SCIENCE

CLASS-9

MOTION

ASPIRING YOUNG MINDS

E SHIKSHA PIE PROGRAMS

CLASSES VI, VII, VIII, IX & X

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INTRODUCTION

In everyday life, we see some objects at rest and others in motion. Birds fly, fish swim, blood flows through veins and arteries and cars move. Atoms, molecules, planets, stars and galaxies are all in motion. We often perceive an object to be in motion when its position changes with time.

In the physical world, one of the most common phenomena is motion.

PHYSICAL SCIENCE

This science deals with the properties and behaviour of nonliving things.

PHYSICS (IN GREEK NATURE)

It is the branch of science which deals with the study of the natural laws and their manifestation in the natural phenomenon.

MECHANICS (OLDEST BRANCH)

If deals with the conditions of rest or motion of the material objects around us.

STATICS

It deals with the study of object at rest or in equilibrium, even when they are under the action of several forces (measurement of time is not essential).

KINEMATICS

If deals with the study of motion of objects without considering the cause of motion (measurement of time is essential).

DYNAMICS

It deal with the study of objects taking into consideration the cause of their motion.

REST

An object is said to be at rest if it does not change its position w.r.t. its surroundings with the passage of time.

MOTION

A body is said to be in motion if its position changes continuously w.r.t. the surroundings (or with respect to an observer) with the passage of time.

Or

A body is said to be in motion (or moving) when its position changes continuously with respect to a stationary object taken as reference point. For example, when the position of a car changes continuously with respect to stationary objects like houses and trees, etc., we say that the car is moving or that the car is in motion. Let us take an example to understand the meaning of motion more clearly

Most motions are complex. Some objects may move in a straight line, others may take a circular path. Some may rotate and a few others may vibrate. There may be situations involving a combination of these. In this chapter, we shall first learn to describe the motion of objects along a straight line. We shall also learn to express such motions through simple equations and graphs. Later, we shall discuss ways of describing circular motion.

When a body does not change its position with time, we can say that the body is at **rest**, while if a body changes its position with time, it is said to be in **motion**.

1. An object is said to be a **point object** if it changes its position by distances which are much greater than its size.
2. A point or some stationary object with respect to which a body continuously changes its position in the state of motion is known as **origin** or **reference point**.

Eg.:1 If one travels by a car from one place to another far away place, then length of the car is ignored as compared to distance traveled.

Eg.:2 We know that the earth is rotating about its axis and revolving around the sun. The stationary objects like your classroom, a tree and the lamp posts etc., do not change their position with respect to each other i.e. they are at rest. Although earth is in motion. To an observer situated outside the earth, say in a space ship, our classroom, trees etc. would appear to be in motion. Therefore, all motions are relative. There is nothing like absolute motion.

TYPES OF MOTION

ACCORDING TO DIRECTIONS

1. **ONE DIMENSIONAL MOTION:** It is the motion of a particle moving along a straight line.
   (i) Motion of train along straight railway track.
   (ii) An object falling freely under gravity.
2. **TWO DIMENSIONAL MOTION:** A particle moving along a curved path in a plane has 2-dimensional motion.
   (i) Motion of queen on carom board.
   (ii) An insect crawling on the floor of the room.

(iii) Motion of object in horizontal and vertical circles etc.
(iv) Motion of planets around the sun.

3. **THREE DIMENSIONAL MOTION:** Particle moving randomly in space has 3-dimensional motion.
   (i) A bird flying in the sky (also kite).
   (ii) Random motion of gas molecules.
   (iii) Motion of an aeroplane in space.

ACCORDING TO STATE OF MOTION:

UNIFORM MOTION:

1. A body is said to be in a state of uniform motion if it travels equal distances in equal intervals of time.
2. If the time distance graph is a straight line the motion is said to be uniform motion.

NON-UNIFORM MOTION:

1. A body has a non-uniform motion if it travels unequal distances in equal intervals of time. **Ex.** a freely falling body.
2. Time - distance graph for a body with non-uniform motion is a curved line.

LINEAR MOTION (OR TRANSLATORY MOTION)

The motion of a moving car, a person running, a stone being dropped.

ROTATIONAL MOTION

The motion of an electric fan, motion of earth about its own axis.

OSCILLATORY MOTION

The motion of a simple pendulum, a body suspended from a spring (also called to and fro motion).

Note:

If a body moves fairly fast, then its movement (or motion) can be observed easily. But if a body moves very slowly, then it becomes difficult to observe its movement immediately. For example, a wrist watch has three hands : a seconds' hand, a minutes' hand and an hours' hand, which move round and round on the dial of the watch. Now, the seconds' hand of a watch moves quite fast, so we can observe the movement (or motion) of the seconds' hand of the watch very easily. But the minutes' hand and hours' hand of a watch move quite slow, so their movement cannot be observed easily. We will have to keep on observing the position of minutes' hand and hours' hand for quite some time to find out whether they are moving or not. This is because when a body moves, its position changes with time

SCALER AND VECTOR QUANTITY

Physically quantities (i.e. quantities of physics) can be divided into two types:

(i) **Scalar quantity:** Any physical quantity, which can be completely specified by its magnitude alone, is a scalar quantity or a scalar.

Eg.: Charge, distance, area, speed, time temperature, density, volume, work, power, energy, pressure, potential etc.

(ii) **Vector quantity:** Any physical quantity, which requires direction in addition to its magnitude is known as a vector.

Eg. : Displacement, velocity, acceleration, force, momentum, weight and electric field etc.

REPRESENTATION OF A VECTOR

A vector is represented a directed line segment drawn in the given direction on a certain scale.

Tail $\longrightarrow$ head (symbolic representation)

DIFFERENCE BETWEEN SCALAR AND VECTOR

SCALAR: 1. They have a magnitude only
2.They are added or subtracted arithmetically like 3 kg + 5 kg = 8 kg

VECTOR: 1.They have magnitude as well as direction.
2.They are added or subtracted by the process of vector addition.

TERMS USED TO DEFINE MOTION

The motion of a body can be described by three terms: Speed, Velocity and Acceleration. Let us study them in detail, one by one.

Note: (i) Distance and displacement
(ii) Speed and velocity (iii) Acceleration

DISTANCE & DISPLACEMENT

In order to study the motion of bodies (or objects), we should first know the meanings of two terms : distance and displacement. These are discussed below. Another point to be noted is that in the study of motion, whether we use the term 'body' 'or 'object', it means the same thing.

1. The path length between the initial and final positions of the particle gives the **distance** covered by the particle.
2. The minimum distance between the initial and final positions of a body during that time interval is called **displacement**
3. Distance and displacement both are measured in *meter* in m.k.s. system.

DIFFERENCE BETWEEN DISTANCE AND DISPLACEMENT

The distance travelled by a body is the actual length of the path covered by a moving body irrespective of the direction in which the body travels.

When a body moves from one point to another, the distance travelled refers to the actual length of the indirect path whereas displacement refers to the straight line path between the initial and the final positions.

When a body moves from one position to another, the shortest (straight line) distance between the initial position and final position of the body, along with direction, is known as its displacement.

1. Distance travelled is a scalar quantity while displacement is a vector quantity.
2. When a body continuously moves in the same straight line and in the same direction then displacement will be equal to the distance travelled. But if the body changes its direction while moving, then the displacement is smaller than the distance travelled. $\boxed{\text{Displacement} \leq \text{Distance}}$
3. Displacement in any interval of time may be zero, positive or negative where as distance cannot be negative..
4. Distance will never decrease, while Displacement may decrease.

The distance travelled by a moving body cannot be zero but the final displacement of a moving body can be zero. The displacement of a moving body will be zero if, after travelling a certain distance, the moving body finally comes back to its starting point (or starting position).

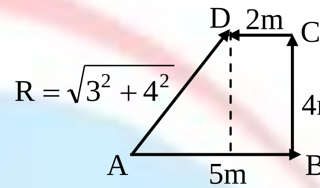
NOTE:
If a body travels in such a way that it comes back to its starting position, then the displacement is zero. However, distance traveled is never zero.

EXAMPLE – 1

A person travels a distance of 5 m towards east, then 4 m towards north and then 2 m towards west.
(i) Calculate the total distance travelled.
(ii) Calculate the resultant displacement.

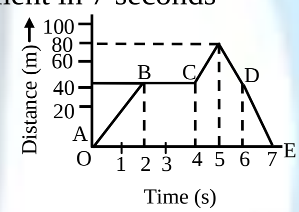
Solution:
(i) Total distance travelled by the person
= 5 m + 4 m + 2 m = 11 m

(ii) To calculate the resultant displacement, we choose a convenient scale, where 1 cm represents 1 m. We draw a 5 cm long line AB towards east and then 4 cm long line BC towards north. Finally, a 2 cm long line CD towards west. The resultant displacement is calculated by joining the initial position A to the final position D. We measure AB = 5 cm.
Since 1 cm = 1 m So, 5 cm = 5 m
Hence, the displacement of the person
= 5m towards AD.



EXAMPLE – 2

A body is moving in a straight line. Its distances from origin are shown with time in Fig. A, B, C, D and E represent different parts of its motion. Find the following :
(i) Displacement of the body in first 2 seconds.
(ii) Total distance travelled in 7 seconds.
(iii) Displacement in 7 seconds



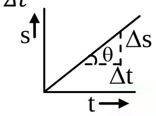
Displacement-time graph

Solution:
(i) Displacement of the body in first 2s = 40m
(ii) From t = 0 to t = 7 s, the body has moved a distance of 80 m from origin and it has again come back to origin. Therefore, the total distance covered = 80 × 2 = 160 m
(iii) Since the body has come back to its initial position, the displacement is zero.

SPEED AND VELOCITY

1. The 'distance' travelled by a body in unit time interval is called its **speed**. When the position of a body changes in particular direction, then speed is denoted by 'velocity'. i.e. the rate of change of displacement of a body is called its **Velocity.**
2. Speed is a scalar quantity while velocity is a vector quantity.
3. Speed = $\frac{\text{distance}}{\text{time}}$
4. Velocity = $\frac{displacement}{time}$
5. Unit : In M.K.S. system = ms^{-1}
   In C.G.S. system = cm/s.
   In F.P.S. system = ft/s

6. If time distance graph is given then speed can be given by the slope of the line, at given time $v = \frac{\Delta s}{\Delta t}$ = slope



7. The area of velocity time graph gives displacement travelled.

TYPES OF SPEED

(A) AVERAGE AND INSTANTANEOUS SPEED AVERAGE SPEED :

It is obtained by dividing the total distance travelled by the total time interval. i.e.

$$\text{average speed} = \frac{\text{total distance}}{\text{total time}}$$

$$Average velocity = \frac{displacement}{totaltime}$$

1. Average speed is a scalar, while average velocity is a vector.
2. For a moving body average speed can never be –ve or zero (unless $t \to \infty$), while average velocity can be i.e. $v_{av} > 0$ while $\vec{v}_{av} > = \text{or} < 0$
3. In general average speed is not equal to magnitude of average velocity. However it can be so if the motion is along a straight line without change in direction
4. If a particle travels distances L_1, L_2, L_3 at speeds v_1, v_2, v_3 etc respectively, then

$$v_{av} = \frac{\Delta s}{\Delta t} = \frac{L_1 + L_2 + \ldots + L_n}{\frac{L_1}{v_1} + \frac{L_2}{v_2} + \ldots + \frac{L_n}{v_n}} = \frac{\sum Li}{\sum \frac{L_i}{v_i}}$$

5. If a particle travels at speeds v_1, v_2 etc for intervals t_1, t_2 etc respectively, then

$$v_{av} = \frac{v_1 t_1 + v_2 t_2 + \ldots}{t_1 + t_2 + \ldots} = \frac{\sum v_1 t_1}{\sum t_1}.$$

EXAMPLE – 3

An object travels 16 m in 4 s and then another 16 m in 2 s. What is the average speed of the object?

Solution:

Total distance travelled by the object

= 16 m + 16 m = 32 m

Total time taken = 4 s + 2 s = 6 s

Average speed

= Total distance travelled/Total time taken

= 32m/6s = 5.33 ms^{-1}

Therefore, the average speed of the object is 5.33 ms^{-1}.

EXAMPLE – 4

The odometer of a car reads 2000 km at the start of a trip and 2400 km at the end of the trip. If the trip took 8 h, calculate the average speed of the car in km h^{-1} and ms^{-1}.

Solution:

Distance covered by the car, s = 2400 km – 2000 km = 400 km, Time elapsed, t = 8 h

Average speed of the car is, v_{av} = s/t = 400 km/8h

= 50 km h^{-1} = 13.9 m s^{-1}

The average speed of the car is 50 km h^{-1} or 13.9 m s^{-1}.

EXAMPLE – 5

Pooja swims in a 90 m long pool. She covers 180 m in one minute by swimming from one end to the other and back along the same straight path. Find the average speed and average velocity of Pooja.

Solution:

Total distance covered by Pooja in 1 min is 180 m.

Displacement of in 1 min = 0 m

Average speed

= Total distance covered/Total time taken

= 180m/1 min = 3 m s^{-1}

Average velocity = Displacement/Total time taken

= 0m/60 s = 0 m s^{-1}

The average speed of Pooja is 3 m s^{-1} and her average velocity is 0 m s^{-1}.

INSTANTANEOUS SPEED

The speed of a body at a particular instant of time is called its instantaneous speed. $= \lim_{\Delta t \to 0} \frac{\Delta s}{\Delta t} = \frac{ds}{dt}$

UNIFORM AND NON UNIFORM SPEED

A. UNIFORM SPEED :

If an object covers equal distance in equal interval of time, then time speed graph of an object is a straight line parallel to time axis then body is moving with a uniform speed.

B. 77NON-UNIFORM SPEED :

If the speed of a body is changing with respect to time it is moving with a non-uniform speed.

EXAMPLE – 6

The distance between two points A and B is 100 m. A person moves from A to B with a speed of 20 m/s and from B to A with a speed of 25 m/s. Calculate average speed and average velocity.

Solution:

(i) Distance from A to B = 100 m

Distance from B to A = 100 m

Thus, total distance = 200 m

Time taken to move from A to B, is given by

$$t_1 = \frac{\text{distance}}{\text{velocity}} = \frac{100}{20} = 5 \text{ seconds}$$

Time taken from B to A, is given by

$t_2 = \frac{\text{distance}}{\text{velocity}} = \frac{100}{25} = 4$ seconds

Total time taken = $t_1 + t_2 = 5 + 4 = 9$ sec.

Average speed of the person

$= \frac{\text{Total distance covered}}{\text{Total time taken}} = \frac{200}{9}$ m/s = 22.2 m/s

(ii) Since person comes back to initial position A, displacement will be zero, resulting zero average velocity.

EXAMPLE – 7

A car moves with a speed of 40 km/hr for first hour, then with a speed of 60 km/hr for next half hour and finally with a speed of 30 km/hr for next $1\frac{1}{2}$ hours. Calculate the average speed of the car.

Solution:

Distance travelled in first hour, is given by

s_1 = speed × time = 40 km/hr × 1 hr = 40 km

Distance travelled in next half an hour, is given by

s_2 = speed × time = 60 km/hr × $\frac{1}{2}$ hr = 30 km

Distance travelled in last $1\frac{1}{2}$ hours, is given by

s_3 = speed × time = 30 km/hr × $\frac{3}{2}$ hr = 45 km

Thus, total distance travelled = $s_1 + s_2 + s_3$

= 40 + 30 + 45 = 115 km

Total time taken = $1 + \frac{1}{2} + 1\frac{1}{2}$ = 3 hours

So, Average speed $= \frac{\text{Total distance covered}}{\text{Total time taken}} = \frac{115 km}{3 hrs}$

= 38.33 km/hr

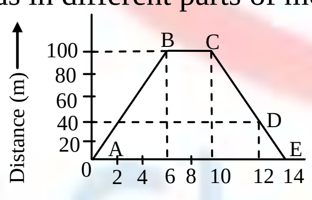
EXAMPLE – 8

Figure shows time distance graph of an object. Calculate the following :

(i) Which part of the graph shows that the body is at rest ?

(ii) Average speed in first 10 s.

(iii) Speeds in different parts of motion.



Distance-time graph

Solution:

(i) The part BC shows that the body is at rest.

(ii) In first 10 seconds, distance travelled = 100m

Thus, average speed $= \frac{\text{Distance covered}}{\text{Time taken}} = \frac{100}{10} = 10$ m/s

(iii)Speed of the object in part AB is given by

slope $= \frac{100}{6}$ = 50/3 m/s

Speed of object in part BC = 0 m/s

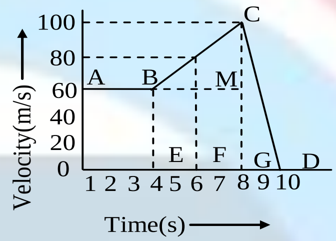
Speed of the object in part CD

$= \frac{100-40}{12-10} = \frac{60}{2} = 30$ m/s

Speed of object in part DE $= \frac{40-0}{14-12} = \frac{40}{2} = 20$m/s

EXAMPLE – 9

Time-velocity graph of a particle is shown in Figure. Calculate the distance travelled in first seconds.



Solution:

Distance travelled in first 8s is given by area OABCG = area of rectangle OAMG + area of triangle BMC

$= 8 \times 60 + \frac{1}{2} \times 4 \times 40 = 480 + 80 = 560$ m.

DPP#1

1. A body whose position with respect to surrounding does not change, is said to be in a state of :
   (A) Rest (B) Motion
   (C) Vibration (D) Oscillation
2. In case of a moving body :
   (A) Displacement > Distance
   (B) Displacement < Distance
   (C) Displacement ≥ Distance
   (D) Displacement ≤ Distance
3. Vector quantities are those which have :
   (A) Only direction (B) Only Magnitude
   (C) Magnitude and direction both
   (D) None of these
4. What is true about scalar quantities ?
   (A) Scalars quantities have direction also.
   (B) Scalars can be added arithmetically.
   (C) There are special law to add scalars.
   (D) Scalars have special method to represent.
5. A body is said to be in motion if :
   (A) Its position with respect to surrounding objects remains same
   (B) Its position with respect to surrounding objects keep on changing
   (C) Both (A) and (B)
   (D) Neither (A) nor (B)
6. A distance is always :
   (A) shortest length between two points

(B) path covered by an object between two points
(C) product of length and time
(D) none of the above

7. A displacement :
(A) is always positive
(B) is always negative
(C) may be positive as well as negative
(D) is neither positive nor negative

8. Examples of vector quantities are :
(A) velocity, length and mass
(B) speed, length and mass
(C) time, displacement and mass
(D) velocity, displacement and force

9. Which of the following is not characteristic of displacement ?
(A) It is always positive.
(B) Is has both magnitude and direction.
(C) It can be zero.
(D) Its magnitude is less than or equal the actual path length of the object.

10. S.I. unit of displacement is :
(A) m (B) ms-1 (C) ms-2 (D) None of these

11. Which of the following is not a vector ?
(A) Speed (B) Velocity
(C) Weight (D) Acceleration

12. Time is an example of :
(A) Scalar (B) Vector
(C) Scalar or vector
(D) Neither scalar nor vector

13. In five minutes distance between a pole and a car changes progressively. What is true about the car ?
(A) Car is at rest
(B) Car is in motion
(C) Nothing can be said with this information
(D) None of the above

14. A distance :
(A) Is always positive
(B) Is always negative
(C) May be positive as well as negative
(D) Is neither positive nor negative

ANSWERS:

1. A 2. D 3. C 4. B 5. B 6. B
7. C 8. D 9. A 10. A 11. A 12. A
13. B 14. A.

ACCELERATION

1. Rate of change of velocity is called acceleration. It is a vector quantity

   i.e. $a = \frac{v-u}{t}$

2. Unit of acceleration = m/s^2 or ms^{-2} .

TYPES OF ACCELERATION

UNIFORM ACCELERATION

If a body travels in a straight line and its velocity increases by equal amounts in equal intervals of time then it is said to be in state of uniform acceleration.

e.g. motion of a freely falling body.

NON UNIFORM ACCELERATION

A body has a non-uniform acceleration if its velocity increases by unequal amounts in equal intervals of time.

INSTANTANEOUS ACCELERATION

The acceleration of a body at any instant is called its instantaneous acceleration.

1. If the velocity of a body decreases, then it will experience a negative acceleration which is called deceleration or retardation.
2. **Acceleration is determined by the slope of time-velocity graph.** $\tan\theta = \frac{dv}{dt}$

(i) If the time velocity graph is a straight line, acceleration remains constants.
(ii) If the slope of the straight line is positive, positive acceleration occurs.
(iii) If the slope of the straight line is negative, negative acceleration or retardation occurs.

EXAMPLE – 10

Time-velocity graph of a body is shown in the figure. Find its acceleration in m/s^2.

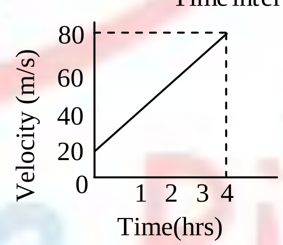
Solution:

As it is clear from the figure,

At t = 0 s, v = 20 m/s

At t = 4 s, v = 80 m/s

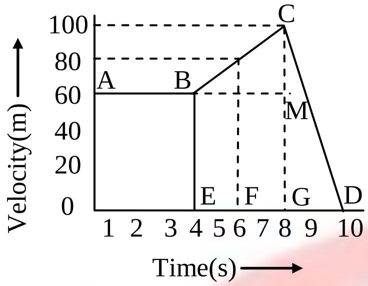
$\therefore$ Acceleration, $a = \frac{\text{Change in velocity}}{\text{Time interval}}$



So, $a = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{(80-20)m/s}{(4-0)}$ $15 m/s^2$

EXAMPLE – 11

Time-velocity graph of a particle is shown in figure. Find its instantaneous acceleration at following intervals:



(i) at t = 3s (ii)at t = 6s (iii) at t = 9s

Solution:

(i) Instantaneous acceleration at t = 3s, is given by

a = slope of line AB = zero

(ii) Instantaneous acceleration at t = 6 s, is given by a = slope of line

BC $=\frac{CM}{BM} = \frac{100-60}{8-4} = -10$ m/s^2

(iii)Instantaneous acceleration at t = 9 s, is given by a = slope of line CD $=\frac{0-100}{10-8} = -50$ m/s^2

EXAMPLE – 12

Starting from rest, Deepak paddles his bicycle to attain a velocity of 6 m/s in 30 seconds then he applies brakes so that the velocity of the bicycle comes down to 4 m/s in the next 5 seconds. Calculate the acceleration of the bicycle in both the cases.

Solution:

(i) Initial velocity, u = 0, final velocity, v = 6 m/s, time, t = 30 s

Using the equation v = u + at, we have

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

substituting the given values of u, v and t in the above equation, we get

$a = \frac{6-0}{30} = 0.2$ m/s^2 ;

which is positive acceleration.

(ii) Initial velocity, u = 6 m/s, final velocity, v = 4 m/s, time, t = 5 s, then

$a = \frac{v-u}{t} = \frac{4-6}{5} = -0.4$ m/s^2 ;

which is retardation.

Note : The acceleration of the case (i) is positive and is negative in the case (ii).

EQUATION OF MOTION

MOTION UNDER UNIFORM ACCELERATION

(A) 1ST EQUATION OF MOTION

Consider a body having initial velocity 'u'. Suppose it is subjected to a uniform acceleration 'a' so that after time 't' its final velocity becomes 'v'. Now we know,

Acceleration = $\frac{change in velocity}{Time}$

$a = \frac{v-u}{t}$ **or** **v = u + at** **…..(i)**

(B) 2ND EQUATION OF MOTION

Suppose a body has an initial velocity 'u' and uniform acceleration 'a' for time 't' so that its final velocity becomes 'v'. The distance travelled by moving body in time 't' is 's' then the average velocity

= (v + u)/2.

Distance travelled=Average velocity × time

$s = \left(\frac{u+v}{2}\right)t \Rightarrow s = \left(\frac{u+u+at}{2}\right)t$ (as v = u + at)

$s = \left(\frac{2u+at}{2}\right)t \Rightarrow s = \frac{2ut+at^2}{2}$

$\mathbf{s = ut + \frac{1}{2}at^2}$ **……(ii)**

(C) 3RD EQUATION OF MOTION

Distance travelled = Average velocity x time $s = \left(\frac{u+v}{2}\right)t$ ……(iii)

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

Substituting the value of t in equation (iii), we get $s = \left(\frac{v-u}{a}\right)\left(\frac{v+u}{2}\right)$ Or $s = \left(\frac{v^2-u^2}{2a}\right)$

So, $2as = v^2 - u^2$ or

$\mathbf{v^2 = u^2 + 2as}$ **….(iv)**

EXAMPLE – 13

A car accelerates uniformly from 18 km h^{-1} to 36 km h^{-1} in 5 s. Calculate (i) the acceleration and (ii) the distance covered by the car in that time.

Solution:

We are given that u = 18 km h^{-1} = 5 m s^{-1}

v = 36 km h^{-1} = 10 m s^{-1} and t = 5 s .

(i) From equation, we have

a = (v– u)/t = (10 - 5)/ 5 = 1 m s^{-2}

(ii) From E, we have

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

$= 5 \times 5 + \frac{1}{2} \times 1 \times (5)^2 = 25$ m + 12.5 m = 37.5 m

The acceleration of the car is 1 m s^{-2} and the distance covered is 37.5 m.

MOTION UNBER GRAVITY

1. The equations of motion under gravity can be obtained by replacing acceleration by acceleration due to gravity (g) and can be written as follows:
2. When the body is coming towards the centre of earth

   (a) v = u + gt **(b)** $h = ut + \frac{1}{2}gt^2$

   (c) $v^2 = u^2 + 2gh$
3. When a body is thrown upwards with some initial velocity, then a retardation produced

due to attraction of the earth. In equations of motion, a is replaced by (–g) and thus equations become.

(a) $v = u - gt$ **(b)** $h = ut - \frac{1}{2}gt^2$

(c) $v^2 = u^2 - 2gh$

FREE FALL

When any object is dropped from a building or a tower or any high points, that time its initial velocity will be zero. This type of fall is called free fall. In this case: initial velocity is zero, u = 0.

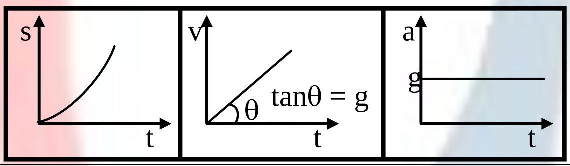
Now, the equation of motions will be:

1. $v = gt$ 2. $h = \frac{1}{2}gt^2$ 3. $v^2 = 2gh$.

BODY FALLING FREELY UNDER GRAVITY

Assuming u = 0 for a freely falling body :

t is given	h is given	v is given
$v = gt$ $h = \frac{1}{2}gt^2$	$t = \sqrt{\frac{2h}{g}}$ $v = \sqrt{2gh}$	$t = \frac{v}{g}$ $h = \frac{v^2}{2g}$

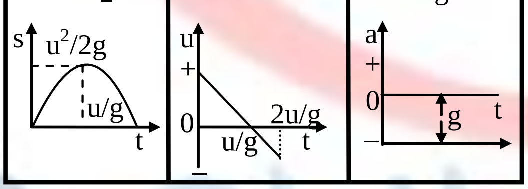


BODY IS PROJECTED VERTICALLY UP :

Taking initial position as origin and direction of motion (i.e. vertically up) as positive.

(a) At the highest point v = 0 (b) a = – g

t is given	h is given	u is given
$u = gt$ $h = \frac{1}{2}gt^2$	$t = \sqrt{2h/g}$ $u = \sqrt{2gh}$	$t = \frac{u}{g}$ $h = \frac{u^2}{2g}$



It is clear that in case of motion under gravity

(a) Time taken to go up is equal to the time taken to fall down through the same distance.

(b) The speed with which a body is projected up is equal to the speed with which it comes back to the point of projection.

(c) The body returns to the starting point with the same speed with which it was thrown.

EXAMPLE – 14

A body starts moving with an initial velocity 50 m/s and acceleration 20 m/s². How much distance it will cover in 4s ? Also, calculate its average speed during this time interval.

Solution:

Given : u = 50 m/s, a = 20 m/s²,

t = 4s, s = ?

$s = ut + \frac{1}{2}at^2 = 50 \times 4 + \frac{1}{2} \times 20 \times (4)^2$

$= 200 + 160 = 360$ m

Average speed during this interval,

$\overline{V} = \frac{\text{distance travelled}}{\text{time interval}} = \frac{360}{4} = 90$ m/s

EXAMPLE – 15

A body is moving with a speed of 20 m/s. When certain force is applied, an acceleration of 4 m/s² is produced. After how much time its velocity will be 80 m/s ?

Solution:

Given : u = 20 m/s, a = 4 m/s², v = 80 m/s, t = ?

Using equation, v = u + at, we get

$80 = 20 + 4 \times t$

or $4t = 80 - 20 = 60$

or $t = 15$ s

Therefore, after 15 seconds, the velocity of the body will be 80 m/s.

EXAMPLE – 16

A body starts from rest and moves with a constant acceleration. It travels a distance s_1 in first 10 s, and a distance s_2 in next 10 s. Find the relation between s_2 and s_1.

Solution:

Given : u = 0, t_1 = 10 s

Distance travelled in first 10 seconds, is given by

$s_1 = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2} \times a \times (10)^2$

$= 50a$ ...(1)

To calculate the distance travelled in next 10s, we first calculate distance travelled in 20 s and then subtract distance travelled in first 10 s.

$s = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2} \times a \times (20)^2$

$= 200a$ ...(2)

Distance travelled in 10th second interval,

$s_2 = s - s_1 = 200a - 50a$ ...(3)

or $s_2 = 150a$

Now, $\frac{s_2}{s_1} = \frac{150a}{50a} = \frac{3}{1}$ or $s_2 = 3s_1$

EXAMPLE – 16

A train is moving with a velocity 400 m/s. With the application of brakes a retardation of 10 m/s^2 is produced. Calculate the following :

(i) After how much time it will stop ?

(ii) How much distance will it travel before it stops?

Solution:

(i) Given: u = 400 m/s, a = –10 m/s^2, v = 0, t = ?

Using equation, v = u + at, we get

0 = 400 + (–10) × t

or t = 40 s

(ii) For calculating the distance travelled, we use equation,

$v^2 = u^2 + 2as$, we get

$(0)^2 = (400)^2 + 2 \times (-10) \times s$

or 20s = 400 × 400 or s = 8000 m = 8 km

EXAMPLE – 17

A body is thrown vertically upwards with an initial velocity of 19.6 m/s. If g = –9.8 m/s^2. Calculate the following :

(i) The maximum height attained by the body.

(ii) After how much time will it come back to the ground ?

Solution:

(i) Given: u = 19.6 m/s, g = –9.8 m/s^2, v = 0, h = ?

Using equation $v^2 = u^2 + 2gh$, we get

$(0)^2 = (19.6)^2 + 2(-9.8) \times h$

or $h = \frac{19.6\times19.6}{2\times9.8} = 19.6$ m

(ii) Time taken to reach the maximum height can be calculated by the equation,

v = u + gt

or 0 = 19.6 + (–9.8) × t or t = 2s

In the same time, it will come back to its original position. So, Total time = 2 × 2 = 4s

EXAMPLE – 18

From the top of a tower of height 490 m, a shell is fired horizontally with a velocity 100 m/s. At what distance from the bottom of the tower, the shell will hit the ground ?

Solution:

We know that the horizontal motion and the vertical motion are independent of each other. Now for vertical motion, we have u = 0, h = 490 m, g = 9.8 m/s^2, t = ?

Using equation, $h = ut + \frac{1}{2}gt^2$, we get

$490 = 0 + \frac{1}{2} \times 9.8 \times t^2$

or $t^2 = \frac{490}{4.9} = 100$

or t = 10 s

⇒ It takes 10 seconds to reach the ground.

Now, horizontal distance

= horizontal velocity × time

= 100 m/s × 10 s = 1000 m

⇒ The shell will strike the ground at a distance of 100 m from the bottom of the tower.

DPP#2

1. When a body covers equal distance in equal intervals of time, its motion is said to be :
(A) Non-uniform (B)Uniform
(C) Accelerated (D) Back and forth
2. The motion along a straight line is called :
(A) Vibratory (B) Stationary
(C) Circular (D) Linear
3. A particle is traveling with a constant speed. This means :
(A) Its position remains constant as time passes.
(B) It covers equal distance in equal interval of time
(C) Its acceleration is zero
(D) It does not change its direction of motion
4. The rate of change of displacement is :
(A) Speed (B) Velocity
(C) Acceleration (D) Retardation
5. Speed is never :
(A) zero (B) Fraction (C) Negative (D) Positive
6. The motion of a body covering different distances in same intervals of time is said to be :
(A) Zig - Zag (B) Fast (C) Slow (D) Variable
7. Unit of velocity is :
(A) ms (B) ms-1 (C) ms2 (D) none of these
8. A speed :
(A) is always positive (B) is always negative
(C) may be positive as well as negative
(D) is neither zero nor negative
9. A particle moves with a uniform velocity :
(A) The particle must be at rest
(B) The particle moves along a curved path
(C) The particle moves along a circle
(D) The particle moves along a straight line
10. A quantity has value of -6.0 ms-1. It may be the :
(A) Speed of a particle
(B) Velocity of a particle
(C) Position of a particle
(D) Displacement of a particle
11. In 10 minutes, a car with speed of 60 kmh-1 travels a distance of :
(A) 6 km (B) 600 km (C) 10 km (D) 7 km
12. A particle covers equal distances in equal

intervals of times, it is said to be moving with uniform :

(A) Speed (B) Velocity
(C) Acceleration (D) Retardation

ANSWERS:

1. B 2. D 3. B 4. B 5. C 6. D 7. B
8. A 9. D 10. B 11. C 12. A 13. A 14. C.

1. Fill in the following blanks with suitable words: .
   (a) Displacement is a .... quantity whereas distance is a .... quantity.
   (b) The physical quantity which gives both, the speed and direction of motion of a body is called its............
   (c) A motorcycle has a steady .... of 3 m/s2. This means that every................its................increases by............
   (d) Velocity is the rate of change of ....It is measured in ....
   (e) Acceleration is the rate of change of............... It is measured in ....
2. A tortoise moves a distance of 100 metres in 15 minutes. What is the average speed of tortoise in km/h?
3. If a sprinter runs a distance of 100 metres in 9.83 seconds, calculate his average speed in km/h.
4. A motorcyclist drives from place A to B with a uniform speed of 30 km/h and returns from place B to A with a uniform speed of 20 km/h. Find his average speed.
5. A motorcyclist starts from rest and reaches a speed of 6 m/s after travelling with uniform acceleration for 3 s. What is his acceleration?

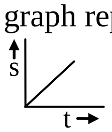
ANSWERS

1. (a) vector ; scalar (b) velocity
(c) acceleration ; second ; speed (or velocity) ; 3 m/s (d) displacement ; m/s
(e) velocity ; m/s2
2. 0.4 km/h 3. 36.62 km/h 4 . 24 km/H
5. 31. 2 m/s^2.

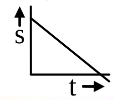
VARIOUS GRAPHS RELATED TO MOTION

DISPLACEMENT- TIME GRAPH

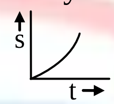
1. The straight line inclined to time axis in s-t graph represents constant velocity.



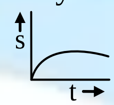
2. In s-t graph the straight line inclined to time axis at angle greater than 90^o shows negative velocity



3. Body with accelerated motion

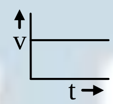


4. Body with decelerated motion

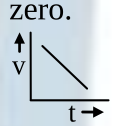


VELOCITY - TIME GRAPH

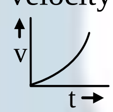
1. For the body having constant velocity or zero acceleration.



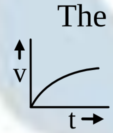
2. The body is moving with constant retardation and its initial velocity is not zero.



3. The body is accelerated and the initial velocity is zero.

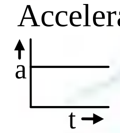


4. The body is decelerated

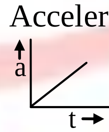


ACCELERATION-TIME GRAPH

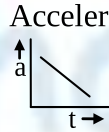
1 Acceleration is constant



2. Acceleration is increasing and is +ve



3. Acceleration is decreasing and is –ve

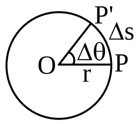


CIRCULAR MOTION

When a body moves in such a way that its distance from a fixed point always remains constant, then its motion is said to be the circular motion.

UNIFORM CIRCULAR MOTION

1. If the radius vector sweeps out equal angles in equal times, then its motion is said to be uniform circular motion.



2. In uniform circular motion speed remains const.
3. Linear velocity, being a vector quantity, its direction changes continuously.
4. The direction of velocity is along the tangent at every point.

ANGULAR VELOCITY

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

1. A vector quantity
2. Direction is perpendicular to plane of rotation

Note : If the particle is revolving in the clockwise direction then the direction of angular velocity is perpendicular to the plane downwards. Whereas in case of anticlockwise direction, the direction will be upwards.

3. Unit is Radian/sec.
4. In uniform circular motion the direction of angular velocity is along the axis of rotation which is constant throughout.
5. Angular velocity remains constant in magnitude as well as in direction.
6. $v = r\theta$, where r = radius of the circle.

CENTRIPETAL ACCELERATION

1. In uniform circular motion the particle experiences an acceleration called the centripetal acceleration.
2. $a_C = \frac{v^2}{r}$
3. The direction of centripetal acceleration is along the radius towards the centre.

CENTRIPETAL FORCE

1. Always acts towards centre.
2. Centripetal force is required to move a particle in a circle.
3. Because F_C is always perpendicular to velocity or displacement, hence the work done by this force will always be zero.

Note :

1. Circular motion in horizontal plane is usually uniform circular motion.

2. Remember that equations of motion are not applicable for circular motion.

TIME PERIOD

1. It is the time taken to complete one complete revolution.
2. In one revolution, angle subtended is 2π and if T is time period, then the angular velocity is given by

$\omega = \frac{2\pi}{T}$ or $T = \frac{2\pi}{\omega}$

FREQUENCY

1. Frequency is defined as the number of revolutions per second.

i.e. $n = \frac{1}{T} = \frac{\omega}{2\pi}$

EXAMPLE – 19

A particle moves in a circle of radius 2 m and completes 5 revolutions in 10 seconds. Calculate the following :

(i) Angular velocity and (ii) Linear velocity.

Solution:

Since, it completes 5 revolutions in 10 seconds.

Time period = $\frac{10}{5}$ = 2s

(i) Now angular velocity, $\omega = \frac{2\pi}{T} = \frac{2\pi}{2} = \pi$ rad/s

(ii) Linear velocity is given by

$v = r\,\omega = 2\pi \Rightarrow v = 2\pi$ m/s

EXAMPLE – 20

The length of second's needle in a watch is 1.2 cm. Calculate the following :

(i) Angular velocity and

(ii) Linear velocity of the tip of the needle.

Solution:

(i) We know that the second's needle in a watch completes one revolution in 60 seconds.

$\Rightarrow$ Time period, T = 60 s

Angular velocity,

$\omega = \frac{2\pi}{T} = \frac{2\pi}{60} = \frac{\pi}{30}$ rad/s

(ii) Length of the needle = 1.2 cm = Radius of the circle

Linear velocity of the tip of the needle is given by

$v = r\,\omega = 1.2 \times \frac{\pi}{30} = \frac{\pi}{25}$

or $v = \frac{\pi}{2s} = 1.266 \times 10^{-1}$ cm/sec.

EXAMPLE – 21

Earth revolves around the sun in 365 days. Calculate its angular velocity.

Solution:

Time period, T = 365 days

= 365 × 24 × 60 × 60 seconds

So, Angular velocity, $\omega = \frac{2\pi}{T}$

$= \frac{2\pi}{365\times24\times60\times60}$ rad/s = 1.99 × 10^{-7} rad/s.

DPP # 3

1. 1c is equal to :
(A) 57.30 (B) 5730 (C) 1800 (D) 3600
2. An athlete complete one round of a circular track of diameter 200 m in 40 s. What will be the displacement at the end of 2 minutes 40 s.?
(A) 2200 m (B) 220 m (C) 22 m (D) Zero
3. What will be the distance in the above equation?
(A) 2512 m (B) 2500 m (C) 2200 m (D) Zero
4. The distance traveled by a body is directly proportional to the time, then the body is said to have :
(A) Zero speed (B) Zero velocity
(C) Constant speed (D) None of these
5. An athlete runs along a circular track of diameter 28m. The displacement of the athlete after he completes one circle is :
(A) 28 m (B) 88 m (C) 44 m (D) Zero
6. A boy is running along a circular track of radius 7 m. He completes one circle in 10 second. The average velocity of the boy is :
(A) 4.4 m-1 (B) 0.7 ms-1
(C) Zero (D) 70 ms-1
7. A body is moving with a uniform speed of 5 ms-1 in a circular path of radius 5 m. The acceleration of the body is :
(A) 25 ms-2 (B) 15 ms-2
(C) 5 ms-2 (D) 1 ms-2
8. Unit of angular velocity is :
(A) red (B) m/s (C) rad/s2 (D) rad/s

ANSWERS:

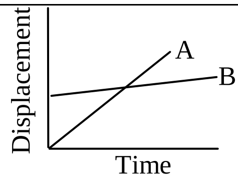
1. A 2. D 3. A 4. C 5. D 6. C
7. C 8. D

SOME POINTS TO REMEMBER

1. Motion is a change of position; it can be described in terms of the distance moved or the displacement.
2. The motion of an object could be uniform or non-uniform depending on whether its velocity is constant or changing.
3. The speed of an object is the distance covered per unit time, and velocity is the displacement per unit time.
4. The acceleration of an object is the change in velocity per unit time.
5. Uniform and non-uniform motions of objects can be shown through graphs.
6. The motion of an object moving at uniform acceleration can be described with the help of the following equations, namely:
$v = u + at$
$s = ut + ½ at^2$
$2as = v^2 – u^2$
where u is initial velocity of the object, which moves with uniform acceleration a for time t, v is its final velocity and s is the distance it travelled in time t.
7. If an object moves in a circular path with uniform speed, its motion is called uniform circular motion.

PROBLESM ON MOTION
LEVEL – 1

1 Can the speed of a body moving with a constant velocity change ?
2 Can the velocity of a body moving with a uniform speed change ?
3 Can average velocity of a moving body be zero?
4 Can average speed of a moving body be zero?
5 Time-displacement graph is a straight line parallel to the time axis. What is its velocity and the acceleration ?
6 What is the acceleration of a body moving with constant velocity ?
7 A stone is thrown upwards, reaches a height h and comes back. What are the distance moved and displacement ?
8 A particle moves along the circumference of a circle in half cycle. Calculate the distance travelled and displacement.
9 Define uniform circular motion.
10 What is the relation between linear velocity and angular velocity ?
11 Does uniform circular motion has accelerated motion or no acceleration at all?
12 What is the direction of angular velocity ?
13 In uniform circular motion, does the angular velocity remain constant or if changes with time.
14 A car starts moving with 20 m/s and its velocity becomes 80 m/s after 6 sec. Calculate its acceleration.
15 A body is thrown vertically up with a velocity 98 m/s. How much high it will rise ? ($g = 9.8\ m/s^2$).
16 A body falls from a height of 500 m. In how much time, will it strike the ground ?
17 Time-displacement graphs of two bodies A and B are shown in the Figure. Which one has larger velocity ?



18 The velocity of a body is 72 km/hr. Calculate its value in m/s.

19 Define state of motion.

20 Differentiate between the following :

(i) speed and velocity,

(ii) distance and displacement

21 Displacement of a body can be zero even when the distance travelled is not zero. Explain.

22 What do you mean by negative and positive acceleration ? Explain.

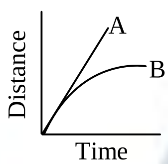
23 A train is moving with a constant speed of 40 km/hr. Draw time-speed graph. From this, draw time-distance graph upto 5 hours from the start.

24 Draw the graph for uniform motion.

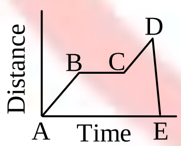
(i) Displacement - Time

(ii) Velocity - Time

25 In the given figure A and B represent uniform motion or accelerated motion.

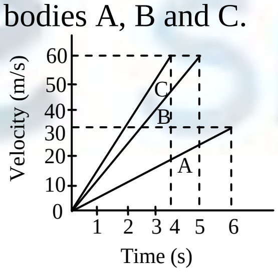


26 In the given Figure. What type of motion are represented by the parts AB, BC, CD and DE.



27 For a moving body distance travelled is directly proportional to the time. What do you conclude about its speed ?

28 Figure shows the time velocity graphs for three bodies A, B and C.



(i) Which body has minimum acceleration ?

(ii) Which body has maximum acceleration ?

29 A body starting with initial velocity u moves with a constant acceleration a. Find the expression for distance travelled in nth seconds.

30 A body starting from rest moves with a constant acceleration. It moves a distance s_1 in first 5 seconds and a distance s_2 in next 5 seconds. Prove that □$s_2 = 3s_1$.

31 An engine is moving with a velocity 44 m/s. After applying the brakes, it stops after covering a distance of 121 m. Calculate retardation and time taken by the engine to stop.

32 A body is thrown vertically up with an initial velocity of 60 m/s. If $g = 10\ m/s^2$, at what time, it will be at a height of 100 m.

33 What do you mean by average speed ? How will you find average speed from time-distance graph ?

34 What is the difference between time-speed and time-velocity graph ? In what condition, they are similar ?

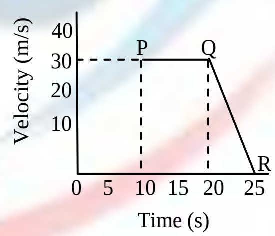
35 What do you mean by acceleration ? How do you find acceleration from time-velocity graph?

36 Time-velocity graph of a body is shown in figure Calculate the following :

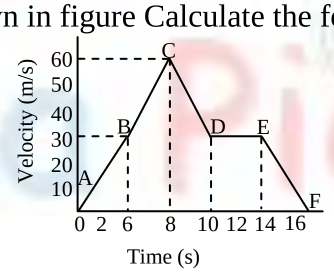
(i) Distance travelled in first 10 s

(ii) Acceleration at t = 15 s

(iii)Acceleration between t = 20 s to t = 25s.



37 Time velocity graph of a moving body is shown in figure Calculate the following :



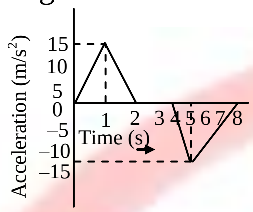
(i) Change in velocity during t = 6s to t = 8s

(ii) Average acceleration during t = 10s to t = 12s.

(iii) In which time interval acceleration will be zero.

(iv) Acceleration during t = 14 s to t = 16 s.

38 Time-acceleration graph of a moving body is shown in figure Calculate the following :



(i) Time interval in which acceleration will be zero.

(ii) Acceleration at t = 5 s.

(iii) Change in velocity during time interval t = 4s and t = 8 s.

39 An artificial satellite is moving in a circular orbit of radius 42, 250 km. Find its speed if it takes 24 hours to revolve round the earth.

40 On 120 km track, a train travels the first 30 km with a uniform speed of 30 km/h. How fast must the train travel the next 90 km so as to average 60 km/hr for entire trip ?

ANSWERS:

1. no **2.**yes **3.** Yes **4.** No **5.** 0, 0 **6.** 0
7. 2h, 0 **8.** πr, 2r **10.** v = rθ **11.** accelerated motion
12. along the axis of rotation **13.** remains constant
14. 10m/sec^2 **15.** 490 m **16.** 10s
17. A **18.** 20 m/sec **27.**A uniform motion, B. accelerated motion **28.** (i) A, (ii) C
31. 8 m/sec^2, 5.5s **32.** 2s, 10s **36.** **(**i) 300 m (ii) 0 m/s^2, (iii) –6 m/s^2 **37.** (i) 30 m/s, (ii) 0, (iii) 10 to 14 s, (iv) – 15 m/s^2 **38.** (i) 2 to 4s, (ii) – 15 m/s^2 (iii) 30 m/s **39.** 3.1 km/sec **40.** 90 km/h

LEVEL – 2

1. A particle is moving in a circular path of radius r. The displacement after half a circle would be :
(a) 0 (b) πr (c) 2r (d) 2πr

2. The numerical ratio of displacement to distance for a moving object is :
(a) always less than 1
(b) equal to 1 or more than 1
(c) always more than 1
(d) equal to 1 or less than 1

3. A boy is sitting on a merry-go-round which is moving with a constant speed of 10 m/s This means that the boy is :
(a) at rest
(b) moving with no acceleration
(c) in accelerated motion
(d) moving with uniform velocity

4. In which of the following cases of motion, the distance moved and the magnitude of displacement are equal ?
(a) if the car is moving on straight road
(b) if the car is moving on circular road
(c) if the pendulum is moving to and fro
(d) if a planet is moving around the sun

5. The speed of a moving object is determined to be 0.06 m/s. This speed is equal to :
(a) 2.16 km/h (b) 1.08 km/h
(c) 0.216 km/h (b) 0.0216 km/h22

6. A freely falling object travels 4.9 m in 1st second, 14.7 m in 2nd second, 24.5 m in 3rd second, and so on. This data shows that the motion of a freely falling object is a case of :
(a) uniform motion
(b) uniform acceleration
(c) no acceleration (d) uniform velocity

7. When a car runs on a circular track with a uniform speed, its velocity is said to be changing. This is because :
(a) the car has a uniform acceleration
(b) the direction of car varies continuously
(c) the car travels unequal distances in equal time intervals
(d) the car travels equal distances in unequal time intervals

8. Which of the following statement is correct regarding velocity and speed of a moving body ?
(a) velocity of a moving body is always higher than its speed
(b) speed of a moving body is always higher than its velocity
(c) speed of a moving body is its velocity in a given direction
(d) velocity of a moving body is its speed in a given direction

9. Which of the following can sometimes be 'zero' for a moving body ?
(i) average velocity (ii) distance travelled
(iii) average speed (iv) displacement
(a) only (i) (b) (i) and (ii)
(c) (i) and (iv) (d) only (iv)

10. When a car driver travelling at a speed of 10 m/s applies brakes and brings the car to

rest in 20 s, then retardation will be :
(a) + 2 m/s2 (b) – 2 m/s2
(c) – 0.5 m/s2 (d) + 0.5 m/s2

11. Which of the following could not be a unit of speed ?
(a) km/h (b) s/m
(c) m/s (d) mm/s

12. One of the following is not a vector quantity. This one is :
(a) displacement (b) speed
(c) acceleration (d) velocity

13. Which of the following could not be a unit of acceleration ?
(a) km/s2 (b) cm s–2
(c) km/s (d) m/s2

14. A graph is plotted showing of a car as a function of time. If the graph is a straight line, it means that
(a) the car started at rest
(b) acceleration was constant
(c) acceleration was increasing
(d) velocity was constant

15. If the initial velocity of an object is equal to final velocity, the value of acceleration is
(a) positive (b) negative
(c) zero (d) infinite

16. A body thrown vertically upwards reaches a maximum height h. It then returns to ground. The distance and the displacement travelled by the body respectively are
(a) 2h , zero (b) h , zero
(c) zero, 2h (d) zero, h

17. If a car is traveling north on a straight road and its brakes are applied, it will
(a) have no acceleration
(b) accelerate to the south
(c) accelerate to the north
(d) accelerate either east or west

18. 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. The what is the displacement of the athletes when they touch the finish line?
(a) zero (b) 3 m
(c) 5 m (d) 7 m

19. When an object travels equal distances in equal intervals of time, howsoever small the interval may be, the motion of the object is said to be
(a) uniform (b) non-uniform
(c) circular motion (d) oscillatory motion

20. Which of the following is an example of non-uniform acceleration?
(a) The motion of a bicycle going down the slope of a road when the rider is not pedalling and wind resistance is negligible.
(b) The motion of a ball rolling down an inclined plane.
(c) The motion of a freely falling body.
(d) The movement of a car in a crowded road.

21. A quantity has a value of 6 0. m/s. It may be the
(a) speed of a particle
(b) velocity of a particle
(c) position of a particle
(d) displacement of a particle

22. If a body is moving at constant speed in a circular path, its
(a) velocity is constant and its acceleration is zero.
(b) velocity and acceleration are both changing direction only.
(c) velocity and acceleration are both increasing.
(d) velocity is constant and acceleration is changing direction acceleration are both changing direction only.

23. The area under speed-6time graph represents a physical quantity whose unit is equal to the unit of
(a) light year (b) area
(c) volume (d) acceleration

24. Fill in the following blanks with suitable words :
(a) If a body moves with uniform velocity, its acceleration is ....
(b) The slope of a distance-time graph indicates ....of a moving body.
(c) The slope of a speed-time graph of a moving body gives its...................
(d) In a speed-time graph, the area enclosed by the speed-time curve and the time axis gives the .... by the body.
(e) It is possible for something to accelerate but not change its speed if it moves in a ....

ANSWERS:

1. (c) 2. (d) 3. (c) 4. (a) 5. (c)
6. (b) 7. (b) 8. (d) 9. (c) 10. (d) 11. (b)
12. (b) 13. (c) 14. (b) 15. (c) 16. (a) 17. (b)

18. (a) 19. A 20. (d) 21. (b) 22. (a) 23. a

FILL IN THE BLANSKS:

2. (a) zero (b) speed (c) acceleration
(d) distance travelled (e) circular path

LEVEL – 2

1 A body whose position with respect to surrounding does not change, is said to be in a state of -
(A) Rest (B) Motion
(C) Vibration (D) Oscillation

2 In case of a moving body-
(A) Displacement > Distance
(B) Displacement < Distance
(C) Displacement = Distance
(D) Displacement $\geq$ Distance

3 Vector quantities are those which have :
(A) Only direction
(B) Only Magnitude
(C) Magnitude and direction both
(D) None of these

4 What is true about scalar quantities ?
(A) Scalars quantities have direction also.
(B) Scalars can be added arithmetically.
(C) There are special laws for scalar addition.
(D) Scalars have special method to represent.

5 A body is said to be in motion if -
(A) Its position with respect to surrounding objects remains same
(B) Its position with respect to surrounding objects keep on changing
(C) both (A) and (B)
(D) Neither (A) nor (B)

6 A distance is always-
(A) shortest length between two points
(B) path covered by an object between two points
(C) product of length and time
(D) none of the above

7 A displacement-
(A) is always positive
(B) is always negative
(C) may be positive as well as negative
(D) is neither positive nor negative

8 Examples of vector quantities are:
(A) velocity, length and mass
(B) speed, length and mass
(C) time, displacement and mass
(D) velocity, displacement and force

9 Which of the following is not characteristic of displacement ?
(A) It is always positive.
(B) It has both magnitude and direction.
(C) It can be zero.
(D) Its magnitude is less than or equal to the actual path length of the object.

10 S.I. unit of displacement is-
(A) m (b) ms^{-1}
(C) ms^{-2} (D) none of these

11 Which of the following is not a vector?
(A) Speed (B) Velocity
(C) Weight (D) Acceleration

12 Time is an example of:-
(A) Scalar (B) Vector
(C) Scalar or vector
(D) Neither scalar nor vector

13 In five minutes distance between a pole and a car changes progressively. What is true about the car ?
(A) Car is at rest (B) Car is in motion
(C) Nothing can be said with this information
(D) None of the above

14 A distance -
(A) Is always positive
(B) Is always negative
(C) May be positive as well as negative
(D) Is neither positive nor negative

15 When a body covers equal distance in equal intervals of time, its motion is said to be :
(A) Non-uniform
(B) Uniform
(C) Accelerated
(D) Back and forth

16 The motion along a straight line is called:
(A) Vibratory (B) Stationary
(C) Circular (D) Linear

17 A particle is traveling with a constant speed. This means-
(A) Its position remains constant as time passes
(B) It covers equal distances in equal interval of time
(C) Its acceleration is zero
(D) It does not change its direction of motion

18 The rate of change of displacement is -
(A) Speed (B) Velocity
(C) Acceleration (D) Retardation

19 Speed is never -
(A) Zero (B) Fraction

(C) Negative (D) Positive

20 The motion of a body covering different distances in same intervals of time is said to be -
(A) Zig-Zag (B) Fast
(C) Slow (D) Variable

21 Unit of velocity is :
(A) ms (B) ms^{-1}
(C) ms^{-2} (D) none of these

22 Metre per second is not the unit of -
(A) Displacement (B) Velocity
(C) Speed (D) None of them

23 A particle moves with a uniform velocity -
(A) The particle must be at rest
(B) The particle moves along a curved path
(C) The particle moves along a circle
(D) The particle moves along a straight line

24 A quantity has value of $-6.0\ ms^{-1}$. It may be the-
(A) Speed of a particle
(B) Velocity of a particle
(C) Position of a particle
(D) Displacement of a particle

25 In 10 minutes, a car with speed of 60 kmh^{-1} travels a distance of -
(A) 6 km (B) 600 km
(C) 10 km (D) 7 km

26 A particle covers equal distances in equal intervals of time, it is said to be moving with uniform-
(A) Speed (B) Velocity
(C) Acceleration (D) Retardation

27 The SI unit of the average velocity is -
(A) m/s (B) km/s
(C) cm/s (D) mm/s

28 A car accelerates uniformly from 18 km/h to 36km/ h in 5 s. The acceleration in ms^{-2} is -
(A) 1 (B) 2 (C) 3 (D) 4

29 Out of energy and acceleration which is vector ?
(A) Acceleration (B) Energy
(C) Both (D) None of these

30 C.G.S. unit of acceleration is -
(A) ms^{-2} (B) $cm\ s^{-2}$
(C) ms^{-2} (D) $cm\ s^{2}$

31 A train starting from a railway station and moving with uniform acceleration, attains a speed of 40 kmh^{-1} in 10 minutes. Its acceleration is -
(A) 18.5 ms^{-2} (B) 1.85 $cm\ s^{-2}$
(C) 18.5 cms^{-2} (D) 1.85 $m\ s^{-2}$

32 The brakes applied to a car produce a negative acceleration of $6ms^{-2}$. If the car stops after 2 seconds, the initial velocity of the car is -
(A) 6 ms^{-1} (B) 12 ms^{-1}
(C) 24 ms^{-1} (D) Zero

33 A body is moving with uniform velocity of 10 ms^{-1}. The velocity of the body after 10 s is -
(A) 100 ms^{-1} (B) 50 ms^{-1}
(C) 10 ms^{-1} (D) 5 ms^{-1}

34 In 12 minutes a car whose speed is 35kmh^{-1} travels a distance of -
(A) 7 km (B) 3.5 km
(C) 14 km (D) 28 km

35 A body is moving along a straight line at 20 ms^{-1} undergoes an acceleration of 4 ms^{-2}. After 2 s, its speed will be-
(A) 8 ms^{-1} (B) 12 ms^{-1}
(C) 16 ms^{-1} (D) 28 ms^{-1}

36 A car increase its speed from 20 kmh^{-1} to 50 kmh^{-1} in 10 s., its acceleration is -
(A) 30 ms^{-2} (B)3 ms^{-1}
(C) 18 ms^{-2} (D) 0.83 ms^{-2}

37 When the distance travelled by an object is directly proportional to the time, it is said to travel with-
(A) zero velocity (B) constant speed
(C) constant acceleration
(D) uniform velocity

38 A body freely falling from rest has a velocity v after it falls through a height h. The distance it has to fall further for its velocity to become double is -
(A) 3 h (B) 6 h (C) 8 h (D) 10 h

39 The velocity of a bullet is reduced from 200 m/s to 100 m/s while travelling through a wooden block of thickness 10 cm. The retardation, assuming it to be uniform, will be
(A) $10 \times 10^4\ m/s^2$ (B) $1.2 \times 10^4\ m/s^2$
(C) $13.5 \times 10^4\ m/s^2$ (D) $15 \times 10^4\ m/s^2$

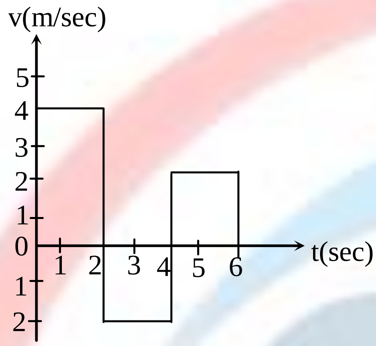
40 A body starts falling from height 'h' and travels distance h/2 during the last second of motion. The time of travel (in sec.) is-
(A) $\sqrt{2}-1$ (B) $2+\sqrt{2}$
(C) $\sqrt{2}+\sqrt{3}$ (D) $\sqrt{3}+2$

41 Area between speed-time graph and time axis gives-
(A) Distance (B) Velocity
(C) Speed (D) None of these

42 An object undergoes an acceleration of

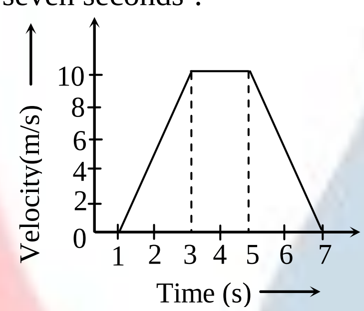
$8 ms^{-2}$ starting from rest. Distance travelled in 1 sec. is-
(A) 2 m (B) 4 m (C) 6 m (D) 8 m

43 The velocity-time graph of a body moving in a straight line is shown in figure. The displacement and distance travelled by the body in 6 second are respectively-



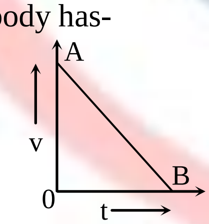
(A) 8m , 16m (B) 16m, 8m
(C) 16m, 16m (D) 8m, 8m

44 For the velocity time graph shown in figure, the distance covered by the body in the last two seconds of its motion is what fraction of the total distance covered in all the seven seconds ?



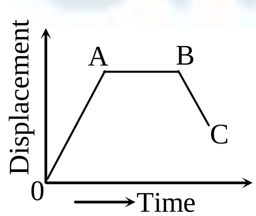
(A) 1/2 (B) 1/4 (C) 1/3 (D) 2/3

45 Velocity-time graph AB (Figure) shows that the body has-



(A) A uniform acceleration
(B) A non uniform retardation
(C) Uniform speed
(D) Initial velocity OA and is moving with uniform retardation

46 In figure BC represents a body moving-



(A) Backwards with uniform velocity
(B) Forward with uniform velocity
(C) Backward with non-uniform velocity
(D) Forward with non-uniform velocity

47 1^C is equal to-
(A) 57.3° (B) 573°
(C) 180° (D) 360°

48 An athlete complete one round of a circular track of diameter 200 m in 40 s. What will be the displacement at the end of 2 minutes 40 s?
(A) 2200 m (B) 220 m
(C) 22 m (D) Zero

49 What will be the distance in the above question?
(A) 2512 m (B) 2500 m
(C) 2200 m (D) Zero

50 The distance travelled by a body is directly proportional to the time, then the body is said to have -
(A) Zero speed (B) Zero velocity
(C) Constant speed (D) None of these

51 An athlete runs along a circular track of diameter 28 m. The displacement of the athlete after he completes one circle is -
(A) 28 m (B) 88 m
(C) 44 m (D) Zero

52 A boy is running along a circular track of radius 7 m. He completes one circle in 10 second. The average velocity of the boy is -
(A) 4.4 ms^{-1} (B) 0.7 ms^{-1}
(C) Zero (D) 70 ms^{-1}

53 A body is moving with a uniform speed of 5 ms^{-1} in a circular path of radius 5 m. The acceleration of the body is:
(A) 25 ms^{-2} (B) 15 ms^{-2}
(C) 5 ms^{-2} (D) 1 ms^{-2}

54 Unit of angular velocity is –
(A) rad (B) m/s
(C) rad/s^2 (D) rad/s

55 Two bodies in circular paths of radii 1 : 2 take same time to complete their circles. The ratio of their linear speeds is-
(A) 1 : 2 (C) 2 : 1
(C) 1: 3 (D) 3 : 1

56 In a circular path of radius 1 m, a mass of 2 kg moves with a constant speed of 10m/s. The angular speed in radian/sec. is -
(A) 5 (B) 10 (C) 15 (D) 20

57 The relation among v, θ and r is -
(A) $\omega = \frac{v}{r}$ (B) $v = \frac{\omega}{r}$

(C) $\omega = \frac{r}{v}$ (D) None of these

58 Uniform circular motion is an example of:
(A) Constant acceleration
(B) Variable acceleration
(C) A and B both (D) None of these

59 Rate of change of angular velocity refer to:
(A) angular speed
(B) angular displacement
(C) angular acceleration
(D) None of these

60 A car travels $\left(\frac{1}{4}\right)^{th}$ of a circle with radius r. The ratio of the distance to its displacement is-
(A) $1 : \frac{\pi}{2\sqrt{2}}$ (B) $\frac{\pi}{2\sqrt{2}} : 1$
(C) $2\sqrt{2} : \pi$ (D) $\pi 2\sqrt{2} : 1$.

FILL IN THE BLANK

1. 1. The magnitude of average velocity .... equal to the average speed.
2. Distance travelled divided by elapsed time gives ....
3. A body, dropped from a tower with zero velocity, reaches the ground in 4 sec. The height of the tower is about .... m
4. A ball thrown vertically upwards return to its starting point in 4s. If g = 10 m s/ 2 , its initial speed was ....
5. When negative acceleration acts on a moving body its velocity ....
6. A stone is let to fall from a building of height 30m. The ratio of heights fallen by it after 2s and 3s is..........
7. If a car starts at rest and accelerates uniformly, the distance it travels is proportional to the .... of the time it travels.
8. The speed-time graph of a moving object is a straight line parallel to the time-axis. It means the speed is ....
9. If a car is going northward and the driver jams on its brakes, the direction of its acceleration is ....
10. A body moving with a uniform speed along a circle has .... velocity.

ANSWERS

1. A 2. D 3. C 4. B 5. B 6. B 7. C
8. D 9. A 10. A 11. A 12. A 13. B
14. A 15. B 16. D 17. B 18. B 19. C
20. D 21. B 22. A 23. D 24. B 25. C
26. A 27. A 28. A 29. A 30. B 31. B
32. B 33. C 34. A 35. D 36. D 37. B
38. A 39. D 40. B 41. A 42. B 43. A
44. B 45. D 46. A 47. A 48. D 49. A
50. C 51. D 52. C 53. C 54. D 55. A
56. B 57. A 58. B 59. C 60. B

FILL IN THE BLANKS:

1. may or may not be 2. average speed 3. 80
4. 20 m/s 5. Decrease 6. 4 : 9 7. Square
8. Uniform 9. South 10. variable

LEVEL – 4

1. A bus increases its speed from 36 km/h to 72 km/h in 10 seconds. Its acceleration is :
(a) 5 m/s2 (b) 2 m/s2
(c) 3.6 m/s2 (d) 1 m/s2

2. A bus moving along a straight line at 20 m/s undergoes an acceleration of 4 m/s2. After 2 seconds, its speed will be :
(a) 8 m/s (b) 12 m/s
(c) 16 m/s (d) 28 m/s

3. The slope of a speed-time graph gives :
(a) distance travelled (b) velocity
(c) acceleration (d) displacement

4. The area under a speed-time graph represents a physical quantity which has the unit of :
(a) m (b) m^2 (c) m/s (d) m/s^2

5. If the displacement of an object is proportional to the square of time, then the object is moving with :
(a) uniform velocity
(b) uniform acceleration
(c) increasing acceleration
(d) decreasing acceleration

6. A car of mass 1000 kg is moving with a velocity of 10 m s–1. If the velocity-time graph for this car is a horizontal line parallel to the time axis, then the velocity of car at the end of 25 s will be :
(a) 25 m/s (b) 40 m/s
(c) 10 m/s (d) 250 m/s

7. A motorcycle is being driven at a speed of 20 m/s when brakes are applied to bring it to rest in five seconds. The deceleration produced in this case will be :
(a) + 4 m/s^2 (b) – 4 m/s^2
(c) + 0.25 m/s^2 (d) – 0.25 m/s^2

8. A sprinter is running along the circumference of a big sports stadium with

constant speed. Which of the following do you think is changing in this case ?
(a) magnitude of acceleration being produced
(b) distance covered by the sprinter per second
(c) direction in which the sprinter is running
(d) centripetal force acting on the sprinter

9. Which one of the following is most likely not a case of uniform circular motion ?
(a) motion of the earth around the sun
(b) motion of a toy train on a circular track
(c) motion of a racing car on a circular track
(d) motion of hours' hand on the dial of a clock

10. A particle is moving in a circular path of radius r. The displacement after half a circle would be:
(a) Zero (b) πr
(c) 2 r (d) $2\pi r$

11. A body is thrown vertically upward with velocity u, the greatest height h to which it will rise is,
(a) u/g (b) $u^2/2g$
(c) u^2/g (d) u/2g

12. The numerical ratio of displacement to distance for a moving object is
(a) always less than 1
(b) always equal to 1
(c) always more than 1
(d) equal or less than 1

13. If the displacement of an object is proportional to square of time, then the object moves with
(a) uniform velocity
(b) uniform acceleration
(c) increasing acceleration
(d) decreasing acceleration

14. Suppose a boy is enjoying a ride on a merry-go-round which is moving with a constant speed of 10 m/s. It implies that the boy is
(a) at rest
(b) moving with no acceleration
(c) in accelerated motion
(d) moving with uniform velocity

15. Area under a v – t graph represents a physical quantity which has the unit
(a) m^2 (b) m (c) m^3 (d) m/s

16. In which of the following cases of motions, the distance moved and the magnitude of displacement are equal?
(a) If the car is moving on straight road
(b) If the car is moving in circular path
(c) The pendulum is moving to and fro
(d) The earth is revolving around the Sun

ANSWERS:

1. (d) 2. (d) 3. (c) 4. (b) 5. (b) 6. (c)
7. (a) 8. (c) 9. (c) 10. (c) 11. (b) 12. (d)
13. (b) 14. (d) 15. (b) 16. (a)

LEVEL – 5

11. 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?
12. Joseph jogs from one end A to the other end B of a straight 300 m road in 2 minutes 50 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
(a) from A to B and (b) from A to C?
13. Abdul, while driving to school, computes the average speed for his trip to be 20 km/h. On his return trip along the same route, there is less traffic and the average speed is 40 km/h. What is the average speed for Abdul's trip?
14. A motorboat starting from rest on a lake accelerates in a straight line at a constant rate of 3.0 m s^{-2} for 8.0 s. How far does the boat travel during this time?
15. A driver of a car travelling at 52 km/h applies the brakes and accelerates uniformly in the opposite direction. The car stops in 5 s. Another driver going at 3 km/h in another car applies his brakes slowly and stops in 10 s. 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?
16. 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 an acceleration in the perpendicular direction.
17. 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.

18. Match the Column

Column-I	Column-II
(A) Uniform speed	(p) Unequal distance in equal time
(B) Constant speed	(q) Zero acceleration
(C) Uniform acceleration	(r) Unequal velocity in equal time change
(D) Non-uniform acceleration	(s) Equal distance in equal time
(E) Non-uniform speed	(t) Equal velocity change in equal time

ANSWERS:

18. (A) - (s), (B) - (q), (C) - (t), (D) - (r), (E) - (p)

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