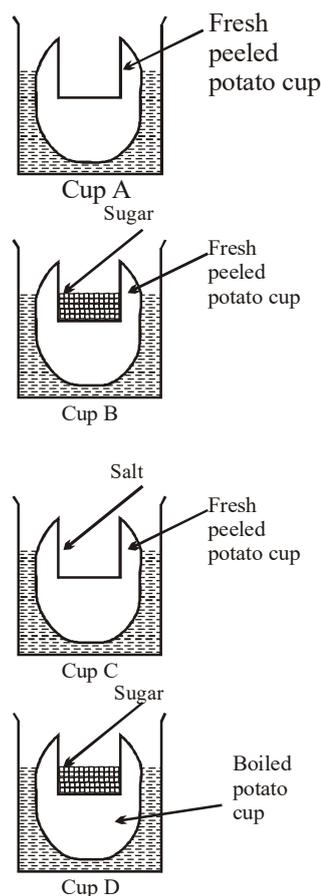
**Sol.** Osmosis is the passage of water or any solvent (diffusion) from a region of its higher concentration to its lower concentration through a semipermeable membrane. Thus, osmosis is a special type of diffusion through a selectively permeable membrane.

**Q.15** Carry out the following osmosis experiment : Take four peeled potato halves and scoop each one out to make potato cups. One of these potato cups should be made from a boiled potato. Put each potato cup in a trough containing water. Now :

- Keep cup A empty.
- Put one teaspoon sugar in cup B.
- Put one teaspoon salt in cup C.
- Put one teaspoon sugar in the boiled potato cup D.

Keep these for two hours. Then observe the four potato cups and answer the following :

- Explain why water gathers in the hollowed portion of B and C.
- Why is potato A necessary for this experiment?
- Explain why water does not gather in the hollowed out portions of A and D.



- Sol.**
- The water gathers in the hollowed portion of B and C due to the process of osmosis. Since the concentration of solute (sugar in cup B and salt in cup C) is higher inside the cup as compared to the water which is outside the cup. Therefore, water (solvent) from its higher concentration (outside the cup) will move towards the lower concentration (inside the cup). This process of osmosis (moving in of solvent) is known as endosmosis.
  - Potato A acts as a control for the experiment. This is very necessary for comparing the results of the experiment.
  - Water does not gather in the hollowed out portions of A and D because of the following reasons.
    - The hollowed portion of potato A is empty. Thus, there is no concentration difference and, therefore, no osmosis takes place.
    - The hollowed portion of potato D contains sugar inside it but this potato is boiled one. Therefore, osmosis will not take place as its semipermeable membrane is destroyed by boiling.

**Q.16** Fill in the gaps in the following table illustrating differences between prokaryotic and eukaryotic cells.

Prokaryotic Cell	Eukaryotic Cell
Size : Generally small (1 – 10 $\mu\text{m}$ ) $1\mu\text{m} = 10^{-6}\text{m}$	Size : Generally large (5– 100 $\mu\text{m}$ .)
Nuclear region : _____ (a) _____ and known as _____ (b) _____	Nuclear region : well defined and surrounded by a nuclear membrane
Chromosome single	More than one chromosome.
Membrane bound cell organelles absent.	_____ (c) _____ _____ (d) _____.

**Q.17** Make a comparison and write down ways in which plant cells are different from animal cells.

S.No.	Plant Cell	Animal Cell
1	A cell wall made up of cellulose, is present outside the plasma membrane.	Cell wall is absent.
2	Plastids (chloroplast, leucoplasts and chromoplasts) are present.	Plastids are absent.
3	Vacuoles are present usually a large cell vacuole lies in the centre.	Vacuoles are either absent or very small.
4	Centriole is absent (except in few lower plants).	Centriole with centrosome is present.
5	They are usually regular in shape.	They are usually irregular in shape.
6	Reserve food occurs in the form of starch.	Food is stored in the form of glycogen.
7	Lysosomes are either absent or very few in number.	Lysosomes are prominent and more in number.

**Sol.**

**Q.18** How is a prokaryotic cell different from a eukaryotic cell.

S.No.	Prokaryotic Cell	Eukaryotic Cell
1	Size : Generally (1 – 10 $\mu\text{m}$ ) $1\mu\text{m} = 10^{-6}\text{m}$	Size : Generally large (5 – 100 $\mu\text{m}$ ).
2	Nuclear region : Undefined nuclear region containing only nucleic acids (genetic material) and known as nucleoid	Nuclear region : Well defined and surrounded by a nuclear membrane.
3	Chromosome : single.	More than one chromosomes
4	Membrane bound cell organelles absent.	Membrane bound cell organelles present.

**Sol.**

## EXERCISE -II

## Knowledge Vault



## MCQ BASED QUESTIONS:

- Q.1** “Cell is a unit of life” (OR the term cell was proposed by) :  
 (A) Malpighi (B) Leeuwenhoek  
 (C) Schleiden (D) Hooke
- Q.2** Plant cell is characterized by :  
 (A) Presence of wall, absence of vacuole  
 (B) Presence of wall, vacuole starch and the absence of centriole or centrosome.  
 (C) Presence of vacuole and absence of plastids  
 (D) Presence of centriole and lysosomes and absence of plastids.
- Q.3** The main difference between an animal and a plant cell is :  
 (A) Plant cells lack rigid cell wall  
 (B) Animal cells lack rigid cell wall  
 (C) Plant cells possess small vacuoles  
 (D) Animal cells possess large vacuoles
- Q.4** Example of unicellular animal is/are :  
 (A) Amoeba (B) Paramecium  
 (C) Plasmodium (D) All of these
- Q.5** Who applied cell theory to plants?  
 (A) Schwann (B) Schleiden  
 (C) Swanson (D) Jensen
- Q.6** Cell theory states that :  
 (A) All living cells do mitosis and meiosis  
 (B) All cells are living  
 (C) All cells have nucleus  
 (D) Cell is structural unit of all living organisms
- Q.7** Selective permeability is the property of :  
 (A) Cell membrane  
 (B) Cell wall  
 (C) ER & Nuclear membrane  
 (D) All of these
- Q.8** Major component of cell membrane is  
 (A) Lipid (B) Protein  
 (C) Carbohydrate (D) Nucleic acid
- Q.9** Plasma membrane  
 (A) Controls the passage of water and soluble substances in and out of the cell  
 (B) Helps in protein synthesis  
 (C) Serves as a selective permeable membrane  
 (D) (A) and (C)
- Q.10** Outermost membrane enclosing the contents of a plant cell is called  
 (A) Tonoplast (B) ER  
 (C) Plasmalemma (D) Cell wall
- Q.11** Plasma membrane or unit membrane is made up of  
 (A) Phosphoprotein and carbohydrate  
 (B) Protein and fat/phospholipid  
 (C) Phospholipid/fat and carbohydrate  
 (D) Carbohydrate and fat/phospholipid
- Q.12** What is the latest model for the structure of plasmalemma  
 (A) Unit membrane model  
 (B) Fluid mosaic model  
 (C) Molecular sieve model  
 (D) Sandwich model
- Q.13** Controlling centre of a cell is :  
 (A) Nucleus (B) Nucleolus  
 (C) Chloroplast (D) Ribosome
- Q.14** What happen to a cell, if its nucleus is removed :  
 (A) Cell dies  
 (B) Its catabolism increases  
 (C) Its metabolism decreases  
 (D) It becomes non-osmotic
- Q.15** An enucleated living plant cell is :  
 (A) Vessel (B) Tracheid  
 (C) Sieve cell (D) All of the above
- Q.16** A Prokaryotic cell does not possess :  
 (A) Nuclear membrane  
 (B) Plasma membrane  
 (C) Cell wall  
 (D) Cytoplasm

- Q.17** Main difference between living and non living is the presence of :  
 (A) Nucleus and growth  
 (B) Protoplasm  
 (C) Mitochondria and cytoplasm  
 (D) Movements
- Q.18** Who coined the term protoplasm?  
 (A) Dujardin (B) Purkinje  
 (C) Nirenberg (D) Francis P. Roux
- Q.19** Protoplasm includes :  
 (A) only cytoplasm  
 (B) only nucleus and centrosome  
 (C) Both cytoplasm and nucleus  
 (D) None of these
- Q.20** The compound present in the largest quantity in an active protoplasm is :  
 (A) Glucose (B) Fat  
 (C) Protein (D) Water

**FILL IN THE BLANKS:**

- Q.21** Protoplasm consist of two parts \_\_\_\_\_ and \_\_\_\_\_ .
- Q.22** \_\_\_\_\_ is the basic unit of life.
- Q.23** \_\_\_\_\_ seprates the content of a cell from its surrounding medium.
- Q.24** Cell wall is absent in \_\_\_\_\_ cells
- Q.25** Cell wall is made up of \_\_\_\_\_ in plant cell.
- Q.26** \_\_\_\_\_ allows exchange of substances between nucleus and cytoplasm.
- Q.27** \_\_\_\_\_ are units of hereditary material.
- Q.28** RER helps in the synthesis of \_\_\_\_\_ .
- Q.29** When lysosomes bring self destruction of a cell, they are called \_\_\_\_\_ .
- Q.30** Vacuoles are fluid filled sacs covered by a membrane called \_\_\_\_\_ .

**MATCH THE COLUMN :**

- [A] [ONE TO ONE]:**  
**Column-I** and **Column-II** contains **four** entries each. Entries of column-I are to be matched with some entries of column-II. Only One entries of column-I may have the matching with the same entries of column-II and one entry of column-II Only one matching with entries of column-I

**Q.31 Column I**

- (a) Mitochondria  
 (b) Golgi complex  
 (c) Lysosomes  
 (d) Centrosome

**Column II**

- (p) Secretion  
 (q) Digestive bags  
 (r) ATP  
 (s) Cell division

- (A) (a)-(r), (b)-(p), (c)-(q), (d)-(s)  
 (B) (a)-(q), (b)-(s), (c)-(p), (d)-(r)  
 (C) (a)-(p), (b)-(s), (c)-(q), (d)-(r)  
 (D) (a)-(p), (b)-(r), (c)-(s), (d)-(q)

**[B] [ONE TO MANY]:**

**Column-I** and **Column-II** contains **four** entries each. Entries of column-I are to be matched with some entries of column-II. One or more than one entries of column-I may have the matching with the same entries of column-II and one entry of column-II may have one or more than one matching with entries of column-I.

**Q.32 Column I**

- (a) Cell membrane  
 (b) Enzyme  
 (c) Polymer of amino acid  
 (d) Ribosome

**Column II**

- (p) Biocatalyst  
 (q) Entry and exit  
 (r) Protein and lipid  
 (s) Protein

- (A) (a)-(q,r), (b)-(p,s), (c)-(s), (d)-(s)  
 (B) (a)-(pqr), (b)-(pq), (c)-(q), (d)-(q)  
 (C) (a)-(p), (b)-(q,r), (c)-(q), (d)-(p,s)  
 (D) (a)-(p,r), (b)-(q), (c)-(p,q), (d)-(p,q,r)

## ASSERTION &amp; REASON TYPE QUESTIONS

**Direction :** In the following questions as Assertion (A) is given followed by a Reason (R). Mark your responses from the following options.

(A) Both Assertion and Reason are true and Reason is the correct explanation of 'Assertion'

(B) Both Assertion and Reason are true and Reason is not the correct explanation of 'Assertion'

(C) Assertion is true but Reason is false

(D) Assertion is false but Reason is true

**Q.33 Assertion:** Cell placed in a hypertonic solution shows plasmolysis

**Reason:** Not all cells show plasmolysis.

**Q.34 Assertion:** Plant cells remain covered by a dead, rigid cell wall.

**Reason:** Due to cell wall, plant cells couldn't change their shape.

## COMPREHENSIVE :

Continuity of living organisms depends upon the process of cell division. For a cell to divide normally, instructions come from the nucleus.

Nucleus contains DNA, RNA and protein. DNA together with a nucleoprotein forms chromosomes. These chromosomes are in a thread-like structure in a resting cell.

**Q.35** The nucleoprotein present in the nucleus is :

- (A) Rhizome (B) Histone  
(C) Insulin (D) None of these

**Q.36** DNA is :

- (A) Deoxyribose acid  
(B) Deoxyribose sugar  
(C) Deoxyribonucleic acid  
(D) Deoxynucleic acid

**Q.37** Proteins are the polymer of :

- (A) Fatty acid (B) Nucleic acid  
(C) Amino acid (D) Citric acid

## EXERCISE-III

## Subjective Stuff



## VERY SHORT TYPE QUESTIONS:

- Q.1** All activities inside the cell and interaction of the cell with its environment are possible due to some features found in almost every cell. Name any two such features.
- Q.2** What is protoplasm ? Who coined this term and when ?
- Q.3** Name the process of building of cell membrane.
- Q.4** Who observed the free living cells in pond water for the first time ?
- Q.5** What can be seen when cell is placed in a hypertonic solution ?
- Q.6** What is the composition of chromosomes?
- Q.7** Which cell organelle is responsible for making fat molecules or lipids?
- Q.8** Name the cell organelles that help to keep the cell clear by digesting the worn out cell organelles.

## SHORT TYPE QUESTIONS:

- Q.9** (a) Name the different cell organelles which perform functions like protein/lipids make, specific digestion, and energy generation.  
(b) Which ER plays a crucial role in detoxifying many poisons and drugs ?
- Q.10** State two functions of vacuoles in a plant cell.
- Q.11** What type of enzymes are present in the lysosomes? What is their function? Which cell organelles manufacture these enzymes?
- Q.12** Write the composition of a chromosome. Name the part of a cell where it is formed.
- Q.13** What type of information is contained in DNA and in which form it is present?
- Q.14** What is cellular reproduction ? Which organelle plays an important role in it ?
- Q.15** What is nucleoid? Where it can be seen ?
- Q.16** What are chloroplasts? What is their function? What other pigments are present in chloroplasts?

- Q.17** Name the stain used to prepare slides like that of onion peel and cheek cell. Why is the use of stain necessary ? Do all organelles absorb stain equally?
- Q.18** (a) Where are chromosome present in the cell? What is their chemical composition?  
(b) How many pairs of chromosomes are present in humans?
- Q.19** Where are proteins synthesised inside the cells? How are they transported to various places inside the cells? What is the role of proteins in the functioning of lysosomes?
- Q.20** Name the two cell organelles that contain their own DNA and ribosomes. What is the site of respiration to fulfil energy demands within the cell ? In which form energy is stored in a cell?
- Q.21** Define the following terms :  
(i) Endocytosis                      (ii) Phagocytosis  
(iii) Exocytosis
- Q.22** List any six functions of nucleus of a cell.

## LONG TYPE QUESTIONS:

- Q.23** On the basis of number of cells, living organisms are classified as unicellular and multicellular.  
(a) Name two unicellular organisms.  
(b) What is meant by division of labour in multicellular organisms?  
(c) Name one prokaryotic and one eukaryotic unicellular organism.  
(d) "Every multicellular organism has come from a single cell." Justify this humans.  
(e) Write one common feature between an *Amoeba* and white blood cells of humans.
- Q.24** Draw a neat diagram of a plant cell and label the following parts :  
(i) Cell wall                      (ii) Nucleus  
(iii) Vacuole                      (iv) Golgi apparatus  
(v) Mitochondrion              (vi) Lysosome  
(vii) Chloroplast
- Q.25** Draw a neat diagram of animal cell and label only four parts.

**EXERCISE-IV**

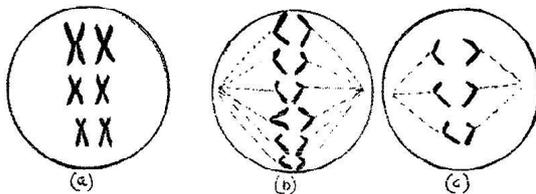
**Competitive Edge**



**Q.1** The one that CANNOT be used for DNA fingerprints is : **(IJSO/Stage I/2009)**  
 (A) Leucocytes (B) erythrocytes  
 (C) hair bulbs (D) sperms

**Q.2** The number of chromosomes can be counted at **(IJSO/Stage I/2009)**  
 (A) anaphase (B) interphase  
 (C) metaphase (D) prophase

**Q.3** The cells in the following figure were all taken from the same individual (a mammal). Identify the cell division events happening in each cell. **(IJSO/Stage II/2009)**



- (A) (a) Meiotic Metaphase I, (b) Mitotic Anaphase, (c) Meiotic Anaphase II
- (B) (a) Mitotic Metaphase, (b) Mitotic Anaphase, (c) Meiotic Anaphase II
- (C) (a) Mitotic Metaphase, (b) Mitotic Anaphase, (c) Meiotic Anaphase I
- (D) (a) Meiotic Metaphase II, (b) Meiotic Anaphase I, (c) Meiotic Anaphase II

**Q.4** The signal for mitotic division is generated when the ratio of volume of nucleus to that of cell becomes - **(IJSO/Stage I/2010)**  
 (A) less than a certain value.  
 (B) greater than a certain value.  
 (C) reaches a certain value.  
 (D) closer to one.

**Q.5** The process involved in healing of the wound is **(IJSO/Stage I/2011)**  
 (A) Meiosis I and II (B) Mitosis  
 (C) Meiosis I (D) Meiosis II

**Q.6** When a cell fails to communicate with other cells in multicellular organism, it- **(IJSO/Stage I/2012)**  
 (A) becomes cancerous  
 (B) enters mitotic phase  
 (C) chooses to die  
 (D) is eaten up by other cells

**Q.7** Chromosomes in metaphase get arranged at the equatorial plate. When these cells are treated with colchicine, cell division is arrested and the cells never enter anaphase. If we were to compare treated cell at metaphase and an untreated cell in the same phase, we notice that chromosomes are more dispersed and do not arrange themselves on the equatorial plate in the treated cells **(IJSO/Stage II/2012)**



Fig. 1 : Metaphase



Fig. 2 : Colchicine treated Metaphase

Using the information, which of the following will be affected by colchicine ?

- (A) Centromere
- (B) Spindle fibre
- (C) Centriole
- (D) Arms of chromosomes

**Q.8** If Brain is controlling unit of an organism, then at cellular level which cell organelle can be comparable to Brain ? **(IJSO/Stage I/2013)**  
 (A) Chloroplast  
 (B) Ribosome  
 (C) Nucleus  
 (D) Lysosome

**Q.9** Identify the correct order of sequence from exterior to interior. **(IJSO/Stage I/2013)**  
 (A) Cell → Nucleus → Chromosome → DNA → Protein  
 (B) Nucleus → Cell → Chromosome → DNA → Protein  
 (C) Cell → Nucleus → DNA → Chromosomes → Protein  
 (D) Cell → Nucleus → Protein → DNA → Chromosome

**Q.10** Most of the cellular RNA is synthesised and stored respectively in : **(IJSO/Stage I/2014)**  
 (A) cytoplasm and ribosomes.  
 (B) ribosomes and cytoplasm  
 (C) ribosomes and nucleus  
 (D) nucleus and ribosomes

**Q.11** The erythrocytes separated from human blood were mixed with certain fluids on a slide and observed under the microscope. Which of the following will be the expected result ?

(IJSO/Stage I/2014)

- (A) With serum the cells clump and coagulate.
- (B) With distilled water the cells swell and eventually burst.
- (C) With sea water the cells undergo no apparent change.
- (D) With tap water cells shrink and appear crenated.

**Q.12** In the cells of oil seeds which of the cell organelles have to be more active :

(IJSO/Stage I/2014)

- (A) Mitochondria
- (B) Rough endoplasmic Reticulum
- (C) Smooth endoplasmic Reticulum
- (D) Nucleoli

**Q.13** A human T lymphocyte in the mitotic metaphase stage will contain how many DNA molecules? (Exclude the DNA of mitochondria)

(IJSO/Stage II/2014)

- (A) 23
- (B) 46
- (C) 184
- (D) 92

**Q.14** The given diagram represents a dividing cell stained with giemsa. From the options given below, identify the correct stage of cell division.

(IJSO/Stage II/2014)



- (A) Leptotene
- (B) Zygotene
- (C) Pachytene
- (D) Diakinesis

**Q.15** Stem cells in animals are pluripotent cells as they possess the potential of giving rise to many types of cell lineage. Presence of stem cell in a differentiated tissue gives it potential to regenerate. From the combination of tissues presented below, predict the best combination of tissues containing maximum and minimum amount of stem cells respectively :

(IJSO/Stage II/2014)

- (A) Brain and kidney
- (B) Kidney and brain
- (C) Brain and liver
- (D) Liver and brain

**Q.16** Each chromosome contains

(IJSO/Stage I/2015)

- (A) one long DNA molecule
- (B) one long RNA molecule
- (C) one long sequence of amino acids
- (D) a single gene for a protein

**Q.17** Mitochondrial equivalent in prokaryotic bacterial cell is

(IJSO/Stage I/2015)

- (A) ribosomes
- (B) thylakoid
- (C) cytoplasmic plasma membrane
- (D) cyanosomes

**Q.18** When a red blood cell was placed which is an animal cell in 3 different solutions, the following morphological observations were made under a microscope.

(IJSO/Stage I/2015)

<b>Solution 1</b>	Normal morphology
<b>Solution 2</b>	Swollen and hemolysed
<b>Solution 3</b>	Shrunk or cremated

The above three solutions can be classified in the order of

- (A) isotonic, hypotonic and hypertonic
- (B) hypotonic, isotonic and hypertonic
- (C) hypotonic, hypertonic and isotonic
- (D) isotonic, hypertonic and hypotonic

**Q.19** Genetic material (DNA) in plants occurs in which of the following cell organelles?

(IJSO/Stage I/2015)

- (A) Nucleus
- (B) Nucleus and chloroplast
- (C) Nucleus, chloroplast and mitochondria
- (D) Chloroplast and mitochondria

**Q.20** *Rhodospirillum rubrum* is a species of photosynthetic bacteria. From your knowledge about bacteria in general, identify the components that cannot be present in this organism

(IJSO/Stage I/2016)

- (A) Chloroplasts
- (B) ATP
- (C) Ribosomes
- (D) Cell wall

**Q.21** Which of the following is NOT produced by the endoplasmic reticulum?

(IJSO/Stage I/2016)

- (A) Lipids
- (B) Proteins
- (C) Monosaccharides
- (D) Hormones

**Q.22** Which amongst the following are not plastids?

(IJSO/Stage I/2017)

- (A) Leucoplasts
- (B) Chromoplasts
- (C) Amyloplasts
- (D) Tonoplasts

**Q.23** In a self-pollinated plant, what would be minimum number of meiotic divisions required for setting 400 seeds ? **(IJSO/Stage I/2017)**  
 (A) 100 (B) 200  
 (C) 400 (D) 500

**Q.24** Health is all about 'eating-fasting' balance. When you fast for extended periods, your cells clean out and recycle the intracellular garbage. The organelles responsible for this are : **(IJSO/Stage I/2018)**  
 (A) Microfilaments (B) Lysosomes  
 (C) Golgi Apparatus (D) Microtubules

**Q.25** The intracellular organelle that is responsible for formation of acrosomal vesicle is : **(IJSO/Stage I/2018)**  
 (A) endoplasmic reticulum  
 (B) Golgi apparatus  
 (C) mitochondrion  
 (D) none of the above

**Q.26** A student recorded the data for five types of cells as given below : **(IJSO/Stage I/2018)**

Character	P	Q	R	S	T
Cell wall	+	+	-	-	+
Centioles	-	-	-	+	-
Chloroplast	-	+	-	-	-
Mitochondrion	-	+	-	+	+
Nucleus	-	+	-	+	+
RNA/DNA	+	+	+	+	+
Vacuoles	+	+	-	+	+

The five cell types of P, Q, R, S and T are :  
 (A) P-Bacterium, Q-Plant, R-Virus, S-Animal, T-Fungus  
 (B) P-Bacterium, Q-Plant, R-Virus, S-Fungus, T-Animal  
 (C) P-Fungus, Q-Plant, R-Bacterium, S-Animal, T-Virus  
 (D) P-Plant, Q-Bacterium, R-Virus, S-Animal, T-Fungus

**Q.27** A bacterium has a generation time of 50 minutes. A culture contain  $10^8$  cells per mL is incubated for 300 minutes. What will be the number of cells after 300 minutes ? **(IJSO/Stage I/2018)**  
 (A)  $64 \times 10^3$  cells (B)  $6.4 \times 10^8$  cells  
 (C)  $64 \times 10^9$  cells (D)  $6.4 \times 10^9$  cells

**Q.28** A stain was developed by a group of scientists to stain a particular cell organelle. The stain was tested on various tissues derived from an autopsy sample from a mammal. The

organelles were counted. The results showed maximum number of the organelles in cell of brain, lesser in cells of heart, least in mature sperms and absent erythrocytes. Identify the organelles from following options.

**(IJSO/Stage I/2019)**  
 (A) Nissl bodies (B) Mitochondria  
 (C) Golgi bodies  
 (D) Endoplasmic reticulum

**Q.29** An organism has 27 pairs of homologous chromosomes. In each daughter cell after completion of mitosis and in each gamete after completion of meiosis II, and chromosomes would be present respectively : **(IJSO/Stage I/2019)**  
 (A) 27 and 27 (B) 54 and 27  
 (C) 108 and 54 (D) 54 and 108

**Q.30** In the baking industry, when the dough is prepared, various ingredients are mixed together with the flour. At one instance, the dough was fermented, but failed to rise sufficiently during the baking process. Choose the correct cause(s) from following possibilities.  
 i. The salt was mixed before the fermentation process was completed  
 ii. The sugar was added in excess  
 iii. Yeast granules were not activated prior to mixing with the flour. **(IJSO/Stage I/2019)**  
 (A) i, iii (B) iii only  
 (C) i, ii, iii (D) i, ii

**Q.31** Given below are four statements. **(IJSO/Stage I/2019)**  
 I. Prokaryotic cells are unicellular while eukaryotes are multicellular.  
 II. Histones are present in eukaryotes and absent in prokaryotes.  
 III. The nucleoid contains the genetic material in prokaryotes and eukaryotes.  
 IV. Prokaryotic flagellum is composed of flagellin while eukaryotic flagellum is composed of tubulin. Identify which amongst these are false.  
 (A) I and II (B) III and IV  
 (C) II and III (D) I and III

**Q.32** A  $4 \mu\text{m}$  long bacterial cell was magnified and drawn to a dimension of 6 cm. How many times has it been magnified? **(IJSO/Stage I/2019)**  
 (A)  $1.5 \times 10^3$  (B)  $15 \times 10^4$   
 (C)  $1.5 \times 10^4$  (D) 1.5

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**ANSWER KEY**

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**EXERCISE-II**

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**MULTIPLE CHOICE QUESTIONS :**

<b>Q.1</b>	D	<b>Q.2</b>	B	<b>Q.3</b>	B	<b>Q.4</b>	D	<b>Q.5</b>	B	<b>Q.6</b>	D	<b>Q.7</b>	A
<b>Q.8</b>	A	<b>Q.9</b>	D	<b>Q.10</b>	D	<b>Q.11</b>	B	<b>Q.12</b>	B	<b>Q.13</b>	A	<b>Q.14</b>	A
<b>Q.15</b>	C	<b>Q.16</b>	A	<b>Q.17</b>	B	<b>Q.18</b>	B	<b>Q.19</b>	C	<b>Q.20</b>	D		

**FILL IN THE BLANKS :**

<b>Q.21</b>	Cytoplasm, nucleus	<b>Q.22</b>	Cell	<b>Q.23</b>	Plasma membrane
<b>Q.24</b>	Animal	<b>Q.25</b>	Cellulose	<b>Q.26</b>	Nuclear pore
<b>Q.27</b>	Genes	<b>Q.28</b>	Proteins	<b>Q.29</b>	Suicidal bags
<b>Q.30</b>	Tonoplast				

**MATCH THE COLUMN :**

**Q.31** (A)    **Q.32** (A)

**ASSERTION & REASON TYPE QUESTIONS :**

**Q.33** (B)    **Q.34** (A)

**COMPREHENSIVE :**

**Q.35.** B    **Q.36** C    **Q.37** C

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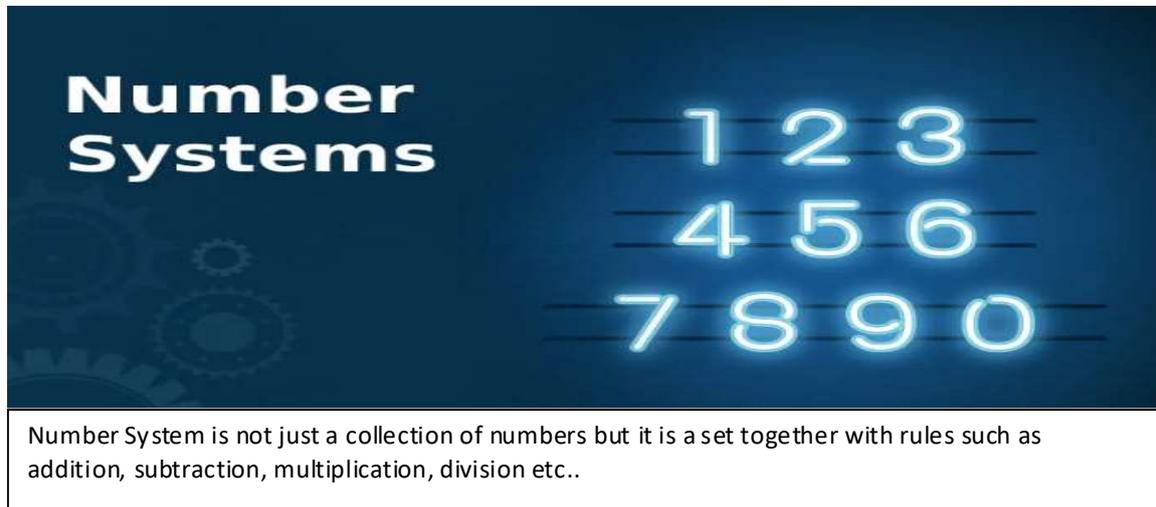
**EXERCISE-IV**

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<b>Q.1</b>	B	<b>Q.2</b>	C	<b>Q.3</b>	A	<b>Q.4</b>	A	<b>Q.5</b>	B	<b>Q.6</b>	C	<b>Q.7</b>	B
<b>Q.8</b>	C	<b>Q.9</b>	A	<b>Q.10</b>	D	<b>Q.11</b>	B	<b>Q.12</b>	C	<b>Q.13</b>	D	<b>Q.14</b>	D
<b>Q.15</b>	D	<b>Q.16</b>	A	<b>Q.17</b>	C	<b>Q.18</b>	A	<b>Q.19</b>	C	<b>Q.20</b>	A	<b>Q.21</b>	C
<b>Q.22</b>	D	<b>Q.23</b>	D	<b>Q.24</b>	B	<b>Q.25</b>	B	<b>Q.26</b>	A	<b>Q.27</b>	D	<b>Q.28</b>	B
<b>Q.29</b>	B	<b>Q.30</b>	C	<b>Q.31</b>	D	<b>Q.32</b>	C						

# 1

# Number System



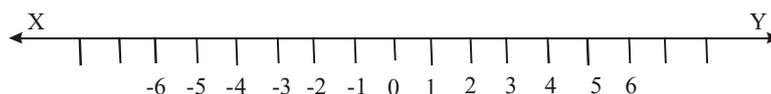
## 1. INTRODUCTION

In earlier classes, we have learnt about natural numbers, whole numbers and integers. As we have learnt that the counting numbers 1,2,3, ..... etc. are called natural numbers and all the natural numbers together with zero are called whole numbers. In this chapter, we shall introduce the system of rational numbers and we shall also extend our study on real numbers, their decimal representation, representation on the number line and operations on real numbers.

### Types of Numbers :

- (1) **Natural Numbers :** Counting numbers are called natural numbers.  
 $N = \{1,2,3,4,\dots\}$  is a set of all natural numbers.
- (2) **Whole Numbers :** All counting numbers together with zero form a set of all whole numbers.  
 $W = \{0,1,2,3,4,\dots\}$  is a set of all whole numbers.
- (3) **Integers :** All natural numbers, 0 and negative of natural numbers form integers.  
 $I = \{\dots, -4, -3, -2, -1, 0, 1, 2, 3, \dots\}$   
All integers can be represented on the number line.

### ➤ Number line



### ➤ Positive Integers

On the right hand side of 0, the points at distances of 1 unit, 2 units, 3 units etc. from 0 denote respectively the integers 1,2,3 etc.

### ➤ Negative Integers :-

On the left side of 0, the points at distances of 1 units, 2 units, 3 units etc. from 0 denote respectively the integers  $-1, -2, -3 \dots$  etc.

**Let's know**

- (i) "0" is neither positive, nor negative.
- (ii) Non-negative integers : 0, 1, 2, .....
- (iii) Non-positive integers : ..... - 3, - 2, - 1, 0,
- (iv) Positive integers : 1, 2, 3, .....
- (v) Negative integers : ..... - 3, - 2, - 1.

**2. IRRATIONAL NUMBERS**

A number is an irrational number, if it has a non terminating and non-repeating decimal representations. A number that cannot be put in the form  $p/q$  where  $p, q$  are integers and  $q \neq 0$  is called irrational number.

**Example:**  $\sqrt{2}$ ,  $\sqrt{3}$ ,  $\sqrt{11}$ ,  $\pi$  etc.

**Some Properties of irrational numbers :**

- (a) The -ve of an irrational number is an irrational number.
- (b) The sum of a rational and an irrational number is an irrational number.
- (c) The product of a non-zero rational number with an irrational number is always an irrational number.

**Decimal expansions of irrational numbers**

**The decimal expansion of an irrational number is non-terminating non-recurring. In other words, a number whose decimal expansion is non-terminating non-recurring is irrational.**

**EXAMPLES**

**Example 1 :** Find an irrational number between  $\frac{1}{7}$  and  $\frac{1}{3}$ .

**Solution :** To find irrational number, firstly we will divide 1 by 7 and 1 by 3.

$$\begin{array}{r}
 0.142857 \\
 7 \overline{) 10} \\
 \underline{7} \phantom{00} \\
 30 \\
 \underline{28} \\
 20 \\
 \underline{14} \\
 60 \\
 \underline{56} \\
 40 \\
 \underline{35} \\
 50 \\
 \underline{49} \\
 1
 \end{array}$$

$$\therefore \frac{1}{7} = 0.142857... = 0.\overline{142857}$$

$$\text{Now, } 3 \overline{) 10} \begin{array}{l} 0.33... \\ \underline{9} \\ 10 \\ \underline{9} \\ 1 \end{array}$$

Thus,  $\frac{1}{3} = 0.333... = 0.\bar{3}$

That means the required irrational numbers will lie between  $0.\overline{142857}$  and  $0.\bar{3}$ . Also the irrational numbers have non-terminating non-repeating decimals. Hence the required irrational number between  $\frac{1}{7}$  and  $\frac{1}{3}$  is 0.2101001000.....

**Example 2 :** Prove that  $3 - \sqrt{5}$  is an irrational number.

**Solution :** Let assume that on the contrary that  $3 - \sqrt{5}$  is rational. Then, there exist co-prime positive integers a and b such that,

$$3 - \sqrt{5} = \frac{a}{b} \quad \Rightarrow \quad 3 - \frac{a}{b} = \sqrt{5} \quad \Rightarrow \quad \frac{3b - a}{b} = \sqrt{5}$$

$$\Rightarrow \quad \sqrt{5} \text{ is rational} \quad [ \because a, b \text{ are integer } \therefore \frac{3b - a}{b} \text{ is a rational number} ]$$

This contradicts the fact that  $\sqrt{5}$  is an irrational number. Hence,  $3 - \sqrt{5}$  is an irrational number.

### 3. REAL NUMBERS AND THEIR DECIMAL EXPANSIONS

In Mathematics, a **Real number** is a combination of rational number and irrational numbers. The rational and irrational numbers can be expressed in their decimal form. The real number can be represented using the number line. If the numbers cannot be expressed on the number line, then the number are called imaginary numbers.

#### 3.1 Decimal expansion of rational numbers

Every rational number can be expressed as terminating decimal or non-terminating but repeating decimals

**Terminating decimal (The remainder becomes zero)**

The word “terminate” means “end”. A decimal that ends is a terminating decimal

OR

A terminating decimal doesn't keep going. A terminating decimal will have finite number of digits after the decimal point.

$$\frac{3}{4} = 0.75, \frac{8}{10} = 0.8, \frac{5}{4} = 1.25, \frac{25}{16} = 1.5625$$

**EXAMPLES**

**Example 3 :** Express  $\frac{7}{8}$  in the decimal form.

**Solution :** We have,

$$\begin{array}{r} 8 \overline{) 70} \phantom{0} \phantom{0} \phantom{0} \\ \underline{64} \phantom{0} \phantom{0} \phantom{0} \\ 60 \phantom{0} \phantom{0} \phantom{0} \\ \underline{56} \phantom{0} \phantom{0} \phantom{0} \\ 40 \phantom{0} \phantom{0} \phantom{0} \\ \underline{40} \phantom{0} \phantom{0} \phantom{0} \\ 0 \phantom{0} \phantom{0} \phantom{0} \end{array}$$

$\therefore \frac{7}{8} = 0.875$

➤ **Non-terminating & repeating (recurring decimal The remainder never becomes zero)**

A decimal in which a digit or a set of finite number of digits repeats periodically is called Non-terminating repeating (recurring) decimals.

$$\frac{5}{3} = 1.666..... = 1.\overline{6}, \frac{7}{11} = 0.636363..... = 0.\overline{63},$$

$$\frac{1}{999} = 0.001001001..... = 0.\overline{001}$$

**Example 4 :** Express  $\frac{2}{11}$  as a decimal fraction.

$$\begin{array}{r} 11 \overline{) 20} 0.181818 \\ \underline{11} \phantom{00} \\ 90 \phantom{00} \\ \underline{88} \phantom{00} \\ 20 \phantom{00} \\ \underline{11} \phantom{00} \\ 90 \phantom{00} \\ \underline{88} \phantom{00} \\ 20 \phantom{00} \\ \underline{11} \phantom{00} \\ 90 \phantom{00} \\ \underline{88} \phantom{00} \\ 2 \phantom{00} \end{array}$$

**Solution :** We have,

$$\therefore \frac{2}{11} = 0.181818..... = 0.\overline{18}$$

**Example 5 :** If,  $\frac{1}{7} = 0.\overline{142857}$  write the decimal expansion of  $\frac{2}{7}, \frac{3}{7}, \frac{4}{7}$ , and  $\frac{5}{7}$  without actually doing the long division.

**Solution :** Thus, we have  $\frac{2}{7} = 2 \times \frac{1}{7} = 0.\overline{285714}; \frac{3}{7} = 3 \times \frac{1}{7} = 0.\overline{428571}$

$$\frac{4}{7} = 4 \times \frac{1}{7} = 0.\overline{571428}; \frac{5}{7} = 5 \times \frac{1}{7} = 0.\overline{714285}$$

➤ **Method to convert non-terminating decimal to the form  $\frac{p}{q}$ .**

In a non-terminating decimal, we have two types of decimal representations

- (a) Pure recurring decimal                      (b) Mixed recurring decimal

**(a) Pure recurring decimal**

It is a decimal representation in which all the digits after the decimal point are repeated.

Following are the steps to convert it in the form  $\frac{p}{q}$ .

- Denote pure recurring decimal as x.
- Write the number in decimal form by removing bar from top of repeating digits.
- Count the number of digits having bar on their heads.
- Multiply the repeating decimal by 10, 100, 1000, ..... depending upon 1 place repetition, 2 place repetition, 3 place repetition and so on present in decimal number.
- Subtract the number obtained in step 2 from a number obtained in step 4.
- Find the value of x in the form  $\frac{p}{q}$ .

**(b) Mixed recurring decimal**

It is a decimal representation in which there are one or more digits present before the repeating digits after decimal point. Following are the steps to convert it to the form  $\frac{p}{q}$ .

- Denote mixed recurring decimal as x.
- Count the number of digits after the decimal point which do not have bar on them. let it be ‘n’.
- Multiply both sides of x by  $10^n$  to get only repeating decimal numbers on the right side of the decimal point.
- Further use the method of converting pure recurring decimal to the form  $\frac{p}{q}$  and get the value of x.

 **EXAMPLES** 

**Example 6 :** Express each of the following pure recurring decimals in the form  $\frac{p}{q}$ .

- (i)  $0.\overline{6}$                       (ii)  $0.\overline{585}$                       (iii)  $23.\overline{43}$

**Solution :**

(i) Let  $x = 0.\overline{6}$   
 $\Rightarrow x = 0.666 \dots\dots\dots$ (i)  
 Here, we have only one repeating digit, so we multiply both sides of (i) by 10 to get  
 $\rightarrow 10x = 6.66 \dots\dots\dots$ (ii)  
 On subtracting (i) from (ii)  
 $10x - x = (6.66\dots) - (0.66\dots\dots)$   
 $\rightarrow 9x = 6 \Rightarrow x = \frac{6}{9} \Rightarrow x = \frac{2}{3}$ ,  
 Hence  $0.\overline{6} = \frac{2}{3}$ ,

(ii) Let  $x = 0.\overline{585} \Rightarrow x = 0.585585585\dots\dots\dots 0.\overline{585}$  .....(i)  
 Here, we have three repeating digits, so we multiply both sides of (i) by  $10^3 = 1000$  to get  
 $\rightarrow 1000x = 585.585585 \dots\dots\dots$ (ii)  
 On subtracting (i) from (ii)  
 $1000x - x = (585.585585\dots) - (0.585585)$   
 $\rightarrow 999x = 585$   
 $\Rightarrow x = \frac{585}{999}$   
 Hence,  $0.\overline{585} = \frac{585}{999} = \frac{65}{111}$

(iii) Let  $x = 23.\overline{43}$   
 $\rightarrow x = 23.434343 \dots\dots\dots(i)$   
 Multiplying both sides of (i) by 100  
 $\rightarrow 100x = 2343.4343 \dots\dots\dots(ii)$   
 On subtracting (i) from (ii)  
 $\rightarrow 99x = 2320$   
 $\Rightarrow x = \frac{2320}{99}$

Hence,  $23.\overline{43} = \frac{2320}{99}$

**Alter Method :**

We have,  $23.\overline{43} = 23 + 0.\overline{43} = 23 + \frac{43}{99}$  [Using the above rule, we have  $0.\overline{43} = \frac{43}{99}$ ]

$\Rightarrow 23.\overline{43} = \frac{23 \times 99 + 43}{99} = \frac{2277 + 43}{99} = \frac{2320}{99}$

**4. REPRESENTING REAL NUMBERS ON THE NUMBER LINE**

The collection of real numbers consists of all the rational and irrational numbers and is denoted by R. Every real number corresponds to a point on the line and conversely, every point on the number line represents a real number,

**I. Representing the Square Root of a Positive Number on the Number Line**

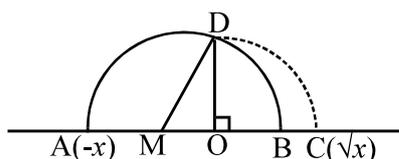
Let x be a positive real number. We will now locate  $\sqrt{x}$  on the number line.

**Step. 1 :** Mark  $-x$  on the number line. Let this point be represented by A. Mark 1 unit on the number line. Let this be represented by B.

**Step. 2 :** Locate the midpoint M of AB.

**Step. 3 :** With M as the centre and MA or MB as radius draw a semicircle. Since diameter  $AB = (x + 1)$  units,  $MA = MB = \frac{1}{2}(x + 1)$  units.

**Step. 4 :** Draw OD perpendicular to AB meeting the semicircle in D. Join MD. Note the  $\Delta DMO$  is a right triangle with  $MD = \frac{1}{2}(x+1)$  units and  $MO = [\frac{1}{2}(x + 1) - 1]$  units.  $= \frac{1}{2}(x - 1)$  units.



**Step 5 :** Using the Pythagorean theorem, we obtain :

$OD^2 = MD^2 - MO^2 = \frac{1}{4}(x+1)^2 - \frac{1}{4}(x - 1)^2 = \frac{1}{4}(4x) = x = OD = \sqrt{x}$

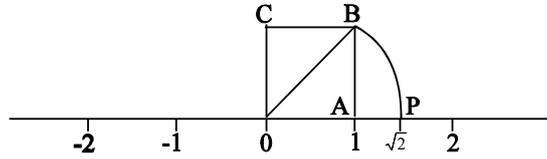
With O as the centre and OD as the radius, draw an arc to meet the number line at C. The point C represents  $\sqrt{x}$ .

**EXAMPLES**

**Example 7 :** Locate  $\sqrt{2}$  on the number line.

**Solution :** **Step 1 :** Draw the number line with O representing the number 0 and A representing the number 1.

**Step 2 :** Construct a square OABC with each side equal to 1 unit.



By the Pythagorean theorem :

$$OB^2 = OA^2 + AB^2 = 1^2 + 1^2 = 1 + 1 = 2$$

$$OB = \sqrt{2}$$

**Step 3 :** With O as centre and OB as radius, draw an arc to meet the number line at point P.

Since  $OP = OB = \sqrt{2}$ , the point P represents  $\sqrt{2}$  on the number line.

**Example 8: Visualise 2.437 on the number line.**

**Solution :** Observe that 2.437 lies between 2 and 3.

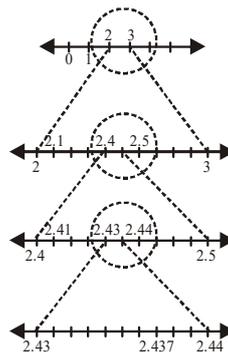
**Step 1:** Locate 2 on the number line.

**Step 2:** Locate 2.4 on the number line as follows.

Divide the segment between 2 and 3 into ten equal parts and mark each point of the division. The first mark is 2.1, the second 2.2, and so on. The fourth mark represents point 2.4.

**Step 3:** Locate 2.43 on the number line as follows : Divide the segment 2.4 to 2.5 into 10 equal parts. Mark the first part 2.41, the next as 2.42 and so on. The third mark represents the number 2.43.

**Step 4:** Locate 2.437 on the number line by dividing the segment 2.43 to 2.44 into 10 equal parts. Mark each part and take the 7th part.



## 5. DECIMAL NUMBERS

**I. Finite or Terminating Decimal :** Every fraction  $p/q$  can be expressed as a decimal, if the decimal expression of  $p/q$  terminates, i.e. comes to an end, then the decimal so obtained is called a terminating decimal.

**Example :**  $1/4 = 0.25$ ,  $5/8 = 0.625$ ,  $2\frac{3}{5} = \frac{13}{5} = 2.6$

Thus, each of the numbers  $\frac{1}{4}$ ,  $\frac{5}{8}$  and  $2\frac{3}{5}$  can be expressed in the form of a terminating decimal.



**Let's know**

A fraction  $p/q$  is a terminating decimal only, when prime factors of  $q$  are 2 and 5 only.

**Example :** Each one of the fractions  $\frac{1}{2}, \frac{3}{4}, \frac{7}{20}, \frac{13}{25}$  is a terminating decimal, since the denominator of each has no prime factor other than 2 and 5.

**II. Repeating (or Recurring) Decimals:** A decimal in which a digit or a set of digits repeats periodically, is called a repeating or a recurring decimal.

In a recurring decimal, we place a bar over the first block of the repeating part and omit the other repeating blocks.

**Example :** (i)  $\frac{2}{3} = 0.666 \dots\dots\dots = 0.\overline{6}$

(ii)  $\frac{15}{7} = 2.142857142857 \dots\dots\dots = 2.\overline{142857}$

• **Procedure for terminating decimal :**

**Step. 1 :** Count the number of numerals to the right of the decimal point. Let it be  $m$ .

**Step. 2 :** Drop the decimal point and in the denominator write 1 followed by  $m$  zeros.

**Step. 3 :** Simplify the fraction.



**Let's know**

1. A rational number  $a$  is called the reciprocal or multiplicative inverse of a rational number  $b$  if

$$a \times b = b \times a = 1$$

i.e.,  $b = \frac{1}{a}$  (or)  $a = \frac{1}{b}$

2. Zero has no reciprocal.

3. 1 and  $-1$  are the only rational numbers having their own reciprocals.

4. The reciprocal or the multiplicative inverse of a non zero rational number  $\frac{a}{b}$  is written as  $\left(\frac{a}{b}\right)^{-1}$

**6. OPERATIONS ON REAL NUMBERS**

The following points are to be kept in mind when you deal with real numbers and mathematical operation on them :

- When the addition or subtraction operation is done on a rational and irrational number, the result is an irrational number.
- When the multiplication or division operation is done on a rational number with an irrational number, the result is an irrational number
- When two irrational numbers are added, subtracted, multiplied or divided, the result may be a rational or an irrational number.

If  $a$  and  $b$  are positive real numbers, then we have,

(i)  $\sqrt{ab} = \sqrt{a} \times \sqrt{b}$

(ii)  $\sqrt{\frac{a}{b}} = \frac{\sqrt{a}}{\sqrt{b}}$

- (iii)  $(\sqrt{a} + \sqrt{b})(\sqrt{a} - \sqrt{b}) = a - b$                       (iv)  $(a + \sqrt{b})(a - \sqrt{b}) = a^2 - b$
- (v)  $(\sqrt{a} + \sqrt{b})(\sqrt{c} - \sqrt{d}) = \sqrt{ac} + \sqrt{ad} + \sqrt{bc} + \sqrt{bd}$
- (vi)  $(\sqrt{a} + \sqrt{b})^2 = a + 2\sqrt{ab} + b$
- (vii)  $(\sqrt{a} - \sqrt{b})^2 = a + b - 2\sqrt{ab}$
- (viii) If  $a + \sqrt{b} = c + \sqrt{d} \Rightarrow a = c$  and  $b = d$ . (equating rational parts and irrational parts)



## TRY YOURSELF

- Q.1** Rational number between  $\sqrt{2}$  and  $\sqrt{3}$  is  
 (A)  $\frac{\sqrt{2} + \sqrt{3}}{2}$                       (B)  $\frac{\sqrt{2} \times \sqrt{3}}{2}$                       (C) 1.5                      (D) 1.8
- Q.2** The rational number between  $1/2$  and  $1/3$  is  
 (A)  $2/5$                       (B)  $1/5$                       (C)  $3/5$                       (D)  $4/5$
- Q.3** Which of the following fraction lie between  $1/5$  and  $1/4$ ?  
 (1)  $\frac{7}{33}$                       (2)  $\frac{4}{11}$                       (3)  $\frac{15}{57}$                       (4)  $\frac{7}{17}$   
 (A) 1 and 2                      (B) 1 and 3                      (C) 2, 3 and 4                      (D) 1, 2 and 4
- Q.4**  $\sqrt{7 + \sqrt{48}} = \underline{\hspace{2cm}}$ .  
 (A)  $\sqrt{2} + \sqrt{3}$                       (B)  $\sqrt{3} + 2\sqrt{2}$                       (C)  $2\sqrt{3} + \sqrt{2}$                       (D)  $2 + \sqrt{3}$
- Q.5** The smallest integral value of x, for which  $7/x$  is an integer is:  
 (A) 1                      (B) -1                      (C) 7                      (D) -7
- Q.6** Which one of the numbers listed below is not a divisor of the number  $N = (2^{30} - 1)$ , is equal to:  
 (A)  $2^5 - 1$                       (B)  $2^5 + 1$                       (C)  $2^6 - 1$                       (D)  $2^{10} + 1$
- Q.7** When  $4^{101} + 6^{101}$  is divide by 25, the remainder is:  
 (A) 20                      (B) 10                      (C) 5                      (D) 0
- Q.8** A number n is said to be perfect if the sum of all its divisors (excluding n itself) is equal to n, An example of perfect number is  
 (A) 6                      (B) 9                      (C) 15                      (D) 21

## ANSWER KEY

- Q.1** C      **Q.2** A      **Q.3** B      **Q.4** D      **Q.5** D      **Q.6** D      **Q.7** B  
**Q.8** A



**Let's know**

"Zero is a real number which has no multiplicative inverse".

**7. EXPONENTS**

The repeated multiplication of the same factor can be written in a more compact form, called exponential form.

**Laws of exponents for real numbers**

**I.**  $a^m \times a^n = a^{m+n}$  (Product of powers)

**Examples :**

1.  $2^3 \times 2^6 = 2^{3+6} = 2^9$
2.  $\left(\frac{5}{6}\right)^4 \times \left(\frac{5}{6}\right)^5 = \left(\frac{5}{6}\right)^{4+5} = \left(\frac{5}{6}\right)^9$
3.  $2^3 \times 2^4 \times 2^5 \times 2^8 = 2^{(3+4+5+8)} = 2^{20}$
4.  $(\sqrt{7})^3 \times (\sqrt{7})^5 = (\sqrt{7})^{3+5} = (\sqrt{7})^8$



**Let's know**

$$a^{m_1} \times a^{m_2} \times a^{m_3} \dots \times a^{m_n} = a^{m_1+m_2+m_3+\dots+m_n}$$

**II.**  $a^m \div a^n = a^{m-n}$ ,  $a \neq 0$  (Quotient of power)

**Examples :**

- (a)  $7^8 \div 7^3 = 7^{8-3} = 7^5$                       (b)  $\left(\frac{7}{3}\right)^9 \div \left(\frac{7}{3}\right)^5 = \left(\frac{7}{3}\right)^{9-5} = \left(\frac{7}{3}\right)^4$



**Let's know**

We now consider what meaning we can assign to  $a^0$ .

If we want these laws to be true for all values of m and n, i.e. even for  $n = m$ . from (ii) above we get

$$\frac{a^m}{a^m} = a^{m-m}. \quad \text{or} \quad 1 = a^0.$$

We see that if we define  $a^0$  as 1, this law will be true even for  $n = m$ . Therefore, we define  $a^0$  as 1, provided  $a \neq 0$ .

When  $a = 0$ ,  $a^{n-n} = \frac{a^n}{a^n} = \frac{0}{0}$ , which is not defined.

$\therefore 0^0$  is not defined.



**Let's know**

We shall now consider, what meaning we can assign to  $a^n$ , where n is a negative integer.

We have  $a^m \times a^n = a^{m+n}$

consider  $a^n \times a^{-n} = a^{n+(-n)}$  (if we want the law to be true)  $= a^0 = 1$

$$\therefore a^n \times a^{-n} = 1$$

III.  $a^{-n} = \frac{1}{a^n}$  and  $\frac{1}{a^{-n}} = a^n$ . If we define  $a^{-n}$  as  $\frac{1}{a^n}$ , this law is true even for negative value of  $n$ .

**Example :**  $2^{-4} = \frac{1}{2^4}$ ,  $5^{-1} = \frac{1}{5}$ ,  $a^{-n} = \frac{1}{a}$  (Provided  $a \neq 0$ )



### Let's know

$$\left(\frac{a}{b}\right)^{-1} = \frac{1}{\frac{a}{b}} = \frac{b}{a}$$

IV.  $(a^m)^n = a^{m \times n}$  (power of a power)

**Example :**

(a)  $(5^2)^3 = 5^{2 \times 3} = 5^6$

(b)  $\left[\left(\frac{2}{3}\right)^4\right]^5 = \left(\frac{2}{3}\right)^{4 \times 5} = \left(\frac{2}{3}\right)^{20}$

V.  $(ab)^n = a^n \times b^n$  (power of a product)

**Example :**

(a)  $(20)^5 = (4 \times 5)^5 = 4^5 \times 5^5$

(b)  $(42)^7 = (2 \times 3 \times 7)^7 = 2^7 \times 3^7 \times 7^7$

In problems, we may often want to write  $a^n \times b^n$  as  $(ab)^n$

(a)  $8 \times 27 = 2^3 \times 3^3 = (2 \times 3)^3 = 6^3$       (b)  $\frac{125}{343} \times \frac{729}{8} = \left[\left(\frac{5}{7}\right)\left(\frac{9}{2}\right)\right]^3 = \left(\frac{45}{14}\right)^3$

VI.  $\left(\frac{a}{b}\right)^n = \frac{a^n}{b^n}$  (Power of a quotient)

**Example :**

(a)  $\left(\frac{4}{5}\right)^7 = \frac{4^7}{5^7}$

(b)  $\left(\frac{6}{5}\right)^8 = \frac{(2^8)(3^8)}{5^8}$

VII.  $\left(\frac{a}{b}\right)^{-n} = \left(\frac{b}{a}\right)^n$

**Example :**

(a)  $\left(\frac{5}{9}\right)^{-3} = \left(\frac{9}{5}\right)^3$

(b)  $\left(\frac{1}{5}\right)^{-1} = \left(\frac{5}{1}\right)^1 = 5$

- (viii)  $a^{bn} = a^{b+b+\dots+n \text{ times}}$  where a, b are positive real numbers and m, n are rational numbers.
- (ix)  $(\sqrt[n]{a})^n = a$ , where 'n' is a positive integer and 'a' is a positive rational numbers.
- (x)  $\sqrt[n]{a} \sqrt[n]{b} = \sqrt[n]{ab}$ , where 'n' is a positive integer and 'a', 'b' are rational numbers.
- (xi)  $\frac{\sqrt[n]{a}}{\sqrt[n]{b}} = \sqrt[n]{\frac{a}{b}}$ , where 'n' is a positive integer and 'a', 'b' are rational numbers.
- (xii)  $\sqrt[m]{\sqrt[n]{a}} = \sqrt[mn]{a} = \sqrt[n]{\sqrt[m]{a}}$ , where 'm', 'n' are positive integer and 'a' is a positive rational numbers.
- (xiii)  $\sqrt[n]{\sqrt[m]{(a^k)^m}} = \sqrt[n]{a^k} = \sqrt[mn]{a^{km}}$  where 'm', 'n' are 'k' are positive integers and 'a' is a positive rational number.
- (xiv)  $\sqrt{a} \times \sqrt{a} = a$



**Let's know**

The concept of cyclicity is used to identify the last digit of the number. The concepts utilize the fact that remainders repeat themselves after a certain interval when divided by a number.

First of all, we know remainder = 0 to d-1,

where d= number by which the divisor is divided. If we divide  $a^n$  by d, the remainder can be any value from 0 to d

1. If we keep on increasing the value of n, the remainders are cyclical in nature. The pattern of the remainders would repeat.

Number	Cyclicity
2, 3, 7, 8	4
5, 6	1
4, 9	2



**TRY YOURSELF**

- Q.1** If  $\sqrt{5^n} = 125$ , then  $5^{\sqrt{64}} =$  \_\_\_\_\_.
- (A) 25                      (B)  $\frac{1}{25}$                       (C) 625                      (D)  $\frac{1}{25}$
- Q.2** Which of the following pairs having two equal values? (Where  $x \in \mathbb{R}$ ) \_\_\_\_\_.
- (A)  $9^{x/2}, 27^{x/3}$                       (B)  $(256)^{4/x}, (4^3)^{4/x}$   
 (C)  $(343)^{x/3}, (7^4)^{x/12}$                       (D)  $(36^2)^{2/7}, (6^3)^{2/7}$
- Q.3** If  $\sqrt{2^n} = 1024$ , then  $3^{\left(\frac{n-4}{4}\right)} =$  \_\_\_\_\_.
- (A) 3                      (B) 9                      (C) 27                      (D) 81
- Q.4**  $(\sqrt[5]{5})(\sqrt[3]{2})(\sqrt{3})(\sqrt[12]{6}) =$
- (A)  $\sqrt[12]{1749600}$                       (B)  $\sqrt[3]{2} \times \sqrt[12]{109350}$                       (C)  $\sqrt[12]{177960}$                       (D) Both (A) and (B)

- Q.5** If  $m$  and  $n$  are positive integers, then for a positive number  $a$ ,  $\left\{\sqrt[n]{(\sqrt[m]{a})}\right\}^{mn}$  \_\_\_\_\_.
- (A)  $a^{mn}$                       (B)  $a$                       (C)  $a^{m/n}$                       (D) 1
- Q.6** Express the following in the simplest form  $\frac{\sqrt[3]{81}}{\sqrt[3]{3}}$
- (A) 9                      (B) 3                      (C) 27                      (D) 81

### ANSWER KEY

**Q.1** A    **Q.2** A    **Q.3** B    **Q.4** A    **Q.5** B    **Q.6** B

## 8. RADICALS

An expression written under a radical sign is called a radical expression. The **radicand** is the number under the radical.

A surd is the simplest type of irrational number, one whose radicand is a rational number.

**Example:**  $\sqrt{5}$ ,  $3\sqrt{7}$  and  $\frac{1}{\sqrt{3}}$  are surds whereas  $3\sqrt{5-\sqrt{2}}$  and  $\sqrt{\sqrt{3}}$  are not surds.

The order of a surd is indicated by its index.

The order of a radical is the denominator of its fractional exponent.

Order  $\rightarrow \sqrt[n]{a} = a^{1/n} \leftarrow$  order

**I. Pure surd :** A surd in which the whole of the rational number is under the radical sign. & makes the **radicand**, is called pure surd.

**Example:**  $\sqrt{8}$ ,  $\sqrt[3]{15}$ ,  $\sqrt[4]{11}$  etc.

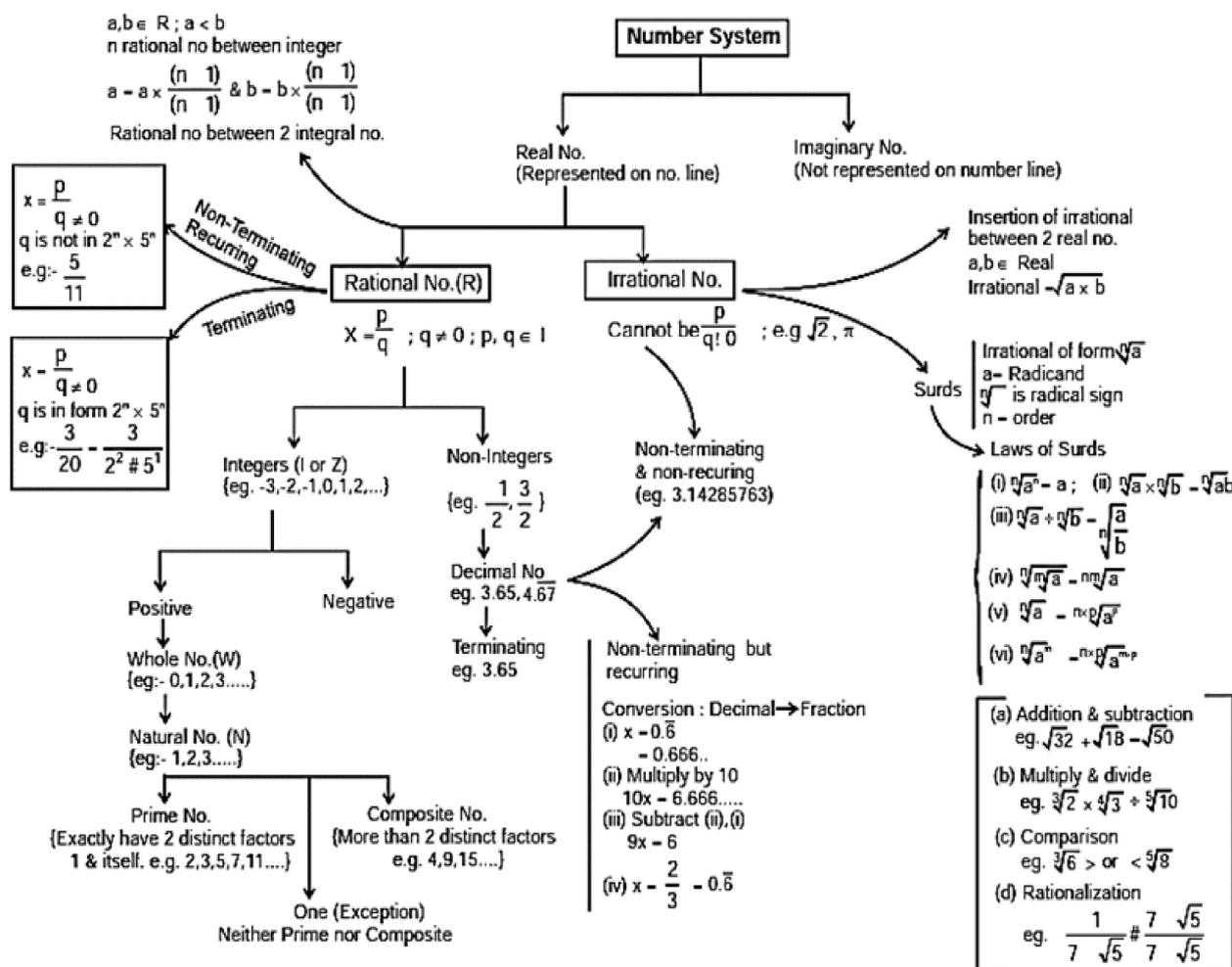
**II Mixed surd :** If some part of the quantity under the radical sign is taken out of it then it makes the surd mixed.

For e.g.  $3\sqrt{2}$ ,  $4\sqrt{2}$  etc.

**III. Like surds (Similar surds) :** The surds having the same irrational factor are called



# MIND MAP



**EXERCISE-I**

**NCERT Solutions**



**Q.1** Find five rational numbers between  $\frac{3}{5}$  and

$\frac{4}{5}$ . [NCERT, Ex. 1.1, Q.3]

**Sol.** Multiplying numerator and denominator of both numbers with (5 + 1)

$\frac{3 \times 6}{5 \times 6}$  and  $\frac{4 \times 6}{5 \times 6} = \frac{18}{30}$  and  $\frac{24}{30}$ .

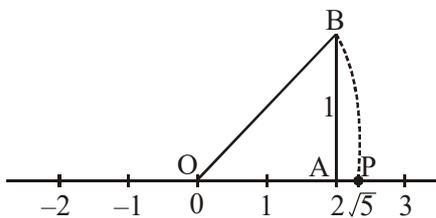
Therefore, five rational numbers between  $\frac{18}{30}$

and  $\frac{24}{30}$  are :

$\frac{19}{30}, \frac{20}{30}, \frac{21}{30}, \frac{22}{30}$  and  $\frac{23}{30}$ . **Ans.**

**Q.2** Show how  $\sqrt{5}$  can be represented on the number line. [NCERT, Ex. 1.2, Q.3]

**Sol.** Step-I : Draw the number line with O representing the number 0 and A representing the number 2.



**Step-II :** Draw a perpendicular of length 1 unit at point A.

By Pythagoras theorem,  
 $OB^2 = AO^2 + AB^2$   
 $= 2^2 + 1^2 = 4 + 1$   
 $OB^2 = 5$   
 $OB = \sqrt{5}$ .

**Step-III :** With O as centre and OB as radius, draw an arc to meet the number line at point P.

Since  $OP = OB = \sqrt{5}$ .

The point P represents  $\sqrt{5}$  on the number line.

**Q.3** Write the following in decimal form and say what kind of decimal expansion each has

(i)  $4\frac{1}{8}$  (ii)  $\frac{329}{400}$

[NCERT, Ex. 1.3, Q.1]

**Sol.** (i)  $4\frac{1}{8} = \frac{33}{8} = \frac{33 \times 125}{8 \times 125} = \frac{4125}{1000} = 4.125$   
 = terminating

(ii)  $\frac{329}{400} = \frac{329 \times 25}{400 \times 25} = \frac{8225}{10000} = 0.8225$   
 = terminating.

**Q.4** Find three different irrational numbers between the rational numbers  $\frac{5}{7}$  and  $\frac{9}{11}$ .

[NCERT, Ex. 1.3, Q.8]

**Sol.**  $\frac{5}{7} = 5 \times \frac{1}{7} = 5 \times 0.142857 \dots\dots$   
 $= 0.714285 \dots\dots$

$\frac{9}{11} = 9 \times \frac{1}{11} = 9 \times 0.090909 \dots\dots$   
 $= 0.818181 \dots\dots$  **Ans.**

**Q.5** Classify the following numbers as rational or irrational [NCERT, Ex. 1.3, Q.9]

(i)  $\sqrt{225}$  (ii) 0.3796  
 (iii) 1.10100100010000....

**Sol.** (i)  $\sqrt{225} = \sqrt{(15)^2} = 15 = \frac{15}{1}$   
 = Rational.

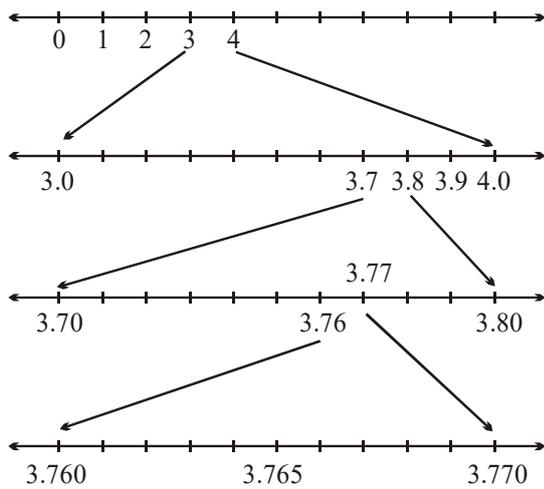
(ii)  $0.3796 = \frac{3796}{10000} = \text{Rational}$

(iii) Irrational. **Ans.**

**Q.6** Visualise 3.765 on the number line, using successive magnification.

[NCERT, Ex. 1.4, Q.1]

Sol.



**Q.7 Find :** (i)  $9^{\frac{3}{2}}$  (ii)  $16^{\frac{3}{4}}$  (iii)  $125^{\frac{-1}{3}}$   
 [NCERT, Ex. 1.6, Q.2]

**Sol.** (i)  $9^{\frac{3}{2}} = (9^{1/2})^3 = 3^3 = 27.$

(ii)  $16^{\frac{3}{4}} = (16^{1/4})^3 = 2^3 = 8.$

(iii)  $125^{\frac{-1}{3}} = \frac{1}{125^{1/3}} = \frac{1}{5}.$

**Ans.**

**Q.8 Simplify :** (i)  $2^{\frac{2}{3}} \cdot 2^{\frac{1}{5}}$  (ii)  $\frac{11^{\frac{1}{2}}}{11^{\frac{1}{4}}}$   
 [NCERT, Ex. 1.6, Q.3]

**Sol.** (i)  $2^{\frac{2}{3}} \cdot 2^{\frac{1}{5}} = 2^{\frac{2}{3} + \frac{1}{5}} = 2^{\frac{10+3}{15}} = 2^{\frac{13}{15}}.$

(ii)  $\frac{11^{\frac{1}{2}}}{11^{\frac{1}{4}}} = 11^{\left(\frac{1}{2} - \frac{1}{4}\right)} = 11^{\frac{1}{4}}.$  **Ans.**

**EXERCISE-II**

**Knowledge Vault**



**MCQ BASED QUESTIONS:**

- Q.1** An irrational number between 2 and 2.5 is  
 (A)  $\sqrt{11}$  (B)  $\sqrt{5}$   
 (C)  $\sqrt{22.5}$  (D)  $\sqrt{12.5}$
- Q.2** The digit at the 100<sup>th</sup> place in the decimal representation of  $\frac{6}{7}$ , is :  
 (A) 1 (B) 2 (C) 4 (D) 5
- Q.3** If n is a natural number, then  $\sqrt{n}$  is  
 (A) always a natural number  
 (B) always an irrational number  
 (C) always a rational number  
 (D) sometimes a natural number and sometimes an irrational number
- Q.4** The value of  $0.\overline{23} + 0.\overline{22}$  is  
 (A)  $0.\overline{45}$  (B)  $0.\overline{43}$   
 (C)  $0.\overline{47}$  (D) 0.45
- Q.5** If  $4^x - 4^{x-1} = 24$ , then  $(2x)^x$  equals  
 (A)  $5\sqrt{5}$  (B)  $\sqrt{5}$   
 (C)  $25\sqrt{5}$  (D) 125
- Q.6** If  $x^{-2} = 64$ , then  $x^{1/3} + x^0 =$   
 (A) 2 (B) 3 (C)  $3/2$  (D)  $2/3$
- Q.7** If  $0 < y < x$ , which statement must be true ?  
 (A)  $\sqrt{x} - \sqrt{y} = \sqrt{x-y}$   
 (B)  $\sqrt{x} + \sqrt{x} = \sqrt{2x}$   
 (C)  $x\sqrt{y} = y\sqrt{x}$   
 (D)  $\sqrt{xy} = \sqrt{x} \sqrt{y}$
- Q.8** If a, a + 2, and a + 4 are prime numbers, then the number of possible solution for a is :  
 (A) three (B) two  
 (C) one (D) more than three
- Q.9** The value of  $\sqrt{3-2\sqrt{2}}$  is  
 (A)  $\sqrt{2}-1$  (B)  $\sqrt{2}+1$   
 (C)  $\sqrt{3}-\sqrt{2}$  (D)  $\sqrt{3}+\sqrt{2}$
- Q.10** If  $x = 7 + 4\sqrt{3}$  and  $xy = 1$ , then  $\frac{1}{x^2} + \frac{1}{y^2} =$   
 (A) 64 (B) 134 (C) 194 (D)  $1/49$
- Q.11** If  $x = \sqrt[3]{2+\sqrt{3}}$ , then  $x^3 + \frac{1}{x^3} =$   
 (A) 2 (B) 4 (C) 8 (D) 9
- Q.12** If  $\sqrt{2} = 1.4142$ , then  $\sqrt{\frac{\sqrt{2}-1}{\sqrt{2}+1}}$  is equal to  
 (A) 0.1718 (B) 5.8282  
 (C) 0.4142 (D) 2.4142
- Q.13** If  $\sqrt{2} = 1.414$ , then the value of  $\sqrt{6} - \sqrt{3}$  upto three places of decimal is  
 (A) 0.235 (B) 0.707  
 (C) 1.414 (D) 0.471
- Q.14** If  $\sqrt{13-a\sqrt{10}} = \sqrt{8} + \sqrt{5}$ , then a =  
 (A) -5 (B) -6  
 (C) -4 (D) -2
- Q.15** The rationalising factor of  $\sqrt[5]{3^2 \cdot 2^3 \cdot 5^4}$   
 (A)  $\sqrt{3^2 \cdot 2^3 \cdot 5^4}$  (B)  $\sqrt[5]{3^3 \cdot 2^2 \cdot 5}$   
 (C)  $\sqrt{3^3 \cdot 2^2 \cdot 5}$  (D) None
- Q.16** Which of the following statements is true?  
 (A)  $-\frac{2}{3} < \frac{4}{-9} < \frac{-5}{12} < \frac{7}{-18}$   
 (B)  $\frac{7}{-18} < \frac{-5}{12} < \frac{4}{-9} < \frac{-2}{3}$   
 (C)  $\frac{4}{-9} < \frac{7}{-18} < \frac{-5}{12} < \frac{-2}{3}$   
 (D)  $\frac{-5}{12} < \frac{-2}{3} < \frac{4}{-9} < \frac{7}{-18}$
- Q.17** The value of  $4 - \frac{5}{1 + \frac{1}{3 + \frac{1}{2 + \frac{1}{4}}}}$  is  
 (A)  $\frac{40}{31}$  (B)  $\frac{4}{9}$   
 (C)  $\frac{1}{8}$  (D)  $\frac{31}{40}$

- Q.18** If  $(1^2 + 2^2 + 3^2 + \dots + 10^2) = 385$ , then the value of  $(2^2 + 4^2 + 6^2 + \dots + 20^2)$ .  
 (A) 770 (B) 1155  
 (C) 1540 (D)  $(385 \times 385)$

- Q.19** The value of  $\frac{a + \sqrt{a^2 - b^2}}{\sqrt{a^2 + b^2} + b} \div \frac{\sqrt{a^2 + b^2} - b}{a - \sqrt{a^2 - b^2}}$   
 (A)  $\frac{a^2}{b^2}$  (B)  $\frac{b^2}{a^2}$   
 (C)  $\frac{a}{b}$  (D) none

- Q.20**  $4^{3.5} : 2^5$  is the same as  
 (A) 4 : 1 (B) 2 : 1  
 (C) 7 : 5 (D) 7 : 10

- Q.21**  $\frac{\sqrt[3]{8}}{\sqrt{16}} \div \frac{\sqrt{100}}{\sqrt{49}} \times \frac{\sqrt[3]{125}}{\sqrt{49}}$  is equal to  
 (A) 7 (B)  $\frac{1}{4}$  (C)  $\frac{7}{100}$  (D)  $\frac{4}{7}$

- Q.22** How many three-digit numbers would you find, which when divided by 3, 4, 5, 6, 7 leave the remainders 1, 2, 3, 4, and 5 respectively?  
 (A) 4 (B) 3 (C) 2 (D) 1

- Q.23** Find the unit digit of  $(7^{95} - 3^{58})$ .  
 (A) 6 (B) 4  
 (C) 3 (D) None of these

- Q.24** How many even integers n, where  $100 \leq n \leq 200$ , are divisible neither by seven nor by nine?  
 (A) 40 (B) 37 (C) 39 (D) 38

**FILL IN THE BLANKS**

- Q.25** There are \_\_\_\_\_ many rational numbers between any two given rational number.  
**Q.26** Every \_\_\_\_\_ numbers is a whole number.  
**Q.27** All counting number together with 0 constitute set of \_\_\_\_\_.  
**Q.28** All natural number together with 0 and negatives of all the natural number form the set of \_\_\_\_\_.  
**Q.29** The two rational numbers which are their own multiplicative inverses are \_\_\_\_\_

**TRUE AND FALSE**

- Q.30** Every rational number is a natural number.  
**Q.31** Irrational number are not real numbers.  
**Q.32** If you subtract a rational number from an irrational number is an irrational number.  
**Q.33** If we multiply two irrational numbers, the results is only irrational.  
**Q.34** The addition of two irrational numbers always results in an irrational number.

**MATCH THE COLUME**

**[A] [ONE TO ONE]:**

**Column-I** and **column-II** contain **four** entries each. Entries of column-I are to be matched with some entries of column-II. One or more than one entries of column-I may have the matching with the same entries of column-II and one entry of column-II may have one or more than one matching with entries of column-I

**Q.35**

- | <b>Column I</b>                          | <b>Column II</b>   |
|--|--------------------|
| (a) $\sqrt{7 + 4\sqrt{3}}$               | (p) $\sqrt{6}$     |
| (b) $\sqrt[6]{216}$                      | (q) $\sqrt[6]{72}$ |
| (c) $\left(\frac{2ab^3}{5c^3d}\right)^0$ | (r) $2 + \sqrt{3}$ |
| (d) $\sqrt[3]{3} \times \sqrt[2]{2}$     | (s) 1              |
- (A) (a)-(r), (b)-(p), (c)-(s), (d)-(q)  
 (B) (a)-(q), (b)-(p), (c)-(r), (d)-(s)  
 (C) (a)-(s), (b)-(r), (c)-(p), (d)-(q)  
 (D) (a)-(p), (b)-(r), (c)-(s), (d)-(q)

**Q.36** It is given that  $x = -2$ ,  $y = -3$  match the following

- | <b>Column I</b>     | <b>Column II</b>   |
|---------------------|--------------------|
| (a) $x^{1-y}$       | (p) 1              |
| (b) $(x - y)^{x-y}$ | (q) 9              |
| (c) $(x + y)^{y-x}$ | (r) $-\frac{1}{5}$ |
| (d) $y^{-x}$        | (s) 16             |
- (A) (a)-(r), (b)-(p), (c)-(q), (d)-(s)  
 (B) (a)-(q), (b)-(p), (c)-(r), (d)-(s)  
 (C) (a)-(s), (b)-(p), (c)-(r), (d)-(q)  
 (D) (a)-(p), (b)-(r), (c)-(s), (d)-(q)

**Q.37****Column I****Column II**

- (a)  $\frac{4+\sqrt{5}}{4-\sqrt{5}} + \frac{4-\sqrt{5}}{4+\sqrt{5}}$  (p) 42/11
- (b)  $(\sqrt{8}-\sqrt{2})(\sqrt{8}+\sqrt{2})$  (q) Rational
- (c)  $\frac{\sqrt[4]{243 \times 16}}{\sqrt[4]{3}}$  (r) 6
- (d)  $(2\sqrt{5}+3\sqrt{2})^2$  (s) Irrational
- (A) (a)-(p,q), (b)-(q,r), (c)-(r,q), (d)-(s)  
 (B) (a)-(pqr), (b)-(pq), (c)-(q), (d)-(q)  
 (C) (a)-(p), (b)-(q,r), (c)-(q), (d)-(p,s)  
 (D) (a)-(p,r), (b)-(q), (c)-(p,q), (d)-(p,q,r)

**Q.38****Column I****Column II**

- (a)  $(\sqrt{3} + \sqrt{5})^2$  (p) Rational
- (b)  $0.\overline{54}$  (q) Non terminating and recurring
- (c)  $\sqrt{\frac{216}{121}}$  (r) Irrational
- (d)  $\sqrt[3]{\frac{216}{1331}}$  (s)  $\frac{6}{11}$
- (A) (a)-(q,r), (b)-(p,s), (c)-(s), (d)-(s)  
 (B) (a)-(pqr), (b)-(pq), (c)-(q), (d)-(q)  
 (C) (a)-(p), (b)-(q,r), (c)-(q), (d)-(p,s)  
 (D) (a)-(r), (b)-(p,q,s), (c)-(r), (d)-(p,q,s)

**ASSERTION REASON TYPE QUESTIONS**

**Direction.** In the following questions, a statement of Assertion (A) is followed by a statement of reason (R). Mark the correct choice as:

- Both assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
- Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
- Assertion (A) is true but Reason (R) is false.
- Assertion (A) is false but Reason (R) is true.

**Q.39 Assertion:** 5 is a rational number.**Reason:** The square root of all positive integers are irrationals.

- (A) 1 (B) 2 (C) 3 (D) 4

**Q.40 Assertion:** Sum of two irrational number  $2 + \sqrt{3}$  is an irrational number.**Reason:** Sum of a rational number and an irrational number is always an irrational number.

- (A) 1 (B) 2 (C) 3 (D) 4

**Q.41 Assertion:**  $7^8 \div 7^4 = 7^4$ **Reason:** If  $a > 0$  be a real number and p and q be rational number. Then  $a^p \times a^q = a^{p+q}$ .

- (A) 1 (B) 2 (C) 3 (D) 4

**Q.42 Assertion:**  $\sqrt{5}$  is an irrational number.**Reason:** A number is called irrational, if a cannot be written in the form  $\frac{p}{q}$ , where p and  $q \neq 0$ .

- (A) 1 (B) 2 (C) 3 (D) 4

**CASE/SOURCE BASED QUESTIONS**

**Q.43** To examine the preparation of class 9 students on topic 'Number System' Mathematics teachers write two numbers on blackboard, and asks few questions to students. Based on the above information, answer the following questions

- Write the decimal form of  $\frac{2}{11}$
- Write the  $\frac{p}{q}$  form of  $0.3\overline{8}$ 

(A)  $\frac{5}{18}$  (B)  $\frac{7}{18}$   
 (C)  $\frac{11}{18}$  (D)  $\frac{1}{18}$
- Write the decimal expansion of  $\frac{2}{11}$ 

(A) Non-terminating  
 (B) Terminating  
 (C) Non-Terminating repeating  
 (D) Non-Terminating non-repeating
- If  $\frac{p}{q}$  Form of  $0.3\overline{8}$  is  $\frac{m}{n}$ , Then value of a  $(m+n)$  is
 

(A) 25 (B) 11 (C) 29 (D) 23

- Q.44** A teacher conductor an activity on real number where each student has to pick a number card from a bunch of cards and frame a question for the rest of the students. The number cards picked up by first 5 students and their questions on the number has been recorded and shown below. Answer these questions
- (i) Shreshtha picked up  $\sqrt{8}$  and framed up a question - which of the following is true about?
- (A) It is a rational number  
(B) It is a natural number  
(C) It is an irrational number  
(D) All of the above
- (ii) Nisha picked up a number and framed a question which of these in not an irrational number?
- (A)  $\sqrt{8} - \sqrt{3}$                       (B)  $2 - \sqrt{6}$   
(C)  $2\sqrt{7} - 4$                       (D)  $3\sqrt{16} - \sqrt{9}$
- (iii) Advik picked up the number  $\sqrt{15} - \sqrt{10}$  and framed a question - The number is \_\_\_ number.
- (A) A whole  
(B) A natural  
(C) A rational  
(D) An irrational number
- (iv) Shamata picked up  $5\sqrt{25}$  and framed a question - The number  $5\sqrt{25}$  is \_\_\_ number.
- (A) A whole  
(B) A natural  
(C) A rational  
(D) All of the above

## EXERCISE - III

## Subjective Stuff



## VERY SHORT ANSWER TYPE QUESTIONS:

- Q.1 Simplify  $\sqrt{2} + 4\sqrt{2} + 6\sqrt{2}$
- Q.2 Simplify  $b = \frac{1}{7 + 4\sqrt{3}}$
- Q.3 Find the product of  $5\sqrt{3}$  and  $6\sqrt{3}$
- Q.4 Divide  $\sqrt{108}$  by  $\sqrt{147}$
- Q.5 Find an irrational number between  $\frac{1}{5}$  and  $\frac{15}{16}$ .
- Q.6 Represent 1.129129129..... as a fraction.

## SHORT ANSWER TYPE QUESTIONS :

- Q.7 Insert 5 rational numbers between 3 and 4.
- Q.8 Insert three irrational numbers between 4 and 5.
- Q.9 Represent the number  $\frac{3}{5}$  on the number line.
- Q.10 Find a fraction between  $\frac{3}{8}$  and  $\frac{2}{5}$ .
- Q.11 Represent  $\sqrt{6}$  on the number line.
- Q.12 Find two irrational numbers between  $\sqrt{5}$  and  $\sqrt{6}$ .

## LONG ANSWER TYPE QUESTIONS:

- Q.13 Find the value of a and b, if

$$\frac{7+3\sqrt{5}}{3+\sqrt{5}} - \frac{7-3\sqrt{5}}{3-\sqrt{5}} = a + \sqrt{5}b$$

- Q.14 If  $a = \frac{1}{7-4\sqrt{3}}$  and  $b = \frac{1}{7+4\sqrt{3}}$ , find the

values of the following.

(i)  $a^2 + b^2$                       (ii)  $a^3 + b^3$

- Q.15 If  $x = (5+2\sqrt{6})$ , then show that

$$\sqrt{x} + \frac{1}{\sqrt{x}} = 2\sqrt{3}$$

- Q.16 Simplify

$$\frac{-3}{\sqrt{3}+\sqrt{2}} - \frac{3\sqrt{2}}{\sqrt{6}+\sqrt{3}} + \frac{4\sqrt{3}}{\sqrt{6}+\sqrt{2}}$$

- Q.17 Rationalise  $\frac{1}{\sqrt{7}+\sqrt{3}-\sqrt{2}}$

## EXERCISE-IV

## Competitive Edge



**Q.1** If  $2^x = 4^y = 8^z$  and  $\frac{1}{2x} + \frac{1}{4y} + \frac{1}{6z} = \frac{24}{7}$ , then the value of  $z$  is [Raj. NTSE Stage-1 2005]

- (A)  $\frac{7}{16}$  (B)  $\frac{7}{32}$  (C)  $\frac{7}{48}$  (D)  $\frac{7}{64}$

**Q.2** If  $a^x = b$ ,  $b^y = c$  and  $c^z = a$ , then value of  $xyz$  is [Rajasthan NTSE Stage-1 2007]

- (A) 1 (B) 0  
(C) -1 (D)  $a + b + c$ .

**Q.3** An equivalent expression of  $\frac{5}{\sqrt{3}-\sqrt{5}}$  after rationalizing the denominator is

[Raj. NTSE Stage-1 2013]

(A)  $\left(\frac{5}{2}\right)(\sqrt{3} + \sqrt{5})$

(B)  $\left(-\frac{5}{2}\right)(\sqrt{3} + \sqrt{5})$

(C)  $\left(\frac{5}{2}\right)(\sqrt{3} - \sqrt{5})$

(D)  $\left(-\frac{5}{2}\right)(\sqrt{3} - \sqrt{5})$

**Q.4** If  $a^x = b$ ,  $b^y = c$  and  $c^z = a$ , then value of  $x^2y^2z^2$  is .....

[Madhya Pradesh NTSE Stage-1 2013]

- (A)  $a^2b^2c^2$  (B) 1  
(C) 3 (D)  $\frac{1}{a^2b^2c^2}$

**Q.5** The simplest rationalizing factor of  $3\sqrt{72}$  is

[M.P. NTSE Stage-1 2014]

- (A)  $\frac{1}{3}$  (B)  $\frac{1}{3^3}$  (C)  $\frac{1}{3^2}$  (D)  $\frac{1}{2}$

**Q.6** Of the following four number the largest is [Haryana NTSE Stage-1 2014]

- (A)  $3^{210}$  (B)  $7^{140}$   
(C)  $(17)^{105}$  (D)  $(31)^{84}$

**Q.7** Simple form of  $\frac{\sqrt{5}-2}{\sqrt{5}+2} + \frac{\sqrt{5}+2}{\sqrt{5}-2}$  is

[M.P. NTSE Stage-1 2015]

- (A)  $9 + \sqrt{5}$  (B) 18  
(C)  $18 + \sqrt{5}$  (D) 9

**Q.8** The simplified value of  $\frac{1}{\sqrt{2} + \sqrt{3} - \sqrt{5}} + \frac{1}{\sqrt{2} - \sqrt{3} - \sqrt{5}}$  is

[Delhi NTSE Stage-1 2015]

- (A) 1 (B) 0 (C)  $\sqrt{2}$  (D)  $\frac{1}{\sqrt{2}}$

**Q.9** An equivalent expression of  $\frac{5}{7+4\sqrt{5}}$  after rationalizing the denominator is

[Gujarat NTSE Stage-1 2016]

- (A)  $\frac{20\sqrt{5}-35}{31}$  (B)  $\frac{20\sqrt{5}-35}{129}$   
(C)  $\frac{35-20\sqrt{5}}{31}$  (D)  $\frac{35-20\sqrt{5}}{121}$

**Q.10** What is the value of  $2.\bar{6} - 2.\bar{9}$ ?

[Bihar NTSE Stage-1 2016]

- (A)  $0.\bar{6}$  (B) 0.9 (C) 0.7 (D)  $0.\bar{7}$

**Q.11** Among the number  $2^{250}$ ,  $3^{200}$ ,  $4^{150}$  and  $5^{100}$ , the greatest is

[West Bengal NTSE Stage-1 2016]

- (A)  $2^{250}$  (B)  $3^{200}$  (C)  $4^{150}$  (D)  $5^{100}$

**Q.12** Read the following statements carefully and choose the correct alternative.

**[Maharashtra NTSE Stage-1 2018]**

(A) The ratio of the circumference of a circle to its diameter is denoted by the Greek letter  $\pi$

(B)  $\pi$  is non-terminating, recurring decimal fraction and its extra value is

$$\frac{22}{7} \left( \pi = \frac{22}{7} \right)$$

**Alternatives :**

- (1) Statement A and B false
- (2) Statement A and B correct
- (3) Statement A correct but B false
- (4) Statement A false but B correct

**Q.13** The value of

$$\frac{3}{4} + \frac{5}{36} + \frac{7}{144} + \dots + \frac{17}{5184} + \frac{19}{8100}$$
 is

**[STSE 2022, 23]**

- (A) 0.95
- (B) 0.98
- (C) 0.99
- (D) 1

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**ANSWER KEY**


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**EXERCISE-II**


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**MULTIPLE CHOICE QUESTIONS:**

<b>Q.1</b>	B	<b>Q.2</b>	A	<b>Q.3</b>	D	<b>Q.4</b>	A	<b>Q.5</b>	C
<b>Q.6</b>	C	<b>Q.7</b>	D	<b>Q.8</b>	A	<b>Q.9</b>	A	<b>Q.10</b>	C
<b>Q.11</b>	B	<b>Q.12</b>	C	<b>Q.13</b>	B	<b>Q.14</b>	C	<b>Q.15</b>	B
<b>Q.16</b>	A	<b>Q.17</b>	C	<b>Q.18</b>	C	<b>Q.19</b>	B	<b>Q.20</b>	A
<b>Q.21</b>	B	<b>Q.22</b>	C	<b>Q.23</b>	B	<b>Q.24</b>	C		

**FILL IN THE BLANKS**

<b>Q.25</b>	Infinitely	<b>Q.26</b>	Natural	<b>Q.27</b>	Whole	<b>Q.28</b>	Integers
<b>Q.29</b>	[1,-1]						

**TRUE FALSE**

<b>Q.30</b>	False	<b>Q.31</b>	False	<b>Q.32</b>	True	<b>Q.33</b>	False
<b>Q.34</b>	False						

**MATCH THE COLUMN**

<b>Q.35</b>	(A)	<b>Q.36</b>	(C)	<b>Q.37</b>	(A)	<b>Q.38</b>	(D)
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**ASSERTION REASON**

<b>Q.39</b>	C	<b>Q.40</b>	A	<b>Q.41</b>	B	<b>Q.42</b>	A
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**CASE / SOURCE BASED**

<b>Q.43</b>	(i)B	(ii)B	(iii)C	(iv)A
<b>Q.44</b>	(i)C	(ii)D	(iii)D	(iv)D

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**EXERCISE-III**


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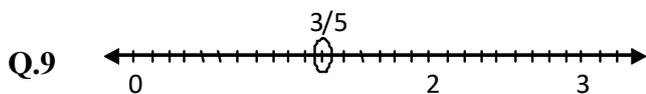
**VERY SHORT ANSWER TYPE :**

<b>Q.1</b>	$11\sqrt{2}$	<b>Q.2</b>	$9\sqrt{3}$	<b>Q.3</b>	$30\sqrt{6}$	<b>Q.4</b>	$\frac{6}{7}$
<b>Q.5</b>	0.2751234...	<b>Q.6</b>	$\frac{376}{333}$				

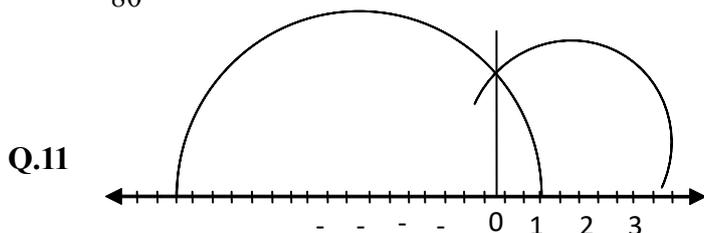
**SHORT ANSWER TYPE :**

**Q.7**  $\frac{7}{2}, \frac{13}{4}, \frac{25}{8}, \frac{15}{4}, \frac{29}{8}$

**Q.8** (i) 4.1258673758... (ii) 4.342157913458..... (iii) 4.615857342168...



**Q.10**  $\frac{31}{80}$



**Q.12** 2.32156.... and 2.36101.....

**LONG ANSWER TYPE :**

**Q.13** a = 0 , b = 1

**Q.14** (i) 194 (ii) 2702

**Q.16**  $6\sqrt{2} - 5\sqrt{3}$

**Q.17**  $\frac{3\sqrt{3} - 4\sqrt{2} + \sqrt{42} - \sqrt{7}}{10}$

**EXERCISE-IV**

<b>Q.1</b>	C	<b>Q.2</b>	B	<b>Q.3</b>	B	<b>Q.4</b>	B	<b>Q.5</b>	D
<b>Q.6</b>	C	<b>Q.7</b>	B	<b>Q.8</b>	D	<b>Q.9</b>	A	<b>Q.10</b>	A
<b>Q.11</b>	B	<b>Q.12</b>	C	<b>Q.13</b>	C				

# 1

# The French Revolution

## 1. INTRODUCTION

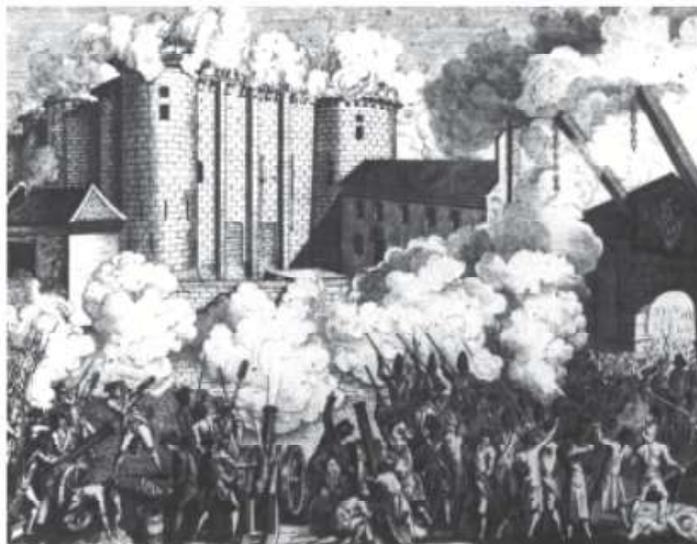
Today we often take the ideas of liberty, freedom and equality. But these ideas also have a history. The French revolution led to the end of monarchy in France. A society based on privileges gave way to a new system of governance. The Declaration of the Right of Man and Citizen during the revolution, announced the coming of a new time. The notions of equality and freedom emerged as the central ideas of a new age but in different countries they were reinterpreted and rethought in many different ways.

On 14th July 1789, a group of several hundred people marched towards eastern part of the city and stormed the fortress prison the Bastille. The fortress was demolished and its fragments sold in the market. The days that followed saw more rioting both in Paris and the countryside and it saw a beginning of chain of events that ultimately led to the execution of the king in France. How and why did this happen?



### Let's know

- **Aristocracy** : The highest class in some societies, comprising people of noble birth with hereditary titles.
- **Convention** : A formal agreement, especially between countries about particular rules or behavior. (Here, a name given to newly elected assembly in France).
- **Guillotine** : A machine or a device consisting of two poles and a blade with which a person is beheaded. It was named after Dr Guillotine who invented it.
- **Insurrection** : An attempt by a large group of people to take control (of political authorities) using force and violence.
- **Monarchy** : A government by monarch (a sovereign head of state).
- **Despot** : Someone such as a ruler who used power in a cruel and unfair way.
- **Emancipation** : The act of making someone free from social, political or legal restrictions that limit what they can do.



Storming of the Bastille

Soon after the demolition of the Bastille, artists made prints commemorating the event.

## 2. CAUSES OF THE FRENCH REVOLUTION

### I. Wars and Economic crisis :

In 1774 Louis XVI of Bourbon family of kings ascended the throne of France. Upon his accession the new king found an empty treasury.

### II. Excessive Taxation :

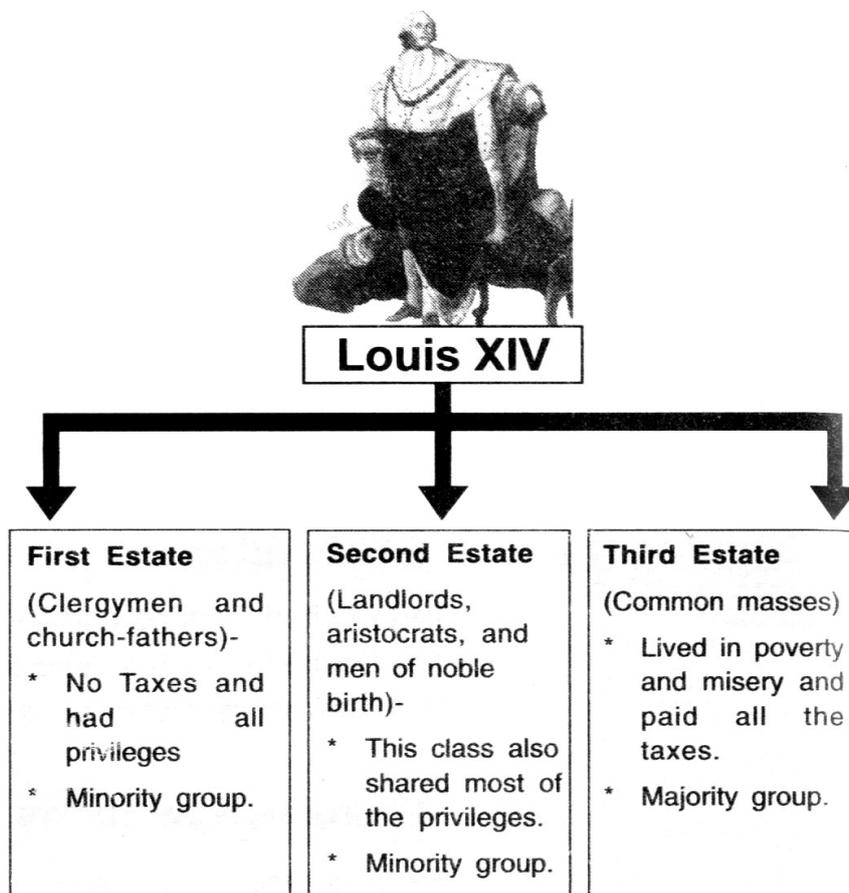
Before the Revolution, the common people were groaning under the burden of heavy taxes. The system of taxation was unjust and unreasonable. The upper class, which consisted of the nobles and the church-fathers was exempted from all sorts of taxes. The burden of taxation was passed on to the masses whose life was one of misery, starvation and humiliation. The expenditure of the government was ever increasing on account of useless wars and extravagance of rulers. With every increase in the demand for money, fresh taxes were imposed on the common people.

People were forced to pay all kinds of taxes. These included a direct tax called *taille*, the land tax, road tax, church tax, salt tax, and tariff duties charged for moving goods from one province to another, up or down or across a river and so on. The Church too extracted its share to taxes called tithes from the peasants. Sometimes four-fifth of the total income of a farmer would go towards the payment of taxes.

### III. Social Disparity :

In the 17th century, the French Society was divided into three groups, called Estates:

- (A) **The First Estate:** It consisted of the clergymen and church-fathers who were the custodians of religion and conscience of man. They were the most venerated persons in the society.
- (B) **The Second Estate:** It consisted of landlords, men of noble birth and aristocrats.
- (C) **The Third Estate:** It consisted of the vast majority of the common masses which included the landless peasants, petty peasant proprietors, artisans, masons, craftsmen, manufacturers, traders, merchants and other businessmen.

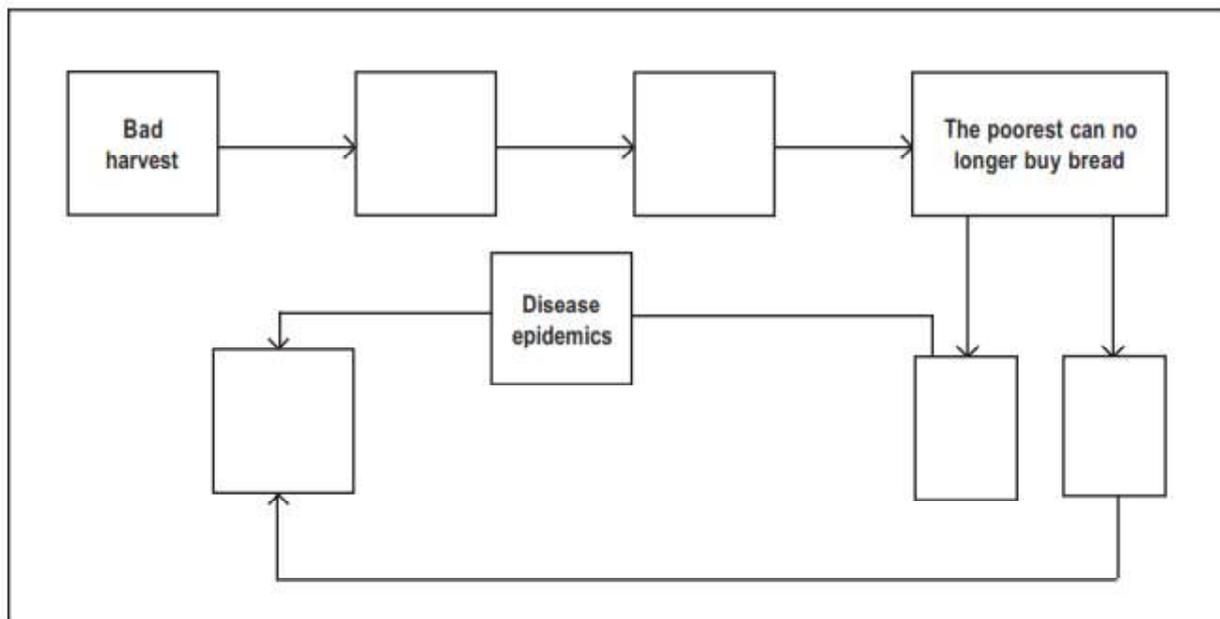


#### IV. The Struggle to survive :

**Subsistence crisis:** An extreme situation where the basic means of livelihood are endangered

**Causes of subsistence crisis:**

- (A) The population of France rose from 23 million to 28 million in 1789. this led to a rapid increase in the demand for foodgrains. Production of grains could not keep pace with the demand. So the prices of bread which was the staple diet of majority rose.
- (B) Most workers were employed as labourers in workshops. Whose owner fixed their wages. But wages did not keep pace with rise in prices. So the gap between the rich and poor widened.
- (C) Things become worse wherever drought or hail reduced the harvest. This led to subsistence crisis.



The course of a subsistence crisis.

#### V. A growing Middle Class :

The eighteenth century witnessed the emergence of social groups, termed as middle class, who earned their wealth through an expanding overseas trade and from manufacture of goods.

In addition to merchants and manufacturers the third estate included professions such as lawyers or administrative officials. All of these were educated and believed that no group in the society should be privileged by birth : A persons social position must depend on his merit.

#### VI. Role and Ideas of philosophers and Writers :

##### (A) John Locke

In his *Two Treatises of Government*. Locke Sought to refute the doctrine of divine and absolute right of the monarch.

##### (B) Rousseau

Rousseau in *Social contract* carried the idea forward, proposing a government based on social contract between people and the representatives.

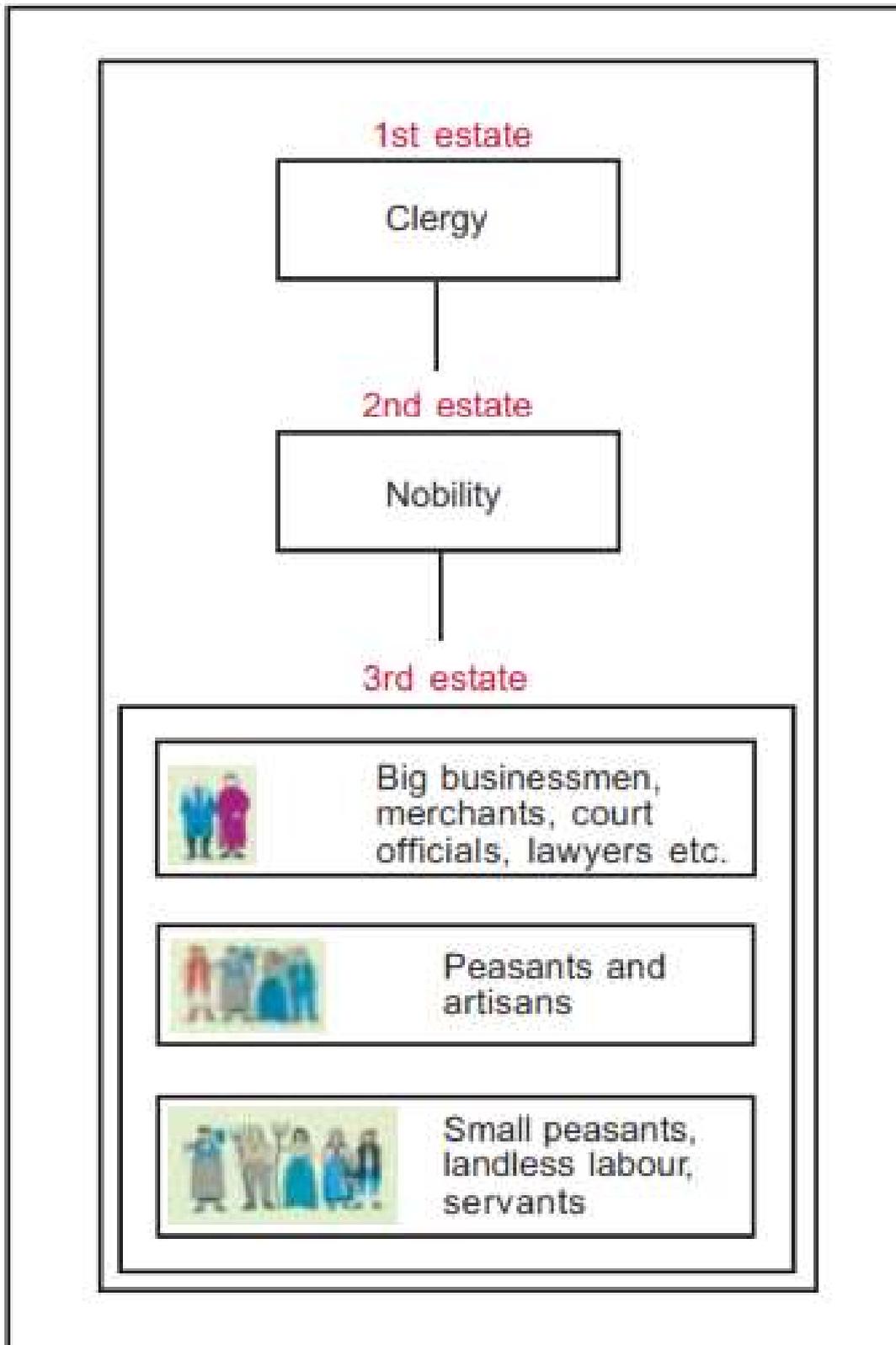
##### (C) Montesquieu

In *The Spirit Of Laws*, Montesquieu a division of power with in the government between the legislature, the executive and the judiciary.

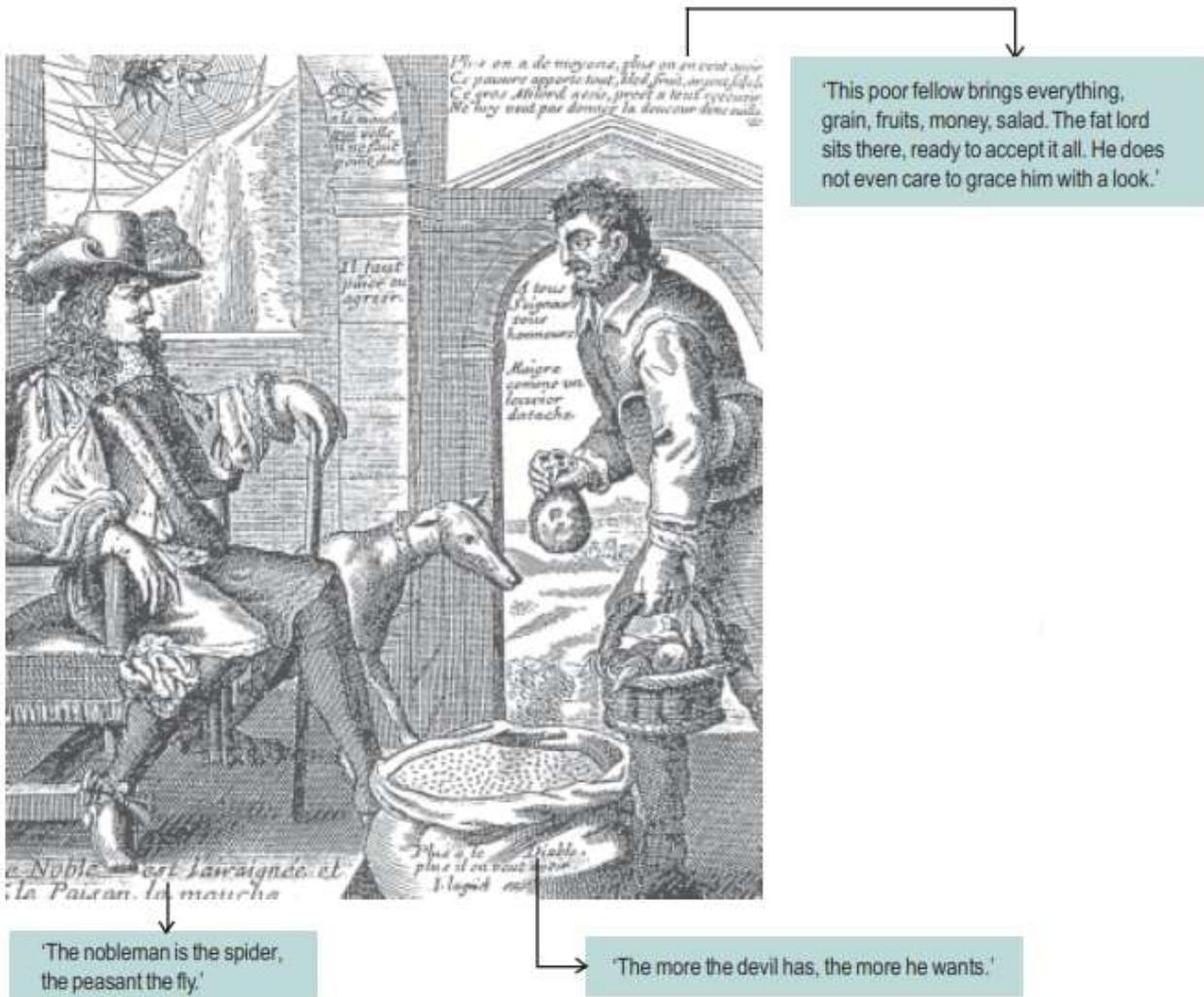
Ideas of these philosophers were discussed and spread among people through books and newspapers. There were frequently read aloud in group for the benefit of those who could not read and write.

**EXAMPLES**

- Example: 1 :** (i) Who is the spider and who is the fly in the above picture  
 (ii) Explain why the artist has portrayed the nobleman as the spider and the peasant as the fly.



**A Society of Estates.**



The Spider and the Fly.

### 3. THE OUTBREAK OF REVOLUTION

#### I. Composition of Estates General :

On 5 May 1789, called together assembly of the Estates General to pass proposals for new taxes. The first and the second Estates sent 300 representatives each who were seated in a rows facing each other on two sides : while 600 members of the third estate had to the back. The third estate was represented by its more prosperous and educated members. Peasants artisans and women were denied entry to the assembly.

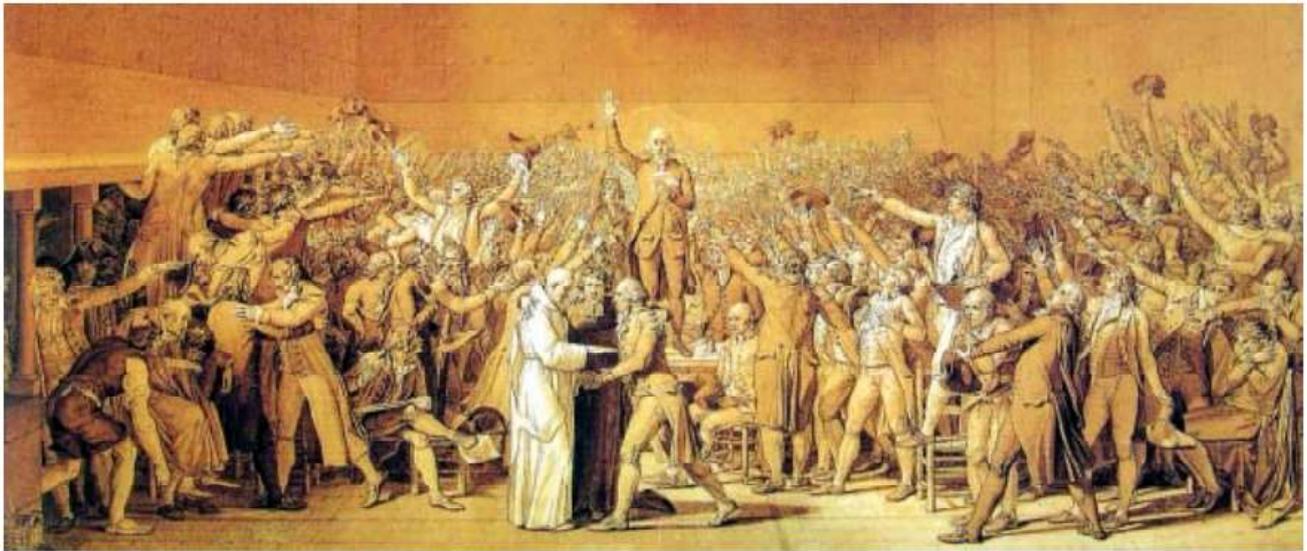
#### II. Demands of Third Estate :

Voting in estates general in the past had been conducted according to the principle of that each estate had one vote. This time too Louis XVI was determined to continue the same practice. But members of the third estate demanded that voting now be conducted by assembly as a whole where each member would have one vote. When the king rejected this proposal members of the third estate walked out of the assembly in protest.

#### III. Formation of National Assembly :

On 20<sup>th</sup> June the representatives of Third Estate assembled in a hall of an indoor tennis court in the grounds of Versailles. They declared themselves a National Assembly and swore not to disperse till they had drafted a constitution of France that would bind the powers of the monarch. They were led by Mirabeau and Abbe's seiyes. MIRABEAU was born in a noble family but was convinced of the need to do away with a society of feudal privilege. He brought out a journal and delivered powerful speeches to the crowds assembled at Versailles.

Abbe's seiyes originally a priest wrote an influential pamphlet called. 'What is the Third Estate ?



**The Tennis Court Oath.**

**IV. Spread of the great fear or revolt :**

While the National Assembly was busy at Versailles drafting a constitution, the rest of France seethed with turmoil. A severe winter meant a bad harvest, the prices of bread rose, often bakers exploited the situation and hoarded supplies. After spending hours in long queues at the bakery, crowds of angry women stormed into the stores. At the same time the king ordered the troops to move into Paris. On 14<sup>th</sup> July the agitated crowd stormed and destroyed Bastille.

The countryside rumours spread from village to village that lords of the manor had hired bands of brigands who were on their way to destroy the crops. Caught in frenzy of fear peasants in all districts seized hoes and pitchfork and attacked chateaux. They looted the hoarded grains and burnt down documents containing records of manorial dues. A large number of nobles fled from their homes.

Louis XVI finally accorded recognition to the National Assembly and accepted the principle that his powers would now on be checked by a constitution.

- (A) On the Night of the 4 August 1789 the assembly passed a decree abolishing the feudal system of obligation and taxes.
- (B) Members of the clergy too were forced to give up their privileges.
- (C) Tithes were abolished and land owned by the church were confiscated. As a result the government acquired assets worth at least 2 billion livres.

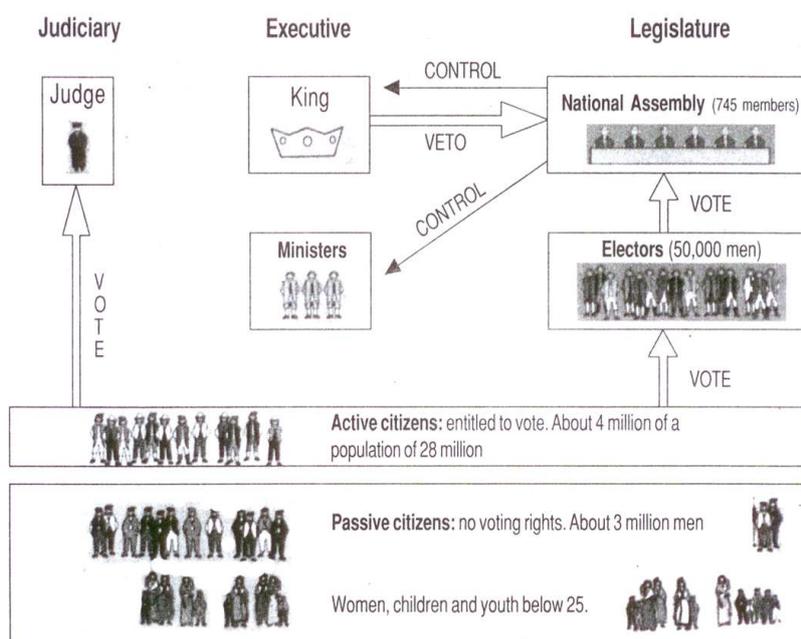


**The spread of the Great Fear.**

The map shows how bands of peasants spread from one point to another.

#### 4. FRANCE BECOMES A CONSTITUTIONAL MONARCHY

- The National Assembly drafted the constitution of France in 1791. It limited the power of the monarch. Now power was separated and assigned to different institutions the **legislature**, the **executive** and the **judiciary**.
- The constitution of 1791 vested the power to make laws in the National Assembly which was indirectly elected. Citizens voted for a group of electors who in turn chose the assembly. Only men above 25 years of age who paid taxes equal to at least 3 days of a labourer's wage were given the status of active citizen. Remaining all men and women were classed as passive citizen. To qualify as an elector a man had to belong to the highest bracket of tax payer.
- The constitution began with a Declaration of the Rights of Man and citizen. Rights such as right to life, freedom of speech, freedom of opinion, equality before law, were established as Natural and inalienable rights, that is they belonged to each human being by birth and could be taken away. It was the duty of the state to protect citizens natural rights. **Fig. The Political system under the Constitution of 1791.**



**The Political system under the Constitution of 1791.**

#### 5. FRANCE ABOLISHES MONARCHY AND BECOMES A REPUBLIC

Although Louis XVI had signed the constitution he entered into secret negotiations with the king of Prussia. Rulers of other neighbouring countries too were worried about the developments in France and made plans to send troops to put down the events that had been taking place since the summer of 1789. Before that could happen the National Assembly voted in April 1792 to declare war against Prussia and Austria. Thousands of Volunteers thronged from provinces to join the army.

Among the patriotic song they sang was the Marseillaise, composed by poet-Roget de L'Isle. The Marseillaise is now the National Anthem of France. Large sections of the population were convinced that the revolution had to be carried further as the constitution of 1791. gave political rights to the richer section of the society. Political clubs became important rallying point for the people who wished to discuss government policies and plan their own form of action.

#### 6. JACOBINS

The most successful of these clubs was that of the Jacobins, who got its Name from the former convent of St. Jacob in Paris. The Members of the Jacobins club belonged mainly to the less prosperous section of the society. They included small shopkeepers, artisans, servants and daily wage workers. Their leader was **Maximilian Robespierre**.

A large group among Jacobins decided to start wearing long striped trousers similar to those worn by dock workers. This was to set themselves a part from the fashionable section of society, especially nobles, who wore knee breeches.



**A sans-culottes couple.**

It was a way of proclaiming the end of the power wielded by wearers of knee breeches. These Jacobins came to be known as **sans culottes**, literally meaning 'those without knee breeches'. Sans culottes men wore in addition, the red cap that symbolised liberty.

On the morning of Aug. 10 the Jacobins stormed the place of Tuileries, massacred the king's guards and held the king himself as hostage for several hours. Later the assembly voted to imprison royal family. Elections were held and from now on all men above 21 years and above, regardless of wealth got right to vote.

The newly elected assembly was called the convention. On 21 sept. 1792 it abolished the monarchy and declared France a republic. Republic is a form of government where the people elect the government including the head of the government. There is no hereditary monarch. Louis XVI and queen Marie Antoinette were charged of Treason and executed publicly at Place de la Concorde on 21 Jan. 1793.



### Let's know

- **Feudal System** : This system existed in the Middle Ages (in Europe). It is people received land and protection from a lord from which they worked and fought.
- **Republic** : A country government elected by representatives of the people and headed by a president, not a king or queen.
- **Sovereign Nation** : A nation which is independent and governs itself without outside interference in its affairs.
- **Suffrage** : The right to vote in national election.
- **Taille** : Tax to be paid directly to the state.
- **Tithes** : A tax levied by the church, comprising one tenth of the agricultural produce.
- **Treason** : Betrayal of one's country or government.

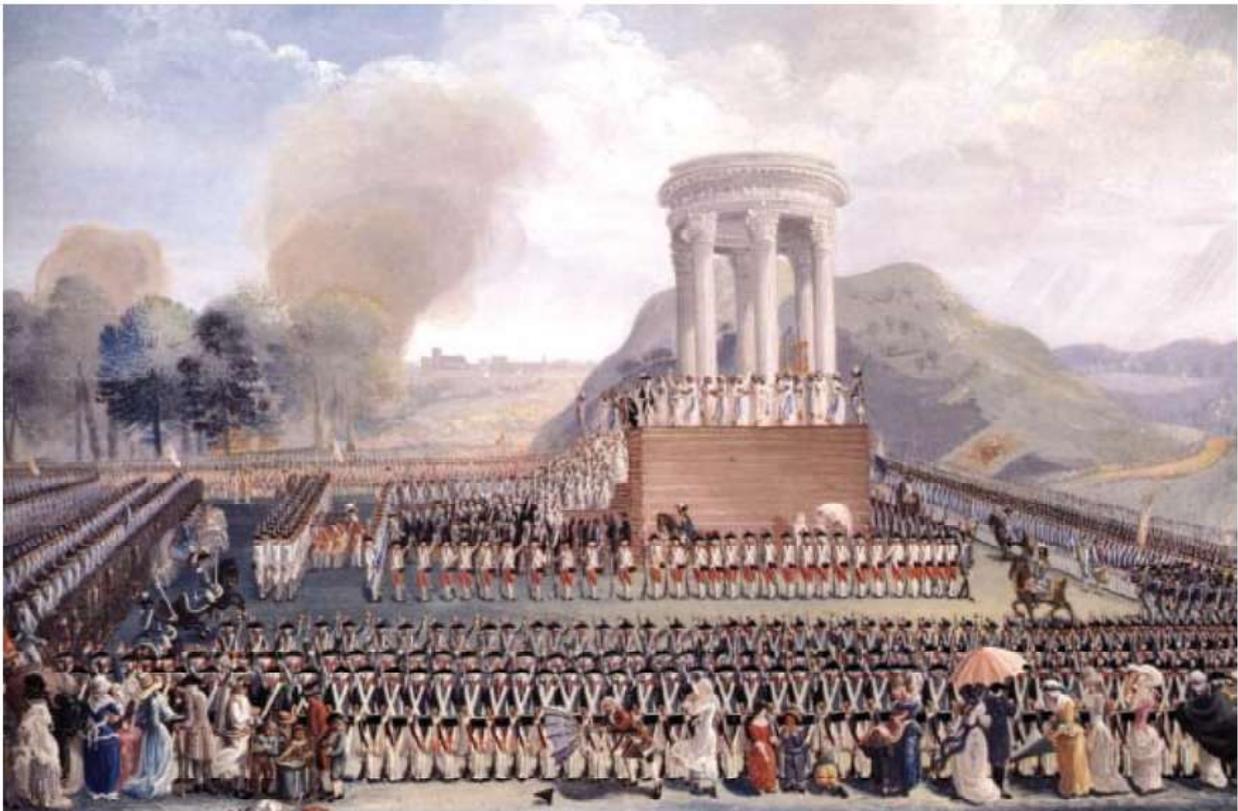
## 7. THE REIGN OF TERROR

The period from 1793 to 1794 is referred to as the **Reign of Terror**. Robespierre followed a policy of severe control and punishment. All those whom he saw as being an enemy of the republic were arrested, imprisoned and then tried by a revolutionary tribunal. If the court found them guilty they were guillotined. The guillotine is a device consisting of two poles and a blade with which a person is beheaded. It is named after Dr. Guillotine who invented it.

### I. Measures taken by Robespierre :

- (A) Robespierre's government issued laws placing maximum ceiling on wages and prices.
- (B) Meat and bread were rationed
- (C) Peasants were forced to transport their grains to the cities and sell it at fixed prices by the government
- (D) The use of more expensive white flour was forbidden. All citizens were required to eat the pain d'egalite (equality bread) a loaf made of whole wheat
- (E) instead of the traditional monsieur (sir) and madame (Madam) all French men and women were citizen and citoyenne (citizen)
- (F) Churches were shut down and their buildings converted into barracks or offices.

In July 1794 Robespierre was arrested, convicted by a court and guillotined.



The revolutionary government sought to mobilise the loyalty of its subjects through various means? one of them was the staging of festivals like this one. Symbols from civilisations of ancient Greece and Rome were used to convey the aura of a hallowed history. The pavilion on the raised platform in the middle, carried by classical columns, was made of perishable material that could be dismantled. Describe the groups of people, their clothes, their roles and actions. What impression of a revolutionary festival does this image convey?

## II. A Directory rules France :

After the fall of Jacobins a new constitution was introduced which denied the vote to non-propertied section of the society.

- (A) It provided for two elected Legislative councils. These then appointed a directory an executive made of five members.
- (B) The directors often clashed with one another and with legislative councils, who then sought to dismiss them. The political instability of the directory paved the way for the rise of a military dictator; Napoleon Bonaparte.



**Parisian women on their way to Versailles. This print is one of the many pictorial representations of the events of 5 October 1789, when women marched to Versailles and brought the king back with them to Paris.**

## 8. DID WOMEN HAVE A REVOLUTION

### ➤ Role of women in revolutionary movement :

- From the very beginning women were active participants in the events which brought about so many changes in French society.
- The Revolutionary wars brought losses and economic difficulties. While the men were away fighting at the front, women were left to cope with the task of earning a living and looking after their families.
- Women also started their own political clubs and newspapers in order to discuss and voice their interests. They hoped that their involvement would pressurise the revolutionary government to introduce measures to improve their lives.
- The Society of Revolutionary and Republican women was the most famous political club which demanded equal political rights for women.
- Women were disappointed by the constitution of 1791 as it reduced them to passive citizens. They demanded the right to vote, to be elected to the assembly and to hold political office.

### I. Condition of Women in French Society :

- Most of the women in the third estate had to work. They worked as seamstresses or laundresses, sold flowers, fruits and vegetables at the market or were employed as domestic servants in the houses of prosperous people.
- Most women did not have access to education or job training only daughters of Nobles or wealthier members of the third estate could study at a convent.
- Working women had also to care for their families. Their wages were low than those of men.

### II. Laws Which Improved The Lives of Women :

- With the creation of state schools, schooling was made compulsory for all girls.
- Their fathers could no longer force them into marriage against their will.
- Marriage was made into a contract entered into freely and registered under civil law.
- Divorce was made legal and could be applied for by both women and men.
- Women could now train for jobs could become artists and run on small business.

Womens movements for voting rights and equal wages continued through the next 200 years in many countries of the world. It was finally in 1946 that women in France won the right to vote.

## 9. SOME OF THE BASIC RIGHTS SET FORTH IN OLYMPE DE GOUGE' DECLARATION

- Women is born free and remains equal to man in rights.
- The goal of all political associations is the preservation of the natural rights of woman and man : These rights are liberty, property, security, and above all resistance to oppression.
- the source of all sovereignty resides in the nation, which is nothing but the union of woman and man.
- The law should be the expression of the general will; all female and male citizens should have a say either personally or by their representatives in its formulation; it should be the same for all. All female and public employment according to their abilities and without any other distinction than that of their talents.
- No woman is an exception; she is accused, arrested, and detained in cases determined by law. Women, like men, obey this rigorous law.



## 10. ABOLITION OF SLAVERY

### ➤ Importance of slavery of France :

- The colonies in the **Caribbean Martinique, Guadeloupe and San Dominigo** were important suppliers of commodities such as tobacco, indigo, sugar and coffee. But the Europeans were unwilling to go and work in unfamiliar land. This meant a shortage of labour on plantations . So this was met by triangular slave trade between Europe, Africa and the Americas.
- French merchants sailed from the **port of Bordeaux or Nantes to the Caribbean African coast**, where they bought slaves from local chieftains. From here the slave were sent to the Caribbean and sold to plantation owners.

The exploitation of slave labour made it possible to meet the growing demand in European market for sugar, coffee and indigo.

- The national assembly held long debates about abolishing slavery But it did not pass any laws fearing opposition from businessmen whose income depended on slave trade. It was finally the convention which in 1794 legislated to free all slaves in the French overseas possessions. But Napoleon re-introduced slavery after ten years slavery was finally abolished in French colonies in 1848.

## 11. THE REVOLUTION AND EVERY DAY LIFE

One important law that came into effect soon after the storming of the Bastille in the summers of 1789 was the abolition of censorship. In the old regions all written material and cultural activities could be only published or performed only after they had been approved by the censors of the king.

### I. Impact of Abolition of Censorship :

- (A) Now the Declaration of Rights of man and citizen proclaimed freedom of speech and expression to be a natural rights. Newspaper, pamphlet, books and printed pictures flooded the towns of France from where they travelled rapidly to the country side. They all described and discussed the events and changes taken place in France.
- (B) Freedom of press also meant that opposing views of events could be expressed. Each side sought to convince the other of its position through the medium of print. Plays, songs and festive processions attracted large number of people.

## 12. RISE AND FALL OF NAPOLEON

The instability and clashes between the directory and legislative councils gave rise to Napoleon. In 1804 Napoleon Bonaparte crowned himself the Emperor of France

- He set out to conquer neighbouring European Countries dispossessing dynasties and creating Kingdoms where he placed his family members.
- He introduced many reforms such as the protection of private property and a uniform system of weights and measures provided by decimal system.
- Initially many saw Napoleon as a liberator but soon his armies came to be viewed everywhere as an invading force.
- He was finally defeated at Waterloo in 1815.

### ➤ Achievement of Napoleon :

- Many of the measures that Napoleon had taken carried the revolutionary ideas of liberty and modern laws to other parts of Europe had an impact on people long after Napoleon had left.
- The ideas of liberty and democratic rights were the most important legacy of the French Revolution. These spread from France to the rest of the Europe
- Colonised people reworked the ideas of freedom from bondage to their movements to create a sovereign nation state.
- Tipu Sultan and Raja Ram Mohan Roy responded to the ideas coming from revolutionary France.

## TIME LINE OF FRENCH REVOLUTION

### Year

<b>1774</b>	Louis XVI of the Bourbon family of king ascended the throne of France.
<b>1789</b>	
January 24	Louis XVI summons the Estates General may 5 Louis XVI called together an assembly of the Estates General to pass proposals for few taxes.
June 20	They declared themselves a National Assembly. Famous Tennis Court Oath.
July 14	French Revolution started by storming of bastille.
August 4	National Assembly passed a decree abolishing the feudal system of obligation and taxes.
August 26	Declaration of the Rights of man.
<b>1791</b>	
June 20-21	Louis & Marie Antoinette flee but captured.
August 27	Austria & Prussia express support for Louis.
September 3	Constitution Drafting Completed.
<b>1792</b>	
April	France declares war on Austria & Prussia.
21 September	Convention abolished the monarchy and Declared France as Republic.
<b>1793</b>	
January 21	Louis XVI was executed Publicly at The <b>Place de la Concorde</b> .
October 16	Marie Antoinette executed Publicly at the <b>Place de la Concorde</b> .
<b>1793-1794</b>	<b>The Reign of Terror</b>
July 28 1794	Rebespierre guillotined
10 February 1794	Free all Slaves in French Overseas possessions.
<b>1804</b>	
December 2	Napoleon proclaimed himself emperor of France.
1815	The Battle of Waterloo and final defeat of Napoleon Bonapare.
1848	Slavery was finally abolished in French colonies.
1946	Women in France got the Voting Right.



## TRY YOURSELF

- Q.1** Which two countries witnessed revolution in the later part of the eighteenth century ?  
 (A) France and America (B) Russia & Germany  
 (C) Poland and Spain (D) China & India
- Q.2** In the French society the first estate consisted of  
 (A) Nobility (B) Farmers (C) Clergy (D) Monarch
- Q.3** Which classes were privileged in French society ?  
 (A) Nobles & Clergy (B) Merchant & Artists  
 (C) Peasants & Lawyers (D) Artisans & Labourer
- Q.4** Who was the king of France at the time of the Revolution ?  
 (A) Napoleon (B) Louis XVI (C) Louis XIV (D) Nicholus
- Q.5** Which day is celebrated as the National Day of France?  
 (A) 14th July (B) 19th July (C) 25th July (D) 30th July
- Q.6** Revolution means  
 (A) a drastic or radical change (B) slow transformation of power  
 (C) change in one particular field (D) overthrow of a government
- Q.7** Because of growing emphasis on reason the period of the 18<sup>th</sup> Century in European history is called as  
 (A) Age of Machine (B) Age of Discoveries  
 (C) Age of Enlightenment (D) Age of Adventure
- Q.8** The man who asserted the colonists right to rebellion was ?  
 (A) Locke (B) Paine (C) Thomas Jefferson (D) Milton
- Q.9** The National Assembly was formed on 20 June 1789 by  
 (A) Aristocrats (B) Clergy (C) Third Estate (D) Propertied class
- Q.10** The French Revolution gave its modern meaning to the term  
 (A) Republic (B) Socialism (C) Democracy (D) Nation

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### ANSWER KEY

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- |            |   |            |   |            |   |            |   |             |   |
|------------|---|------------|---|------------|---|------------|---|-------------|---|
| <b>Q.1</b> | A | <b>Q.2</b> | C | <b>Q.3</b> | A | <b>Q.4</b> | B | <b>Q.5</b>  | A |
| <b>Q.6</b> | A | <b>Q.7</b> | C | <b>Q.8</b> | C | <b>Q.9</b> | C | <b>Q.10</b> | D |
-

## EXERCISE-I

## NCERT Solutions



**Q.1** Describe the circumstances leading to the outbreak of revolutionary protest in France ?

**Sol.** The following circumstances led to the outbreak of revolutionary protest in France.

- (i) **Social Inequality** : France was suffering from social inequality. The clergy and the nobility led a luxurious life and enjoyed many privileges by birth. While the peasants and the labourers lived very hard life. They had to pay heavy taxes.
- (ii) **Extravagant King** : Louis XVI spent lot of his money on luxurious living and wasteful festivities. The high post were generally auctioned which caused inefficiency in the administration. The people were irritated with such system.
- (iii) **Worse Economic Condition** : Long years of war had drained the financial resources of France. Added to this was the cost of maintaining extravagant court. To meet these expenses, the state was forced to increase taxes that also irked the people of France.
- (iv) **Immediate Cause** : On 5 May 1789, Louis XVI called together an assembly of Estates General to pass proposals for new taxes. This proved to be the immediate cause of the French Revolution.

**Q.2** Which group of French society benefited from the revolution ? Which groups were forced to relinquish Power ? which sections of society would have been disappointed with outcome of revolution ?

**Sol.** The benefited groups of the French Society :

- (i) All the groups of the Third Estate were benefited from the revolution. These included peasants, artisans., landless, labour, servants, merchants, court, officials, lawyers etc.
- (ii) The clergy and the nobility who enjoyed many privileges were forced to relinquish power
- (iii) Feudal lords, nobles, clergy, and women would have been disappointed with the outcome of the revolution.

**Q.3** Describe the legacy of French Revolution for the people of world during the 19<sup>th</sup> and 20<sup>th</sup> century?

**Sol.** The legacy of the French Revolution for the People of the world: Consequences of the French Revolution (1789) did not bring several vital results for France only but for the other parts of the world as well.

- (i) It inspired revolutionary movements in almost every country of Europe and in South and Central America.
- (ii) The French Revolution gave the term 'nation' its modern meaning. A nation is not the territory that the people belonging to it inhabit but the people themselves.
- (iii) It ended the arbitrary rule and developed the idea of people's republic.
- (iv) This revolution inspired people with the ideal of freedom which became the basic of sovereignty.
- (v) It gave the concept of social equality, i.e. equal rights for all the citizens of the country
- (vi) It also spreads the idea of world fraternity.

**Q.4** Draw up a list of democratic rights we enjoy today whose origin could be traced to the French revolution?

**Sol.** We can trace the origin of the following democratic rights we enjoy today to the French revolution.

- (i) **Right to equality** : It is one of the most important democratic rights. Democracy can flourish and function in a society of equals. Our constitution guarantees that all citizens will be equally protected by the law of the land. This also implies that State cannot discriminate against a citizen on the bases of race, caste, sex, religion or place of birth in the matter of employment. Untouchability has been made a punishment offence.
- (ii) **Right of Freedom** : This right is actually a cluster of six rights-  
\* freedom of speech and expression, to assemble peacefully and without arms,

to form association or union, to move freely through the territory of India, to reside and settle in any part of India and to practice any profession or to carry on any occupation, trade or business.

(iii) **Right against Exploitation :** We are also indebted to the French Revolution for this right. Our Constitution bars beggar (or forced labour), employment of children under 14 years in factories, mines and other hazardous jobs.

(iv) **Educational Rights :** After the French Revolution schools for girls were set up in France. The education for girls was made compulsory. Similarly in India, our constitution also directs the State to impart education to all citizens up to the age of 14

**Q.5** Would you agree with the view that the message of universal rights was beset with contradictions? Explain.

**Sol.** Though after the French Revolution the Republic of France was established and equality became one of its guiding principles, the message of Union Rights was beset with contradictions.

- (i) The Suffrage was not granted to the women
- (ii) The citizens having no property were deprived of this right.
- (iii) Only the people who belonged to the highest bracket of tax payers were granted the right to vote
- (iv) The France under Robespierre passed through a period (from 1793 to 1794) if the Reign of Terror. Robespierre pursued his policies so relentlessly that even his supporters began to demand moderation.
- (v) With the fall of the Jacobin government the power in France passed into the hands of the wealthier middle classes. A new constitution was introduced which denied the vote to non - propertied sections of society. Then the Directory was appointed. However, it clashed with the legislative council. The political instability of the Directory paved the rise of a military dictator, Napoleon Bonaparte.

**Q.6** How would you explain the rise of Napoleon?

- Sol.**
- (i) **Political Instability:** The rise of Napoleon Bonaparte was also an indirect result of the French Revolution. As often happens in revolutions, there was political and economic instability in France and there was a struggle for power
  - (ii) **New Constitution:** After the fall of the Jacobin government, a new constitution was introduced. It provided for two elected legislative councils and a Director (an executive made up of five members). However the Directors often clashed with the legislative councils, who then sought to dismiss them. This clash was responsible for political instability. Napoleon took advantage of the situation and became a dictator with the help of the army.
  - (iii) **Napoleon as the Emperor of France:** In 1804, Napoleon declared himself the Emperor of France. He was a brilliant General and used his armies to conquer and dominate all short - lived. Britain, Russia, Austria and Russia jointly defeated him at Leipzig, and again at Waterloo in 1815. He Was captured and sent as a prisoner to the Island of St Helena where he died in 1821.

**Q.7** Describe the Reign of Terror.

- Sol.**
- (i) The period form 1793 to 1794 is referred to as "Reign of Terror".
  - (ii) Jacobins leader Robespierre followed a policy of severe control and punishment.
  - (iii) All those whom he saw as being 'enemies' of republic, i.e. ex - nobles, clergy members of other political parties were arrested, imprisoned and then tried by a revolutionary tribunal.
  - (iv) If they were found ' guilty they were guillotined, i.e. beheaded.
  - (v) He issued laws placing maximum ceiling on wages and prices.
  - (vi) Meat and bread were rationed.
  - (vii) Churches were shut down and buildings converted into barracks or offices.
  - (viii) Peasants were forced to sell grains at prices fixed by government this was referred to 'Reign of Terror'.

## EXERCISE - II

## Knowledge Vault



## MCQ BASED QUESTION :

- Q.1** Into how many estates was the French Society divided  
(A) One (B) Two  
(C) Three (D) Four
- Q.2** Who proposed the division of power with the government based on social contract between people and representatives?  
(A) Montesquieu (B) Rousseau  
(C) Voltaire (D) Locke
- Q.3** When was the National Assembly formed  
(A) Aug 1790 (B) June 1789  
(C) October 1790 (D) Jan 1789
- Q.4** What symbol was used to personify law in the Declaration of Rights for Men and Citizens?  
(A) The bundle of rods  
(B) Sceptre  
(C) The broken chain  
(D) The winged woman
- Q.5** When did Napoleon become the emperor of France?  
(A) 1809 (B) 1805  
(C) 1804 (D) 1802
- Q.6** The Bastille was hated by all in France because  
(A) it stood for the despotic power of the kings  
(B) it was a fortress prison  
(C) its commander tortured the inmates  
(D) it housed some dreaded criminals
- Q.7** The tax called 'taille' was collected from the French peasants by  
(A) The Emperor  
(B) The Church  
(C) The Nobles  
(D) The Army Commander
- Q.8** Why was the subsistence crisis caused by France?  
(A) The wages of the people were low  
(B) there was widespread unemployment  
(C) increase in population led to rapid increase in the demand of food grains  
(D) the government imposed various taxes.
- Q.9** Who among the following proposed the Social Contract Theory?  
(A) Locke (B) Rousseau  
(C) Montesquieu (D) Thomas Paine
- Q.10** Which of the following theories was proposed by Montesquieu?  
(A) Social Contract Theory  
(B) Theory of Division of Powers  
(C) Theory of Popular Sovereignty  
(D) Theory of Democracy
- Q.11** Marseillaise is the \_\_\_\_\_ of France.  
(A) National Flag  
(B) National assembly  
(C) National Anthem  
(D) National University
- Q.12** Who among the following was crowned as the French emperor in 1804?  
(A) Louis XVII  
(B) Louis XVIII  
(C) Napoleon Bonaparte  
(D) Robespierre
- Q.13** By whom was the Reign of Terror introduced in France between 1793-94?  
(A) Louis XIV (B) Louis XVI  
(C) Robespierre (D) Napoleon
- Q.14** At which of the following battles was Napoleon finally defeated?  
(A) Paris (B) Waterloo  
(C) Elba (D) Versailles
- Q.15** On what charge was the Emperor Louis XVI sentenced to death?  
(A) On the charge of corruption  
(B) on the charge of misgovernment  
(C) On the charge of treason  
(D) on the charge of exploitation
- Q.16** The France Guillotine referred to a system of \_\_\_\_\_  
(A) Beheading a person  
(B) Awarding a person  
(C) Taxing a person  
(D) Threatening a person

**Q.17** The greatest achievement of the National Assembly convened in France in 1789 was  
 (A) issuing of Declaration of Rights  
 (B) passing of laws checking the power of the monarch  
 (C) establishment of a new judiciary  
 (D) establishment of a new legislature

**Q.18** The Jacobians of France were known as sans-culottes because  
 (A) they wore red caps  
 (B) they stopped wearing knee-breaches  
 (C) they wore striped pants  
 (D) they wore red waist bands

**Q.19** Match the following historical years with the events mentioned against them

**Year**

- (a) 1774
- (b) 1789
- (c) 1804
- (d) 1815

**Event**

- (i) Battle of Waterloo and defeat of Napoleon
  - (ii) Napoleon became the emperor of France
  - (iii) Louis XVI became the king of France
  - (iv) Bastille was stormed
- (A) A-4, B-3, C-1, D-2  
 (B) A-3, B-2, C-1, D-4  
 (C) A-3, B-4, C-2, D-1  
 (D) A-4, B-3, C-1, D-2

**Q.20** French women got the right to vote in \_\_\_\_\_  
 (A) 1945 (B) 1936  
 (C) 1956 (D) 1926

**IMAGE BASED QUESTIONS :**

**Q.21**



Identify the event which is given above ?  
 (A) Estate general meeting  
 (B) National Assembly  
 (C) Tennis court oath  
 (D) Louis XVI Trial  
**Ans : C**

**Q.22**



Identify the event which was related to French revolution ?  
 (A) Killing of French King  
 (B) Protest for National Assembly  
 (C) Storming of the Bastille  
 (D) Both A & C  
**Ans : C**

**Q.23**



Identify the event which is related with French revolution ?  
 (A) Women march for bread  
 (B) Women march to Versailles  
 (C) Support in French monarch  
 (D) Both A & C  
**Ans : B**

**Q.24**



This dress was belong to which of the political club ?  
 (A) Jacobin club (B) Marrie club  
 (C) Marseille club (D) None of the above  
**Ans : A**

**EXERCISE -III****Subjective Stuff****VERY SHORT TYPE QUESTIONS :**

- Q.1** Who was the ruler of France during the French Revolution?
- Q.2** What was feudal system?
- Q.3** When was the draft of the National Assembly's constitution completed and what was its main objective?
- Q.4** Who all got the right to vote for the National Assembly?
- Q.5** Name the three 'Estates' into which the French society was divided before the Revolution?

**SHORT TYPE QUESTIONS :**

- Q.6** What were the reforms introduced by Napoleon Bonaparte in France?
- Q.7** "One of the most revolutionary social reforms of the Jacobins regime was the abolition of slavery in the French colonies. Justify the statement.
- Q.8** Explain triangular slave trade carried on during 18th and 19th century.
- Q.9** Why were women disappointed by the Constitution of 1791 in France? What laws did the revolutionary government introduce to improve the lives of women?
- Q.10** What changes were brought in France after the fall of Robespierre's government? How did it lead to the rise of Napoleon Bonaparte?

**LONG TYPE QUESTIONS :**

- Q.11** Who was Olympe de Gouges. What role did she play in the French Revolution?
- Q.12** Which laws were made to improve the status of women in the French society?
- Q.13** Explain the impact of French Revolution on French in everyday life of people.
- Q.14** Who was Napoleon Bonaparte? Why was he called a 'liberator'?
- Q.15** 'While the National Assembly was busy at Versailles drafting a constitution, the rest of France seethed with turmoil.' Elucidate.

## EXERCISE-IV

## Competitive Edge



- Q.1** When did the French Revolution take place?  
[Chandigarh\_NTSE\_Stage-1\_2013]  
(A) 1789 (B) 1786  
(C) 1795 (D) 1781
- Q.2** The club which was most successful constituted by the men and women of France, after the Constitution of 1791 was  
[Rajasthan\_NTSE\_Stage-1\_2014]  
(A) Liberty club (B) Zollverein  
(C) Jacobin club (D) Equality club
- Q.3** The great Indians who were influenced by the thoughts of French Revolution were  
[Rajasthan\_NTSE\_Stage-1\_2014]  
(A) Haider Ali & Tipu Sultan  
(B) Tipu Sultan & Raja Rammohan Roy  
(C) Lala Lajpat Rai & Tilak  
(D) Bahadur Shah Jafar & Laxmi Bai
- Q.4** The institution like Indian parliament that was established after the French Revolution in France was  
[Rajasthan\_NTSE\_Stage-1\_2014]  
(A) Duma  
(B) Zollverein  
(C) House of Lords  
(D) national Assembly
- Q.5** “Without Rousseau, the French Revolution would not have taken place”, proclaimed by:  
[Maharashtra\_NTSE\_Stage-1\_2014]  
(A) Napoleon Bonaparte  
(B) Mirabo  
(C) Robespierre  
(D) Callone
- Q.6** Which tax on salt was to be paid by the French people?  
[Maharashtra\_NTSE\_Stage-1\_2014]  
(A) Crown tax (B) Tally  
(C) Wainstam (D) Gabble
- Q.7** Suffrage Movement was started for:  
[Delhi\_NTSE\_Stage-1\_2014]  
(A) The Right to Vote for Women  
(B) Right to Education  
(C) Food for Poors  
(D) Peasant’s Right
- Q.8** Jacobin Club was the most powerful political organization in:  
[Delhi\_NTSE\_Stage-1\_2014]  
(A) Germany (B) Russia  
(C) France (D) Britain
- Q.9** The writer of ‘The Social Contract’ is  
[Rajasthan\_NTSE\_Stage-1\_2015]  
(A) Rousseau (B) Montesquieu  
(C) Tilak (D) Mirabeau
- Q.10** Napoleon Bonaparte was defeated at Waterloo in  
[Rajasthan\_NTSE\_Stage-1\_2015]  
(A) 1915 (B) 1825  
(C) 1815 (D) 1819
- Q.11** Match the table I with table II and select the correct response from the options given thereafter:[Haryana\_NTSE\_Stage-1\_2015]
- Table-I**  
(a) Louis XVI became the king of France  
(b) Convocation of Estate General  
(c) France became a republic, the king was beheaded  
(d) Napoleon became emperor of France
- Table-II**  
(i) 1792-93  
(ii) 1804  
(iii) 1774  
(iv) 1789  
(A) a-i, b-ii, c-iii, d-iv  
(B) a-ii, b-iv, c-i, d-iii  
(C) a-iii, b-iv, c-i, d-ii  
(D) a-iv, b-iii, c-ii, d-i
- Q.12** Match the table I with table II and select the correct response from the options given thereafter :  
[Haryana\_NTSE\_Stage-1\_2015]
- Table-I**  
(a) Montesquieu  
(b) Rousseau  
(c) Karl Marx  
(d) Adolf Hitler
- Table-II**  
(i) social contract  
(ii) Mein Kampf  
(iii) Das Capital  
(iv) The spirit of Laws

- (A) a-iv, b-i, c-iii, d-ii  
 (B) a-ii, b-i, c-iv, d-iii  
 (C) a-i, b-iv, c-iii, d-ii  
 (D) a-ii, b-iii, c-i, d-iv

**Q.13** Who introduced the reign of terror?  
**[Andhra Pradesh\_NTSE\_Stage-1\_2015]**

- (A) Mirabeau  
 (B) Napoleon Bonaparte  
 (C) John Locke  
 (D) Maximillien Robespierre

**Q.14** What was Bastille?  
**[Chattisgarh\_NTSE\_Stage-1\_2015]**

- (A) Fortres of france  
 (B) Biggest gym of france  
 (C) Biggest theatre of france  
 (D) Biggest garden of france

**Q.15** Tithe is**[Rajasthan\_NTSE\_Stage-1\_2016]**

- (A) religious tax (B) implied tax  
 (C) taille tax (D) feudal tax

**Q.16** Who wrote 'The Spirit of Laws'?  
**[West Bengal\_NTSE\_Stage-1\_2016]**

- (A) Adam Smith (B) Rousseau  
 (C) Montesquieu (D) Voltaire

**Q.17** Which among the following is not correctly matched in relation to the symbols of the French Revolution?

**[Rajasthan\_NTSE\_Stage-1\_2017]**

**(Attribute)**

- (a) Broken Chains  
 (b) Breast plate with eagle  
 (c) Sceptre  
 (d) The winged woman

**(Significance)**

- Being freed  
 - Willingness to make peace  
 - Symbol of royal power  
 - Personification of the law

**Q.18** Match List-I with List-II correctly and choose the correct code from the following:

**[Rajasthan\_NTSE\_Stage-1\_2017]**

**List-I**

- (a) Napoleon defeated at Waterloo  
 (b) Formation of the Hindustan Socialist Republican Army  
 (c) Formation of Comintern  
 (d) Lahore Congress

**List-II**

- (i) 1929  
 (ii) 1919  
 (iii) 1928  
 (iv) 1815

- |     | a   | b   | c  | d   |
|-----|-----|-----|----|-----|
| (A) | iii | ii  | iv | i   |
| (B) | iv  | iii | ii | i   |
| (C) | i   | iv  | ii | iii |
| (D) | ii  | iv  | i  | iii |

**Q.19** Find out the correct explanation  
**[Rajasthan\_NTSE\_Stage-1\_2017]**

- (A) Livre: Unit of currency in France, discontinued in 1794  
 (B) Clergy: Building belonging to a community devoted to a religious life  
 (C) Tithe: Tax to be paid directly to the state  
 (D) Taille: A tax levied-by the church

**Q.20** The writer of 'Declaration of the Right of women and citizen is

**[Delhi\_NTSE\_Stage-1\_2018]**

- (A) Olympe de Gouges  
 (B) Camille Desmoulins  
 (C) Napoleon Bonapart  
 (D) Henry Mayhew

**Q.21** Tax levied by the church comprising the agriculture produce was

**[Delhi\_NTSE\_Stage-1\_2018]**

- (A) Livre (B) Taille  
 (C) Tithe (D) Suffrage

**Q.22** Match List-I with List-II correctly and choose the correct code from the following:

**[Rajasthan\_NTSE\_Stage-1\_2018]**

**List-I**

- (a) Meeting of the Estates General  
 (b) Bastille was destroyed on  
 (c) Abolishment of feudal system in France  
 (d) Swore of Tennis Court

**List-II**

- (i) 20th June, 1789  
 (ii) 4th August, 1789  
 (iii) 14th July, 1789  
 (iv) 5th May, 1789

- |     | a  | b   | c   | d   |
|-----|----|-----|-----|-----|
| (A) | i  | ii  | iii | iv  |
| (B) | iv | iii | ii  | i   |
| (C) | iv | i   | ii  | iii |
| (D) | i  | iv  | iii | ii  |

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**ANSWER KEY**

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**EXERCISE-II**

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**MULTIPLE CHOICE QUESTIONS:**

<b>Q.1</b>	C	<b>Q.2</b>	A	<b>Q.3</b>	B	<b>Q.4</b>	D	<b>Q.5</b>	C	<b>Q.6</b>	A	<b>Q.7</b>	B
<b>Q.8</b>	C	<b>Q.9</b>	B	<b>Q.10</b>	B	<b>Q.11</b>	C	<b>Q.12</b>	C	<b>Q.13</b>	C	<b>Q.14</b>	B
<b>Q.15</b>	C	<b>Q.16</b>	A	<b>Q.17</b>	A	<b>Q.18</b>	B	<b>Q.19</b>	C	<b>Q.20</b>	A		

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**EXERCISE-IV**

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<b>Q.1</b>	A	<b>Q.2</b>	C	<b>Q.3</b>	B	<b>Q.4</b>	D	<b>Q.5</b>	A	<b>Q.6</b>	D	<b>Q.7</b>	A
<b>Q.8</b>	C	<b>Q.9</b>	A	<b>Q.10</b>	C	<b>Q.11</b>	C	<b>Q.12</b>	A	<b>Q.13</b>	D	<b>Q.14</b>	A
<b>Q.15</b>	A	<b>Q.16</b>	C	<b>Q.17</b>	B	<b>Q.18</b>	B	<b>Q.19</b>	A	<b>Q.20</b>	A	<b>Q.21</b>	C
<b>Q.22</b>	B												

# 1

# Series Completion

## 1. INTRODUCTION

This chapter consists of questions in which series of numbers or alphabetical letters or combinations of both are given, which are generally called the terms of the series. These terms follow a certain pattern through out the series. The candidate is required to study the given series, identify the pattern followed in the series and either complete the given series with the most suitable alternative or find the wrong term in the series. There are mainly four types of series

### I. NUMBER SERIES

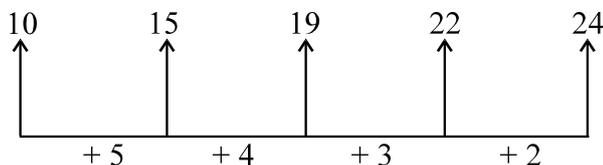
#### Case-I : Completing the given series by finding the missing term(s) :

In problems, a number series is given with one or two terms missing there. The missing term can be either at the end or in the middle or even at the beginning of the series. The missing term is normally indicated by a blank or a question mark. Students are required to identify the pattern followed by the terms in the series and find the missing number. Since the pattern followed by each series is different, it is not possible to give a general formula or technique to solve the problems. Students should observe the terms in the series carefully and find out the pattern followed.

For better understanding, we classify this into the following categories.

**Difference series :** The difference series can be further, classified as follows:

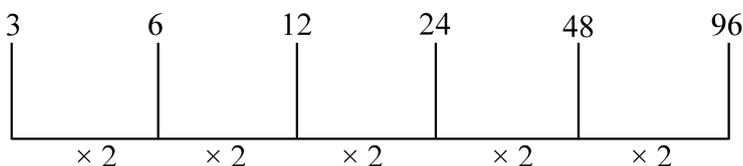
- (a) Number series with a constant difference ; Here the difference between two consecutive numbers is always constant. For example, the numbers of the series 1, 4, 7, 10, 13 ..... are such that the difference between two consecutive terms is constant. Here this difference is 3.
- (b) Number series with increasing /decreasing difference : Here the difference between consecutive terms is not constant. It either decreases or increases, e.g. the series 10, 15, 19, 22, 24 ....



Here the difference between 1st & 2nd terms, 2nd & 3rd terms, 3rd & 4th terms and so on are 5, 4, 3, 2 respectively.

Since the difference between 22 & 24 is 2, the next difference should be 1. So, the number that comes after 24 should be 25.

**Product series :** Consider the series 3, 6, 12, 24, 48, 96.

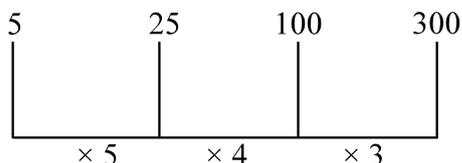


Here, each number in the series is multiplied by 2 to get the next term. So, the term that comes after 96 is 192.

Similarly we can have a series where numbers are obtained by dividing the previous term with a constant number, e.g. consider the series 81, 27, 9, 3..... Here, each term is obtained by dividing the previous term by 3 (or in other words by multiplying the previous term by 1/3).

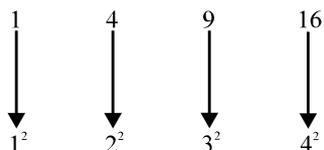
Therefore next term will be  $3 \times \frac{1}{3} = 1$

Consider the series 5, 25, 100, 300.....



Here, the first term is multiplied by 5 to get the second term. The second term is multiplied by 4 to get the third term. The third term is multiplied by 3 to get the fourth term. Therefore to get the fifth term, we have to multiply fourth term by 2, i.e.the fifth term is 600. Here each term is multiplied by decreasing factor (or it could also be an increasing factor) to get the next term.

- **Squares/Cubes series :** There can be a series where all the terms are related to the square of numbers or cube of numbers. There can be many variations in such series. For example, each term of the series may be the square of a natural number such as 1, 4, 9, 16 ....



Here the term that follows 16 will be square of 5, i.e. 25.

The terms of the series may be the square of odd numbers, e.g. 1, 9, 25, 49 ..... or even numbers e.g. 4, 16, 36, 64.....

- **Combination series :** This is a type of series where more than one arithmetic operation is performed.

Let us take an example. 1, 3, 7, 2, 6, 10, 3, 9, 13 .....

Here the first term is multiplied by 3 to get the second term. To get the third term we add 4 to the second term. To get the 4th term, we add 1 to the first term. After this the cycle will be repeated.

This terms      5th term =  $2 \times 3 = 6$   
                     6th term =  $6 + 4 = 10$   
                     7th term =  $2 + 1 = 3$     and so on.

Consider another series, 1, 2, 6, 21, 88 ....

Here, we can observe that 88 is close to the 4 times of 21 or it is  $21 \times 4 + 4$ . Similarly 21 is  $6 \times 3 + 3$ , 6 is  $2 \times 2 + 2$  and 2 is  $1 \times 1 + 1$ . So the next term to 88 should be  $88 \times 5 + 5 = 445$

- **Miscellaneous series :** Take the series 1, 3, 5, 7, 9, 11, 13 .... It is a series of odd numbers. So the next term will be 15. There can be many variations in miscellaneous series e.g. 2, 12, 30, 56, 90, 132 .....

This is series of product of two series, as  $1 \times 2, 3 \times 4, 5 \times 6, 7 \times 8, 9 \times 10, 11 \times 12$ . We can explain this series as product of odd number and even number series.

- **Triangular Pattern Series :** Sometimes, the differences between the consecutive terms of a series, again form a series. The differences between the consecutive terms of the new series so formed, again form a series. This pattern continues till we attain a uniform difference between the consecutive terms of the series.


**EXAMPLES**


**Example 1 :** Find the missing term in the series:

3, 20, 63, 144, 275, ?

(A) 354            (B) 468            (C) 548            (D) 554

**Solution :** As discussed above, we may label the given series I and the form series II to IV as shown below:

<b>Series I :</b>	3	20	63	144	275	?
<b>Series II :</b>	17	43	81	131	?	
<b>Series III :</b>	26	38	50	?		
<b>Series IV :</b>	12	12				

Clearly, in series III successive term is increased by 12.

So, missing term in series III =  $50 + 12 = 62$ ;

missing term in series II =  $131 + 62 = 193$ ;

missing term in series I =  $275 + 193 = 468$ .

Thus, the missing term is 468. Hence, the answer is **(B)**.

**Directions :** The terms given in each of the following questions follow a definite pattern and thus make a series. Find the missing number from the series out of the given alternatives.

**Example 2 :** 3, 6, 18, 72, (.....)

(A) 144            (B) 216            (C) 288            (D) 360

**Solution :** The pattern is  $\times 2, \times 3, \times 4, \dots$

Missing number =  $72 \times 5 = 360$ .

Hence, the answer is (D)

**Example 3 :** 121, 225, 361, (.....)

(A) 441            (B) 484            (C) 529            (D) 729

**Solution :** The numbers are  $11^2, 15^2, 19^2, \dots$

Missing number =  $(23)^2 = 529$ .

Hence, the answer is (C)

**Example 4 :** 1, 2, 3, 5, 8, (.....)

(A) 9            (B) 11            (C) 13            (D) 15

**Solution :** Each term in the series is the sum of the preceding two terms.

Therefore, the missing term =  $5 + 8 = 13$

Hence, the answer is (C)

**Example 5 :** 5, 9, 17, 29, 45, (.....)

(A) 60            (B) 65            (C) 68            (D) 70

**Solution :** The pattern is  $+4, +8, +12, +16, \dots$

Missing number =  $45 + 20 = 65$

Hence, the answer is (B)

**Example 6 :** 1, 9, 17, 33, 49, 73, (.....)

(A) 97            (B) 98            (C) 99            (D) 100

**Solution :** The pattern is  $+8, +8 + 16, +16 + 24, \dots$

Missing number =  $73 + 24 = 97$ .

Hence, the answer is (A)

**Example 7 :** 1, 6, 13, 22, 33 (.....)

(A) 44            (B) 45            (C) 46            (D) 47

**Solution :** The pattern is  $+5, +7, +9, +11, \dots$

Missing number =  $33 + 13 = 46$ .

Hence, the answer is (C)

**Example 8 :** 20, 19, 17, (.....), 10, 5  
 (A) 12 (B) 13 (C) 14 (D) 15

**Solution :** The pattern is -1, -2, .....  
 Missing number = 17 - 3 = 14.  
 Hence, the answer is (C)

**Example 9 :** 5, 16, 49, 104, (.....), 280  
 (A) 115 (B) 148 (C) 170 (D) 181

**Solution :** The pattern is + 11, + 33, + 55, ....., i.e. + (11 × 1), + (11 × 3), + (11 × 5), .....  
 Missing number = 104 + (11 × 7) = 181.  
 Hence, the answer is (D)

**Example 10 :** 5, 17, 37, 65, (.....), 145  
 (A) 95 (B) 97 (C) 99 (D) 101

**Solution :** The numbers are  $2^2 + 1$ ,  $4^2 + 1$ ,  $6^2 + 1$ ,  $8^2 + 1$ , .....,  $12^2 + 1$ , .....  
 Missing number =  $10^2 + 1 = 101$ .  
 Hence, the answer is (D)

**Example 11 :** 4, 10, (.....), 82, 244, 730  
 (A) 24 (B) 28 (C) 77 (D) 218

**Solution :** Each number in the series is the preceding number multiplied by 3 and then decreased by 2. Therefore, missing number =  $10 \times 3 - 2 = 30 - 2 = 28$   
 Hence, the answer is (B)

**Case-II : Finding the wrong terms in the given series. (Number oddman out) :**

The concept is very much similar to the one learnt in ‘number series’. In number series we are required to find the missing term, whereas in ‘number oddman’ we are required to find the wrong term which does not follow the pattern. In both the cases, our main work is to observe the terms of the given number series carefully and to identify the pattern followed therein.

Let us consider some examples to understand the concept of oddman.

(a) 1 4 9 16 25 36 63 81  
 On observing the terms of the above number series carefully, we notice that all the terms except 63 are perfect squares of natural numbers. 63 is not a square of a natural number. Hence, 63 is the oddman.

(b) 235 354 424 541 613  
 This problem is somewhat tricky. The sum of digits of each term except 354 is 10. The sum of digits of 354 is  $3 + 5 + 4 = 12$ . Hence 354 is the oddman.

**Example 12 :** Identify the number oddman out of the following numbers.  
 (A) 385 (B) 572 (C) 671 (D) 427

**Solution :** On careful observation of the above numbers, we notice that in all the numbers except 427, the middle digit is the sum of the first and last digits. In 427, this pattern is not followed. Hence, (D) 427 is an oddman.

**Example 13 :** Identify the wrong term in the following number series.  
 20 24 40 76 150 240  
 (A) 20 (B) 40 (C) 76 (D) 150

**Solution** :  $20 + 2^2 = 20 + 4 = 24$   
 $24 + 4^2 = 24 + 16 = 40$   
 $40 + 6^2 = 40 + 36 = 76$   
 $76 + 8^2 = 76 + 64 = 140 \neq 150$   
 $140 + 10^2 = 140 + 100 = 240$

**Hence, the answer is (D)**

**Example 14 :** Find the wrong term in the series:

26, 34, 41, 46, 56, 68, 80, 88

(A) 26 (B) 41 (C) 56 (D) 68

**Solution** : On carefully observing each term of the series, we notice that the sum of digits of a term is added to the same term to get the next term.

$26 + (2 + 6) = 34$   
 $34 + (3 + 4) = 41$   
 $41 + (4 + 1) = 46$   
 $46 + (4 + 6) = 56$   
 $56 + (5 + 6) = 67 \neq 68$   
 $67 + (6 + 7) = 80$   
 $80 + (8 + 0) = 88$

**Hence, the answer is (D)**

**Example 15 :** Identify the number which is different from others.

(A) 49 (B) 67 (C) 139 (D) 176

**Solution** : Sum of digits is 13 in all the numbers except in 176. Therefore, 176 is the oddman.

**Hence, the answer is (D)**

**Case-III : Correlation of the series [Two series are given in which second series follows the pattern of first series] :**

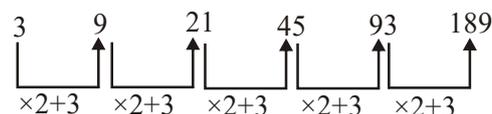
**Directions -** In the following Illustrations, one number series is given. There is another series in which a number and (a), (b), (c), (d), (e) are given below this series. You have to complete this second series by choosing the best from the given alternatives. This series will correlate with the first series.

**Example 16 :** 3 9 21 45 93 189  
 5 (a) (b) (c) (d) (e)

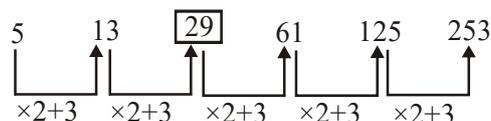
Which number can replace (b) from the following alternatives.

(A) 29 (B) 31 (C) 28 (D) 23

**Solution :**



Same way,



Hence, 29 will replace (b).

Therefore Answer (A)

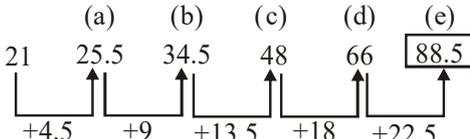
**Example 17:** 17    21.5    30.5    44    62    84.5  
 21    (a)    (b)    (c)    (d)    (e)

Which number can replace (e) ?

- (A) 81                                      (B) 88.5                                      (C) 88                                      (D) 85

**Solution :** 

Same way,

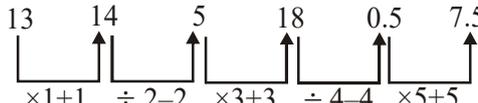


∴ 88.5 will replace (e). Therefore Answer (B)

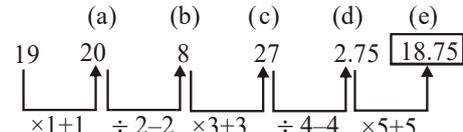
**Example 18 :** 13    14    5    18    0.5    7.5  
 19    (a)    (b)    (c)    (d)    (e)

Which number can replace (e) ?

- (A) 27                                      (B) 6.75                                      (C) 18.75                                      (D) 13.75

**Solution :** 

Same way,

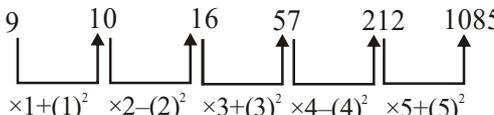


∴ 18.75 will replace (e). Therefore Answer (C)

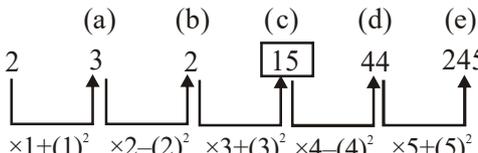
**Example 19:** 9    10    16    57    212    1085  
 2    (a)    (b)    (c)    (d)    (e)

Which number can replace (c) ?

- (A) 18                                      (B) 24                                      (C) 15                                      (D) 25

**Solution :** 

Same way,



∴ 15 will replace (c). Therefore Answer (C).

**II. ALPHABET SERIES :**

In this type of questions, a series of single, pairs or groups of letters or combinations of letters and numerals is given. The terms of the series form a certain pattern as regards the position of the letters in the English alphabet. Identify this pattern and accordingly find the missing term or the wrong term in the given series.

**Example 20 :** Find the missing term in the given alphabet series :

H, I, K, N ?

- (A) O (B) Q (C) R (D) S

**Solution :** The pattern is  $H \xrightarrow{+1} I \xrightarrow{+2} K \xrightarrow{+3} N \xrightarrow{+4} R$

**Example 21 :** Which term comes next in the series : YEB, WFD, UHG, SKI, ?

- (A) QOL (B) QGL (C) TOL (D) QNL

**Solution :** Clearly, we observe the following pattern in the first, second and third letters of the given series :

**1st letter :**  $Y \xrightarrow{-2} W \xrightarrow{-2} U \xrightarrow{-2} S \xrightarrow{-2} \textcircled{Q}$

**2nd letter :**  $E \xrightarrow{+1} F \xrightarrow{+2} H \xrightarrow{+3} K \xrightarrow{+4} \textcircled{O}$

**3rd letter :**  $B \xrightarrow{+2} D \xrightarrow{+3} G \xrightarrow{+2} I \xrightarrow{+3} \textcircled{L}$

Thus, the missing term is QOL. Hence, the answer is (A).

### III. ALPHA NUMERIC SERIES :

This type of question is just a jumbled form of questions of Type 1 and Type 2, which you have just read. Here, the terms of the given series are a combination of letters and numerals, which move according to a set pattern. Study the following illustrations.

**Example 22 :** Find the next term in the alpha-numeric series :

Z1A, X2D, V6G, T21J, R88M, P445P, ?

- (A) N2676S (B) N2676T (C) T2670N (D) N2670S

**Solution :** Clearly, the patterns followed by the letters are as follows :

**1st letters :**  $Z \xrightarrow{-2} X \xrightarrow{-2} V \xrightarrow{-2} T \xrightarrow{-2} R \xrightarrow{-2} P \xrightarrow{-2} \textcircled{N}$

**2nd letters :**  $A \xrightarrow{+3} D \xrightarrow{+3} G \xrightarrow{+3} J \xrightarrow{+3} M \xrightarrow{+3} P \xrightarrow{+3} \textcircled{S}$

The series formed by the numerals i.e. 1,2,6,21,88,445,.....follows the pattern  $\times 1 + 1, \times 2 + 2, \times 3 + 3, \times 4 + 4, \times 5 + 5, \dots$

So, numeral in the desired term =  $445 \times 6 + 6 = 2676$ .

Hence, desired term is N2676S.

So, the answer is (A)

**Example 23 :** Find the term which does not fit into the series given below.

G4T, J10R, M20P, P43N, S90L

- (A) G4T (B) J10R (C) M20P (D) P43N (E) S90L

**Solution :** The pattern followed by the letters are :

**1st letters :**  $G \xrightarrow{+3} J \xrightarrow{+3} M \xrightarrow{+3} P \xrightarrow{+3} S$

**3rd letters :**  $T \xrightarrow{-2} R \xrightarrow{-2} P \xrightarrow{-2} N \xrightarrow{-2} L$

The number series 4, 10, 20, 43, 90 should follow the pattern  $\times 2 + 1, \times 2 + 2, \times 2 + 3, \times 2 + 4$ .

So, 10 is wrong and must be replaced by  $(4 \times 2 + 1)$  i.e. 9

Thus, the term J10R does not fit in the given series. The correct term is J9R.

Hence, the answer is (B).

**IV. CONTINUOUS PATTERN SERIES :**

This type of questions usually consists of a series of small letters which follow a certain pattern. However, some letters are missing from the series. These missing letters are then given in a proper sequence as one of the alternatives. Choose this alternative as the answer.

**Example 24 :** aab \_\_\_ aaa \_\_\_ bba \_\_\_

- (A) baa (B) abb (C) bab (D) aab

**Solution :** We proceed step by step shown-below.

- The first blank space should be filled in by 'b' so that we have two a's followed by two b's.
- The second blank space should be filled in either by 'a' so that have four a's followed by two b's, or 'b' so that we have three a's followed by three b's.
- The last space must be filled in by 'a'.
- Thus, we have two possible answers : 'baa' and 'bba'. But, only 'baa' appears in the alternatives. So, the answer is (A).

**Example 25 :** a — ba — bb — ab — a.

- (A) aaba (B) baab (C) baaa (D) abab

**Solution :** The pattern is abba|abba|abba.  
Hence, the answer is (B).

**Example 26 :** r — sr — tsrrt — rr — sr.

- (A) ttss (B) tsts (C) trst (D) sstt

**Solution :** The pattern is rtsr|rtsr|rtsr|rtsr.  
Hence, the answer is (C).

**VI. CORRESPONDENCE SERIES :**

**Correspondence Series :** This type of series consists of three sequences with three different elements (usually capital letters, digits and small letters). On the basis of the similarity in positions in the three sequences, a capital letter is found to correspond with a unique digit and a unique small letter, whenever it occurs. The candidate is required to trace out this correspondence and accordingly choose the elements to be filled in at the desired places.

Consider the following example :

**Example 27:** In the following series, choose the alternative which contains the numerals to be filled in the marked space, in the correct order :

B \_\_\_ D \_\_\_ C A B D A C B  
\_\_\_ 4 1 3 2 \_\_\_ ? ? ?

a \_\_\_ a \_\_\_ b c \_\_\_ c \_\_\_  
(A) 1, 2, 3, 4 (B) 2, 3, 1, 4 (C) 1, 2, 4, 3 (D) 2, 1, 4, 3

**Solution :** Clearly, in the second series, 1 occurs at the same position as D occurs in the first series So, 1 corresponds to D. Thus, the first question mark below D is to be replaced by 1. Now, in the third series, c at the eighth place corresponds to A in the first series, while c at the sixth place corresponds to 2 in the second series. So 2 corresponds to A. Thus the second questions mark below A is to be replaced by 2.  
In the third series, a at the first place corresponds to B in the first series and a at the third place corresponds to 4 in the second series. So, 4 corresponds to B. Thus, the question mark below B is to be replaced by 4.  
Now, only 3 remains. So, 3 corresponds to C. Thus, the question mark below C is to be replaced by 3. Thus, DACB corresponds to 1, 2, 3, 4 .  
Hence, the answer is (A).

## EXERCISE-I

## Analytical Questions



**Direction (Q. 1 to 16) :** Find the missing term(s) in the following questions :

**Q.1** 0, 6, 24, 60, 120, 210, ?  
(A) 290 (B) 240 (C) 504 (D) 336

**Q.2** 1, 2, 5, 12, 27, 58, 121, ?  
(A) 246 (B) 247 (C) 249 (D) 248

**Q.3** 19, 2, 38, 3, 114, 4, ?  
(A) 228 (B) 256 (C) 352 (D) 456

**Q.4** 49, 51, 54, 27, 9, 11, 14, ?  
(A) 12 (B) 15 (C) 7 (D) 6

**Q.5** 1, 4, 2, 8, 6, 24, 22, 88, ?  
(A) 86 (B) 90 (C) 154 (D) 352

**Q.6** 600, 180, 54, ?  
(A) 27 (B) 0.18 (C) 18 (D) 16.2

**Q.7** 2, 2, 5, 13, 28, ?  
(A) 49 (B) 50 (C) 51 (D) 52

**Q.8** 24, 60, 120, 210, ?  
(A) 300 (B) 336 (C) 420 (D) 525

**Q.9** 589654237, 89654237, 8965423, 965423, ?  
(A) 58965 (B) 65423  
(C) 89654 (D) 96542

**Q.10** 20, 20, 19, 16, 17, 13, 14, 11, ?, ?  
(A) 10, 10 (B) 10, 11  
(C) 13, 14 (D) 13, 16

**Q.11** 2, 1, 2, 4, 4, 5, 6, 7, 8, 8, 10, 11, ?  
(A) 9 (B) 10 (C) 11 (D) 12

**Q.12** 90, 180, 12, 50, 100, 200, ?, 3, 50, 4, 25, 2, 6, 30, 3  
(A) 150 (B) 175 (C) 225 (D) 250

**Q.13**  $\frac{2}{\sqrt{5}}, \frac{3}{5}, \frac{4}{5\sqrt{5}}, \frac{5}{25}, ?$   
(A)  $\frac{6}{5\sqrt{5}}$  (B)  $\frac{6}{25\sqrt{5}}$  (C)  $\frac{6}{125}$  (D)  $\frac{7}{125}$

**Q.14** 2, 9, 28, ?, 126, 217, 344  
(A) 50 (B) 65 (C) 70 (D) 82

**Q.15** 2, 12, 36, 80, 150, ?  
(A) 194 (B) 210 (C) 252 (D) 258

**Q.16** 3, 10, 29, 66, 127, ?  
(A) 164 (B) 187 (C) 218 (D) 216

**Direction (Q.17 to 22) :** Find the wrong term in the following questions :

**Q.17** 6, 13, 24, 51, 98, 201, 408  
(A) 13 (B) 51 (C) 201 (D) 408

**Q.18** 2, 3, 4, 6, 12, 12, 48, 24, 250  
(A) 4 (B) 6 (C) 48 (D) 250

**Q.19** 1112, 1314, 1516, 1718, 1921, 2122, 2324  
(A) 1516 (B) 1921  
(C) 2122 (D) 2324

**Q.20** 7, 28, 63, 124, 215, 342, 511  
(A) 7 (B) 28 (C) 124 (D) 342

**Q.21** 69, 55, 26, 13, 5  
(A) 5 (B) 13 (C) 26 (D) 55

**Q.22** 89, 78, 86, 80, 85, 82, 83  
(A) 83 (B) 82 (C) 86 (D) 78

**Direction (Q.23 to 26) :**

Two series are given in which second series follows the pattern of first series.

**Q.23** 5 6 11 17 28 45  
3 (a) (b) (c) (d) (e)  
Which number can replace (d) ?  
(A) 19 (B) 29 (C) 18 (D) 21

**Q.24** 2 10 14 34 62 130  
1 (a) (b) (c) (d) (e)  
Which number can replace (b) ?  
(A) 6 (B) 8  
(C) 10 (D) 7

**Q.25** 4 2.25 3.25 7.125 18.25 51.875  
 7 (a) (b) (c) (d) (e)  
 Which number can replace (b) ?  
 (A) 4.125 (B) 5.25  
 (C) 6.75 (D) 4.75

**Q.26** 3 40 176 537 1078 1079  
 1 (a) (b) (c) (d) (e)  
 Which number can replace (e) ?  
 (A) 839 (B) 738  
 (C) 829 (D) 938

**Q.27** In the series 10, 17, 24, 31, 38,.....which of the following will be a number of the series ?  
 (A) 45 (B) 48  
 (C) 574 (D) 1003

**Q.28** In the series 3, 9, 15, ....., what will be the 21st term ?  
 (A) 117 (B) 121 (C) 123 (D) 129

**Q.29** Which term of the series 5, 8, 11, 14, .....is 320 ?  
 (A) 104th (B) 105th  
 (C) 106th (D) 64th

**Direction (Q.30 to 36)** In each of the following questions various terms of an alphabet series are given with one or more terms missing as shown by (?). Choose the missing terms out of the given alternatives.

**Q.30** A, G, L, P, S, ?  
 (A) U (B) W (C) X (D) Y

**Q.31** A, B, N, C, D, O, E, F, P, ?, ?, ?  
 (A) G, H, I (B) G, H, J  
 (C) G, H, Q (D) J, K, L

**Q.32** C, Z, F, X, I, V, L, T, O, ?, ?  
 (A) O, P (B) P, Q  
 (C) R, R (D) S, R

**Q.33** GH, JL, NQ, SW, YD, ?  
 (A) EJ (B) FJ (C) EL (D) FL

**Q.34** PMT, OOS, NQR, MSQ, ?  
 (A) LUP (B) LVP  
 (C) LVR (D) LWP

**Q.35** EJO, TYD, INS, XCH, ?  
 (A) NRW (B) MRW  
 (C) MSX (D) NXS

**Q.36** ATTRIBUTION, TTRIBUTIO, RIBUTIO, IBUTI, ?  
 (A) IBU (B) UT  
 (C) UTI (D) BUT

**Direction (Q.37 to 39)** : In each of the following questions a letter number series is given with one or more terms missing as shown by (?). Choose the missing terms out of the given alternatives.

**Q.37** C4X, F9U, I16R, ?  
 (A) K25P (B) L25P  
 (C) L25O (D) L27P

**Q.38** 2A11, 4D13, 12G17, ?  
 (A) 36I19 (B) 36J21  
 (C) 48J21 (D) 48J23

**Q.39** Z, ?, 25, Y, B, 23, X, C, ?, W, ?, 19, ?, E, 17  
 (A) A, 21, D, V (B) A, 27, C, V  
 (C) X, 21, C, W (D) X, 27, F, W

**Direction (Q.40 to 50)** : In each of the following letter series, some letters are missing which are given in that order as one of the alternatives below it. Choose the correct alternative.

**Q.40** ab \_\_\_ baa \_\_\_ ab \_\_\_  
 (A) aaaaa (B) aabaa  
 (C) aabab (D) baabb

**Q.41** \_\_\_ aba \_\_\_ cabc \_\_\_ dcba \_\_\_ baba  
 (A) abdca (B) bcadc  
 (C) abcdd (D) cbdaa

**Q.42** \_\_\_ bcdbc \_\_\_ dcabd \_\_\_ bcdbc \_\_\_ dcdb  
 (A) aaaaa (B) ccccc  
 (C) bbbbb (D) ddddd

**Q.43** b \_\_\_ ac \_\_\_ cc \_\_\_ cb \_\_\_ ab \_\_\_ ac  
 (A) cbaba (B) bbaac  
 (C) abbbc (D) aabba

**Q.44** abc \_\_\_ d \_\_\_ bc \_\_\_ d \_\_\_ b \_\_\_ cda  
 (A) bacde (B) cdabe  
 (C) dacab (D) decdb

**Q.45** b \_\_\_ cacca \_\_\_ ba \_\_\_ bbc \_\_\_ bc \_\_\_ a  
 (A) baabc (B) abaaa  
 (C) acbca (D) bacab

**Q.46** a \_ c \_ abb \_ a \_ bc \_ bc \_ ab  
 (A) cbcaaa (B) bcccab  
 (C) bccaac (D) acbabc

**Q.47** a \_ bc \_ c \_ abb \_ bca \_  
 (A) cccbc (B) cbbac  
 (C) accba (D) abbba

**Q.48** c — bba — cab — ac — ab — ac  
 (A) abcbc (B) babcc  
 (C) bcacb (D) acbcb

**Q.49** R — S — T — KSK — RK — KT.  
 (A) RKRTS (B) KKRTS  
 (C) KKTRS (D) KRSTU

**Q.50** A — CG — IM — O — TU — ZA.  
 (A) BHNYS (B) BHNSY  
 (C) HNSYS (D) BHINS

**Direction (Q.51 to 52) :** In each of the following questions, three sequence of letters/numerals are given which correspond to each other in some way. In each question, you have to find out the letters/numerals that come in the vacant places marked by (?). These are given as one of the four alternatives under the question.

**Q.51** C B \_ \_ D \_ B A B C C B  
 \_ \_ 1 2 4 3 \_ \_ ? ? ? ?  
 a \_ a b \_ c \_ b \_ \_ \_ \_  
 (A) 3, 4, 4, 3 (B) 3, 2, 2, 3  
 (C) 3, 1, 1, 3 (D) 1, 4, 4, 1

**Q.52** \_ A C \_ B D \_ C D C D  
 2 \_ 4 1 \_ 1 4 \_ \_ \_ \_  
 c d \_ b c \_ a ? ? ? ?  
 (A) a, b, a, b (B) a, c, a, c  
 (C) c, b, c, b (D) c, d, c, d

**Direction (Q.53 to 57) :** In each of the following questions, one term in the number series is wrong. Find the wrong term :

**Q.53** 89, 78, 86, 80, 85, 82, 83  
 (A) 83 (B) 82 (C) 86 (D) 8

**Q.54** 4, 6, 15, 56, 280, 1644  
 (A) 280 (B) 1644 (C) 56 (D) 15

**Q.55** 143, 156, 169, 182, 221, 232, 247  
 (A) 182 (B) 247  
 (C) 232 (D) 221

**Q.56** 3, 8, 15, 24, 34, 48, 63  
 (A) 15 (B) 24  
 (C) 34 (D) 48

**Q.57** Find the number odd-man out from the alternatives :  
 (A) 25, 5, 5 (B) 51, 3, 17  
 (C) 96, 6, 16 (D) 75, 5, 25

**Directions (Q.58 to 66) :** In each of the following questions number series is given. Find out the missing term(s) of the series.

**Q.58** 806, 519, 287, 232, 55, ?  
 (A) 47 (B) 137 (C) 177 (D) 205

**Q.59** 20, 36, 61, 97, 146, ?  
 (A) 179 (B) 197  
 (C) 207 (D) 210

**Q.60** 57, 79, 911, 1113, 1315, ?  
 (A) 1419 (B) 1503  
 (C) 1517 (D) 1719

**Q.61** 4, 10, 28, ?, 244  
 (A) 64 (B) 81  
 (C) 82 (D) 96

**Q.62** 840, 168, 42, 14, 7, ?  
 (A) 12 (B) 16  
 (C) 7 (D) 9

**Q.63** 2, 6, 14, 30, 62, ?  
 (A) 120 (B) 126  
 (C) 128 (D) 133

**Q.64** 4, 9, 19, 39, 79, ?  
 (A) 169 (B) 159  
 (C) 119 (D) 139

**Q.65** 4, 9, 19, 34, 54, ?  
 (A) 66 (B) 75  
 (C) 79 (D) 84

**Q.66** 3, 8, 15, 24, ?  
 (A) 30 (B) 35  
 (C) 36 (D) 49

**Directions (Q.67 & 68):** In the following questions, letters series are arranged on the basis of some principle. Find out the principle and then select the missing term from the given alternatives.

- Q.67** ZDOA, VHNF, ?, NPLP, JTKU, FXJZ  
 (A) RKLM (B) MLRK  
 (C) RKML (D) RLMK
- Q.68** ZOA, XMF, ?, TIP, RGU, PEZ  
 (A) YXX (B) WLL  
 (C) UKK (D) VKK

**Directions (Q.69 to 73):** The letters given below follow a definite pattern. Find out the missing letters to complete the pattern.

- Q.69** a b a \_ a \_ a b a \_ a b a \_ a b  
 (A) a a a a (B) b b b b  
 (C) a b a a (D) b a b a

- Q.70** k \_ k k l l l \_ m m \_ m \_ n \_ n  
 (A) l k n m n (B) l k m n n  
 (C) l l m m m (D) k l m n n
- Q.71** \_ a b a \_ a \_ a \_ a b \_  
 (A) a a b a a (B) b a b b a  
 (C) a b b a b (D) b b a a b
- Q.72** n \_ m n \_ m m \_ n m \_ n  
 (A) n m m n (B) m n n m  
 (C) n n m m (D) m m n m
- Q.73** b a \_ b b \_ a \_ a \_ b \_ a  
 (A) b a a b a (B) a b a a b  
 (C) a a b a b (D) b b a b a

## EXERCISE-II

## Competitive Edge



**Directions (Q.1 to Q.10):** Find the missing numbers: [NCO 2016]

- Q.1** 2, 3, 5, 7, ?  
(A) 9 (B) 10 (C) 11 (D) 14
- Q.2** 0, 6, 20, 42, ?  
(A) 64 (B) 72 (C) 80 (D) 84
- Q.3** 3, 8, 35, 48, ?, 120  
(A) 72 (B) 64 (C) 80 (D) 99
- Q.4** 4, 25, 64, 121, 196, ?  
(A) 384 (B) 256 (C) 225 (D) 289
- Q.5** 210, 120, ?, 24, 6, 0 .  
(A) 64 (B) 48 (C) 35 (D) 60
- Q.6** 2, 12, 36, 80, 150, ?  
(A) 194 (B) 210 (C) 252 (D) 258
- Q.7** 4, 10, 22, 46, ?  
(A) 56 (B) 66 (C) 76 (D) 94
- Q.8** 8, 15, 28, 53, ?  
(A) 120 (B) 106 (C) 104 (D) 102
- Q.9** 4, 8, 12, 24, 36, 72, ?  
(A) 98 (B) 100 (C) 144 (D) 108
- Q.10** 12, 15, 18, 21, ?  
(A) 24 (B) 23 (C) 22 (D) 25

**Directions (Q.11 to Q.20):** Find the wrong term in a series : [NSO/ IMO 2017]

- Q.11** 3, 7, 9, 21, 27, 66, 81, 189, 243 .  
(A) 27 (B) 66 (C) 243 (D) 21
- Q.12** 27, 34, 40, 45, 49, 53, 54, 55, 56 .  
(A) 53 (B) 45 (C) 56 (D) 34
- Q.13** 0, 2, 3, 6, 6, 20, 9, 54, 12 .  
(A) 3 (B) 6 (C) 20 (D) 54
- Q.14** 0, 2, 10, 36, 68, 130 .  
(A) 10 (B) 36 (C) 68 (D) 130
- Q.15** 9, 54, 44, 264, 254, 1520, 1514 .  
(A) 1514 (B) 1520 (C) 264 (D) 44

- Q.16** 10, 15, 26, 35, 48, 63, 82 .  
(A) 48 (B) 26 (C) 63 (D) 82
- Q.17** 3, 10, 30, 66, 127, 218.  
(A) 3 (B) 66 (C) 30 (D) 218
- Q.18** 7, 9, 17, 42, 91, 172, 293.  
(A) 91 (B) 42 (C) 17 (D) 9
- Q.19** 2, 12, 24, 34, 68, 78, 158, 166.  
(A) 68 (B) 78 (C) 158 (D) 166
- Q.20** 2, 6, 10, 20, 30, 42, 56.  
(A) 6 (B) 10 (C) 20 (D) 30

**Directions (Q.21 to Q.25):** Find the missing letters: [IMO 2018]

- Q.21** B, E, H, ?  
(A) K (B) L (C) J (D) M
- Q.22** Y, W, U, S, Q, ?  
(A) A (B) P (C) O (D) B
- Q.23** AH, DL, GP, JT, ?  
(A) MY (B) NX  
(C) MX (D) NY
- Q.24** LO, IL, FI, CF, ?  
(A) ZB (B) AB (C) ZC (D) ZO
- Q.25** ZYX, BAZ, DCB, FED, ?  
(A) GHF (B) FGH  
(C) FFG (D) HGF

**Directions (Q.26 to Q.30):** Find the missing letters: [NSF 2018]

- Q.26** ATL, BUM, CVN, DWO, ?  
(A) EZP (B) EYQ  
(C) EFP (D) EXP
- Q.27** TYU, NSO, HMI, ?  
(A) AGC (B) CGC  
(C) GBC (D) BGC
- Q.28** MAAL, AALM, ALMA, LMAA, ?  
(A) AMLA (B) MAAL  
(C) AAML (D) LAAM

- Q.29** A3P, C5N, E8K, G12G, ?  
 (A) I16D (B) I17B  
 (C) I17D (D) J16B

- Q.30** Q1F, S2E, U6D, W21C, ?  
 (A) Y66B (B) Y44B  
 (C) Y88B (D) Z88B

**Directions (Q.31 to Q.35):** There is a wrong term in the following numbers/ letters series. Find the wrong term of the series.

[UCO 2019]

- Q.31** ABC, BCD, CDE, DEF, FEG.  
 (A) BCD (B) CDE  
 (C) DEF (D) FEG
- Q.32** ZOA, XMF, VKK, THP, RGU, PEZ.  
 (A) THP (B) XMF  
 (C) VKK (D) RGU
- Q.33** AACC, BBED, CCHE, DDMF, EEQG.  
 (A) AACC (B) DDMF  
 (C) BBED (D) EEQG
- Q.34** ECA, JHF, OMK, TQP, YWU.  
 (A) ECA (B) JHF  
 (C) TQP (D) YWU
- Q.35** DKY, FJW, HIT, JHS, LGQ.  
 (A) FJW (B) LGQ (C) JHJ (D) HIT

**Directions (Q.36 to Q.40):** There is a wrong term in the following numbers/ letters series. Find the wrong term of the series.

[NSO/IMO 2019]

- Q.36** DVG, FSI, HPK, JNM, L J O.  
 (A) DVG (B) JNM  
 (C) HPK (D) LJO
- Q.37** ABD, DGK, HMS, NTB, SBL, ZKW.  
 (A) NTB (B) DGK  
 (C) SBL (D) ZKW
- Q.38** EPV, FQW, GRX, HTY, ITZ.  
 (A) FQW (B) GRX (C) HTY (D) ITZ
- Q.39** PON, RQP, TSR, VVT, XWV, ZYX.  
 (A) VVT (B) TSR  
 (C) XWV (D) RQP

- Q.40** P 3 C, R 5 F, T 8 I, V 12 L, X 18 O, Z 23 R.  
 (A) V 12 L (B) X 18 O  
 (C) Z 23 R (D) R 5 F

**Directions (Q.41 to Q.46):** Which sequence of letters when placed at the blanks one after the other will complete the given letter series ?

[NSF 2020]

- Q.41** \_ a a b b \_ a b b a \_ b.  
 (A) b a b (B) a b a  
 (C) b b a (D) b a a
- Q.42** a \_ b a a \_ b a a \_ b a.  
 (A) a a b (B) b a b  
 (C) b b a (D) b bb
- Q.43** \_ b a a \_ b a \_ aa b \_ .  
 (A) b a b a (B) b b a a  
 (C) a b bb (D) b b a b
- Q.44** b a b bb \_ b \_ b \_ bb.  
 (A) b b a (B) b a a  
 (C) a b a (D) a aa
- Q.45** \_ ha \_ hach \_ c \_ \_ .  
 (A) ccaha (B) achac  
 (C) chaaa (D) aaach
- Q.46** m \_ l \_ ml \_ m \_ llm.  
 (A) lmmm (B) lmlm  
 (C) lmml (D) mllm

**Direction** – Find the missing term ?

[MVPP/DL/2021]

- Q.47** B, F, J, ?, R  
 (A) N (B) P (C) M (D) O
- Q.48** B, C, ? G, K  
 (A) F (B) D (C) E (D) J

**Direction** – Find the missing term ?

[MVPP/DL/2022]

- Q.49** CNL, BLI, AJF, ZHC, ?  
 (A) XDY (B) YFZ  
 (C) YFA (D) XFY
- Q.50** 2, 6, 14, 30, 62, ? [MVPP/DL/2023]  
 (A) 126 (B) 128 (C) 120 (D) 130

**Direction** – Find the missing term ?

[MVPP/DL/2023]

- Q.51** 1, 2, 3, 2, 3, 5, 4, 5, ?  
 (A) 6 (B) 9 (C) 10 (D) 7
- Q.52** A, D, C, G, E, ?  
 (A) G (B) J (C) I (D) L

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**ANSWER KEY**

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**EXERCISE-I**

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Q.1	D	Q.2	D	Q.3	D	Q.4	C	Q.5	A	Q.6	D	Q.7	D
Q.8	B	Q.9	D	Q.10	A	Q.11	B	Q.12	A	Q.13	B	Q.14	B
Q.15	C	Q.16	C	Q.17	D	Q.18	D	Q.19	B	Q.20	B	Q.21	A
Q.22	C	Q.23	C	Q.24	D	Q.25	D	Q.26	A	Q.27	A	Q.28	C
Q.29	C	Q.30	A	Q.31	C	Q.32	C	Q.33	D	Q.34	A	Q.35	B
Q.36	C	Q.37	C	Q.38	D	Q.39	A	Q.40	B	Q.41	A	Q.42	A
Q.43	D	Q.44	C	Q.45	A	Q.46	C	Q.47	C	Q.48	D	Q.49	B
Q.50	B	Q.51	C	Q.52	A	Q.53	C	Q.54	A	Q.55	C	Q.56	C
Q.57	D	Q.58	C	Q.59	D	Q.60	C	Q.61	C	Q.62	C	Q.63	B
Q.64	B	Q.65	C	Q.66	B	Q.67	D	Q.68	D	Q.69	B	Q.70	D
Q.71	A	Q.72	B	Q.73	C								

**EXERCISE-II**

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Q.1	C	Q.2	B	Q.3	D	Q.4	D	Q.5	D	Q.6	C	Q.7	D
Q.8	D	Q.9	D	Q.10	A	Q.11	B	Q.12	A	Q.13	C	Q.14	B
Q.15	B	Q.16	A	Q.17	C	Q.18	D	Q.19	C	Q.20	B	Q.21	A
Q.22	C	Q.23	C	Q.24	C	Q.25	D	Q.26	D	Q.27	D	Q.28	B
Q.29	B	Q.30	C	Q.31	D	Q.32	A	Q.33	B	Q.34	C	Q.35	D
Q.36	B	Q.37	A	Q.38	C	Q.39	A	Q.40	B	Q.41	D	Q.42	D
Q.43	C	Q.44	C	Q.45	C	Q.46	B	Q.47	A	Q.48	C	Q.49	B
Q.50	A	Q.51	B	Q.52	B								