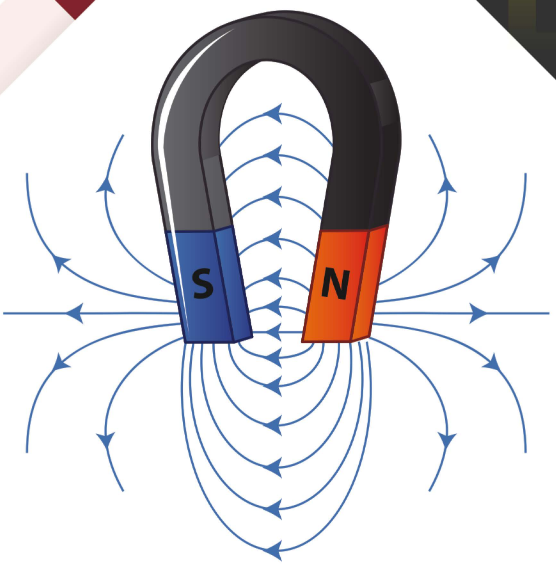
NEET Sarthi KOTA

PHYSICS

CHAPTER

MOTION



HORSESHOE MAGNET

SAMPLE MODULE

CLASS : 9^{th}

Online Platform for

NEET, JEE & NTSE

NEET SARTHI PRE NURTURE MODULES DETAILS

SUBJECTS	Class 6	Class 7	Class 8	Class 9	Class 10
Physics	Module 1	Module 1	Module 1	Module 1	Module 1
Chemistry	Module 1	Module 1	Module 1	Module 1	Module 1
Biology	Module 1	Module 1	Module 1	Module 1	Module 1
Maths	Module 1	Module 1 Module 2	Module 1	Module 1 Module 2	Module 1 Module 2
Social Science	Module 1	Module 1	Module 1	Module 1 Module 2	Module 1 Module 2
Mental Ability	Module 1	Module 1	Module 1	Module 1	Module 1 Module 2
Total No. of Modules	**6**	**7**	**6**	**8**	**9**

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Physics

PRE-NURTURE DIVISION

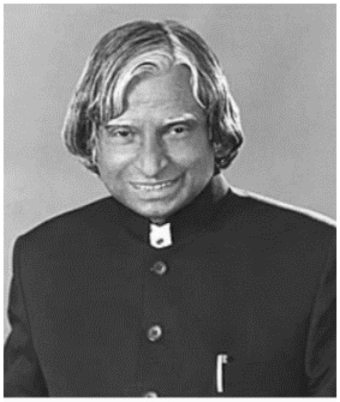
Sample Module English

STUDENT NAME:______________________________________

SECTION: ________________________ROLL NO: ___________

CONTENTS

"To succeed in your mission, you must have single-minded devotion to your goal."



Dr. A.P.J. Abdul Kalam

Dr. A.P.J. Abdul Kalam, popularly known as the 'Missile Man' of India, was a source of inspiration for tens and thousands of Indians. A league apart, his life philosophy and teachings are not only admired by the older generation, but especially reminisced by young. Kalam's prodigious rise from Rameswaram, a small but famous pilgrimage town in Tamil Nadu, led him to become one of the world's most accomplished leaders.

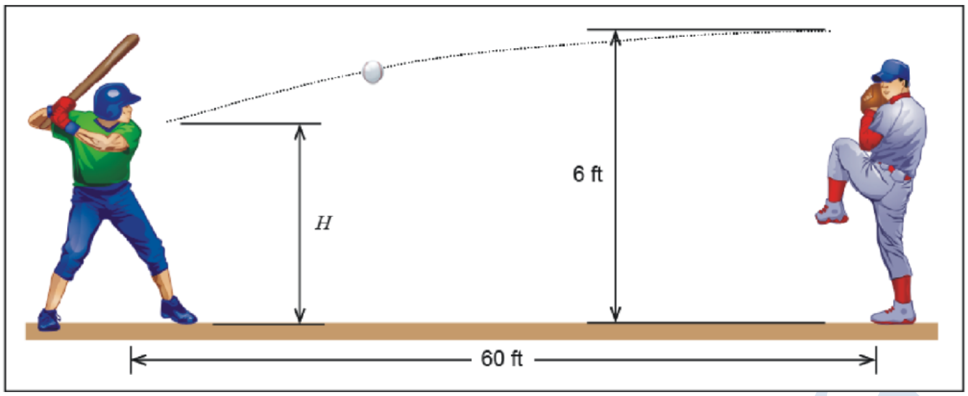
"All power is within you; you can do anything and everything."

Swami Vivekananda

Swami Vivekananda ji's original name was Narendranath. He was born on 12th January, 1863 at Kolkata (Swamiji's Jayanti i.e. birth anniversary is celebrated as the 'International Youth Day'). Right from childhood, two aspects of his behavior could clearly be noticed. One was his devout and compassionate nature and the other was his readiness to perform any act of courage.

Chapter-01

Motion



'Kinematics' is the branch of science describing the motion of objects using words, diagrams, number, graphs and equation.

MOTION

Motion is one of the common events in the surrounding. The foundations for the study of motion were laid down more than 300 years ago by Galileo in Italy and later by Isaac Newton in England.

The study of motion comes in the branch of physics called 'mechanics'. Position and motion of a body involves position and time.

Mechanics in broken down into two parts : Kinematics and Dynamics.

Kinematics is the branch of mechanics which deals with the motion regardless of the causes producing it.

The study of causes of motion is called dynamics.

1. FRAME OF REFERENCE

It is a system of which a set of coordinates are attached and with reference to which observer describes any event.

Position

An object is situated at point O and three observers from three different places are looking at same object, then all three observers will have different observations about the position of point O and no one will be wrong. Because they are observing the object from different positions.

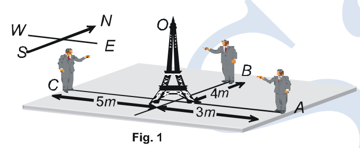


Fig. 1

Observer 'A' says : Point O is 3 m away in west direction.

Observer 'B' says : Point O is 4 m away in south direction.

Observer 'C' says : Point O is 5 m away in east direction.

Therefore position of any point is completely expressed by two factors : Its distance from the observer and its direction with respect to observer.

1.1 Concept of point object

The smallest part of matter with zero dimension which can be described by its mass and position is defined as a particle or point mass.

If the size of a body is negligible in comparison to its range of motion then that body is known as a particle.

A body (Group of particles) can be treated as a particle, depending upon the type of its motion. For examples in a planetary motion around the sun the different planets can be presumed to be the particles.

In above consideration when we treat body as particle, all parts of the body undergo same displacement and have same velocity and acceleration.

1.2 Rest and Motion

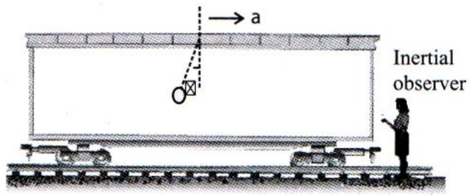
If a body does not change its position as time passes with respect to frame of reference, it is said to be at rest.

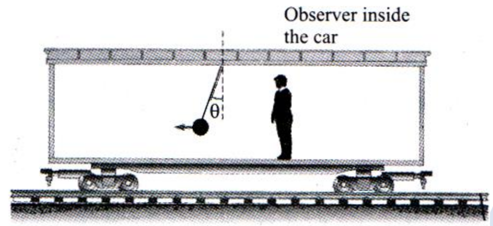
And if a body changes its position as time passes with respect to frame of reference, it is said to be in motion.

Rest and Motion are relative terms

A particle at rest with respect to an observer can be in motion with respect to another observer to the passengers in a moving bus or train, trees, buildings and people on the roadsides observe that the bus or the train and its passengers are moving in the forward direction. At the same time, each passenger in a moving bus or train finds that fellow passengers are not moving, as the distance between them is not changing.

If you will observe the man moving on moving flat car from ground your observation will be different from what man himself will observe. Similarly, if you will observe pendulum in moving car from ground your observation will be different from what person inside car will observe.





2. DISTANCE AND DISPLACEMENT

Distance : The length of the actual path between initial and final positions of a moving object is called 'distance'.

- Distance is a scalar quantity.
- Distance depends on the path.
- Distance is always taken positive.

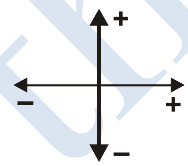


Fig.2-Sign convention for displacement.

Unit of distance : In S.I. system, unit of distance is metre (m). Some other popular units are millimetre (mm) centimetre (cm), kilometre (km).

Displacement : The shortest distance between the initial position and the final poisition of the particle is called displacement.

It is also defined as the change in the position of the particle.

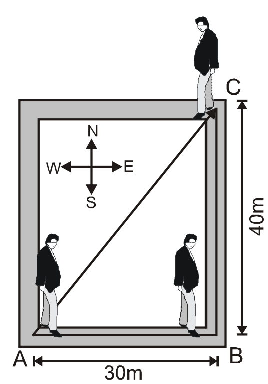
$\mathbf{x_f - x_i}$: where, x_f = final position ; x_i = initial position.

- Displacement is a vector quantity, its direction is always taken from initial position to final position.
- Displacement depends only on initial position and final position, does not depend on path.
- Displacement of a particle in motion can be positive, negative or even zero.

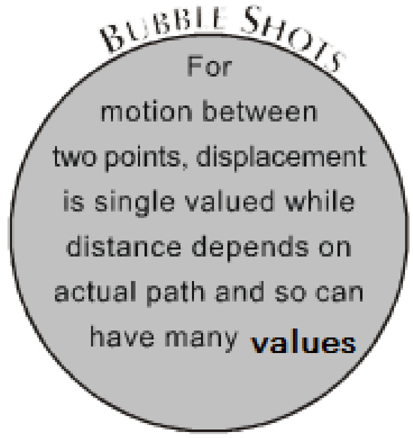
Unit of displacement : Units of distance and displacement are same as both represent some length. Thus, in S.I. system unit of displacement is metre (m). Some other popular units are milimetre (mm), centimetre (cm), kilometre (km). Let us understand the distance and displacement using some real life situation. Suppose a boy walks in a park, as shown in fig.2 His initial position is A. He first walks a distance of 30 m due east. Then, he walks 40 m due north. Here, the distance travelled by him is AB + BC = 30 m + 40 m = 70 m.

His displacement is given by, AC = $\sqrt{AB^2 + BC^2} = \sqrt{(30)^2 + (40)^2} = \sqrt{2500}$ = 50 m

- Distance is always greater than or equal to the magnitude of displacement.
- Whenever a particle changes its direction or follows a curved path, distance is always greater than the magnitude of displacement.
- Distance is exactly equal to displacement (i) when it follows a straight path without changing its direction (ii) when its is in uniform motion.



Understanding distance and displacement



WORKED EXAMPLES

Ex. 1: A particle moves on a circular path of radius ‘r’. It completes one revolution in 40 s. Calculate distance and displacement in 2 min 20 s.

Sol: Radius of path = r

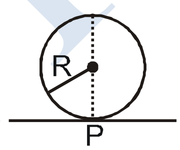
Time period for one revolution = 40 sec

Total number of revolution = $\frac{140}{40} = \frac{7}{2}$

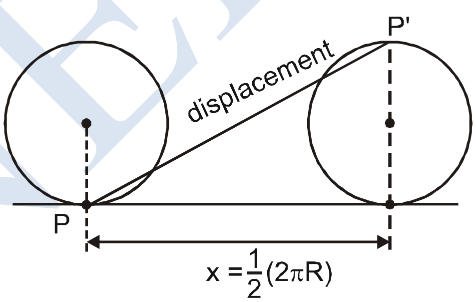
Now distance covered = $2\pi r \times \frac{7}{2} = \frac{44}{7} \times r \times \frac{7}{2} = 22r$

Displacement of particle in one revolution is zero so that displacement of particle = 2r.

Ex. 2: A wheel of radius ‘R’ is placed on ground and its contact point is ‘P’. If wheel rolls down without slipping completing half a revolution, find the displacement of point P.



Sol:



Displacement = $\sqrt{(\pi R)^2 + (2R)^2} = R\sqrt{\pi^2 + 4}$

Ex. 3: The three initial and final position of a man on the x-axis are given as

(i) (–8m, 7m) (ii) (7m, – 3m) and (iii) (–7m, 3m)

which pair gives negative displacement?

Sol: Pair (ii) will give negative displacement.

As (7m, – 3m) has initial position (7m) and final position (–3m)

So,

(Displacement = final position – initial position)

Displacement = – 3m – 7m = – 10m.

Ex. 4: A body is moving along a straight line path with constant velocity. At an instant of time the distance travelled by it is S and its displacement is D, then

(1) D < S (2) D > S (3) D = S (4) $D \le S$

Sol: A———————B

A body is moving on a straight line with constant velocity. Between A and B, the straight line is the shortest distance. This is the distance travelled. The particle starts at A and reaches B along the straight line. Therefore, displacement is also AB. D = S.

My Work Sheet

Q. A farmer has to go 500m due north, 400 m due east and 200m due south to reach his field. If the takes 20 minutes to reach the field.

(a) What distance the has to walk to reach the field?

(b) What is the displacement from his house to field?

Answer: (a) 1100 m, 1(b) 500 m

3. SPEED AND VELOCITY

3.1 Types of Speed

The distance travelled by a particle per unit time is called speed.

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

- Speed is a scalar quantity.
- Speed depends on the path.
- $\boxed{1\text{km}/\text{h} = \frac{5}{18}\text{m}/\text{s}}$
- Speed gives no idea about the direction of motion of the object.
- Speed can never be negative; in motion, it is taken positive; at rest, it is zero.

Unit of speed : C.G.S. system - centimetre/second (cm/s); S.I. system - metre/second (m/s).

Uniform speed : An object is said to be moving with a uniform speed, if it covers equal distance in equal intervals of time. That is, magnitude of speed is constant.

Non uniform speed : An object is said to be moving with a variable speed if it covers unequal distances in equal intervals of time. That is, magnitude of speed is variable.

Average Speed : When an object is moving with a variable speed, then the average speed of the object is thought to be that constant speed with which the object covers the same distance in a given time interval as it does while moving with variable speed during the same time interval.

Average speed is the ratio of the total distance travelled by the object to the total time taken.

$$\boxed{\text{Average speed} = \frac{\text{Total distance travelled}}{\text{Total time taken}}}$$

Instantaneous speed : The speed of the body at any instant of time is called instantaneous speed.

Speedometer of the vehicle measures its instantaneous speed.

- In uniform motion of a particle, the instantaneous speed is equal to its average speed.

3.2 TYPES OF VELOCITY

The rate of change of displacement is called velocity.

- Velocity is a vector quantity.
- Velocity can be negative, positive or zero.
- The direction of average velocity is same as that of the total displacement.
- If average velocity for a journey is positive, it may have a negative instantaneous velocity at some point of time during the journey and vice-versa.

Unit of velocity : C.G.S system - centimetre/second (cm/s) ; S.I. system - metre/second (m/s).

Instantaneous velocity : It is the velocity at some particular instant of time.

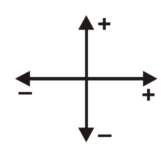
Average velocity : It is the ratio of total displacement of the total time taken.

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

Uniform Velocity : A particle is said to have uniform velocity, if the magnitude as well as the direction of its velocity remains constant. It is possible only when the particles moves in straight line without changing its direction.

Non-uniform Velocity : A particle is said to have non-uniform velocity, if either of magnitude or direction of its velocity changes (or both changes).

- In uniform motion of a particle, the instantaneous velocity is equal to its average velocity.
- Average speed is always greater than or equal to the magnitude of average velocity.
- Whenever a particle changes its direction or follows a curved path, average speed is always greater than the magnitude of average velocity.
- Average speed is exactly equal to average velocity when it follows a straight path without changing its direction.



Sign convention for velocity

- If body covers distance x_1, x_2, x_3 ------ with speeds v_1, v_2, v_3 ------ respectively in same direction then average speed/average velocity of body is given by,

$$\boxed{v_{average} = \frac{x_1 + x_2 + x_3 + ...}{\frac{x_1}{v_1} + \frac{x_2}{v_2} + \frac{x_3}{v_3} + ...}}$$

- **Case of half journey :** If body covers equal distance with different speeds i.e., $x_1 = x_2 = x$ (let),

$$v_{average} = \frac{x+x}{\left(\frac{x}{v_1}+\frac{x}{v_2}\right)} = \frac{2x}{\left(\frac{1}{v_1}+\frac{1}{v_2}\right)} = \frac{2}{\left(\frac{v_2+v_1}{v_1v_2}\right)} = \boxed{\frac{2v_1v_2}{v_1+v_2}}$$

- If a body covers three equal distances with speeds v_1, v_2 and v_3 respectively, then average speed is given by,

$$v_{average} = \frac{x+x+x}{\left(\frac{x}{v_1}+\frac{x}{v_2}+\frac{x}{v_3}\right)} = \frac{3x}{\left(\frac{1}{v_1}+\frac{1}{v_2}+\frac{1}{v_3}\right)} = \frac{3}{\left(\frac{v_1v_2+v_2v_3+v_3v_1}{v_1v_2v_3}\right)} = \boxed{\frac{3v_1v_2v_3}{v_1v_2+v_2v_3+v_3v_1}}$$

- If a body travels with speeds v_1, v_2, v_3, ... during time intervals t_1, t_2, t_3, ... respectively then the average speed of the body is given by, $\boxed{v_{average} = \frac{v_1t_1+v_2t_2+v_3t_3+......}{t_1+t_2+t_3+......}}$

- If the two given time intervals are same i.e., $t_1 = t_2 = t$ (let), then,

$$v_{average} = \frac{v_1t+v_2t}{t+t} = \frac{(v_1+v_2)t}{2t} = \boxed{\frac{v_1+v_2}{2}}$$

BUBBLE SHOTS

For a moving body average speed can never be negative or zero while average velocity can be.

- If the three given time intervals are same i.e. $t_1 = t_2 = t_3 = t$ (let), then,

$$v_{average} = \frac{v_1t+v_2t+v_3t}{t+t+t} = \frac{(v_1+v_2+v_3)t}{3t} = \boxed{\frac{v_1+v_2+v_3}{3}}$$

Ex. 5: A body of mass m moving along a straight line covers half the distance with a speed of 2 m/s. The remaining half of the distance is covered in two equal time intervals with a speed of 3 m/s and 5 m/s respectively. The average speed of the particle for the journey is

(1) $\frac{3}{8}$ m/s (2) $\frac{8}{3}$ m/s (3) $\frac{4}{3}$ m/s (4) $\frac{16}{3}$ m/s

Sol: Let 2S be the total distance travelled by the body. Let t_1 be the time taken by the body to travel first half of the distance.

$\therefore \quad t_1 = \frac{S}{2}$

Let t_2 be the time taken by the body for each time internal for the remaining half journey.

$\therefore \quad S = 3t_2 + 5t_2$ or $\quad t_2 = \frac{S}{8}$

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

$= \frac{2S}{t_1+2t_2} = \frac{2S}{\left(\frac{S}{2}\right)+2\left(\frac{S}{8}\right)} = \frac{2S}{\left(\frac{S}{2}\right)+\left(\frac{S}{4}\right)} = \frac{8}{3}$ m/s

Ex. 6: An auto travels at a rate of 25 km/hr for 4 min. then 50 km/hr for 8 min., finally at 20 km/hr for 2 min., find the distance travelled in km and the average speed for complete trip in m/s.

Sol: Given, v_1 = 25 km/hr ; v_2 = 50 km/hr; v_3 = 20 km/hr ;

t_1 = 4 min = (4/60) hr ; t_2 = 8 min = (8/60) hr ; t_1 = 2 min = (2/60) hr

Distance travelled, s = $v_1t_1 + v_2t_2 = v_3t_3 = 25\times\frac{4}{60}+50\times\frac{8}{60}+20\times\frac{2}{60}=\frac{100+400+40}{60}=\frac{540}{60}=9\text{km}$

Total time, t = $t_1 + t_2 + t_3 = \frac{4}{60}+\frac{8}{60}+\frac{2}{60}=\frac{14}{60}=\frac{7}{30}\text{hr}$

Average speed, v = $\frac{s}{t}=\frac{9\text{km}}{(7/30)\text{hr}}=\frac{9\times30}{7}\text{km/hr}=\frac{9\times30}{7}\times\frac{5}{18}\text{m/s}=\frac{75}{7}\text{m/s}=10.7\text{m/s}$

Ex. 7: On a 60 km track, a train travels the first 30 km at a uniform speed of 30 km/hr. How fast must the train travel the next 30 km so as to average 40 km/hr for entire trip?

Sol: Given, speed for first 30 km, v_1 = 30 km/hr ; speed for next 30 km, v_2 = ?

average speed, $v_{average}$ = 40 km/hr.

This is a case of half journey, therefore, we can apply the formula for half journey directly.

$v_{average}=\frac{2v_1v_2}{v_1+v_2}$ or $40=\frac{2(30)v_2}{30+v_2}$ or $40=\frac{60v_2}{30+v_2}$ or $2=\frac{3v_2}{30+v_2}$

or $2(30 + v_2) = 3v_2$ or $60 + 3v_2 = 3v_2$ or v_2 = 60 km/hr

My Work Sheet

Q. Assertion: The speedometer of an automobile measure the average speed of the automobile.

Reason: Average velocity is equal to total distance divided by total time taken.

(1) If both assertion and reason are true and reason is the correct explanation of assertion.

(2) If both assertion and reason are true but reason is not the correct explanation of assertion.

(3) If assertion is true but reason is false.

(4) If both assertions and reason are false.

Answer: (4)

My Work Sheet

Q.1 A boy walks to his school at a distance of 6 km with constant speed of 2.5 km/hour and walks back with a constant speed of 4 km/hr. His average speed for round trip expressed in km/hour. His average speed for round trip expressed in km/hour, is

(1) 24/13 (2) 40/13 (3) 3 (4) 1/2

Q.2 A man walks on a straight road from his home to a market 2.5 km away with a speed of 5 km/h. Finding the market closed, he instantly turns and walks back home with a speed of 7.5 km/h. The average speed of the man over the interval of time 0 to 40 min. is equal to

(1) 5 km/h (2) $\frac{25}{4}$km/h (3) $\frac{30}{4}$km/h (4) $\frac{45}{8}$km/h

Q.3 A car travels half the distance with constant velocity of 40 kmph and the remaining half with a constant velocity of 60 kmph. The average velocity of the car in kmph is

(1) 40 (2) 45 (3) 48 (4) 50

Answer:1 (2) 2 (4) 3 (3)

4. UNIFORM AND NON-UNIFORM MOTION

- **Uniform motion :** It is a motion in which a material point in a straight line (rectilinear) and covers equal distances in equal intervals of time. The path length of a body in a uniform rectilinear is equal to the magnitude of the displacement. Consequently, the path length (s) in the motion is equal to the magnitude of the velocity (v) multiplied by the time (t) i.e., s = vt.

  $x = x_0 + s = x_0 + vt$

NOTE:

- No force is required to keep an object in uniform motion. When an object has uniform motion along a straight line in a given direction, the magnitude of displacement is equal to actual distance covered.
- **Non-uniform motion**

  If a body covers unequal distances in equal intervals of time, it is said to be moving with a non-uniform motion. It is a motion in which the velocity varies with time.

  The change in the velocity of a material point in nonuniform motion is characterized by acceleration.

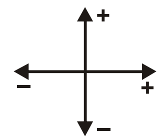
  Uniformly variable motion is a motion with a constant acceleration.

  Uniformly variable motion can be curvilinear like circular motion.

  If a uniformly variable motion is rectilinear, i.e., the velocity v changes only in magnitude, it is convenient to take the straight line in which a material point moves as one of the coordinate axes (say, the x-axis).

5. ACCELERATION

The rate of change of velocity is called acceleration.



Sign convention for acceleration

- It is a vector quantity. Its direction is same as that of change in velocity and NOT of the velocity.
- It is NOT the rate of change of speed. For Ex., when a body moving with constant speed along a circular path, there is no change in its speed but there is a change in velocity as its direction is changing continuously at every point. Thus, there must be some acceleration of the body.
- A change in velocity occurs when (i) only its direction changes, e.g. uniform circular motion. (ii) only its magnitude changes, e.g. a ball dropped from a certain height under gravity (iii) both magnitude as well as direction changes, e.g. a projectile motion. In all these cases, there must be some acceleration present in the motion.
- Whenever velocity and acceleration are in same direction, the velocity of a particle increases. Such motion is called accelerated motion. Such an acceleration for numericals is usually taken' positive acceleration'.
- Whenever velocity and acceleration are in opposite direction, the velocity of a particle decreases. Such motion is called retarded motion. Such an acceleration for numericals is usually taken 'negative acceleration' and also called 'retardation' or 'deceleration'.

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

Unit of acceleration : C.G.S. system - centimetre/(second)^2 ; S.I. system - metre/(second)^2 .

Non-uniform motion with constant acceleration

(Uniformly accelerated motion)

It is a motion in which acceleration is constant in both magnitude as well as direction.

- It is a non-uniform motion.

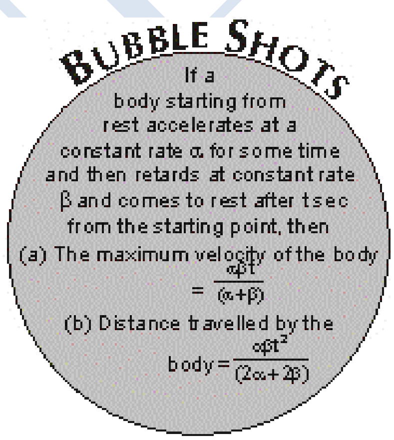
Equations of motion for a uniformly accelerated motion are :

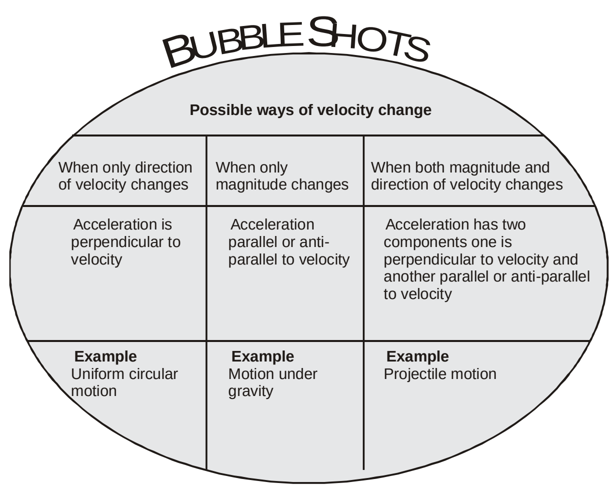
(i) $v = u + at$ (ii) $s = ut + \frac{1}{2}at^2$ (iii) $v^2 = u^2 + 2as$ (iv) $s = \left(\frac{v+u}{2}\right)t$ (v) $v_{average} = \frac{v+u}{2}$

where, u = initial velocity; v = final velocity ; s = distance travelled ; t = time taken, a = acceleration.

- Distance travelled in nth second (i.e. in a particular second) is given by,

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





Ex. 8: At a certain time a particle has a speed of 18 m/s in positive x-direction and 2.4 seconds later its speed was 30 m/s in the opposite direction. What is the magnitude of the average acceleration of the particle during the 2.4 seconds interval ?

(1) 20 m/s^2 (2) 10 m/s^2 (3) 5 m/s^2 (4) 2.5 m/s^2

Sol: Given, u = 18 m/s v = –30 m/s

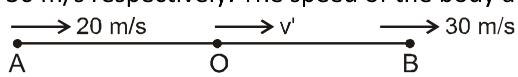
t = 2.4 seconds

$$a = \frac{v-u}{t} = \frac{-30-18}{2.4} = -20\ m/s^2$$

$|a| = 20\ m/s^2$

Ex. 9: A body travelling with uniform acc^n crosses two points A and B with velocities 20 m/s and 30 m/s respectively. The speed of the body at the mid-point of A and B is nearest to?

Sol:



$$v' = \sqrt{\frac{v_1^2 + v_2^2}{2}} = \sqrt{\frac{900+400}{2}} = \sqrt{650} = 25.5\ m/s$$

Ex. 10: A body starts from rest with an acceleration a_1. After 2 seconds, another body B starts from rest and accelerates by a_2. If they travel equal distances in the 5^{th} second, after the start of A, then the ratio $a_1 : a_2$ is equal to?

Sol: According to the problem,

Distance travelled by body A in 5^{th} second and distance travelled by body B in 3^{rd} second of its motion are equal.

So, $0 + \frac{a_1}{2}(2\times5-1) = 0 + \frac{a_2}{2}(2\times3-1)$

$\Rightarrow$ $9a_1 = 5a_2$ $\Rightarrow$ $\frac{a_1}{a_2} = \frac{5}{9}$

Ex. 11 : A boggy of uniformly moving train is suddenly detached from train and stops after covering some distance. The distance covered by the boggy and distance covered by the train in the same time has what relation?

Sol: Let 'a' be the retardation of boggy then distance covered by it be s. If u is the initial velocity of boggy after detaching from train (i.e., uniform speed of train)

$v^2 = u^2 + 2as$

$\Rightarrow$ $0 = u^2 - 2as$

$\Rightarrow$ $s_b = \frac{u^2}{2a}$ ...(1)

Time taken by boggy to stop

$v = u + at$

$\Rightarrow$ $0 = u - at$

$\Rightarrow$ $t = \frac{u}{a}$

In this time 't' distance travelled by train

$\Rightarrow$ $S_t = ut = \frac{u^2}{a}$ ...(2)

By (1) and (2)

$$\frac{S_b}{S_t} = \frac{1}{2}$$

My Work Sheet

Q.1 A particle travels 10 m in first s sec and 10 m in next 3 sec. Assuming constant acceleration what is the distance travelled in next 2 sec.

(1) 8.3 m (2) 9.3 m (3) 10.3 m (4) None of these

Q.2 Two cars A and B at rest at same point initialing. If A starts with uniform velocity of 40 m/sec and B starts in the same direction with constant acceleration of 4 m/s², then B will catch A after how much time.

(1) 10 sec (2) 20 sec (3) 30 sec (4) 35 sec

Answer:1 (1) 2 (2)

6. MOTION IN STRAIGHT LINE WITH CONSTANT ACCELERATION

Equation of motion are valid when acceleration is cosntant.

- $v = u + at$
- $S = ut + 1/2\ at^2$
- $v^2 - u^2 = 2as$
- $S = V_{av}t = \frac{(u+v)}{2}t$
- $S_n - S_{n-1} = S_{nth} = u + \frac{1}{2}a(2n-1)$

EQUATIONS OF MOTION (KINEMATIC EQUATIONS)

- Kinematic equations can be used to describe the motion with constant acceleration.

The symbols used in the kinematic are : v_0 or u intial velocity; v, final velocity; a acceleration; x, displacement; t, time interval. Be aware that the terms initial and final are relative. The end of one event is always the beginning of another. There are three general equations and two algebraic combinations of these equations that provide calculation convenience.

$x = \vec{v}t$ displacement = average velocity × time interval

$\vec{v} = \frac{v+u}{2}$, average velocity = (final velocity + initial velocity) / 2

First equation (Equation for velocity-time relation) : $v = u + at$

$v = u + at$, final velocity = initial velocity + acceleration × time interval,

By definition, acceleration = $\frac{\text{change in velocity}}{\text{time taken}} = \frac{\text{final velocity - initial velocity}}{\text{time taken}}$

or $x = \vec{v}t$ $\Rightarrow at = v - u$

or $v = u + at$ ...... (1)

Second equation (Equation for position-time relation) : $s = ut + \frac{1}{2}at^2$

Displacement = initial velocity × time interval + $\frac{1}{2}$ × acceleration × time interval^2

Distance travelled = average velocity × time = $\left(\frac{\text{Intial velocity + final velocity}}{2}\right)\times \text{time}$

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

But from eq. (1), v = u + at

$$s=\frac{u+(u+at)}{2}\times t \text{ or } s=\frac{2u+at}{2}\times t$$

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

Third equation (Equation for position-velocity relation) : $v^2 = u^2 + 2as$

Final velocity^2 = intial velocity^2 + 2 × acceleration × displacement

Distance travelled = average velocity × time

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

But from eq. (1), v = u + at

$$t=\frac{v-u}{a} \qquad \therefore s=\frac{u+v}{2}\times\frac{v-u}{a}$$

$$\text{or } s=\frac{v^2-u^2}{2a} \quad v^2-u^2=2as$$

or $v^2 = u^2 + 2as$ .... (3)

The three equations listed can be used to solve the majority of kinematic problems.

Which equation should you select for a particular problem ? The equation you select must have the unknow quantity in it and everything else must be given, because we can only solve for one unknown in one equation.

Distance Covered by a Body in nth second

$s = ut + \frac{1}{2}at^2$, the distance covered by a body in t sec

or $s_n = un + \frac{1}{2}an^2$ .....(i) distance covered by a body along straight line in n sec.

$S_{n-1} = u(n-1) + \frac{1}{2}(n-1)^2$ .....(ii) distance covered by a body along straight line in (n – 1)sec

$\therefore$ The distance covered by the body in nth second will be $S_{nth} = S_{n-1}$

$$\therefore S_{nth}=un+\frac{1}{2}an^2-\{u(n-1)+\frac{1}{2}a(n-1)^2\}$$

$$S_{nth}=un+\frac{1}{2}an^2-\{un-u+\frac{1}{2}a(n+1-2n)\}$$

$$\Rightarrow \quad un+\frac{1}{2}an^2-\{nu-u+\frac{an^2}{2}+\frac{a}{2}-an\}$$

$$\Rightarrow \quad u+a\left(n-\frac{1}{2}\right)=n+a\left(\frac{2n-1}{2}\right)$$

So, the distance covered by body in nth second $S_{nth} = u + \frac{a}{2}(2n-1)$

6.1 Concept of stopping distance and stopping time

- A body moving with a velocity *u* is stopped by application of brakes after covering a distance *s*. If the same body moves with velocity nu and same braking force is applied on it then it will come to rest after covering a distance of n^2s.

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

  $\Rightarrow$ $0 = u^2 - 2as$

  $\Rightarrow$ $s = \frac{u^2}{2a} \Rightarrow s \propto u^2$ [since *a* is constant]

  So, we can say that if 'u' becomes n time then 's' becomes n^2 times of previous value.

- Stopping time :

  $v = u - at$

  $\Rightarrow$ $0 = u - at$

  $\Rightarrow$ $t = \frac{u}{a}$ $\Rightarrow$ $t \propto u$ [since a is constant]

  So we can say that if u becomes n times then t becomes n times that of previous value.

6.2 Reaction Time

It is the time gap between observation & execution

- During the reaction time the body travels with constant velocity.

Ex. 12: A bullet fired from a rifle loses 20% of its speed when passing through a wooden plank. Then minimum number of wooden planks required to completely stop the bullet is

(1) 3 (2) 5 (3) 15 (4) 25

Sol: Let x be the thickness of each wooden plank. If u is the initial speed with which the bullet is fired from rifle, then its speed after passing through one wooden plank is

$$v = u - \frac{20}{100}u$$

$$\Rightarrow \quad v = u - \frac{1}{5}u$$

$$\Rightarrow \quad v = \frac{4}{5}u$$

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

$$\therefore \quad \left(\frac{4}{5}u\right)^2 - u^2 = 2ax$$

$$\text{or} \quad 2ax = -\frac{9}{25}u^2 \qquad \text{.......(i)}$$

If n is the minimum number of wooden planks required to stop the bullet, i,e., v = 0.

$(0)^2 - u^2 = 2a(x)$

$$\text{or} \quad n = \frac{-u^2}{2ax} = \frac{-u^2}{-\frac{9}{25}u^2} = \frac{25}{9} = 2.78$$

As n can't be fraction.

n = 3.

Ex. 13: A body is travelling east with speed of 9 m/s and with an acceleration of 2 m/s^2, acting west on it. The displacement of the body during the 5th second of its motion is -

(1) 0.25 m (2) 0.5 m (3) 0.75 m (4*) zero

Sol: Taking west to east as positive, then u = 9 m/s and a = –2 m/s^2

W ———— E

$\longrightarrow$ +ve

As $S_{n^{th}} = u + \frac{a}{2}(2x-1)$

$\therefore \quad S_{5^{th}} = 9 - \frac{2}{2}(2\times5-1) = 9-9=0$

Ex. 14: The bus moving with a speed of 42 km/hr is brought to a stop by braches after 6m. If the same bus is moving at a speed of 90 km/hr, then the minimum stopping distance is -

(1) 15.48 m (2) 18.64 m (3) 22.13 m (4) 27.55 m

Sol: For the first case, initial speed of the bus, u = 42 km/hr = $42\times\frac{5}{10}m/s = \frac{35}{3}m/s$

Final speed of the bus, v = 0

Distance travelled by the bus before it stops,

S = 6 m

As v^2 – u^2 = 2as

$\therefore \quad (0)^2 - \left(\frac{35}{3}\right)^2 = 2\times a\times 6$

or $\quad a = -\frac{1225}{108}m/s^2$

For the second case, u = 90 km/hr

$= \quad 90\times\frac{5}{18}m/s = 25\,m/s$

v = 0, $a = -\frac{1225}{108}m/s^2$ S = ?

$\therefore \quad (0)^2 - (25)^2 = 2\left(-\frac{1225}{108}\right)$

$\Rightarrow \quad S = \frac{25\times25\times108}{2\times125}m = 27.55\,m$

Ex. 15: A particle moves with constant acceleration along the straight line starting from rest. The percentage increased in its displacement during the 4th second compared to that in the 3rd second is

(1) 33% (2) 40% (3) 66% (4) 77%

Sol: Let a be constant acceleration of the particle. Its displacement in nth second in $D_{n^{th}} = u + \frac{a}{2}(2n-1)$.

Since the particle stars from rest, therefore u = 0

$\therefore \quad D_{n^{th}} = \frac{1}{2}a(2n-1)$

$\therefore \quad D_{3^{rd}} = \frac{1}{2}a(2\times3-1) = \frac{5}{2}a$

% increase in its displacement

$= \quad \frac{D_{4^{th}} - D_{3^{rd}}}{D_{3^{rd}}}\times100 = \frac{\frac{7}{2}a - \frac{5}{2}a}{\frac{5}{2}a}\times100 = \frac{2}{5}\times100 = 40\%$

Ex. 16: A bullet on penetrating 30 cm into its target losses its velocity by 50%. What additional distance will it penetrate into the target before it comes to rest-

(1) 30 cm (2) 20 cm (3) 10 cm (4) 5 cm

Sol: For first part of penetration, by equation of motion.

$$\left(\frac{v}{2}\right)^2 - (v)^2 = 2a(30\times10^{-2})$$

$$\Rightarrow \quad a = \frac{-3v^2}{8(30\times10^{-2})} \qquad ....(i)$$

For latter part of penetration, by equation of motion.

$$\Rightarrow 0 - \left(\frac{v}{2}\right)^2 = 2ax$$

or $$x = -\frac{v^2}{8a} \qquad ....(ii)$$

$$x = -\frac{v^2}{8}\left(\frac{8(30\times10^{-2})}{-3v^2}\right)$$

$x = 10 \times 10^{-2}$ m = 10 cm

Ex. 17: A body moving with same initial velocity and having uniform acceleration attains a final velocity V m/s, after travelling x m. If its velocity is $v = \sqrt{180 - 7x}$, find the acceleration of the body.

(1) –3.5 ms/^{2} (2) –7 m/s^2 (3) –15 m/s^2 (4) –30 m/s^2

Sol: $v = \sqrt{180 - 7x}$ where x is the distance.

$\therefore$ $v^2 = 180 - 7x$

From the dimensions, 180 has square of velocity, –7x = 2ax

$\therefore$ a = –3.5 m/s^2

For a body travelling with uniform acceleration, $v^2 - u^2 = 2as$ is valid.

By inspection are can say

$u^2 = 180$, 2as = –7x (here S = x.)

Ex. 18: A body starts from rest with an acceleration of 2 m/s^2. After 5 seconds, the direction of acceleration reveres again for 5 seconds. The displacement is

(1) 0 m (2) 50 m (3) 55 m (4) 500 m

Sol: Body starts from rest, u = 0, a = 2 m/s^2,

t = 5 seconds.

$$S_1 = ut + \frac{1}{2}at^2$$

$$\Rightarrow \quad S_1 = 0\times5 + \frac{1}{2}\times2\times(5)^2 = 25\,m$$

Now, where the body reverse its accelerations.

So, $$S_2 = 10\times5 - \frac{1}{2}\times2\times5\times5$$

$\Rightarrow$ S_2 = 50 – 25 = 25 m

$\therefore$ Total distance travelled = 25 + 25 = 50 m. The distance being a scalar, it will be 50 m but displacement being vector, it comes back to the original position. Therefore, it is zero.

Ex. 19: The distance travelled by a particle starting from rest and moving with an acceleration $\frac{4}{3}$ m/s^2, in the third second is

(1) $\frac{10}{3}$ m (2) $\frac{19}{3}$ m (3) 6 m (4) 4 m

Sol: Distance travelled in the 3rd = (Distance travelled in 3 seconds) – (Distance travelled in 2 seconds).
As u = 0

$$\therefore\ S_{3^{rd}} = \frac{1}{2}a(3)^2 - \frac{1}{2}a(2)^2 = \frac{1}{2}a(5)$$

Given,

$$a = \frac{4}{3}\,m/s^2$$

$$\therefore\ S_{3^{rd}} = \frac{1}{2}\times\frac{4}{3}\times 5 = \frac{10}{3}\ m$$

Ex. 20: Two cars start off a race with velocities 2m/s and 4m/s travel in straight line with uniform accelerations 2 m/s^2 and 1 m/s^2 respectively. What is the length of the path if they reach the final point at the same time ?

Sol: Since both particle reach at same position in same time t then from $s = ut + \frac{1}{2}at^2$

For 1st particle : $s = 4(t) + \frac{1}{2}(1)t^2 = 4t + \frac{t^2}{2}$,

For 2nd particle : $s = 2(t) + \frac{1}{2}(2)\,t^2 = 2t + t^2$

Equating above equation we get $4t + \frac{t^2}{2} = 2t + t^2 \quad \Rightarrow \quad t = 4s$

Substituting value of t in above equation

$s = 4(4) + \frac{1}{2}(1)(4)^2 = 16 + 8 = 24$ m

Ex. 21: A particle moves in a straight line with a uniform acceleration a. Initial velocity of the particle is zero. Find the average velocity of the particle in first 's' distance.

Sol: $\because s = \frac{1}{2}at^2 \quad \therefore \frac{s^2}{t^2} = \frac{1}{2}as$

Average velocity = $\frac{s}{t} = \sqrt{\frac{as}{2}}$

Ex. 22: A driver takes 0.20 s to apply the brakes after he sees a need for it. This is called the reaction time of the driver. If he is driving a car at a speed of 54 km/h and the brakes cause a declaration of 6.0 m/s^2. Find the distance travelled by the car after he sees the need to put the brakes on.

Sol: Reaction time = 0.20 sec
$\Rightarrow$ velocity = 54 km/hr = 15 m/sec
Acceleration = 6 m/sec^2
Now distance travelled in 0.2 sec = 15 × 0.2 = 3 m
distance travelled during deceleration
$\Rightarrow 15^2 = 2 \times 6 \times X \Rightarrow x = 18.75$ m
Total distance = 21.75 m

Ex. 23: A car start for rest and moving with constant acceleration 2 m/sec^2, it covers first 100 meter distance in time t_1 and second 100 meter in time t_2 then find ratio of time $t_1 : t_2$.

Sol: a = 2 m/sec^2

For 1st 100 m $\Rightarrow t_1 = \sqrt{\frac{2\times 100}{2}} = 10$

$t_1 + t_2 = \sqrt{\frac{2\times 200}{2}} = 10\sqrt{2}$

$t_2 = 10(\sqrt{2} - 1) \Rightarrow t_1 : t_2 = 1 : (\sqrt{2} - 1)$

My Work Sheet

Q.1 A car start from rest and moving with constant acceleration $5 m/s^2$. The distance travelled in the first 5 sec in x_1 next 5 sec is x_2 and last 5 sec in x_3. Then $x_1 : x_2 : x_3$ is

(1) 1 : 2 : 3 (2) 2 : 3 : 6 (3) 1 : 4 : 5 (4) 1 : 3 : 5

Q.2 A body starts from rest an moves with constant acceleration for t seconds. It travels a distance x_1 in first half of time and x_2 in next half of time, then.

(1) $x_2 = 3x_1$ (2) $x_2 = x_1$ (3) $x_2 = 4x_1$ (4) $x_2 = 2x_1$

Q.3 A body starts rest and has an acceleration 20 cm/s^2. What is the distance covered by the body in first 8 seconds?

(1) 160 cm (2) 640 cm (3) 1280 cm (4) 1640 cm

Answer:1 (4) 2 (1) 3 (2)

My Work Sheet

Q.1 A car moving with a speed of 50 km/hr can be stopped by applying brakes over a distance of 6 m. If the same car is moving at a speed of 100 km/hr, the stopping distance is -

(1) 12 m (2) 18 m (3) 6 m (4) 24 m

Q.2 A body moves with initial velocity 10 m/s. If it covers a distance of 20 m in 2 seconds, then acceleration of the body is

(1) zero (2) 10 m/s^2 (3) 5 m/s^2 (4) 2 m/s^2

Q.3 Stopping distance of a moving vehicle is directly proportional to

(1) Square of the initial velocity

(2) Square of the initial acceleration

(3) the initial velocity

(4) the initial acceleration

Q.4 A body is acceleration from rest at constant rate α for some time and then de-acceleration at constant rate β unit it comes rest. If the total time taken is t, then maximum velocity attained by the body is

(1) $\frac{\beta^2 t}{\alpha+\beta}$ (2) $\left(\frac{\alpha\beta}{\alpha+\beta}\right)t$ (3) $\frac{\alpha^2 t}{\alpha+\beta}$ (4) $\frac{\beta^2 t}{\alpha-\beta}$

Answer:1 (4) 2 (1) 3 (1) 4 (2)

7. MOTION UNDER GRAVITY

Motion of Body Under Gravity (Free Fall)

The force of attraction of earth on bodies, is called force of gravity. Acceleration produced in the body by the force of gravity, is called acceleration due to gravity. It is represented by the symbol g.

In the absence of air resistance, it is found that all bodies (irrespective of the size, weight or composition) fall with the same acceleration near the surface of the earth. This motion of a body falling towards the earth from a small altitude (h << R) is called free fall.

An ideal Examples of one-dimensional motion is motion under gravity in which air resistance and the small changes in acceleration with height are neglected.

7.1 If a body is dropped from some height (initial velocity zero)

(i) Equations of motion : Taking initial position as origin and direction of motion (i.e., downward direction) as a positive, here we have+

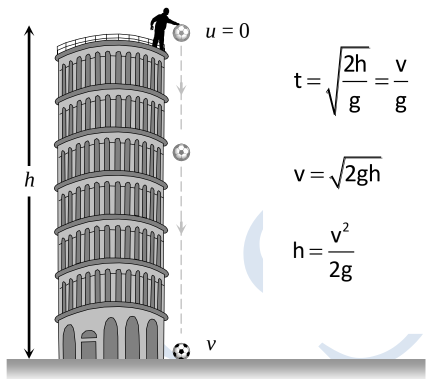


Fig. 2.12

u = 0 [As body starts from rest]

a = +g [As acceleration is in the direction of motion]

$v = g\,t$ ...(i)

$h=\frac{1}{2}gt^2$ ...(ii)

$v^2 = 2gh$ ...(iii)

$h_n=\frac{g}{2}(2n-1)$ ...(iv)

(ii) Graph of distance, velocity and acceleration with respect to time

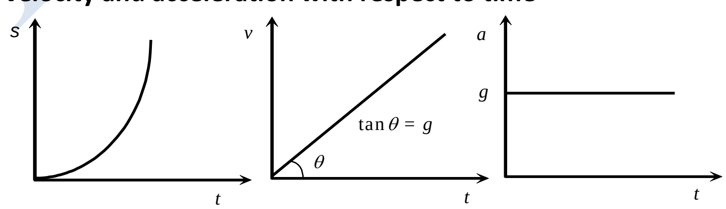


Fig. 2.13

(iii) As $h = (1/2)gt^2$, *i.e.*, $h \propto t^2$, distance covered in time t, $2t$, $3t$, *etc.*, will be in the ratio of $1^2 : 2^2 : 3^2$, *i.e.*, square of integers.

(iv) The distance covered in the *nth sec*,

So distance covered in 1st, 2nd, 3rd *sec*, *etc*., will be in the ratio of 1 : 3 : 5, *i.e.*, odd integers only.

7.2 If a body is projected vertically downward with some initial velocity

Equation of motion : $v = u + gt$

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

$$v^2 = u^2 + 2gh$$

$$h_n = u + \frac{g}{2}(2n - 1)$$

7.3 If a body is projected vertically upward

(i) Equation of motion : Taking initial position as origin and direction of motion (*i.e.*, vertically up) as positive $a = -g$ [As acceleration is downwards while motion upwards]

So, if the body is projected with velocity u and after time t it reaches up to height h then

$$u = u - gt\,;\, h = ut - \frac{1}{2}gt^2\,;\, \upsilon^2 = u^2 - 2gh\ ;\ h_n = u - \frac{g}{2}(2n - 1)$$

(ii) For maximum height $v = 0$

So from above equation $u = gt$,

$$h = \frac{1}{2}gt^2 \text{ and } u^2 = 2gh$$

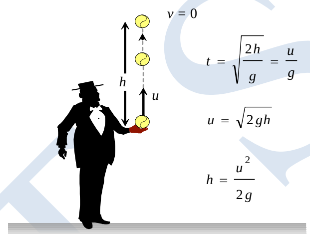


Fig. 2.14

(iii) Graph of displacement, velocity and acceleration with respect to time (for maximum height) :

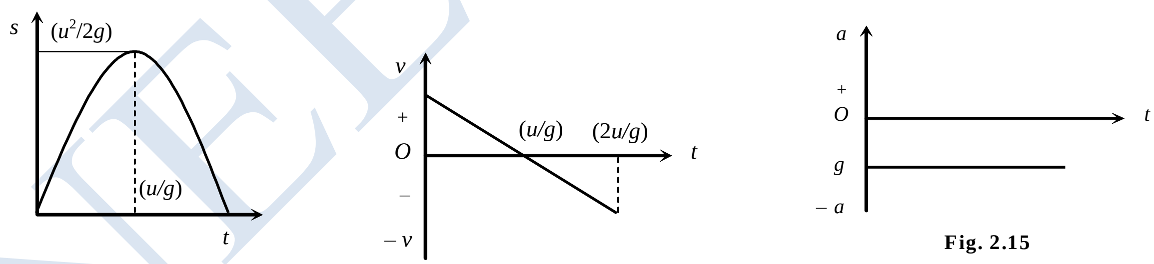


Fig. 2.15

It is clear that both quantities do not depend upon the mass of the body or we can say that in absence of air resistance, all bodies fall on the surface of the earth with the same rate.

7.4 The motion is independent of the mass of the body, as in any equation of motion, mass is not involved. That is why a heavy and light body when released from the same height, reach the ground simultaneously and with same velocity *i.e.*, $t = \sqrt{(2h/g)}$ and . $v = \sqrt{2gh}$

7.5 In case of motion under gravity, time taken to go up is equal to the time taken to fall down through the same distance. Time of descent (t_2) = time of ascent (t_1) = u/g

$\therefore$ Total time of flight $T = t_1 + t_2 = \frac{2u}{g}$

7.6 In case of motion under gravity, the speed with which a body is projected up is equal to the speed with which it comes back to the point of projection.

As well as the magnitude of velocity at any point on the path is same whether the body is moving in upwards or downward direction.

7.7 A body is thrown vertically upwards. If air resistance is to be taken into account, then the time of ascent is less than the time of descent. $t_2 > t_1$

Let u is the initial velocity of body then time of ascent $t_1 = \frac{u}{g+a}$ and $h = \frac{u^2}{2(g+a)}$

where g is acceleration due to gravity and a is retardation by air resistance and for upward motion both will work vertically downward.

For downward motion a and g will work in opposite direction because a always work in direction opposite to motion and g always work vertically downward.

So $h = \frac{1}{2}(g-a)t_2^2 \Rightarrow \frac{u^2}{2(g+a)} = \frac{1}{2}(g-a)t_2^2 \Rightarrow t_2 = \frac{u}{\sqrt{(g+a)(g-a)}}$

Comparing t_1 and t_2 we can say that $t_2 > t_1$

since $(g + a) > (g - a)$

Ex. 24: A balloon is rising vertically up with a velocity of 29 m/s. A stone is dropped from it and it reaches the ground in 10 seconds.

The height of the balloon when the stone was dropped from it will be? (g = 9.8 m/s^2)

Sol: For stone to be dropped from rising balloon of velocity 29 m/s

u = – 23 m/s, t = 10 sec

$\therefore$ h = – 29 × + $\frac{1}{2}$ × 9.8 × 100 = – 290 + 490 = 200 m.

Ex. 25: A ball is dropped downwards. After 1 second another ball is dropped downwards from the same point. What is the distance between them after 3 seconds?

Sol: Distance between the balls = (Distance travelled by first ball in 3 seconds) – (Distance travelled by second ball in 2 seconds)

$\Rightarrow \frac{1}{2}g(3)^2 - \frac{1}{2}g(2)^2 \Rightarrow$ 45 – 20 = 25 m.

Ex. 26: A ball released at rest from the top of a tower reaches the ground in 4 seconds. The height of the ball from the ground at t = 2 second of its journey is

(1) 60 m (2) 40 m (3) 20 m (4) 15 m

Sol: Let h be the height of the tower.

As the ball reaches the ground in 4 seconds,

$\therefore h = \frac{1}{2}gt^2$

$\Rightarrow h = \frac{1}{2}(10)(4)^2 = 80m$

The height fallen by the ball in 2 seconds is

$h' = \frac{1}{2}(10)(2)^2 = 20m$

$\therefore$ The height of the ball above the ground.

$\Rightarrow$ h – h' = 80 m – 20 m = 60 m

Ex. 27: A ball is dropped from the top of the building 100 m high. Simultaneously, another ball is thrown upwards from the bottom of the building with such a velocity that the balls collide exactly mid-way. What is the speed in m/s with which the seconds ball is thrown ? ($g = 10\ m/s^2$)

(1) 31.6 (2) 27.8 (3) 22.4 (4) 19.6

Sol: For first ball, time taken to reach mid-way,

$$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 50}{10}} = \sqrt{10} \text{ sec.}$$

For second ball, using v = u + at

$\Rightarrow$ v = 0, a = –g, u = ?

let t' be time taken by the ball to reach mid-way

$\therefore$ 0 = u – gt'

or $t' = \frac{u}{g} = \frac{u}{10}$

As both the balls collide at same time so, (t – 0) = (t' – 0) or t = t'

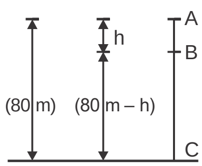
$$\Rightarrow \sqrt{10} = \frac{u}{10}$$

$$\Rightarrow u = 10\sqrt{10} = 31.6\ m/s$$

Ex. 28: A ball is dropped from the top of 80 m high tower. If after 2 seconds of fall the gravity ($g = 10\ m/s^2$) disappears, then time taken to reach ground since the gravity disappeared is

(1) 2 sec (2) 3 sec (3) 4 sec (4) 5 sec

Sol:



In figure A, respectively the top of the tower and C its base.

A ball is dropped from A and after 2 sec. of fall, the gravity disappears. In figure, it denoted by B.

Distance travelled by the ball in 2 seconds is

$$h = \frac{1}{2}gt^2 = \frac{1}{2}(10)(2)^2$$

= 20 m (From $h = ut + \frac{1}{2}gt^2$ and u = 0)

velocity attained by the ball in seconds is

v = gt = (10)(2) (From v = u + gt and u = 0.)

$\Rightarrow$ v = 20 m/s

Time taken by the ball to reach the ground since the gravity disappeared is

$$t = \frac{(80m - h)}{v} = \frac{80m - 20m}{20m/s} = \frac{60}{20m/s} = 3\text{sec.}$$

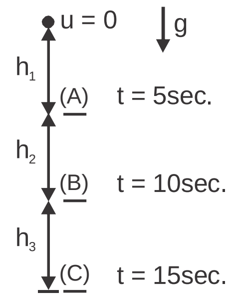
Ex. 29: A stone falls freely under gravity. It covers distance h_1, h_2 and h_3 in the first 5 seconds, the next 5 seconds and the next 5 seconds respectively. The relation between h_1, h_2 and h_3 is

(1) $h_2 = 3h_1$, and $h_3 = 3h_2$ (2) $h_1 = h_2 = h_3$

(3) $h_1 = 2h_1 = 3h_3$ (4) $h_1 = \frac{h_2}{3} = \frac{h_3}{5}$

Sol: Distance covered by the stone in 5 seconds is

$$h_1 = \frac{1}{2}g(5)^2 = \frac{25}{2}g \qquad ....(i)$$



Distance travelled by the stone in 10 seconds is

$$h_1 + h_2 = \frac{1}{2}g(10)^2 = \frac{100}{2}g \qquad ....(ii)$$

Distance travelled by the stone in 15 seconds is

$$h_1 + h_2 + h_3 = \frac{1}{2}g(15)^2 = \frac{225}{2}g \qquad ....(iii)$$

Subtract (i) from (ii), we get

$$(h_1 + h_2) - h_1 = \frac{100}{2}g - \frac{25}{2}g = \frac{75}{2}g$$

or $\quad h_2 = \frac{75}{2}g = 3h_1 \qquad ....(iv)$

Subtract (ii) from (iii), we get

$$(h_1 + h_2 + h_3) - (h_2 - h_1) = \frac{225}{2}g - \frac{100}{2}g$$

or $\quad h_3 = \frac{125}{2}g = 5h_1 \qquad ....(v)$

From (i), (iv) and (v), we get $h_1 = \frac{h_2}{3} = \frac{h_2}{5}$

Ex. 30 : A person throws ball into air vertically upwards in regular intervals of time of one second. The next ball is thrown when the velocity of the ball thrown earlier becomes zero. The height to which the balls rise is (Assume, g = 10 m/s^2)

(1) 5 m (2) 10 m (3) 7.5 m (4) 20 m

Sol: Time taken by the ball to reach highest point is t = 1 second.

As the person throws the second ball, when the velocity of the first ball becomes zero, i, e., v = 0 or when the first ball reach the highest point.

Using, v = u + at

Here, v = 0, a = –g, t = 1 second

$\therefore$ 0 = u –(10)(1) or u = 10 m/s

Using v^2 – u^2 = 2ah, we get (0)^2 – (10)^2 = 2(–10)(h)

$$h = \frac{(10)^2}{20} = 5\,m$$

Ex. 31: A ball is dropped from the roof of a tower of height h. The total distance covered by it in the last second of its motion is equal to the distance covered by it in first three seconds. What is the value of h ?

(1) 125 m (2) 50 m (3) 100 m (4) 200 m

Sol: u = 0

Let the ball remians in air for t seconds.

$\therefore$ Total distance coverted by the ball in last second i.e., t seconds is

$$D_t = u + \frac{g}{2}(2t-1) = 0 + \frac{10}{2}(2t-1) = 10t - 5 \quad ....(i)$$

Distance covered by the ball in first three seconds is

$$S_3 = \frac{1}{2}gt^2 = \frac{1}{2}\times 10\times 3^2 = 45\text{ m} \quad ......(ii)$$

As per question, $D_t = S_3 \Rightarrow 10t - 5 = 45$

$$\therefore h = \frac{1}{2}gt^2 = 125\text{ m}$$

Ex. 32: A ball is dropped from a high rise platform at t = 0 starting from rest. After 6 seconds another ball is thrown downwards from the same platform with a speed v. The two ball meet at t = 18 second. What is the value of v ?

(1) 75 m/s (2) 55 m/s (3) 40 m/s (4) 60 m/s

Sol: Let the two balls meet after t seconds at distance x from the platform. For the first ball, u = 0, t = 18 sec. g = 10 m/s^2.

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

$$\Rightarrow x = \frac{1}{2}\times 10\times (18)^2 \quad ....(i)$$

For the second ball, u = v, t = 12 sec,

g = 10 m/s^2

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

$$\therefore x = v\times 12 + \frac{1}{2}\times 10\times (12)^2 \quad ....(ii)$$

From eq. (i) and (ii), we get

$$\frac{1}{2}\times 10\times (18)^2 = v\times 12 + \frac{1}{2}\times 10\times (12)^2$$

or $12v = \frac{1}{2}\times 10[(18)^2 - (12)^2]$

$$\Rightarrow 12v = \frac{1}{2}\times 10[(18+12)(18-12)]$$

$$\Rightarrow 12v = \frac{1}{2}\times 10\times 30\times 6$$

or v = 75 m/s

Ex. 33: **Assertion :** Two ball of different masses are thrown vertically upward with same speed. They will pass thrown their point of projection in the downward direction with the same speed.

Reason : The maximum height and downward. Velocity attained at the point of projection are independent of the mass of the ball.

(1) If both assertion and reason are true and reason is the correct explanation of assertion.

(2) If both assertion and reason are true but reason is not the correct explanation of assertion.

(3) If assertion is true but reason is false.

(4) If both assertion and reason are false.

Sol: Option (1)

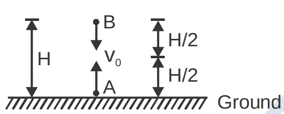
$h = ut - \frac{1}{2}gt^2$ and $v^2 = u^2 - 2gh$

The above equation are independent of mass.

Ex. 34: A body A is thrown up vertically from the groun with a velocity v_0 and another body B is simultaneously dropped from a height H. they meet at a height $\frac{H}{2}$ of v_0 is equal to

(1) $\sqrt{2gH}$ (2) $\sqrt{gH}$ (3) $\frac{1}{2}\sqrt{gH}$ (4) $\sqrt{\frac{2g}{H}}$

Sol: Let the two bodies A and B respectively meet at a time t, at a height from the ground.



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

For body A, $u = v_0$, $a = -g$, $S = \frac{H}{2}$

$$\therefore \frac{H}{2} = v_0 t - \frac{1}{2}gt^2 \quad ....(i)$$

For body B, $u = 0$, $a = +g$, $S = \frac{H}{2}$

$$\therefore \frac{H}{2} = v_0 t - \frac{1}{2}gt^2 \quad ....(ii)$$

Equating equations (i) and (ii), we get

$$v_0 t - \frac{1}{2}gt^2 = \frac{1}{2}g$$

$\Rightarrow v_0 t = gt^2$ or $t = \frac{v_0}{g}$

Substituting the value of t in equation (i), we get

$$\frac{H}{2} = v_0 \times \left(\frac{v_0}{g}\right) - \frac{1}{2}g\left(\frac{v_0}{g}\right)^2$$

$$\frac{H}{2} = \frac{v_0^2}{g} - \frac{1}{2}\frac{v_0^2}{g}$$

$$\frac{H}{2} = \frac{v_0^2}{g} \quad \text{or} \quad v_0^2 = gH$$

or $v_0 = \sqrt{gH}$

My Work Sheet

Q.1 A boy standing at the top of a tower of 20 m height drops a stone. Assuming g = 10 m/s^2, the velocity with which it hits the ground is

(1) 10 m/s (2) 20 m/s (3) 40 m/s (4) 5 m/s

Q.2 The distance traversed during equal interval of time by a freely falling body from rest are in the ratio

(1) 1 : 3 : 5 : 7 (2) 2 : 4 : 6 : 8 (3) 1 : 4 : 9 : 25 (4) 1 : 9 : 25 : 49

Q.3 Two identical metal spheres are released from the top of a tower after t seconds of each other such that they fall along the same vertical line. If air resistance is neglected, then at instant of time during their fall,

(1) the difference in their displacement remains the same.

(2) the difference between their speeds remains the same

(3) the difference between their heights above ground is proportional to t^2.

(4) the difference between their displacements is proportional to t.

Q.4 A stone falls freely from rest and the total distance covered by it in the last second of its motion equals the distance covered by it in the first three seconds of its motion. The stone remains in the air for

(1) 6 s (2) 5 s (3) 7 s (4) 4 s

Answer:1 (2) 2 (1) 3 (2) 4(2)

My Work Sheet

Q.1 Two stones are thrown from the top of a tower, one vertically upward and other vertically downward with same speed. Ratio of velocity where they hit the ground is

(1) 1 : 2 (2) 1 : 1 (3) 2 : 1 (4) 1 : 9

Q.2 A ball is thrown vertically upward with certain velocity from ground. Another ball is released from a height of 60 m. They meet at a height of 15 m. from ground. Then what is the initial velocity of the 1st ball ? ($g = 10\ m/s^2$)

(1) 20 m/s (2) 30 m/s (3) 40 m/s (4) 60 m/s

Q.3 A stone dropped from a certain height can reach the ground in 5 seconds. If the stone is stopped after 3 second of its fall and then allowed to fall again. The time taken by the stone top reach the ground for the remaining distance is

(1) 2 seconds (2) 4 seconds (3) 6 seconds (4) 5 seconds

Q.4 Two bodies are thrown vertically upwards with their initial speeds in the ratio 2 : 3. The ratio of the maximum heights reached by them and the ratio of their time taken by then to return back to the ground respectively are

(1) 4 : 9 and 2 : 3 (2) 2 : 3 and $\sqrt{2} : \sqrt{3}$

(3) $\sqrt{2} : \sqrt{3}$ and 4 : 9 (4) $\sqrt{2} : \sqrt{3}$ and 2 : 3

Q.5 Four marbles are dropped from the top of a tower one after the other with an interval of one second. The first one reaches the ground after 4 seconds. When the first one reaches the ground the distances between the first and second, the second and third and the third and fourth will be respectively.

(1) 35, 25, 15 (2) 30, 20, 10 (3) 20, 10, 5 (4) 40, 30, 20

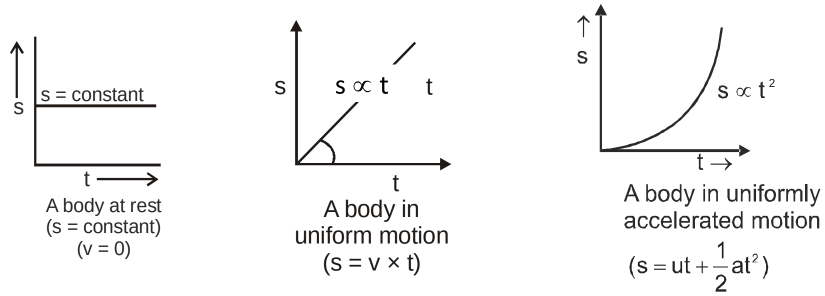
Answer:1 (2) 2 (1) 3 (2) 4 (1) 5 (1)

8. GRAPHS IN MOTION

Usually distance-time, position-time, displacement-time, speed-time, velocity time, acceleration-time graphs are used in understanding motion.

8.1 Distance-time graph

Here, distance is taken on y-axis and time is taken on x-axis.



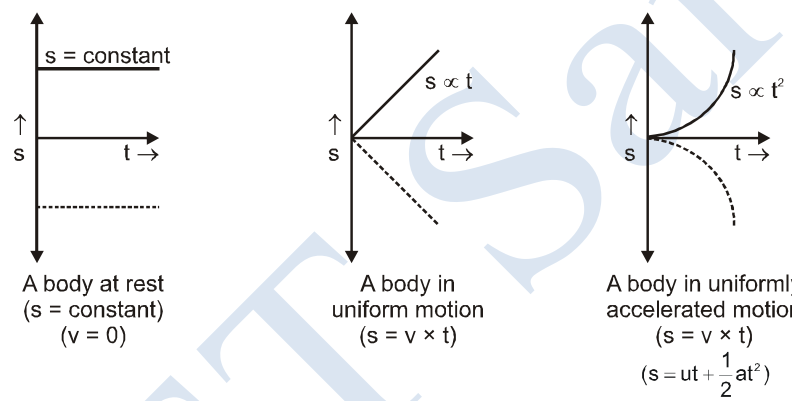
Distance-time graphs for different states of motion

Distance-time graph is always positive, it is always increasing NEVER decreasing.

8.2 Displacement-time graph

Here, displacement is taken on y-axis and time is taken on x-axis.

Displacement-time graph can be positive or negative, it can be increasing or decreasing.

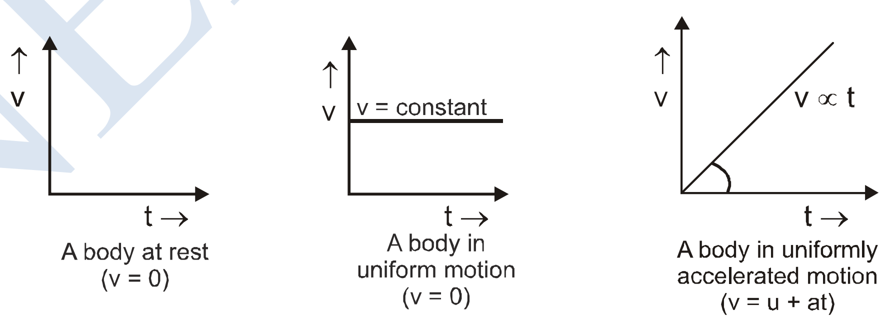


Displacement-time graphs for different states of motion

8.3 Speed-time graph

Here, speed is taken on y-axis and time is taken on x-axis.

- Speed-time graph is always positive, it can be increasing or decreasing.

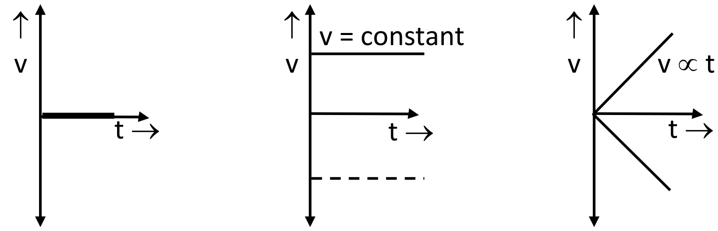


Speed-time grtaphs for different states of motion

8.4 Velocity-time graph

Here, velocity is taken on y-axis and time is taken on x-axis.

- Velocity-time graph can be positive or negative, it can be increasing or decreasing.



A body at rest (v = 0)

A body in incofmation (v = constnat)

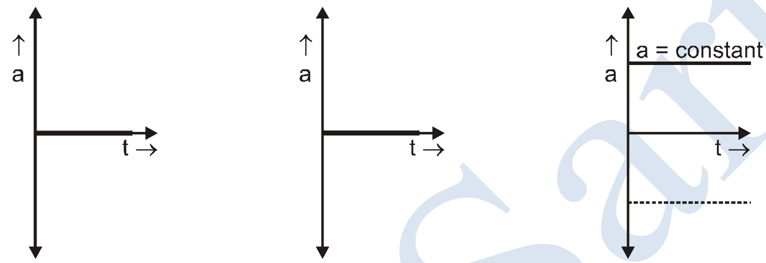
A body in uniformaly accelerated motion (v = u × at)

Velocity-time graphs for different states of motion

8.5 Acceleration-time graph

Here, acceleration is taken on y-axis and timne is taken on x-axis.

- Acceleration-time graph can be positive on negative, it can be increasing or decreasing.



A body at rest (a = 0)

A body in uniform motion (a = 0)

A body in uniformly accelerated motion (a = constant)

Acceleration-time graphs for different states of motion

9. SIGNIFICANCE OF GRAPHS IN MOTION

9.1 Slope of a graph

Slope of a graph is given by,

$$\text{Slope} = \tan\theta = \frac{\text{perpendicular}}{\text{base}} = \frac{p}{b}$$

Where, θ is the angle made by the graph with positive x-axis.

Slope of a graph can be zero, positive, negative or even infinite (∞).

(1) For $\theta = 0°$, slope is zero (e.g. a horizontal line).

(2) For $\theta = 90°$, slope is infinite (e.g. a verticle line).

(3) For $0° < \theta < 90°$, slope is positive (e.g. a line making acute angle with the positive x-axis).

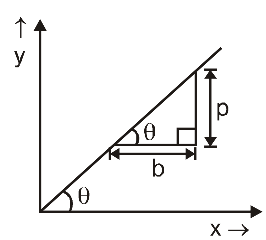
(4) For $90° < \theta < 180°$, slope is negative (e.g. a line making obtuse angle with the positive x-axis).

- More the value of θ, more will be the value of $\tan\theta$ i.e., more will be the slope of the graph.

9.2 Slope of a straight line graph

A straight line has a constant slope

$$\text{Slope} = \tan\theta = \frac{\text{perpendicular}}{\text{base}} = \frac{p}{b}$$



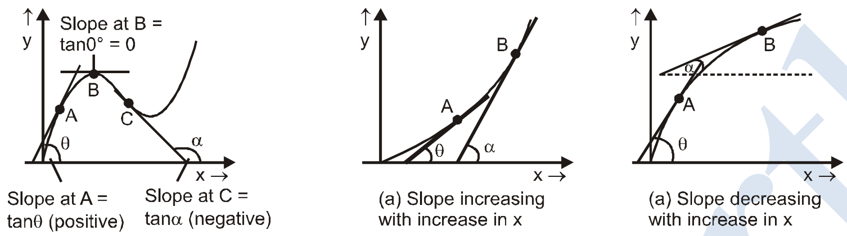
Slope of a straight line graph

9.3 Slope of a curved line graph

The process of finding slopes is more challenging for a curved-line graph because the slope of the curve line changes with the change in the values of variable like x (or time t in motion).

The slope of a curve line at any point on it is found by making a tangent at that point. If θ be the slope of the curve line at that point (See fig.).

In the fig. the slope of the graph is increasing with the increase in value of x (a concave graph) while in fig. the slope of the graph is decreasing with the increase in value of x.

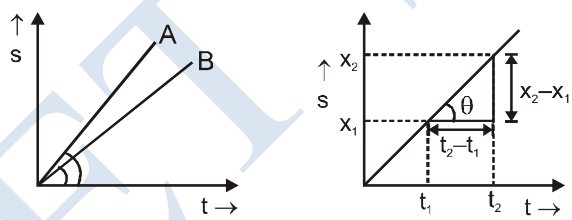


Slope of a curve line graph   Slope of a curve line graph can be increasing or decreasing

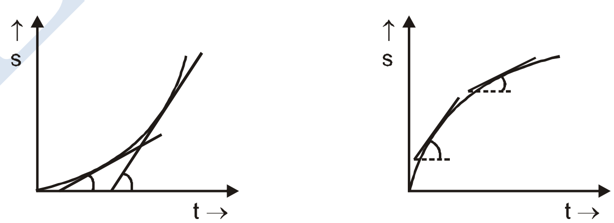
Slope of distance-time graph gives speed. Slope of displacement-time graph gives velocity.

- Fig. shows (s-t) graph in which slope of A is more than slope of B, thus, $v_A > v_B$.
- From the s-t graph shown in fig. we can find the value of v.

$$\boxed{v = \frac{p}{b} = \frac{x_2 - x_1}{t_2 - t_1}}$$



- In the graphs shown in fig. (a) of graph 1 represents accelerated motion i.e., v increasing with time. This is because the slope of the graph is increasing with time. Fig. (b) of graph 2 represents retarded motion i.e., v decreasing with time. This is because the slope of the graph is decreasing with time.



(a) Graph 1
(v increasing with time)
Accelerated motion

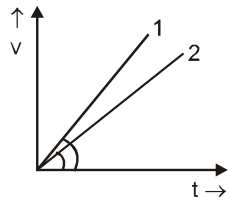
(b) Graph 2
(v decreasing with time)
Retarded motion

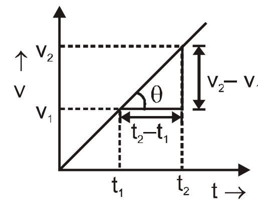
Using the concept of slope in s-t graph

- Slope of speed-time graph or velocity-time graph gives acceleration.
- Fig. shows a v-t graph in which, slope of 1 is more than slope of 2, thus, $a_1 > a_2$.

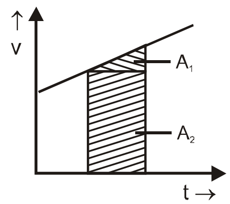
- From the v-t graph shown in fig. we can find the value of a.

$$\boxed{a = \frac{p}{b} = \frac{v_2 - v_1}{t_2 - t_1}}$$

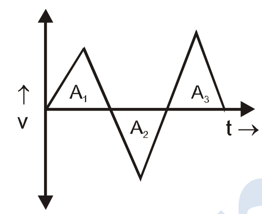




- Total area under the speed-time graph or velocity-time graph always gives total distance travelled by the body during a given time interval. We can also find displacement using a velocity-time graph.



Distance travelled = $A_1 + A_2$

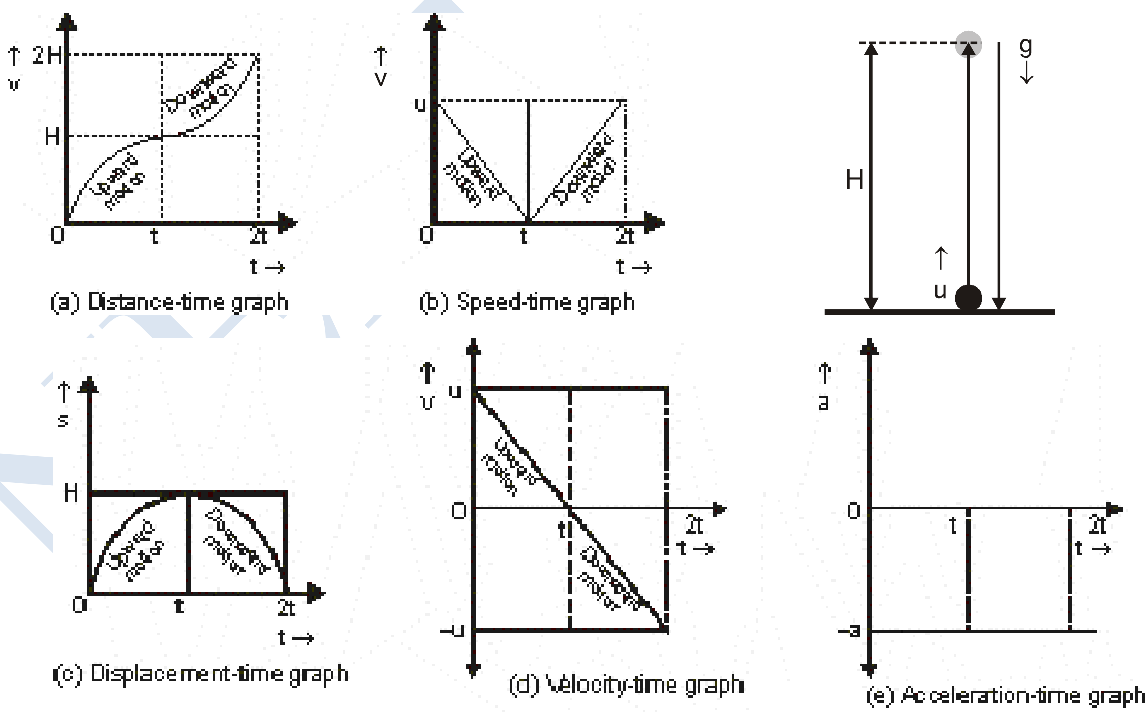


Distance travelled = $A_1 + A_2 + A_3$
Displacement = $A_1 - A_2 + A_3$

Area under v-t graph gives distance travelled by the body.

10. GRAPHS OF MOTION UNDER GRAVITY

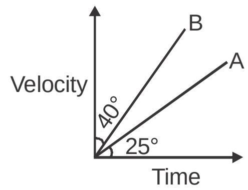
We know that upward motion of an object is a retarded motion while downward motion is an accelerated motion. Let us try to make graphs for an object which is thrown upward and returns back to the same height (See fig.)



Graphs of motion under gravity

The area under the acceleration-time graph gives change in velocity during a given time interval

Ex. 35: The velocity-time graph for two bodies A and B are shown. Then the acceleration of A and B are in the ratio.



(1) tan 25° to tan 50°

(2) cos 25° to cos 50°

(3) tan 25° to tan 40°

(4) sin 25° to sin 50°

Sol: As the slope of velocity-time graph gives acceleration, so acceleration a = tan θ

$\therefore$ From given graph

The acceleration of A is a_A = tan 25° and that of B is a_B = tan 50°.

Their corresponding ratio is

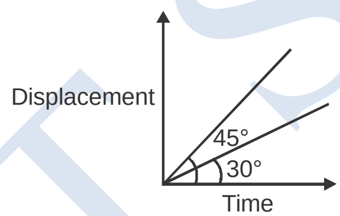
$$\frac{a_A}{a_B} = \frac{\tan 25^\circ}{\tan 50^\circ}$$

Ex. 36: The slope of the tangent drawn on position-time graph at any instant is equal to the instantaneous

(1) acceleration (2) force (3) velocity (4) momentum

Sol: The slope of the tangent drawn on position-time graph at any instant is equal to the instantaneous velocity.

Ex. 37: The displacement-time graphs of two moving particles moving angles of 30° and 45° with the x-axis. The ratio of their velocities is

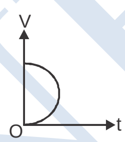


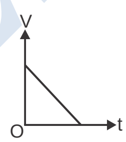
(1) $\sqrt{3}:2$ (2) 1 : 1 (3) 1 : 2 (4) $1:\sqrt{3}$

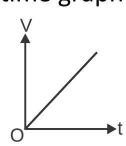
Sol: Slope of displacement-time graph gives velocity.

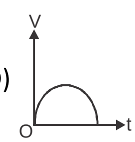
$$\therefore \frac{v_1}{v_2} = \frac{\tan\theta_1}{\tan\theta_2} = \frac{\tan 30^\circ}{\tan 45^\circ} = \frac{1}{\sqrt{3}}$$

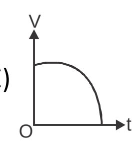
Ex. 38: Which of the following cannot be speed-time graph ?

(A) 

(B) 

(C) 

(D) 

(E) 

(1) (B) and (D) (2) (C) and (E) (3) (D) only (4) (A) only

Sol: A particle can have only one speed at one time and cannot have two speeds at one time.

Therefore the graph(A) cannot be possible. Hence option (4) is the correct option.

Ex. 39: The accelearation of a moving body is found from the

(1) area under velocity-time graph

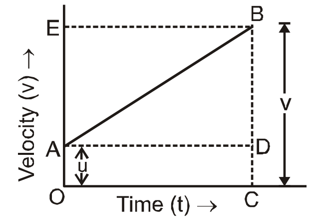
(2) area under displacement - time graph

(3) slope of distance-time graph

(4) slope of velocity-time graph

Sol: The slope of velocity-time graph gives the aceleration of a body.

11 GRAPHICAL DERIVATION OF EQUATIONS OF MOTION



The three equations of motion: $v = u + at$; $s = ut + \frac{1}{2}at^2$ and $v^2 = u^2 + 2as$ can be derived with the help of graphs as described below.

1. To Derive v = u + at by Graphical Method

Consider the velocity-time graph of a body shown in fig. The body has an initial velocity u at point A and then its velocity changes at a uniform rate from A to B in time t. In other words, there is a uniform acceleration a from A to B, and after time t its final velocity becomes v which is equal to BC in the graph (see figure). The time t is represented by OC. To complete the figure, we draw the perpendicular CB from point C, and draw AD parallel to OC. BE is the perpendicular from point B to OE.

Now, Initial velocity of the body, $u = OA$

And, Final velocity of the body, $v = BC$ ....(2)

But from the graph $BC = BD + DC$

Therefore, $v = BD + DC$ ....(3)

Again $DC = OA$

So, $v = BD + u$ ....(4)

We should find out the value of BD now. We know that the slope of a velocity-time graph is equal to acceleration, a.

Thus, Acceleration, a = slope of line AB (See figure)

or $a = \frac{BD}{AD}$

But AD = OC = t (See figure), so putting t in place of AD in the above relation, we get:

$$a = \frac{BD}{t}$$

or $BD = at$

Now, putting this value of BD in equation (4) we get :

$$v = at + u$$

This equation can be rearranged to give :

$$v = u + at$$

And this is the first equation of motion. It has been derived here by the graphical method.

2. To Derive $s = ut + \frac{1}{2}at^2$ by Graphical Method

Suppose the body travels a distance s in time t. In figure the distance travelled by the body is given by the area of the space between the velocity-time graph AB and the time axis OC, which is equal to the area of the figure OABC. Thus :

Distance travelled = Area of figure OABC

= Area of rectangle OADC + Area of triangle ABD

We will now find out the area of the rectangle OADC and the area of the triangle ABD.

(i) Area of rectangle OADC = OA × OC (See figure)

$= u \times t$

$= ut$ ...(5)

(ii) Area of triangle ABD $= \frac{1}{2} \times$ Area of rectangle AEBD

$$= \frac{1}{2} \times AD \times BD$$

$$= \frac{1}{2} \times t \times at \qquad \text{(because AD = t and BD = at)}$$

$$= \frac{1}{2}at^2 \qquad ...(6)$$

So, Distance travelled, s = Area of rectangle OADC + Area of triangle ABD

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

This is the second equation of motion. It has been derived here by the graphical method.

3. To Derive $v^2 = u^2 + 2as$ by Graphical Method

We have just seen that the distance travelled s by a body in time t is given by the area of the figure OABC which is a trapezium (see figure). In othe words,

Distance travelled, s = Area of trapezium OABC

$$s = \frac{(\text{Sum of parallel sides}) \times (\text{Height})}{2}$$

or $$s = \frac{(OA + CB) \times OC}{2}$$

Now, OA + CB = u + v and OC = t. Putting these values in the above relation, we get :

$$s = \frac{(u + v) \times t}{2} \qquad ....(7)$$

We now want to eliminate t from the above equation. This can be done by obtaining the value of t from the first equation of motion.

Thus, $v = u + at$ (First equation of motion)

And, $at = v - u$

So,

Now, putting this value of t in equation (7) above, we get :

$$s = \frac{(u + v)}{2}\frac{(v - u)}{a}$$

or $2as = v^2 - u^2$ [because $(v + u) \times (v - u) = v^2 - u^2$]

or $v^2 = u^2 + 2as$

This is the third equation of motion. It has been derived by the graphical method.

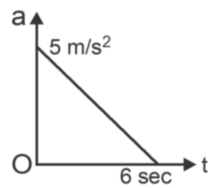
My Work Sheet

Q.1 The graph between displacement and time for a particle moving with uniform acceleration is a-

(1) straight line with a positive slope (2) parabola

(3) ellipse (4) straight line parallel to time axis

Q.2 A particle starts from rest. Its acceleration at time t = 0 is 5 m/s^2 which varies with time as shown in the figure. The maximum speed of the particle will be-



(1) 7.5 m/s (2) 15 m/s (3) 30 m/s (4) 37.5 m/s

Q.3 A graph is drawn between velocity and time for the motion of a particle. The area under the curve between the time intervals t_1 and t_2 gives

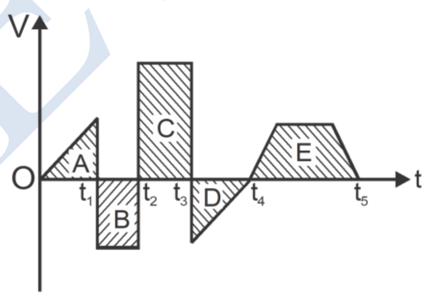
(1) momentum of the particle

(2) displacement of the particle

(3) acceleration of the particle

(4) change in velocity of the particle

Q.4 The velocity-time graph of an object is as shown the displacement during the interval O to t_4 is



(1) Area A + Area B + Area C + Area D + Area E

(2) Area A + Area C – Area B – Area D

(3) Area A + Area B + Area C + Area D

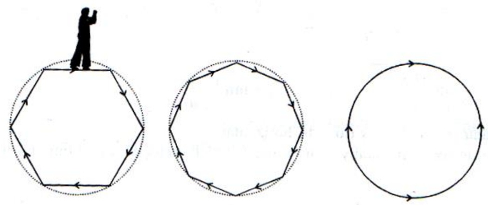
(4) Area A + Area C + Area E – Area B + Area D

Answer:1 (2) 2 (2) 3 (2) 4 (2)

12 CIRCULAR MOTION

Motion of a particle (small body) along a circle (circular path), is called a 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

Explanation : Consider a boy running along a regular hexagonal track (path) as shown in fig. As the boy runs along the side of the hexagon at a uniform speed, he has to take a turn at each corner changing direction but keeping the speed same. In one round he has to take six turns at regular intervals. If the same boy runs along the side of a regular octagonal track with same uniform speed, he will have to take eight turns in one round at regular intervals but the interval, will become smaller.

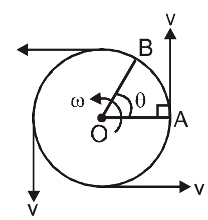


By increasing the number of sides of the regualar polygon, we find the number of turns per round becomes more and the interval between two turns become still shorter. A circle is a limiting case of a polygon with an infinite number of sides on the circular track, the turning becomes a continuous process without any gap in between the boy running along the sides of such a track will be performing a circular motion. Hence, circular motion is the motion of a body along the sides of a polygon of infinite number of sides with uniform speed, the direction changing continuously.

Example of uniform circular motion are (i) motion of moon around the earth. (ii) motion of satellite round its planet.

When a particle moves along a circular path, its motion is called circular motion.

A circular motion is always a non-uniform motion i.e. accelerated motion because the direction of velocity change continuously.



Velocity of a particle along a circular path is tangential to the path

- Velocity of a particle in circular motion is always tangential to the circular path (see figure) i.e., velocity and radius are always $\perp$ to each other.
- **Angular displacement (θ) :** The angle described by particle moving along a circular path is called **angular displacement.**
- S.I. unit of angular displacement is **radian**.

  π radian = 180° 1 radian = 180°/π = 57.3°
- **Angular velocity (ω) :** The rate of change of angular displacement is called angular velocity.

  Formula for ω : $\boxed{\omega = \frac{\theta}{t}}$

  S.I. unit of ω : radian per second or rad s^{-1}.
- **Relation between angular velocity (ω) and linear speed (v) :**

  $\boxed{v = r\omega}$ (r = radius of circular path)
- **Angular acceleration (α)**

  The rate of change of angular velocity is called **angular acceleration.**

  Formula for α : $\boxed{\alpha = \frac{\omega_2 - \omega_1}{t}}$

  S.I. unit of α : radian/(second)^2 or rad s^{-2}.

- **Relation between angular acceleration (α) and linear (tangential) acceleration (a_t) :**

  $\boxed{a = r\alpha}$ (r = radius of circular path)

  Uniform circular motion

  Motion of a particle along the circumferene of a circle with a constant speed is called uniform circular motion

  In uniform circular motion :

- Linear speed, v = constant
- Angular velocity, ω = constant
- Angular acceleration, α = 0

Here, linear speed can also be found by formula, $\boxed{v = \frac{2\pi r}{T}}$ (T = time period of 1 revolution)

Also, angular velocity ω can be found using formula, $\boxed{\omega = \frac{2\pi}{T}}$

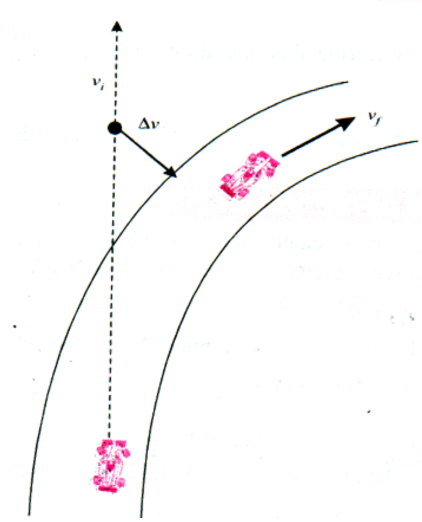
Uniform circular motion is always an accelerated motion. It has a radially inward acceleration called centripetal acceleration.

Formula for centripetal acceleration : $\boxed{a_c = \frac{v^2}{r} = r\omega^2}$

Centripetal force (a_c) and velocity (v) are always perpendicular to each other.

Accleration and Force in Uniform Circular Motion

Any change of velocity-speeding up, slowing down, or turning a corner is an acceleration. We distinguish these different kinds of accelerated motion by assigning a direction to the acceleration. In other words, acceleration is a vector. If you are traveling in a straight line and speed up, your change in velocity (). is in the direction you are going. Then your acceleration is also in that direction. This is the first rule for the direction of an acceleration : when the acceleration is in the same direction as the velocity, the result is an increase in speed.



Now suppose you do not change speed but are making a turn. This is a change in only the direction of velocity since velocity is a vector, this is surely a change in velocity-an acceleration. Figure shows how to find the directionof this acceleration. This dotted line shows what the path of the car would be if its motion were not accelerated that is, if it traveled at constant speed in a straight line.

The arrow is a vector representing the change in the velocity of the car, that is, the vector that must be added to the old velocity to get the new velocity.

NOTE:
- If circular motion of the object is uniform, the object will posses only centripetal acceleration.
- If circular motion of the object is non-uniform, the object will posses both centripetal and transverse accelerations.

The acceleration is in the same direction as the change in velocity. When the car turns to the right, its acceleration is to the right, perpendicular to its velocity, this acceleration is called centripetal acceleration and its value is $\frac{v^2}{r}$ where v is the magnitude of the velocity and r is the radius of the path.

If m be the mass of the object then it experiences a force which directs towards the centre of the path and has a magnitude given by

$$F_c = \frac{mv^2}{r}$$

This force is known as the centripetal force.

Centripetal force

- It is the radially inward force that is required to move an object along a circular path.

  Formula for centripetal force : $\boxed{F = ma_c = \frac{mv^2}{r} = mr\omega^2}$

  Centripetal force is always supplied by a real force, the nature of which depends on the situation. While turning a motocycle on a horizontal circular path, friction provides the necessary centripetal force. The electron moves in a circle around nucleus due to centripetal force provided by the electrostatic force of attraction between positive nucleus and negative electron.

  While whirling a stone tied with a string, the tension in the string provides the centripetal force. Earth revolves round the Sun due to the centripetal force provided by the gravitational force between the Earth and the Sun.

- **Non-uniform circular motion**

  Motion of a particle along the circumference of a circle with a variable speed is called non-uniform circular motion.

  In non-uniform circular motion :

  Linear speed, $v \neq$ constant

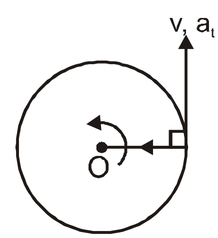
  Angular velocity , $\omega \neq$ constant

  Angular acceleration, $\alpha \neq 0$

  There are two linear accelerations :

  (i) centripetal acceleration (radially inward)

  (ii) tangential acceleration (along the tangent or in the direction of velocity)



- **Non-uniform circular motion with constant angular acceleration**

  Equations of motion for the above motion are :

  (i) $\omega_2 = \omega_1 + \alpha t$

  (ii) $\theta = \omega_1 t + \frac{1}{2}\alpha t^2$

  (iii) $\omega_2^2 = \omega_1^2 + 2\alpha\theta$

  (iv) $\theta = \left(\frac{\omega_2 + \omega_1}{2}\right)t$

  (v) $\omega_{average} = \frac{\omega_2 + \omega_1}{2}$

  where, ω_1 = initial angular velocity ; ω_2 = final angular velocity ; θ = distance travelled ; t = time taken.

- Angular Displacement in the nth second (i.e., in a particular second) is given by,
- Angular speed, $\omega = 2\pi n$, where, n is number of revolutions per second or the frequency of revolution.

  Also, angular speed, $\omega = \frac{2\pi}{T}$, where T is time one revolution (called time period or period).

  If a particle is making N revolution per minute (denoted as rpm), angular speed, $\omega = \frac{2\pi N}{60}$

Ex. 40: The radii of circular paths of two particle of same mass are in ratio 6 : 8 then what will be velocities ratio if they have a constant centripetal force.

(1) $\sqrt{3}:4$ (2) $4:\sqrt{3}$ (3) $2:\sqrt{3}$ (4) $\sqrt{3}:2$

Sol: Here $\frac{r_1}{r_2}=\frac{6}{8}, \frac{m_1}{m_2}=1$

$$\frac{F_1}{F_2}=1 \text{ or } F_1 = F_2 \text{ or } \frac{m_1v_1^2}{r_1}=\frac{m_2v_2^2}{r_2}$$

$$\text{or } \frac{v_1^2}{v_2^2}=\frac{r_1}{r_2}\times\frac{m_2}{m_1}=\frac{6}{8}\times1=\frac{3}{4}$$

$$\therefore \frac{v_1}{v_2}=\frac{\sqrt{3}}{2}$$

Ex. 41: The ratio of angular speed of a second-hand to the hour-hand of a watch is

(1) 60 : 1 (2) 72 : 1 (3) 720 : 1 (4) 3600 : 1

Sol: The second-hand completes one rotation in 1 min and the hour-hand completes in 12 hour

$\therefore$ The angular speed of the secon-hand is

$$\omega_s=\frac{2\pi rad}{1min}=\frac{2\pi rad}{60s}$$

and that of the hour-hand is

$$\omega_h=\frac{2\pi rad}{12\text{ h}}=\frac{2\pi rad}{12\times60\times60s}$$

Their corresponding ratio is

$$\frac{\omega_s}{\omega_h}=\frac{\left(\frac{2\pi rad}{60s}\right)}{\left(\frac{2\pi\text{ rad}}{12\times60\times60s}\right)}=\frac{720}{1}$$

Ex. 42: If the lenght of seconds hand of a clock is 10 cm, the speed of its tip (in cm/s) in nearly-

(1) 2 (2) 0.5 (3) 1.5 (1) 1

Sol: Here, R = 10 cm

The second hand of a clock completes one rotation in its angular speed is

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

The speed of its tip is $v = \omega R$

$$=\frac{\pi}{30}\times10=1\text{ cm/sec}$$

Ex. 43: A child pushes a merry-go-round from rest to a final angular speed of 0.50 rev/s with constant angular acceleration. In doing so, thechild pushes the merry-go-round to 2 revolutions. What is the angular acceleration of the merry-go-round?

Sol: Initial angular speed,

$\omega_1 = 0$

final no. of revolution/sec or frequency, n = 0.50 rev/s

Final angular speed, $\omega_2 = 2\pi n = 2\pi(0.5) = \pi$ rev/s

angular acceleration, α = ?
Total no. of revolutions = 2
using, $\omega_2^2 - \omega_1^2 = 2\alpha\theta$; we get,
$\omega_2^2 - \omega_1^2 = 2\alpha\theta$
or $(\pi)^2 = (0)^2 + 2\alpha\,(4\pi)$
or $\pi^2 = 8\alpha\pi$
$\alpha = \pi/8$ rad/sec^2.

My Work Sheet

Q.1 Uniform circular motion is an Ex. of
(1) constant speed motion (2) constant velocity motion
(3) non-accelerated motion (4) zero accelerated motion

Q.2 A body moves in a circle covers equal distance in equal intervals of time. Which of the following remains constant ?
(1) Velocity (2) Acceleration (3) Speed (4) Displacement

Q.3 A particle moves in a circle of radius 5 cm with constant speed and time period 0.2 πs. The acceleration of the particle is
(1) 15 m/s^2 (2) 25 m/s^2 (3) 36 m/s^2 (4) 5 m/s^2

Q.4 The angular speed of a fly wheel making 120 rpm is
(1) 2π rad/s (2) π rad/s (3) 4π rad/s (4) $4\pi^2$ rad/s

Q.5 The acceleration of an object moving in a circle of radius R with uniform speed v is
(1) $\frac{v^2}{R}$ (2) $\frac{v^2}{2R}$ (3) $\frac{2v^2}{2R}$ (4) $\frac{3v^2}{2R}$

Q.6 A car is moving along a circular road at speed of 20 m/s. The radius of the circular road is 10 m. If the speed is increased at the rate of 30 m/s^2, what is the resultant acceleration ?
(1) 10 m/s^2 (2) 50 m/s^2 (3) 250 m/s^2 (4) 80 m/s^2

Q.7 A particle is describing uniform circular motion. Its acceleration is
(1) along the radius of circular path pointing towards the centre
(2) along the tangent to the circular path
(3) along the radius of the circular path pointing away from the centre
(4) zero.

Answer: 1 (1) **2** (3) **3** (4) 4 (3) **5** (1) **6** (2) **7** (1)

NEET - CHECK POINT

Q.1 Which of the following is a one-dimensional motion ? **[2001]**

(1) landing of an aircraft

(2) earth revolving around the sun

(3) motion of wheels of a moving trains

(4) train running on a straight track

A. **(4)**

Q.2 A 150 m long train is moving with a uniform velocity of 45 km/hr. The time taken by the train to cross a bridge of length 850 metres is **[2001]**

(1) 56 sec (2) 68 sec (3) 80 sec (4) 92 sec

A. **(3)**

Q.3 From the top of a tower, a particle is thrown vertically downwards with a velocity of 10 m/s. The ratio of the distances, covered by it in the 3^{rd} and 2^{nd} seconds of the motion is ($g = 10\ m/s^2$) **[2002]**

(1) 5 : 7 (2) 7 : 5 (3) 3 : 6 (4) 6 : 3

A. **(2)**

Q.4 A man drops a ball downside from the roof of a tower of height 400 metres.

At the same time another ball is thrown upside with a velocity 50 m/sec from the ground, then they will meet at which height from the surface of the ground. **[2003]**

(1) 100 metres (2) 320 metres (3) 80 metres (4) 240 metres

A. **(3)**

Q.5 A body falls from a height h = 200 m (at New Delhi). The ratio of distance travelled in each 2 second during t = 0 to t = 6 seconds of the journey is **[2004]**

(1) 1 : 4 : 9 (2) 1 : 2 : 4 (3) 1 : 3 : 5 (4) 1 : 2 : 3

A. **(3)**

NEET - CHECK POINT

Q.8 A ball is thrown vertically upward. It has a speed of 10 m/s when it has reached one half of its maximum height. How high does the ball rise (Taking g = 10 m/s^2)

[2005]

(1) 15 m (2) 10 m (3) 20 m (4) 5 m

A. **(2)**

Q.9 The distance travelled by a particle staring from rest and moving with an acceleration $\frac{4}{3}$ m/s^2, in the third second is **[2008]**

(1) 6 m (2) 4 m (3) $\frac{10}{3}$m (4) $\frac{19}{3}$m

A. **(3)**

Q.10 A ball is dropped from a high rise platfrom at t = 0 starting from rest. After 6 seconds another ball is thrown downwards from the same platform with a speed V. The two balls meet at t = 18 seconds. What is the value of V ? (g = 10 m/s^2)

[2010]

(1) 74 m/s (2) 55 m/s (3) 40 m/s (4) 60 m/s

A. **(1)**

'JEE (MAIN) CHECK-POINTS'

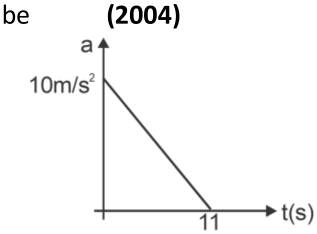
Q.1 A small block slides, without friction, down an inclined plane starting from rest. Let S_n be the distance travelled from time t = (n – 1) to t = (n). Then S_n/S_{n+1} is **(2004)**

(1) $\frac{2n-1}{2n}$ (2) $\frac{2n+1}{2n-1}$

(3) $\frac{2n-1}{2n+1}$ (4) $\frac{2n}{2n+1}$

A. **(3)**

Q.2 A body starts from rest at time = t = 0, the acceleration time graph is shown in the figure. The maximum velocity attained by the body will be **(2004)**



(1) 110 m/s (2) 55 m/s (3) 650 m/s (4) 550 m/s

A. **(2)**

Quick Jack".........

1. For one dimensional motion the angle between acceleration and velocity is either 0° or 180° and it does not change with time.

2. If the angle between acceleration and velocity is 90°, the path of the particle is circle.

3. The average speed is equal to instantaneous speed if the body moves with a constant speed.

4. No force is required to move the body or an object with uniform velocity.

5. When particle covers one-third distance at speed v_1, next one third at speed v_2 and last one third at speed v_3, then $v_{av} = \dfrac{3v_1v_2v_3}{v_1v_2 + v_2v_3 + v_3v_1}$.

6. For two particles having displacement time graph with slopes θ_1 and θ_2 possesses velocities v_1 and v_2 respectively then $a_{av} = \dfrac{a_1t_1 + a_2t_2}{t_1 + t_2}$.

7. If a particle is accelerated for a time t_1 with acceleration a_1 and for time t_2 with acceleration a_2 then average acceleration is

8. If a body starts from rest and moves with uniform acceleration then distance covered by the body in t sec is proportional to t^2(i.e. $s \propto t^2$)

9. If a body starts from rest and moves with uniform acceleration then distance covered by the body in n^{th} second is proportional to $(2n – 1)$

10. A particle moving with uniform acceleration from A to B along a straight line has velocities v_1 and v_2 at A and B respectively. If C is the mid-point between A and B then velocity of the particle at C is equal to $v = \sqrt{\dfrac{v_1^2 + v_2^2}{2}}$

11. A ball is dropped from a building of height h and it reaches after t seconds on earth. From the same building if two balls are thrown (one upwards and other downwards) with the same velocity u and they reach the earth surface after t_1 and t_2 seconds respectively then $t = \sqrt{t_1t_2}$

12. A particle is dropped vertically from rest from a height. The time taken by it to fall through successive distance of 1m each will then be in the ratio of the difference in the square roots of the integers i.e.,

$\sqrt{1}, (\sqrt{2} - \sqrt{1}), (\sqrt{3} - \sqrt{2})......(\sqrt{4} - \sqrt{3})....$

NCERT QUESTIONS WITH SOLUTIONS

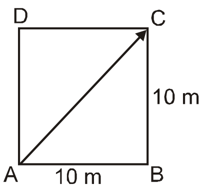
Q.1 An object has moved through a distance. Can it have zero displacement? If yes support your answer with an Examples

Ans. Yes, the object instead of moving through a distance can have zero displacement.

Examples If an object travels from point A and reaches to the same point A, then its displacement is zero.

Q.2 A farmer moves along the boundary of a square field of side 10 m in 40 s. What will be the magnitude of displacement of the farmer at the end of 2 minutes 20 seconds?

Ans. Figure ABCD is a square field of side 10 m.



Time for one round = 40 s

Total time = 2 min 20 s

= (2 × 60 + 20) s = 140 s

Number of round completed = $\frac{140}{40} = 3.5$

If farmer starts from A, it will complete 3 rounds ($A \to B \to C \to D \to A$) at A. In the last 0.5 round starting from A, he will finish at C.

Displacement of farmer = AC

$= \sqrt{AB^2 + AC^2} = \sqrt{10^2 + 10^2} = 10\sqrt{2}\,m$

Q.3 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. (a) False (b) False

Q.4 Distinguish between speed and velocity?

Ans.

Speed	Velocity
The distance travelled by a moving body per unit time is called its speed.	The distance travelled by moving body in a particular direction per unit time is called its velocity.
It is a scalar quantity.	It is a vector quantity.

Q.5 Under what condition(s) is the magnitude of average velocity of an object equal to its average speed?

Ans. The magnitude of average velocity of an object is equal to its average speed if the object moves in a straight line in a particular direction.

Q.6 What does the odometer of an automobile measure?

Ans. The odometer of an automobile measures the distance travelled by a vehicle.

Q.7 What does the path of an object look like when it is in uniform motion?

Ans. It is a straight line.

Q.8 During an experiment, a signal from a spaceship reach reached the ground station in five minutes. What was the distance of the spaceship from the ground station? The signal travels at the speed of light, that is 3×10^8 m s^{-1}?

Ans. Time taken = 5 minutes = 5× 60 s = 300 s

Speed of signal u = 3×10^8 m s^{-1}

distance = ?

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

$\therefore$ distance = speed × time

$\therefore$ distance $3 \times 10^8 \times 300 = 9 \times 10^{10}$ m

Q.9 When will you say a body is in

(i) uniform acceleration

(ii) non-uniform acceleration

Ans. (i) Uniform acceleration : When a body travels with the constant change in velocity in the givne time, then the acceleration is said to be uniform.

(ii) Non-uniform acceleration : When a body moves with unequal change in velocity in the given time, the body is said to be moving with non-uniform acceleration.

Q.10 A bus decreases its speed from 80 km h^{-1} to 60 km h^{-1} in 5 s. Find the acceleration of the bus.

Ans. Initial velocity u = 80 km h^{-1}

$= \frac{80 \times 1000}{60 \times 60}$ = m s^{-1} = 22.22 m s^{-1}

Final velocity v = 60 km h^{-1}

$= \frac{60 \times 100}{60 \times 60}$ = 16.6 m s^{-1}

Time t = 5 s

$\therefore$ a = ?

$$a = \frac{v-u}{t} = \frac{16.66-22.22}{5} = -1.11\ ms^{-2}$$

$\therefore$ The acceleration of bus is – 1.11 m s^{-2}.

Q.11 A racing car has a uniform acceleration of 4 m s^{-2}. What distance will it cover in 10 s after start?

Ans. a = 4 m s^{-2} t = 10 s

s = ?   u = 0

$$\therefore\ s = ut + \frac{1}{2}at^2 = 0 \times 10 + \frac{1}{2} \times 4 \times (10)^2$$

$$= 0 + \frac{1}{2} \times 4 \times 100$$

s = 200 m

The distance covered in 10 s by the car is 200m.

Q.12 A stone is thrown in a vertically upward direction with a velocity of 5 m s^{-1}. If the acceleration of the stone during its motion is 10 m s^{-1} in the downward direction, what will be the height attained by the stone and how much time will it take to reach there?

Ans. u = 5 m s^{-1} v = 0

a = – 10 m s^{-2} s = >

t = ?

(i) v = u + at

0 = 5 + (– 10) t

– 5 = – 10 t

$$\therefore t = \frac{5}{10} = 0.5s$$

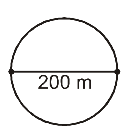
(ii) $v^2 - u^2 = 2as$

$(0)^2 - (5)^2 = 2(-10) \times s$

$$-25 = -20 \times s \ \therefore\ s = \frac{25}{20} = 1.25\ m$$

Q.13 An athelete completes one round of a circular track of diameter 200 m in 40 s. What will bethe distnace covered and the displacement at the end of 2 minutes 20 s?

Ans. Diamter = 200 m, $r = \frac{d}{2}$ = 100 m



Time for one round = 40 s

Distance travelled in 2 minutes and 20 s

$$(2 \times 60 + 20 = 140\ s) = \frac{140}{40} = 3.5\ \text{rounds}$$

Distance travelled=Circumference of the circle×3.5

$$= 2\pi r \times 3.5 = 2 \times \frac{22}{7} \times 100 \times 3.5 = 2200m$$

Displacement after 3.5 revolutions

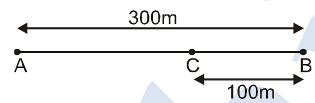
= diameter of the track = 200 m.

Q.14 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.

(a) from A to B and

(b) from A to C?

Ans. (a) From A to B.



Time for A to B = 2 min 30 s

= 2 × 60 + 30 = 150 s

$$\text{Average speed} = \frac{\text{total distance}}{\text{time interval}} = \frac{300}{150} = 2ms^{-1}$$

$$\text{Average velocity} = \frac{\text{displacement}}{\text{time interval}} = \frac{300}{150} = 2\ m\ s^{-1}$$

(b) From A to C,

Time taken (A to B + B to C)

= 150 + 60 = 210 s

total distance = 300 + 100 = 400 m

$$\therefore \text{Average speed} = \frac{\text{total distance}}{\text{timeinterval}} = \frac{400}{210}$$

= 1.9 m s^{-1}

$$\therefore \text{Average velocity} = \frac{\text{displacement}}{\text{time interval}} = \frac{200}{210}$$

= 0.95 m s^{-1}

Q.15 Abdul, while driving to school, computes the average speed for his trip to be 20 km h^{-1}. On his return trip along the same route, there is less traffic and the average speed is 30 km h^{-1}. What is the average speed for Abdul's trip?

Ans. Let the school be at a distance of x ikm. If t_1 is time taken to reach the school, then

$$t_1 = \frac{\text{distance}}{\text{average speed}} = \frac{x}{20}$$

If t_2 is t ime taken to reach back, then

$$t_2 = \frac{\text{distance}}{\text{average speed}} = \frac{x}{30}$$

total time,

$$t = t_1 + t_2 = \frac{x}{20} + \frac{x}{30} = x\left[\frac{1}{20} + \frac{1}{30}\right] = \frac{5x}{60} = \frac{x}{12}$$

total distance x + x = 2x

Average speed

$$= \frac{\text{total distance}}{\text{totaltime}} = \frac{2x}{x/12} = 24km\ h^{-1}$$

Q.16 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?

Ans. u = 0

a = 3.0 m s^{-2}

s = ut + $\frac{1}{2}at^2 = 0 \times t + \frac{1}{2}(3)(8)^2$

s = $\frac{1}{2} \times 3 \times 64 = 96m$

$\therefore$ Boat travelled a distance of 96 m.

Q.17 A driver of a car travelling at 52 km h^{-1} applies the brakes and accelerates uniformly in the opposite direction. The car stops in 5 s. Another driver going at 3 km h^{-1} in another car appluies 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?

Ans. The data given in this numerical problem are in different units.

So, we should first convert km h^{-1} unit into m s^{-1} unit.

For first car :

Initial velocity u = 52 km h^{-1}

= $\frac{52km}{1\,h} = \frac{52 \times 1000\,m}{1 \times 3600s}$ = 14.4 m s^{-1}

Final velocity, v = 0 km h^{-1} = 0.0 m s^{-1}

Time taken, t = 5 s

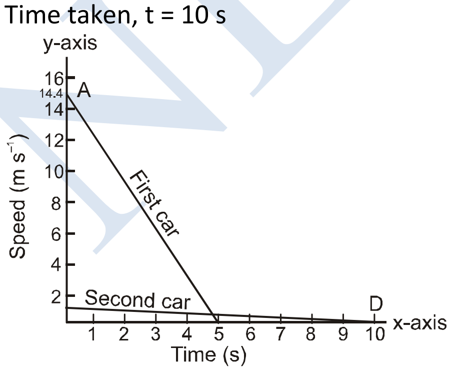
For second car :

Initial velocity, u = 3 km h^{-1}

= $\frac{3km}{1h} = \frac{3 \times 1000m}{1 \times 3600s}$ = 0.83 m s^{-1}

Final velocity, v = 0 km h^{-1} = 0.0 m s^{-1}

Time taken, t = 10 s



The distance travelled by a moving body is given by the area under its speed-time graph. So,

Distance travelled by the first car = Area of the triangle AOB

= $\frac{1}{2} \times OB \times AO = \frac{1}{2} \times 14.4ms^{-1} \times 5s$

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

Similarly,

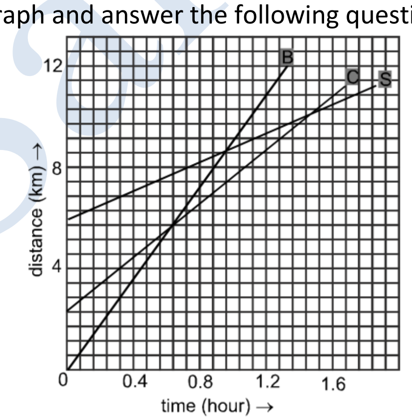
Distance travelled by the second car = Area of triangle COD

= $\frac{1}{2} \times OD \times CO = \frac{1}{2} \times 0.83ms^{-1} \times 10s$

= $\frac{1}{2} \times 0.83 \times 10m = 4.1m$

Thus, the second car travels 4.1 m and the first car travels 36 m before coming to rest. So, the first car travelled farther the brakes were applied.

Q.18 Figure given below shows 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) Area 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?

Ans. (a) Slope = $\frac{y}{x} = \frac{\text{Distance}}{\text{time}}$

Speed = slope of the graph

since slope of object B is greater than A and C, it is travelling the fastest

(b) All three object A, B & C never meet at a single point

(c) On the distance axis.

7 small boxes = 4 km.

1 small box = $\frac{4}{7}$ km.

Object C is 4 blocks away from the origin

i, e $4 \times 4 = \frac{16}{7}$ km from origin so the distance covered by C (when B passes A at 8 km (given) in graph)

$= 8-\frac{16}{7}=\frac{40}{7}=5.714\text{km}$

(d) Now when B passes C, distance covered by B was 9 boxes,

1 box = $\frac{4}{7}$km

Hence, B has travelled $\frac{36}{7}$km

or 5.14 km.

Q.19 A ball is gently dropped from aheight of 20 m. If its velocity increases uniformly at the rate of 10 ms^{-2}, with what velocity will it strike the ground? After what time will it strike the ground?

Ans. s = 20 m, u = 0, a = 10 m s^{-2}

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

$\therefore$ (20) = 0 × $\frac{10}{t}(10)t^2 \Rightarrow 20=\frac{1}{2}\times 10t^2$

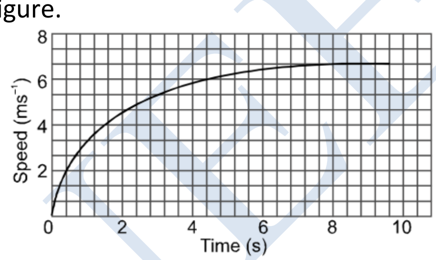
$\frac{20\times 2}{10}=t^2 \Rightarrow t^2=4$

$\therefore$ t = 2 s

v = u + at = 0 + 10 × 2 = 20 m s^{-1}

The ball strike the ground after 2 s with the velocity of 20 m s^{-1}.

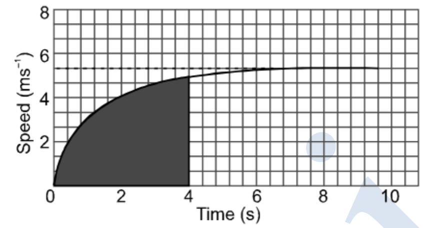
Q.20 The speed-time graph for a car is shown in the figure.



(a) Find how far does thecar 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?

Ans. The motion during first 4 seconds is not uniformly accelerated. So, distance travelled by car in first 4 seconds is calculated by graphical method.



(a) Distance covered = area under speed – time

$\Rightarrow$ Distance $\frac{1}{2}\times 4\times 6=12\text{m}$

(b) After 6 seconds the car moves in uniform motion (at a speed of 6 m/s).

Q.21 State which of thefollowing situations are possible and give an Examples 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

Ans. (a) free fall dueto gravity

(b) object moving in a circular path

Q.22 An artificial satellite is moving in a circular orbit of radius 42250 km. Calculate its speed if it takes 24 hourse to revolve around the earth.

Ans. Radius of the orbit = 42250 km

= 42250 × 1000 m

Time taken for one revolution = 24 hours

= 24 × 60 × 60 s

Speed = ?

$\therefore$ Speed = $\frac{\text{distance}}{\text{time}}=\frac{2\pi r}{\text{time}}$

$= 2\times\frac{22}{7}\times\frac{42250\times 1000}{24\times 60\times 60}$

Speed = 3073.74 m s^{-1}

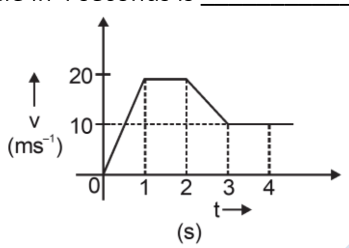
= 3.07 km s^{-1}.

KNOWLEDGE BASKET

Q.1 The ratio of magnitude of displacement to distance is always
(1) less than 1
(2) greater than 1
(3) equal to 1
(4) less than or equal to 1

Q.2 The ratio of the heights from which two bodies are dropped is 3 : 5, respectively. The ratio of their final velocities is
(1) $\sqrt{5}:\sqrt{3}$ (2) $\sqrt{3}:\sqrt{5}$
(3) 9 : 25 (4) 5 : 3

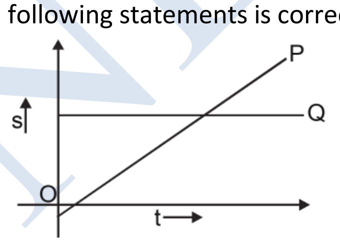
Q.3 The variation of the velocity of a particle moving along a straight line is illustrated in the graph given below. The distance covered by the particle in 4 seconds is ____________m.



(1) 20 (2) 35 (3) 40 (4) 55

Q.4 An ant moves from one corner of a hall to the diagonally opposite corner. If the dimensions of the floor of hall are 8m × 6m, the displacement of the ant is _____________m.
(1) 14 (2) 10 (3) 28 (4) 2

Q.5 The figure given below shows the displacement-time graph of the two particles P and Q. Which of the following statements is correct ?



(1) Both P and Q move with uniform equal speed
(2) P is accelerated and Q is retarded
(3) Both P and Q move with uniform speed, but the speed of P is more than the speed of Q.
(4) Both P and Q move with uniform speeds but the speed of Q is more than the speed of P.

Q.6 When brakes are applied the velocity of a car changes from 40 ms^{-1} in 10 s. The acceleration produced in it is ____________ms^{-2}
(1) – 3 (2) 3
(3) – 5 (4) 5

Q.7 If a body starts from rest and move with uniform acceleration, then
(1) $v \propto t$ (2) $s \propto t$
(3) $v \propto s$ (4) $s \propto \sqrt{t}$

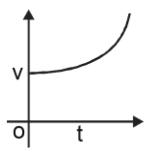
Q.8 If a body is projected vertically upwards, then on reaching maximum height, its
(1) velocity is zero and the acceleration is not zero
(2) velocity is not zero and the acceleration is zero
(3) both velocity and acceleration are not zero
(4) both velocity and acceleration are zero

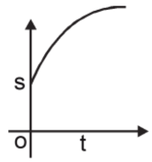
Q.9 The ratio of the times taken by a body moving with uniform acceleration in reaching two points P and Q along a straight line path is 1 : 2. If the body starts from rest, then the ratio of the distances of P and Q from the starting point is
(1) 4 : 1 (2) 1 : 4
(3) 2 : 3 (4) 3 : 1

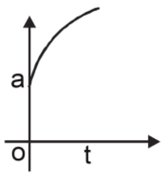
Q.10 A body with an initial velocity of 3 ms^{-1} moves with an acceleration of 2 ms^{-2}. Then the distance travelled in the 4th second is ___________m
(1) 10 (2) 6
(3) 7 (4) 28

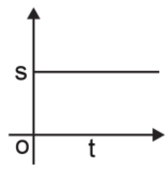
Q.11 A bus travels the first one-third distance at a speed of 10 km h^{-1}, the next one third distance at a speed of 20 km h^{-1} and the next one-third distance at a speed of 30 km h^{-1}. The average speed of the bus is :
(1) 200 ms^{-1} (2) $\frac{50}{11} ms^{-1}$
(3) $\frac{180}{11} ms^{-1}$ (4) 30 ms^{-1}

Q.12 Which of the following graph indicates that a body is undergoing retardation ?

(1) 

(2) 

(3) 

(4) 

Q.13 The velocity of a body is given by the equation v= 6 – 0.02 t, where t is the time taken. The body is undergoing

(1) uniform retardation
(2) uniform acceleration
(3) non-uniform acceleration
(4) zero - acceleration

Q.14 A body starts from rest and moves with uniform acceleration for 2s. It then decelerates uniformly for 3 s and stops. If deceleration is 4 ms^{-2}, the acceleration of the body is ________ms^{-2}

(1) 10 (2) 8.7 (3) 4 (4) 6

Q.15 Density is a ___________quantity

(1) Scalar
(2) derived
(3) neither (1) nor (2)
(4) Both (1) and (2)

Q.16 A particle moves from P to Q with a uniform velocity v_1 and Q to P with a velocity v_2. If it moves along a straight line between P and Q, then its average velocity will be _____________.

(1) $\frac{2v_1v_2}{v_1+v_2}$ (2) $\frac{v_1v_2}{2}$

(3) $\frac{v_1+v_2}{2}$ (4) Zero

Q.17 If a body is projected vertically up from a point and it returns to the same point, its

(1) average speed is zero, but not average velocity
(2) both average speed and average velocity are zero
(3) average velocity is zero but not average speed
(4) both average speed and velocity depend upon the path

Q.18 If a ball thrown vertically up attains a maximum height of 80m, then its velocity of projection is ($g=10\ ms^{-2}$)

(1) 40 ms^{-1} (2) 20 ms^{-1}
(3) 50 ms^{-1} (4) 10 ms^{-1}

Q.19 A vertically projected down body travels with

(1) uniform velocity (2) uniform speed
(3) uniform acceleration (4) uniform retardation

Q.20 A particle revolves along a circle with a uniform speed. The motion of the particle is _____

(1) one dimensional (2) two dimensional
(3) translatory (4) oscillatory

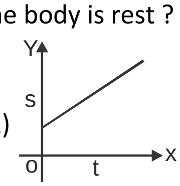
Q.21 If u is the initial velocity, of a body projected with an angle θ with the horizontal, then the maximum height reached

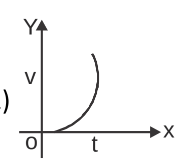
(1) $\frac{u^2}{g}$ (2) $\frac{u^2\sin\theta}{2g}$ (3) $\frac{u\sin\theta}{2g}$ (4) $\frac{u^2\sin^2\theta}{2g}$

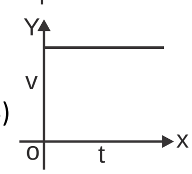
Q.22 If the body is projected up into air with certain angle then the path followed by it is

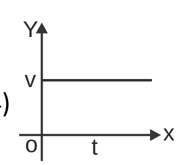
(1) Linear path (2) Elliptical path
(3) Parabolic path (4) Spherical path

Q.23 Which on of the following graph indicates that the body is rest ?

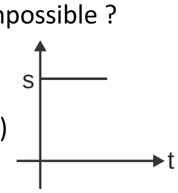
(1) 

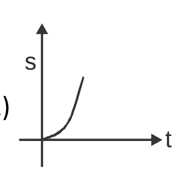
(2) 

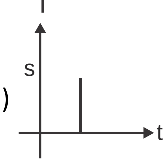
(3) 

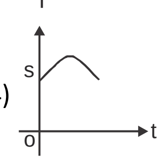
(4) 

Q.24 Which of the following graphs given below is impossible ?

(1) 

(2) 

(3) 

(4) 

Q.25 If a body travels with an acceleration d_1 for time t_1 and acceleration a_2 for time t_2, t_1 and t_2 being successive time intervals, then the average acceleration of the body is

(1) $\frac{a_1t_1+a_2t_2}{2(t_1+t_2)}$ (2) $\frac{a_1t_1+a_2t_2}{(t_1+t_2)}$

(3) $\frac{(a_1+a_2)}{t_1+t_2}$ (4) $\frac{a_1t_1-a_2t_2}{(t_1+t_2)}$

Q.26 If a body covers 26 m and 30 m in the 6th and 7th seconds of its travel, then the initial velocity and acceleration of the body are

(1) 4 ms^{-1}, 4 ms^{-2}

(2) 6 ms^{-1}, 4 ms^{-2}

(3) 10 ms^{-1}, 8 ms^{-2}

(4) 0, 4 ms^{-2}

Q.27 The ratio of maximum height reached by two bodies projected vertically up is a : b, then the ratio of their initial velocity of is

(1) a : b (2) $a^2:\sqrt{b}$

(3) $\sqrt{b}:\sqrt{a}$ (4) $\sqrt{a}:\sqrt{b}$

Q.28 A particle moves along a circular track of 6m radius such that the are of the circular track covered subtends an angle of 30° at the centre. The distance covered by the body is

(1) π m (2) 13 π m

(3) 4π m (4) 6π m

Q.29 A body goes from A to B with a velocity of 20 m/s and comes back from B to A with a velocity of 30 m/s. The average velocity of the body during the whole journey is

(1) zero (2) 25 m/s

(3) 24 m/s (4) none of these

Q.30 If an object covers distances directly proportional to the square to the time lapsed, then the acceleration is

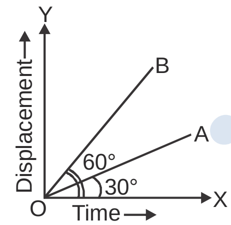
(1) increasing

(2) decreasing

(3) constant

(4) none of these

Q.31 If the displacement time graph for two particles A and B are straight lines inclined at angles of 30° and 60° with the time axis, then ratio of the velocities $v_A:v_B$ will be



(1) 1 : 2 (2) 1 : 3

(3) $\sqrt{3}:1$ (4) 3 : 1

Q.32 A motor ship covers the distance of 300 km between two localities on a river in 10 hrs downstream and in 12 hrs upstream. Find the flow velocity of the river assuming that these velocities are constant.

(1) 2.0 km/hr (2) 2.5 km/hr

(3) 3 km/hr (4) 3.5 km/hr

Q.33 Driver of a train travelling at 115 km/hr sees on the same track, 100 m in front of him, a slow train travelling in the same direction at 25 km/hr. The least retardation that must be applied to faster train to avoid a collision in the same direction at 25 km/hr. The least retardation that must be applied to faster train to avoid a collision

(1) 3.125 m/s^2 (2) 3.5 m/s^2

(3) 2.75 m/s^2 (4) 3.0 m/s^2

Q.34 A farmer has to go 500 m due north, 400 m due east and 200 m due south to reach his field. If he takes 20 min to reach the field, what is the average velocity of farmer during the walk ?

(1) 35 m/min (2) 45 m/min.

(3) 25 m/min (4) 55 m/min.

Q.35 A stone weighing 3 kg falls from the top of a tower 100m high and buries itself 2m deep in the sand. The time of penetration is

(1) 0.09 sec (2) 0.9 sec

(3) 2.1 sec (4) 1.3 sec

Q.36 The velocity of a body at any instant is 10 m/s. After 5 sec, velocity of the particle is 20 m/s. The velocity at 3 seconds before is

(1) 8 m/sec (2) 4 m/sec
(3) 6 m/sec (4) 7 m/sec

Q.37 A body covers 200 cm in the first 2 sec and 220 cm in next 4 sec. What is the velocity of the body at the end of 7th second ?

(1) 40 cm/sec (2) 20 cm/sec
(3) 10 cm/sec (4) 5 cm/sec

Q.38 A boat takes 2 hrs. to travel 8 km and back in still water lake. With water velocity of 4 km/hr, the time taken for going upstream of 8 km and coming back is

(1) 120 min (2) 160 min
(3) 200 min (4) none of these

Q.39 A body falls from a height h = 200m. The ratio of distance travelled in each 2s, during t =0 to t = 6s of the journey is

(1) 1 : 4 : 9 (2) 1 : 2 : 4
(3) 1 : 3 : 5 (4) 1 : 2 : 3

Q.40 A stone is thrown vertically upward with an initial velocity u from the top of a tower. It reaches the ground with a velocity 3u. The height of the tower is

(1) $\frac{3u^2}{g}$ (2) $\frac{4u^2}{g}$ (3) $\frac{6u^2}{g}$ (4) $\frac{9u^2}{g}$

Q.41 It a body of mass 0.10 kg is moving on circular path of diameter 1.0 m at the rate of 10 revolutions per 31.4 sec, then centripetal force acting on the body (π = 3.14) is

(1) 0.2 Newton (2) 2.0 Newton
(3) 0.02 Newton (4) 20.0 Newton

Q.42 The earth's radius is 6400 km. It makes one rotation about its own axis in 24 hrs. The centripetal acceleration of a point on its equator is nearly

(1) 340 cm/s^2 (2) 34 cm/s^2
(3) 3.4 cm/s^2 (4) 0.34 cm/s^2

Q.43 The acceleration of a point on the rim of flywheel 1m 'n diameter, if it makes 1200 revolutions per minute is

(1) 8 π^2 m/s^2 (2) 8 π^2 m/s^2
(3) 800 π^2 m/s^2 (4) none of these

Q.44 A phonograph record on turn table rotates at 30rpm. The linear speed of a point on the record at the needle at the beginning of the recording when it is at a distance of 14 cm from the centre is

(1) 22 cm/sec (2) 44 cm/sec
(3) 48 cm/sec (4) 52 cm/sec

Q.45 A rubber ball dropped from a certain height is an Examples of

(1) uniform acceleration
(2) uniform retardation
(3) uniform speed
(4) non-uniform speed

Q.46 For motion on a straight-line path with constant acceleration, the ratio of the magnitude of the displacement to the distance covered is

(1) = 1 (2) ≥ 1 (3) ≤ 1 (4) < 1

Q.47 The speed of a train increases at a constant rate α from zero to v, and then remains constant for an interval, and finally decreases to zero at a constant rate β. If L be the total distance travelled, then the total time taken is

(1) $\frac{L}{v}+\frac{v}{2}\left(\frac{1}{\alpha}+\frac{1}{\beta}\right)$ (2) $\frac{L}{v}+\frac{2}{v}\left(\frac{1}{\alpha}+\frac{1}{\beta}\right)$

(3) $\frac{L}{v}+2v\left(\frac{1}{\alpha}+\frac{1}{\beta}\right)$ (4) $\frac{L}{v}+\frac{1}{v}\left(\frac{1}{\alpha}+\frac{1}{\beta}\right)$

Q.48 The velocity of a particle moving in the positive direction of x-axis varies as v = $5\sqrt{x}$ m/s. Assuming that at t =0 particle was at x =0, what is the acceleration of the particle ?

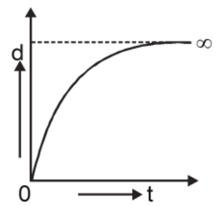
(1) 12.5 m/s^2
(2) 7.5 m/s^2
(3) 5 m/s^2
(4) 2.5 m/s^2

Q.49 A train starts from a station P with a uniform acceleration a_1 for some distance and then goes with uniform retardation a_2 for some more distance to come to rest at the station Q. The distance between the stations P and Q is 4 km and the train takes 4 minutes to complete this journey, then $\frac{1}{a_1}+\frac{1}{a_2}=?$

(where a_1 and a_2 are in km/min^2)

(1) 3 (2) 4 (3) 2 (4) 5

Q.50 The distance of a particle as a function of time is shown below. The graph indicates that



(1) The particle starts with certain velocity but the motion is retarded and finally the particle stops
(2) The velocity of the particle is constant throughout in the direction of motion
(3) The acceleration of the particle is constant throughout in the direction of motion
(4) The particle starts with some constant velocity, the motion is accelerated, and finally the particle moves with some constant velocity.

Q.51 A particle is acted upon by a constant force, the direction of which is always perpendicular to the velocity of particle. The motion of particle takes place in same plane. From the above statement implies

(1) Particle is moving in a circular path
(2) Magnitude of its acceleration is constant
(3) Its velocity is uniform
(4) Both (1) and (2)

Q.52 A particle is moving in a straight line with initial velocity u and uniform acceleration f. If the sum of the distance travelled in t^{th} and $(t+1)^{th}$ seconds is 100 cm, then its velocity after t seconds in cm/s is

(1) 20 (2) 30 (3) 50 (4) 80

Q.53 A body freely falling from rest has velocity v after it falls through a height h. The distance it has to fall down further for its velocity to become double is

(1) 4h (2) 6h
(3) 8h (4) 10 h

Q.54 A body moves along the circumference of a circular track. It returns back to its starting point after completing the circular track twice. If the radius of the track is r, the ratio of displacement to the distance covered by the body will be

(1) 0 (2) $8\pi R$
(3) $\sqrt{3R}$ (4) $\frac{p}{R}$

Q.55 Two cards are going round curves, one car travelling at 60 km/hr and the other at 30 km/hr. Each car experiences the same centripetal acceleration. The radii of the two curves are in the ratio

(1) 4 : 1 (2) 2 : 1
(3) 1 : 2 (4) 1 : 4

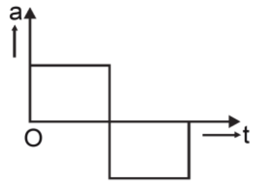
Q.56 A particle is moving eastwards with a velocity of 5 m/s. In 10 seconds the velocity changes to 5 m/s northwards. The average acceleration of the particle is

(1) 0
(2) $\frac{1}{\sqrt{2}}$ m/s^2 towards north-west
(3) $\frac{1}{\sqrt{2}}$ m/s^2 towards north-east
(4) $\frac{1}{\sqrt{2}}$ m/s^2 towards south-east

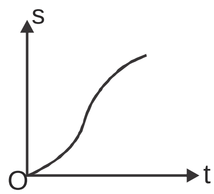
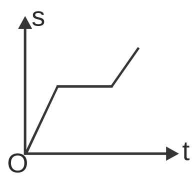
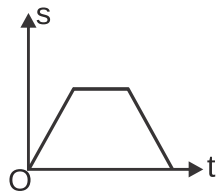
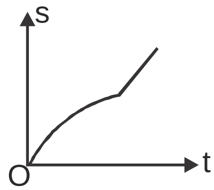
Q.57 An object is moving with velocity 10 m/s. A constant force acts for 4 s on the object and gives it a speed of 2 m/s in opposite direction. The acceleration produced is

(1) 3 m/s^2 (2) – 3m/s^2
(3) 6 m/s^2 (4) –6m/s^2

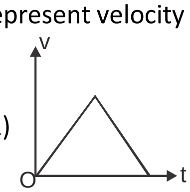
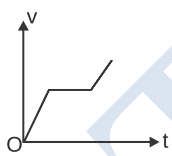
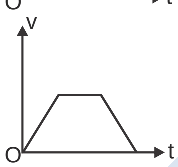
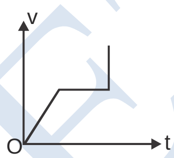
Q.58 A particle starts from rest and its acceleration plotted against time (t) is shown below :



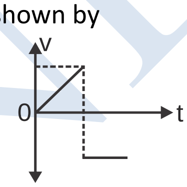
Which of the following represents displacement (s) plotted against time (t) ?

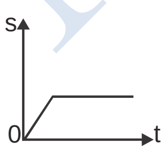
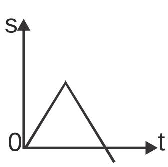
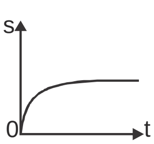
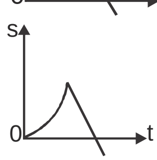
(1) 
(2) 
(3) 
(4) 

Q.59 In question 58, which of the following will represent velocity (v) plotted against time (t) ?

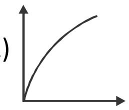
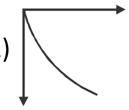
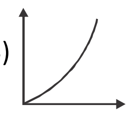
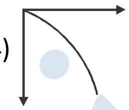
(1) 
(2) 
(3) 
(4) 

Q.60 The velocity time graph for a particle moving along x-axis is shown in the figure. The corresponding displacement time graph is correctly shown by



(1) 
(2) 
(3) 
(4) 

Q.61 Which one of the following distance-time graphs best represents a body with initial velocity u that undergoes

(1) 
(2) 
(3) 
(4) 

Q.62 A fan is making 600 revolutions /minute. If it makes 1200 revolutions/minute, what is the increase in its angular velocity ?

(1) 10 π rad/sec

(2) 20 π rad/sec

(3) 60 π rad/sec

(4) 40 π rad/sec

Q.63 The metal bob of a simple pendulum swings to and fro with simple harmonic motion. Which quantity does not become zero at any time throughout the oscillation ?

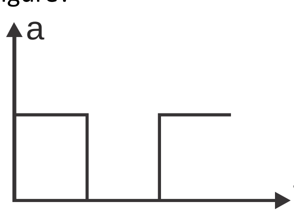
(1) speed

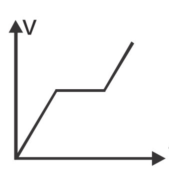
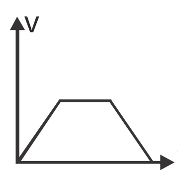
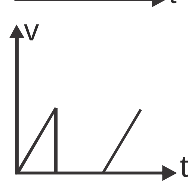
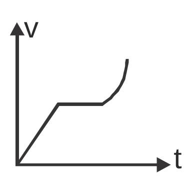
(2) acceleration

(3) momentum

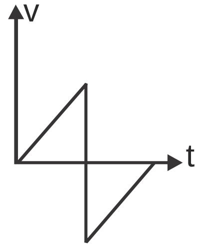
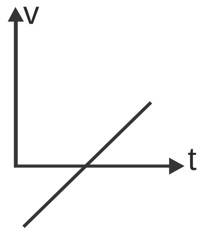
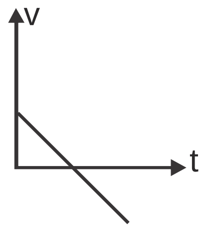
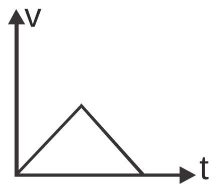
(4) weight

Q.64 Which of the following graphs would probably show the velocity plotted against time graph for a body whose acceleration-time graph is shown in the figure?

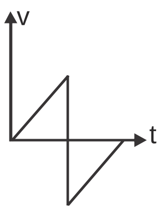
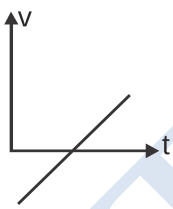
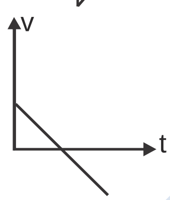
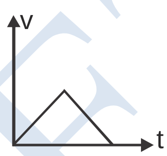


(1) 
(2) 
(3) 
(4) 

Q.65 The velocity-time graph of a body falling from rest under gravity and rebounding from a solid surface is represented by which of the following graphs ?

(1) 
(2) 
(3) 
(4) 

Q.66 The acceleration-time graph for a body is shown in the figure. The most probable velocity-time graph for the body is :

(1) 
(2) 
(3) 
(4) 

Q.67 A stone tied to the end of a 20 cm long string is whirled in a horizontal circle. If the centripetal acceleration is 9.8 m/s^2, its angular speed in rad/sec is

(1) $\frac{22}{7}$ (2) 7 (3) 14 (4) 20

Q.68 One radian is approximately equal to

(1) 10° (2) 5°
(3) 12° (4) 60°

Q.69 A wheel is 1m in diameter. When it makes 30 rev/min, the linear speed of a point on its circumference (in m/s) is

(1) π (2) $\frac{p}{2}$
(3) 30π (4) 60π

Q.70 The ratio of angular speed of minute's hand and hour's hand of a watch is

(1) 1 : 6 (2) 6 : 1
(3) 1 : 12 (4) 12 : 1

Q.71 The angular speed of the second's hand of a watch in rad/sec is

(1) π (2) $\frac{p}{3}$
(3) $\frac{p}{2}$ (4) $\frac{p}{30}$

Q.72 The angular speed of the hour's hand of a watch in rad/min is

(1) $\frac{p}{6}$ (2) $\frac{p}{30}$
(3) $\frac{p}{180}$ (4) $\frac{p}{360}$

Q.73 A stone is dropped from the top of a TV tower 200m high and at the same time another stone is projected vertically up from the ground with a velocity of 50 ms^{-1}. Find where and when the two stones meet. (take g = 10 m/s^2)

(1) 2 s : 60 m from ground
(2) 3 s ; 90 m from ground
(3) 4 s : 120 m from ground
(4) 5 s : 150 m from ground

Q.74 A juggler maintains three balls in motion, making each in turn rise to a height of 11.25 m from his hand. With what velocity does he project them and where will other two balls be at the instant when the third one (B_3) is just leaving the hand ? (here B_1 – 1st ball, B_2 – 2nd ball and B_3 – 3rd ball)

(1) B_1 = at 10 m height moving up, B_1 = at 10 m height moving down
(2) B_1 = at 5 m height moving up, B_2 = at 5 m height moving down
(3) B_1 = at 15 m height moving up, B_2 = at 15 m height moving down
(4) B_1 = at 10 m height moving down, B_2 = at 10 m height moving up

Q.75 Water drops trickle out from a nozzle and fall on the floor 5m below at a rate of 2 drops per second. When first drop reaches the floor, 3rd drop begins to fall. Find the position of 2nd drop when first drop just strikes the floor
(take g =10 ms^{-2})
(1) 1.25 m from nozzle
(2) 2.25 m from nozzle
(3) 3.25 m from nozzle
(4) 4.25 m from nozzle

Q.76 Two bodies of different masses m_a and m_b are dropped from different heights a and b. Find the ratio of the amounts of time taken by the two to cover the distances.
(1) $\frac{1}{\sqrt{a}}:\frac{1}{\sqrt{b}}$ (2) $\sqrt{a}:\sqrt{b}$
(3) $\frac{1}{a}:\frac{1}{b}$ (4) a : b

Q.77 A stone is dropped from the top of a tower. If it travels 34.3m in the last second before it reaches the ground, find the height of the tower.
(1) 39.2m (2) 58.8m (3) 78.4m (4) 98m

Q.78 On a planet, freely falling objects falls through a height h in $\sqrt{h}$ seconds. Find the acceleration due to gravity on that planet.
(1) 2 ms^{-2} (2) 4 ms^{-2}
(3) 6 ms^{-2} (4) 8 ms^{-2}

Q.79 A freely falling object falls through a height h in the nth second. What is the fall of height in the next second ?
(1) h – g (2) hg (3) h+ g (4) $\frac{h}{g}$

Q.80 An object is dropped from a certain height and takes 2 seconds to reach the ground. Find the ratio of the distances covered by the body in the last 1/2 second and the last but one 1/2 second.
(take g = 10 ms^{-2})
(1) 5 : 7 (2) 7 : 5 (3) 3 : 5 (4) 5 : 3

Q.81 A stone is dropped from a certain height and another stone is dropped from the same height after 2 s. What will be their separation after 10 more seconds ?
(1) 115.6 m (2) 156.5 m
(3) 172.3 m (4) 215.6 m

Q.82 A body falls from a height of 100m. After 2 seconds if gravity disappears, find the total time it would take to reach the ground
(take g = 10 ms^{-2})
(1) 2 s (2) 4s (3) 6s (4) 8s

Q.83 A body is falling freely. If the displacement in the last second is equal to the displacement in the first 3 seconds, find the time of free fall
(1) 5s (2) 10 s (3) 15 s (4) 20 s

Q.84 An object is thrown vertically up with a velocity of 49 ms^{-1}. How high will it rise ?
(1) 98m (2) 117.6m (3) 122.5m (4) 137.2m

Q.85 A body thrown vertically upward remains in air for 2 second. Another body is thrown vertically upward with double the velocity. How long does it stay in air ?
(1) 4 s (2) 8 s (3) 16 s (4) 32 s

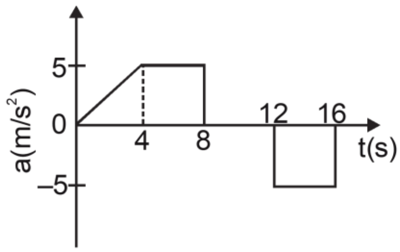
Q.86 An object is thrown vertically up with an initial velocity 9.8 ms^{-1}. Find the displacement and distance covered by it if it reaches the starting point :
(1) 9.8 m ; 0 (2) 0 ; 9.8 m
(3) 0 ; 4.9 m (4) 4.9 m ; 0

Q.87 A stone is thrown vertically up with an initial velocity 49 ms^{-1} from the top of a tower and reaches ground after 12 seconds. Find the height of the tower
(1) 98 m (2) 117. 6 m
(3) 137.2m (4) 156.8 m

Q.88 Two stones are projected from the top of a tower 100 m high each with a velocity 10 ms^{-1}. One is projected vertically up and the other vertically down. Find the ratio of the speeds with which they strike the ground
(1) 1 : 10 (2) 10 :1 (3) 1 : 1 (4) 2 : 1

Q.89 A ball is projected vertically up from the foot of a tower of height 100 m with a velocity of 40 ms^{-1}. At the same instant another ball is dropped from the top of the tower. When and where do they meet each other ? (take g = 10 m/s^{-2})
(1) 2.5 s ; 68.75 m from ground
(2) 2 s ; 65 m from ground
(3) 3 s ; 75 m from ground
(4) 3.5 s ; 85 m from ground

Q.90 The acceleration of a train between two stations is shown in the figure. The maximum speed of the train is :



(1) 60 m/s (2) 30 m/s
(3) 120 m/s (4) 90 m/s

Q.91 An object is projected vertically up from the top of a tower of height 58.8 m with an initial velocity 4.9 ms^{-1}. Calculate the time of flight of the object
(1) 2s (2) 4s (3) 6s (4) 8s

Q.92 If the time of fall of two objects are in the ratio 1 : 2 find the ratio of the heights from which they fall.
(1) 1 : 2 (2) 2 : 1 (3) 1 : 4 (4) 4 : 1

Q.93 An object is dropped from a balloon rising up with a velocity 2 ms^{-1}. Find the velocity of the object after 2 second of its release. (take g = 10 ms^{-2})
(1) 9 ms^{-1} (2) 18 ms^{-1}
(3) 27 ms^{-1} (4) 36 ms^{-1}

Q.94 A girl is throwing balls vertically up whenever the previous one is at its highest point. If she throws twice in a second, find the maximum height of rise of ball
(1) 1.225 m (2) 12.25 m
(3) 122.5 m (4) 1225 m

Q.95 What is the ratio of distances travelled by a freely falling object in the first, second and third second of its fall ?
(1) 1 : 2 : 3 (2) 1 : 3 : 5
(3) 1 : 5 : 3 (4) 3 : 1 : 5

Q.96 A freely falling object covers 58.8m in the last second of its fall. Find the height of fall
(1) 20.7m (2) 207m (3) 10.7m (4) 107m

Q.97 An object dropped from the top of a tower covers in the last second, seven times the distance it covered in the first second. Find the time of flight
(1) 2s (2) 3s (3) 4s (4) 5s

Q.98 A stone is dropped into water from a bridge of height 44.1 m above the water level. Another stone is thrown into water 1 second later. If both strike the water simultaneously, find the initial speed of the second stone.
(1) 12.25 ms^{-1} (2) 12.5 ms^{-1}
(3) 12.75 ms^{-1} (4) 13 ms^{-1}

Q.99 A stone is projected up with a velocity 'u' and at the same time another is dropped from a height 2u. When will they meet in air ?
(1) 1s (2) 2s
(3) 3s (4) 4s

Q.100 An object falls freely for 12.5 seconds. Then suddenly if earth's attraction ceases, find the velocity with which it will move uniformly.
(1) 100 ms^{-1} (2) 125 ms^{-1}
(3) 150 ms^{-1} (4) 175 ms^{-1}

Q.101 Two bodies are held separated by 9.8m vertically one above the other. They are released simultaneously to fall freely under gravity. After 2s the distance between them is
(1) 4.9m (2) 19.6m
(3) 9.8m (4) 39.2m

Q.102 A car is moving along a circular path with a uniform speed 54 kmph. Find the difference in the velocities of the car when it is at the diametrically opposite points
(1) 54 kmph (2) 108 kmph
(3) 81 kmph (4) 27 kmph

Q.103 A point traversed 3/4th of the circle of radius R in time t. The magnitude of the average velocity of the particle in this time interval is
(1) $\frac{\pi R}{t}$ (2) $\frac{3\pi R}{2t}$
(3) $\frac{R\sqrt{2}}{t}$ (4) $\frac{R}{\sqrt{2}t}$

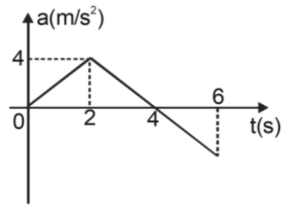
Q.104 A train running at a speed of 120 kmph is approaching a station. Driver applies brakes just 200m before the station to stop it at the station. Find the retardation of the train
(1) $\frac{25}{9}ms^{-2}$ (2) $\frac{30}{11}ms^{-2}$
(3) $\frac{37}{13}ms^{-2}$ (4) $\frac{41}{11}ms^{-2}$

Q.105 A bullet fired into a fixed wooden target loses half of its velocity after penetrating 3 cm. How much further will it penetrate before coming to rest, if it experiences a constant deceleration ?
(1) 1 cm (2) 2 cm (3) 3 cm (4) 4 cm

Q.106 The distance covered by a freely falling body in the first, second and third seconds of its journey i.e. in the n^{th} second of its journey will be always proportional to

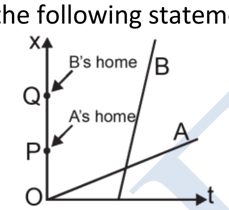
(1) 2n (2) (2n–1) (3) (2n–2) (4) $\frac{n}{2}$

Q.107 Acceleration -time graph for a particle moving in a straight line is as shown in figure. Change in velocity of the particle from t =0 to t =6 s is



(1) 10 m/s (2) 4 m/s (3) 12 m/s (4) 8 m/s

Q.108 Figure shows the position-time(x-t) graph of the motion of two boys A and B returning from their school O to their homes P and Q respectively. Which of the following statement is true ?



(1) A walks faster than B
(2) Both A and B reach home at the same time
(3) B starts fro home earlier than A
(4) B overtakes A on his way to home

Q.109 A particle under the action of a constant force moves from rest upto 20 seconds. If distance covered in first 10 seconds is s_1 and that covered in next 10 seconds is s_2 then
(1) $s_1 = s_2$ (2) $s_2 = 3s_1$ (3) $s_2=2s_1$ (4) $s_2 =4s_1$

Q.110 A very large number of balls are thrown vertically upwards in quick succession in such a way that the next ball is thrown when the previous one is at the maximum height. If the maximum height is 5m, the number of balls thrown per minute is
(Take g = 10 m/s^2)
(1) 40 (2) 60 (3) 80 (4) 120

Q.111 A ball is thrown vertically upward. It has a speed of 10 m/sec when it has reached one half of its maximum height. How high does the ball rise ? (Take g = 10 m/s^2)
(1) 10m (2) 5m (3) 15m (4) 20m

Q.112 A body moves with a uniform acceleration a and zero initial velocity. Another body B starts from the same point and moves in the same direction with a constant velocity v. The two bodies meet after a time 't'. The value of t is

(1) $\frac{2v}{a}$ (2) $\frac{v}{a}$ (3) $\frac{v}{2a}$ (4) $\sqrt{\frac{v}{2a}}$

Q.113 If a ball is thrown vertically upwards with a speed u, the distance covered during the last t seconds of its ascent is

(1) $\frac{1}{2}gt^2$ (2) $ut+\frac{1}{2}gt^2$
(3) $(u-gt)t$ (4) ut

Q.114 Two balls are dropped from height h and 2h respectively. THE ratio of times of these balls to reach the earth is
(1) $1:\sqrt{2}$ (2) $\sqrt{2}:1$
(3) 2 : 1 (4) 1 : 4

Q.115 A car moving with a speed of 50 km/hour can be stopped by brakes after a distance 6m. If the same car is moving at a speed of 100 km/hour, the minimum stopping distance is
(1) 6 m (2) 12 m (3) 18 m (4) 24 m

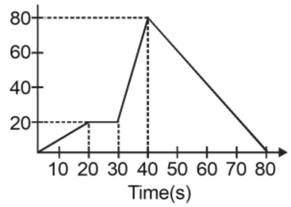
Q.116 A body falls from rest in the gravitational field of the earth. The distance travelled in the fifth second of its motion is (g=10 m/s^2)
(1) 25 m (2) 45 m (3) 90 m (4) 125 m

Q.117 A ball is dropped from the roof of a tower of height h. The total distance covered by it in the last second of its motion is equal to the distance covered by it in first three seconds. The value of h in meters is (g=10 m/s^2)
(1) 125 (2) 200 (3) 100 (4) 80

Q.118 A balloon is flying up with a constant velocity of 5 m/s. At a height of 100m , a stone is dropped from it. At the instant the stone reaches the ground level, the height of the balloon will be
(1) 25m (2) 0m (3) 125m (4) 100m

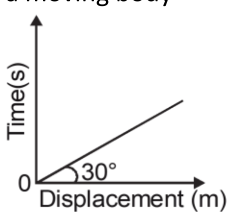
Q.119 A stone is thrown vertically up from the ground. It reaches a maximum height of 50 meters in 10 sec. After what time it will reach the ground ?
(1) 10 sec (2) 20 sec (3) 30 sec (4) 40 sec

Q.120 The v-t graph of a moving object is given in figure. The maximum acceleration is



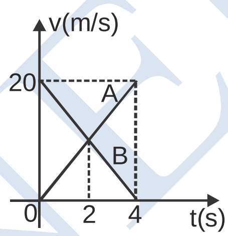
(1) 1 cm/s^2 (2) 2 cm/s^2
(3) 3cm/s^2 (4) 6 cm/s^2

Q.121 From the displacement-time graph, find out the velocity of a moving body



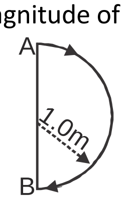
(1) $\frac{1}{\sqrt{3}} m/s$ (2) 3 m/s
(3) $\sqrt{3}$ m/s (4) $\frac{1}{3} m/s$

Q.122 Speed -time graph of two cars A and B approaching towards each other is shown in figure. Initial distance between them is 60m. The two cars will cross each other after time



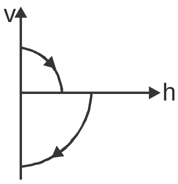
(1) 2 s (2) 3 s (3) 1.5 s (4) $\sqrt{2}$s

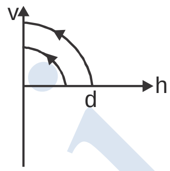
Q.123 In 1.0 s, a particle goes from point A to point B, moving in a semicircle of radius 1.0 m (see figure). The magnitude of the average velocity is

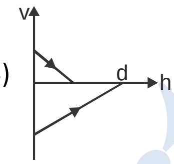


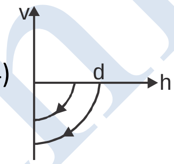
(1) 3.14 m/s (2) 2.0 m/s
(3) 1.0 m/s (4) zero

Q.124 A ball is dropped vertically from a height d above the ground. It hits the ground and bounces up vertically to a height. Neglecting subsequent motion and air resistance, its velocity v varies with the height h above the ground as

(1) 

(2) 

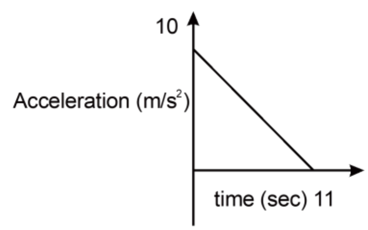
(3) 

(4) 

Q.125 A particle starts sliding down a frictionless inclined plane. If s_n is the distance travelled by it from time t = (n–1) sec to t = n sec, the ration $\frac{s_n}{s_{n+1}}$ is

(1) $\frac{2n-1}{2n+1}$ (2) $\frac{2n+1}{2n}$ (3) $\frac{2n}{2n+1}$ (4) $\frac{2n+1}{2n-1}$

Q.126 A body starts from rest at time t =0. The acceleration -time graph is shown in the figure. The maximum velocity attained by the body will be



(1) 110 m/s (2) 55 m/s
(3) 650 m/s (4) 550 m/s

Q.127 Assertion : A positive acceleration of a body can be associated with 'slowing down' of the body.
Reason : Acceleration is a vector quantity.
(1) Both assertion and reason are correct and reason is the correct explanation of assertion
(2) both assertion and reason are true but reason is not the correct explanation of assertion.
(3) Assertion is true but reason is false
(4) Assertion is false but reason is true

Q.128 A point on the rim of a wheel 3m in diameter has linear velocity of 18m/sec. The angular velocity of the wheel is given by

(1) 12 rad/s (2) 10 rad/s
(3) 8 rad/s (4) 6 rad/s

Q.129 A particle is moving along a circular path of radius 5m with a uniform speed 5 ms^{-1}. What will be the average acceleration when the particle completes half revolution?

(1) zero (2) 10 ms^{-2}
(3) 10 π ms^{-2} (4) $\frac{10}{\pi} ms^{-2}$

Q.130 A person travels along a straight road for the first half time with a velocity v_1 and for the second half time with a velocity v_2. Then the mean velocity $\bar{v}$ is given by

(1) $\bar{v} = \frac{v_1 + v_2}{2}$ (2) $\frac{2}{v} = \frac{1}{v_1} + \frac{1}{v_2}$
(3) $\bar{v} = \sqrt{v_1 v_2}$ (4) $\bar{v} = \sqrt{\frac{v_2}{v_1}}$

Q.131 Which of the following four statements is false

(1) A body can have zero velocity and still be accelerated
(2) A body can have a constant velocity and still have a varying speed
(3) A body can have a constant speed and still have a varying velocity
(4) The direction of the velocity of a body can change when its acceleration is constant

Q.132 If a body starts from rest and travels 120m in the 8^{th} second, then acceleration is

(1) 16 m/s^2 (2) 10 m/s^2
(3) 0.227 m/s^2 (4) 0.03 m/s^2

Q.133 A particle travels 10 m in first 5 s and 10 m in next 3s. Assuming constant acceleration, what is the distance travelled in next 2 s ?

(1) 8.3 m (2) 9.3 m
(3) 10.3 m (4) None of these

Q.134 Initially a body is at rest. If its acceleration is 5 m/s^2 then the distances travelled in the 18^{th} second is

(1) 86.6 m (2) 87.5 m
(3) 88 m (4) 89 m

Q.135 **Assertion :** If the speed of a body is constant, the body cannot have a path other than a circular or straight line path.

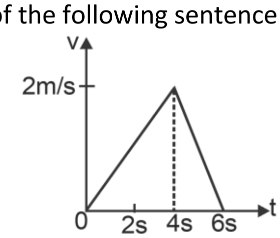
Reason : It is not possible for a body to have a constant speed in an accelerated motion.

(1) Both assertion and reason are correct and reason is the correct explanation of assertion
(2) both assertion and reason are true but reason is not the correct explanation of assertion.
(3) Assertion is true but reason is false
(4) Both assertion and reason are false

Q.136 Two racing cars of masses m_1 and m_2 are moving in circles of radii r_1 and r_2 respectively. Their speeds are such that each makes a complete circle in the same length of time t. The ratio of angular speed of the first car to that of the second car is

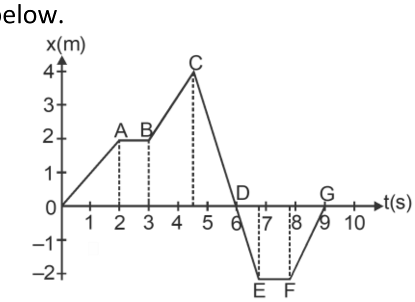
(1) $m_1 : m_2$ (2) $r_1 : r_2$
(3) 1 : 1 (4) $m_1r_1 : m_2r_2$

Q.137 The velocity -time graph of a particle moving along a straight line is shown in figure. Then which of the following sentence is correct ?



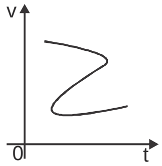
(1) The motion is uniform
(2) The acceleration is uniform
(3) The particle changes its direction of motion
(4) The displacement during the period 0–4 is equal to the area under the velocity-time graph for this period.

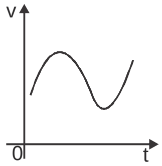
Q.138 A dancer is demonstrating dance steps along a straight line. The position time graph is given below.

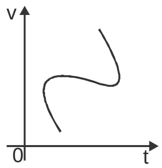


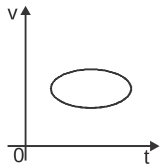
(1) 1 ms^{-1} (2) – 1.33 ms^{-1}
(3) 2.75 ms^{-1} (4) –0.89 ms^{-1}

Q.139 Which of the following velocity-time graphs shows a realistic situation for a body in motion ?

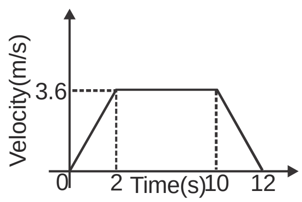
(1) 

(2) 

(3) 

(4) 

Q.140 A lift is going up. The variation in the speed of the lift is as given in the graph. What is the height to which the lift takes the passengers ?



(1) 3.6 m

(2) 28.8 m

(3) 36.0 m

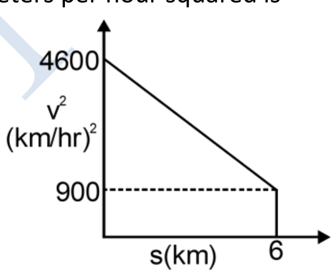
(4) cannot be calculated from the above graph

Q.141 A man walks for some time 't' with velocity 'v' due east. Then he walks for same time 't' with velocity 'v' due north. The average velocity of the man is

(1) 2v (2) $\sqrt{2}\,v$

(3) v (4) $\frac{v}{\sqrt{2}}$

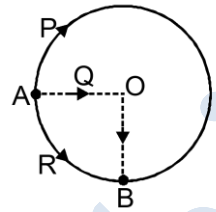
Q.142 A graph between the square of the velocity of a particle and the distance (s) moved is shown in figure. The acceleration of the particle in kilometers per hour squared is



(1) 225 (2) 308.3

(3) –225 (4) –308.3

Q.143 Three particles P, Q and R are situated at point A on the circular path of radius 10m. All three particles move along different paths and reach point B shown in figure. Then the ratio of distance traversed by particle P and Q is



(1) $\frac{3}{4}$ meter (2) $\frac{1}{3}$ meter

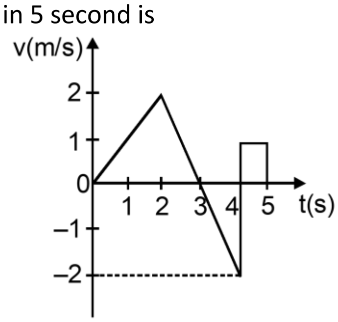
(3) $\frac{3\pi}{4}$ meter (4) $\frac{\pi}{3}$ meter

Q.144 A particle moves along the sideAB, BC, CD of a square of side 25m with a velocity of 15 m/s. Its average velocity is

(1) 15 ms^{-1} (2) 10 ms^{-1}

(3) 7.5 ms^{-1} (4) 5 ms^{-1}

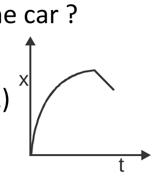
Q.145 The velocity versus time graph of a body moving along a straight line is as shown in figure. The ratio of displacement and distance covered by body in 5 second is

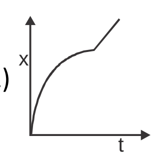


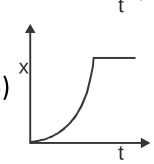
(1) 2 : 3 (2) 3 : 5

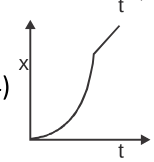
(3) 1 : 1 (4) 1.5 : 5

Q.146 A car starts from rest, accelerates uniformly for 4 seconds and then moves with uniform velocity. Which of the x-t graphs represents the motion of the car ?

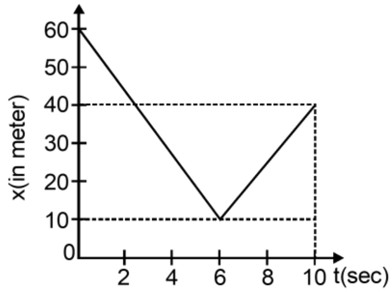
(1) 

(2) 

(3) 

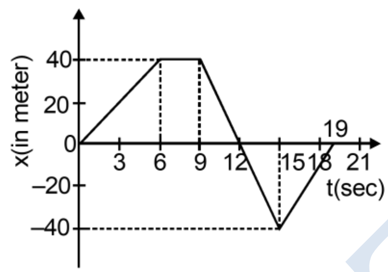
(4) 

Q.147 The figure shows the displacement time graph of a particle moving on a straight line path. What is the average velocity of the particle over 10 seconds?



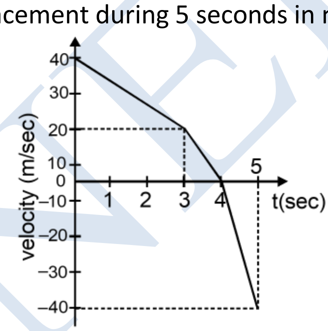
(1) 2 ms^{-1} (2) 4 ms^{-1}
(3) 6 ms^{-1} (4) 8 ms^{-1}

Q.148 A person walks along an east-west street and a graph of his displacement from home is shown in figure. His average velocity for the whole time interval is



(1) 0 ms^{-1} (2) 23 ms^{-1}
(3) 8.4 ms^{-1} (4) None of the above

Q.149 In the following velocity-time graph of a body, the distance travelled by the body and its displacement during 5 seconds in meters will be



(1) 75, 75 (2) 120, 80
(3) 110, 110 (4) 110, 40

Q.150 The angular velocity of a wheel is 70 rad/s. If the radius of the wheel is 0.5m, then linear velocity of the wheel is
(1) 70 m/s (2) 35 m/s
(3) 30 m/s (4) 20 m/s

Q.151 A car is moving with speed 30 m/s on a circular path of radius 500m. Its speed is increasing at the rate of 2 m/s^2. The acceleration of the car at this instant is
(1) 9.8 m/s^2 (2) 1.8 m/s^2
(3) 2 m/s^2 (4) 2.7 m/s^2

Q.152 An insect trapped in a circular groove of radius 12 cm moves along the grooves steadily and completes 7 revolutions in 100s. What is the linear speed of the motion
(1) 2.3 cm/s (2) 5.3 cm/s
(3) 0.44 cm/s (4) None of these

Q.153 A stone tied to the end of a string 80 cm long is whirled in a horizontal circle with a constant speed. If the stone makes 14 revolutions in 22s, then the acceleration of the stone is
(1) 5 m/s^2 (2) 10 m/s^2
(3) 12.8 m/s^2 (4) None of these

CONCEPTUAL

VERY SHORT ANSWER TYPE QUESTIONS

Q.1 Is displacement a scalar quantity?

Q.2 State whether distance is a scalar or a vector quantity.

Q.3 What do the following measure in a car?
(a) Speedometer (b) Odometer

Q.4 Which of the two can be zero under certain conditions : average speed of a moving body or average velocity of a moving body?

Q.5 Name the quantity which is measured by the area occupied under the velocity-time graph.

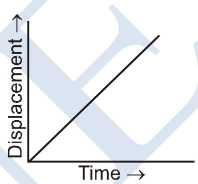
Q.6 What does the slope of a speed-time graph indicate?

Q.7 What does the slope of a distance-time graph indicate?

Q.8 Give one Examples of a motion where an object does not change its speed but its direction of motion changes continuously.

Q.9 (a) What remains constant in uniform circular motion?
(b) What changes continuously in uniform circular motion?

Q.10 What conclusion can you draw about the velocity of a body from the displacement-time graph shown below :



SHORT ANSWER TYPE QUESTIONS

Q.1 What type of motion, uniform or non-uniform, is exhibited by a freely falling body? Give reason for you answer.

Q.2 (a) Write the formula for acceleration. Give the meaning of each symbol which occurs in it.
(b) A train starting from Railway station attains a speed of 21 m/s in one minute. Find its acceleration.

Q.3 Bus X travels a distance of 360 km in 5 hours whereas bus Y travels a distance of 476 km in 7 hours. Which bus travels faster?

Q.4 (a) What term is used to denote the change of velocity with time?
(b) Give one word which means the same as 'moving with a negative acceleration'.
(c) The displacement of a moving object in a given interval of times is zero. Would the distance
travelled by the object also be zero? Give reason for your answer.

Q.5 A tortoise moves a distance of 100 metres in 15 minutes. What is the average speed of tortoise in km/h?

Q.6 If a sprinter runs a distance of 100 metres in 9.83 seconds, calculate his average speed in km/h.

Q.7 Explain why, the motion of a body which is moving with constant speed in a circular path is said to be accelerated.

Q.8 Is the uniform circular motion accelerated? Give reasons for your answer.

Q.9 A motorcycle moving with a speed of 5 m/s is subjected to an acceleration of 0.2 m s^2. Calculate the speed of the motorcycle after 10 seconds, and the dist ance travelled in this time.

Q.10 A cheetah starts from rest, and accelerates at $2ms/^2$ for 10 seconds. Calculate:
(a) the final velocity
(b) the distance travelled.

LONG ANSWER TYPE QUESTIONS

Q.11 (a) What is the difference between 'distance travelled' by a body and its 'displacement'? Explain with the help of a diagram.
(b) An ant travels a distance of 8 cm from P to Q and then moves a distance of 6 cm at right angles to PQ. Find its resultant displacement.

Q.12 Define motion. what do you understand by the terms 'uniform motion' and 'non-uniform motion'? Explain with Examples.

Q.13 (a) What is meant by the term 'acceleration'? State the SI unit of acceleration.

(b) Define the term 'uniform acceleration'. Give one Examples of a uniformly accelerated motion.

Q.14 A train travels the first 15 km at a uniform speed of 30 km/h; the next 75 km at a uniform speed of 50 km/h; and the last 10 km at a uniform speed of 20 km/h. Calculate the average speed for the entire train journey.

Q.15 (a) Explain the meaning of the following equation of motion :

$v = u + at$

where symbols have their usual meanings.

(b) A body starting from rest travels with uniform acceleration. If it travels 100 m in 5 s, what is the value of acceleration?

Q.16 (a) Derive the formula : $v = u + at$, where the symbols have usual meanings.

(b) A bus was moving with a speed of 54 km/h. On applying brakesit stopped in 8 seconds. Calcualte the acceleration.

Q.17 (a) Derive the formula : $s = ut + \frac{1}{2}at^2$ where the symbols have usual meanings.

(b) A train starting from stationary position and moving with uniform acceleration attains a speed of 36 km per hour in 10 minutes. Find its acceleration.

Q.18 (a) Write the three equations of uniformly accelerated motion. Give the meaning of each symbol which occurs in them.

(b) A car acquires a velocity of 72 km perhour in 10 seconds starting from rest. Find (i) the acceleration, (ii) the average velocity, and (iii) the distance travelled in this time.

Q.19 (a) What is meant by uniform circular motion? Give two Examples of uniform circular motion.

(b) The tip of seconds hand of a clock takes 60 seconds to move once on the circular dial of the clock. If the radius of the dial of the clock be 10.5 cm, calculate the speed of the tip of the seconds' hand of the clock (Given).

$\pi = \frac{22}{7}$

Q.20 Derive the following equation of motion by the graphical method :

$v^2 = u^2 + 2as$

where the symbls have their usual meanings.

OLYMPIAD BASED EXERCISE

Q.1 A train starts from rest and accelerates uniformly at a rate of 2 m s^{-2} for 10 s. It then maintains a constant speed for 200 s. The brakes are then applied and the train is uniformly retarded and it comes to rest in 50 s. Find (i) the maximum velocity reached, (ii) the retardation in the last 50 s, (iii) the total distance travelled, and (iv) the average velocity of the train **(Practise)**

Q.2 A particle moves along a straight line AB with constant acceleration. Its velocities are u and v at A and B, respectively. Show that its velocity at the mid-point of AB is $\sqrt{\dfrac{u^2+v^2}{2}}$ **(Practise)**

Q.3 A drunkard walking in a narrow lane takes 5 steps forward and 3 steps backward, and again takes 5 steps forward and 3 steps backward, and so on. Each step is 1 m long and requires 1 s. Determine how long the drunkard takes to fall into a pit 13 m away from the start. **(Practise)**

Q.4 A point moves with uniform acceleration and v_1, v_2 and v_3 denote the average velocities in the three successive intervals of time t_1, t_2 and t_3. Which of the following relations is correct **(Practise)**

(1) $(v_1 - v_2) : (v_2 - v_3) = (t_1 - t_2) : (t_2 - t_3)$
(2) $(v_1 - v_2) : (v_2 - v_3) = (t_1 + t_2) : (t_2 + t_3)$
(3) $(v_1 - v_2) : (v_2 - v_3) = (t_1 - t_2) : (t_1 - t_3)$
(4) $(v_1 - v_2) : (v_2 - v_3) = (t_1 - t_2) : (t_2 - t_3)$

Q.5 Two cars A and B are travelling in the same direction with velocities v_1 and v_2 ($v_1 > v_2$). When the car A is at a distance d ahead of the car B, the driver of the car A applied the brake producing a uniform retardation a. There will be no collision when **(Practise)**

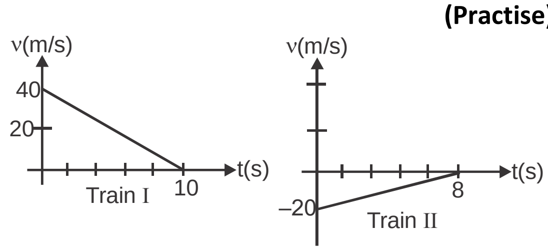
(1) $d < \dfrac{(v_1 - v_2)^2}{2a}$ (2) $d < \dfrac{v_1^2 - v_2^2}{2a}$

(3) $d > \dfrac{(v_1 - v_2)^2}{2a}$ (4) $d > \dfrac{(v_1 - v_2)^2}{2a}$

Q.6 A particle is dropped vertically from rest from a height. The time taken by it to fall through successive distances of 1 m each will then be **(Practise)**

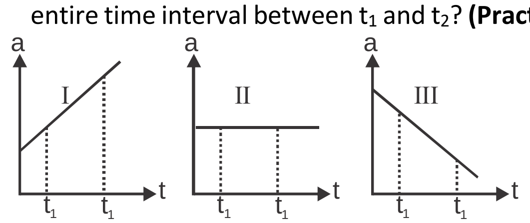
(1) All equal, being equal to $\sqrt{2/g}$ second
(2) In the ratio of the square roots of the integers 1, 2, 3 .....
(3) In the ratio of the difference in the square roots of the integers i.e. $\sqrt{1}, (\sqrt{2}-\sqrt{1}), (\sqrt{3}-\sqrt{2}), (\sqrt{4}-\sqrt{3})$.....
(4) In the ratio of the reciprocal of the square roots of the integers i,e. $\dfrac{1}{\sqrt{1}}, \dfrac{1}{\sqrt{2}}, \dfrac{1}{\sqrt{3}}, \dfrac{1}{\sqrt{4}}$.......

Q.7 Two trains, which are moving along different tracks in opposite direction towards each other, are put on the same track by mistake. Their drivers, on noticing the mistake, start slowing down the trains when the trains are 300 m apart. Graphs given below show their velocities as function of time as the trains slow down. The seperation between the trains after they stop **(Practise)**



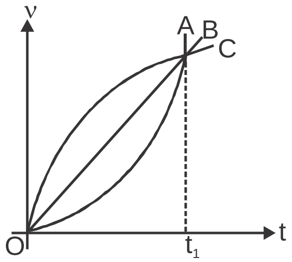
(1) 120 m (2) 280 m (3) 60 m (4) 20 m

Q.8 Each of the three graphs represents acceleration versus time for an object that already has a positive velocity at time t_1. Which graphs show an object whose speed is increasing for the entire time interval between t_1 and t_2? **(Practise)**



(1) graph I, only
(2) graph I and II, only
(3) graphs I and III, only
(4) graphs I, II and III

Q.9 V-t graph for rectilinear motion is given as shown in the figure. Match the column on the basis of the ν-t graph. **(Practise)**



Column I		Column II	
(p)	The magnitude of average velocity from t = 0 to t = t_1	(i)	Same for A, B, C
(q)	Magnitude of acceleration at t = t_1	(ii)	Maximum for A
(r)	Magnitude of acceleration at t = 0	(iii)	Minimum for C
(s)	Speed at t_1	(iv)	Maximum for C

(1) p-d; q-b,c; r-d; s-a (2) p-a; q-c,d; r-b; s-a

(3) p-b; q-b,c; r-b; s-a (4) None of these

Q.10 The position of a particle moving along the x-axis at certain times is given below :

t(s)	0	1	2	3
x(m)	–2	0	6	16

Which of the following describes the motion correctly ? **(Practise)**

(1) Uniform, accelerated

(2) Uniform, decelerated

(3) Non-uniform, accelerated

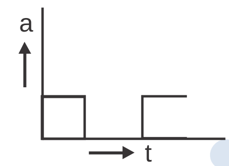
(4) There is not enough data for generalization

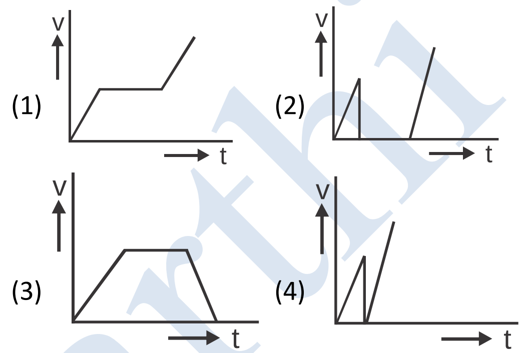
Q.11 A boy runs for 10 minutes at a uniform speed of 9 km h^{-1}. At what speed should he run for the next 20 minutes so that the average speed comes to 12 km h^{-1} ? **(NSO)**

(1) 13.5 km h^{-1} (2) 10.2 km h^{-1}

(3) 8.2 km h^{-1} (4) 7.72 km h^{-1}

Q.12 Which of the following would probably show the velocity-time graph for a body whose acceleration-time graph is shown in figure ? **(NSO)**





Q.13 A particle is moving in a straight line with initial velocity u and uniform acceleration a. If the sum of the distances travelled in t^{th} and $(t + 1)^{th}$ seconds is 100 cm, then its velocity after t seconds in cm s^{-1} is **(NSO)**

(1) 20 (2) 30 (3) 50 (4) 80

Q.14 Two identical balls are at rest side by side at the bottom of a hill. Some time after ball A is kicked up the hill, ball B is given a kick up the hill. Ball A is headed downhill when it passes ball B headed up the hill. At the instant when ball A passes ball B, it has the same **(NSO)**

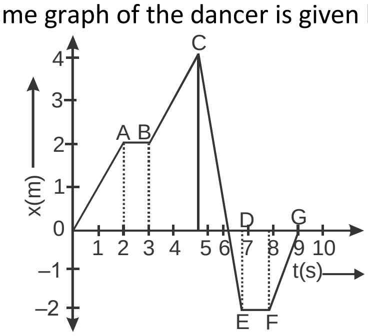
(1) Position and velocity as ball B

(2) Position and acceleration as ball B

(3) Velocity and acceleration as ball B

(4) Displacement and velocity as ball B

Direction (Q.15 and Q.16) : Read the passage carefully **and** answer the following questions. A dancer is **demon**strating dance steps along a straight line. The **positi**on-time graph of the dancer is given here **(NSO)**



Q.15 The average speed for the dance step depicted by CD is

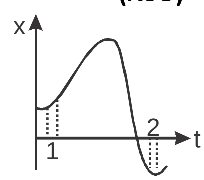
(1) 1 ms^{-1} (2) 1.33 m s^{-1}
(3) 2.75 m s^{-1} (4) 0.89 m s^{-1}

Q.16 The average velocity of the dancer during time interval between t = 2 s to t = 9 s is

(1) 1 m s^{-1} (2) –0.57 m s^{-1}
(3) 2.75 m s^{-1} (4) – 0.29 m s^{-1}

Q.17 Figure shows the x-t plot a particle in one-dimensional motion. The different equal intervals of time are shown. Let v_1 and v_2 be average speeds in time intervals 1 and 2 respectively. The **(NSO)**

(1) $v_1 > v_2$
(2) $v_2 > v_1$
(3) $v_1 = v_2$
(4) Data is insufficient



Q.18 Consider the given statements and select the option which correctly identifies the true (T) and (F) statements.

(i) Distance is the magnitude of displacement in all cases
(ii) When a body moves with uniform speed, then the average speed is same as instantaneous speed.
(iii) Average speed is greater than the average velocity if a body is moving in a straight line without reversing its direction.
(iv) When a body moves with constant velocity, the average velocity is zero. **(NSO)**

	(i)	(ii)	(iii)	(iv)
(1)	T	F	T	F
(2)	T	T	T	T
(3)	F	F	F	F
(4)	F	T	F	F

Q.19 Match the column I with column II and mark the correct option from the codes given below. **(NSO)**

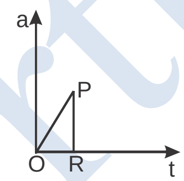
Column I		Column II	
(a)	36 km h^{-1}	(i)	20000 mm
(b)	1 m s^{-2}	(ii)	980 cm s^{-2}
(c)	9.8 m s^{-2}	(iii)	12960 km h^{-2}
(d)	0.02 km	(iv)	10 m s^{-1}

(1) (a) – (iv), (b) – (iii), (c) – (ii), (d) – (i)
(2) (a) – (iii), (b) – (ii), (c) – (i), (d) – (iv)
(3) (a) – (ii), (b) – (i), (c) – (iv), (d) – (iii)
(4) (a) – (i), (b) – (ii), (c) – (iii), (d) – (iv)

Q.20 A ball is dropped on to the floor from a height of 20 m. It rebounds to a height of 10 m. If the ball is in contact with the floor for 0.1 seconds, what is the average acceleration during contact ? **(NSO)**

(1) 142 m s^{-2} (2) 285 m s^{-2}
(3) 338 m s^{-2} (4) 564 m s^{-2}

Q.21 A cyclist starts from centre O and reaches at R along the path OPR as shown in graph. What would you conclude from the velocity-time graph of the cyclist from the given graph ? **(NSO)**



(1) Velocity changes linearly if acceleration is changing non-linearly.
(2) Velocity becomes zero if acceleration becomes zero.
(3) Velocity changes non-linearly if acceleration is changing linearly.
(4) Velocity becomes uniform if acceleration becomes infinite.

Q.22 Read the given statements and select the correct option.

Statement 1 : An object is thrown vertically up with a velocity u reaches the maximum height h after T seconds. At a time 2T seconds its velocity becomes zero.

Statement 2 : An object is thrown vertically up with a velocity comes back to its initial position with same magnitude of velocity but in opposite direction. **(NSO)**

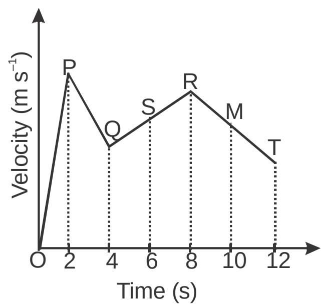
(1) Both statements 1 and 2 are true and statement 2 is the correct explanation of statement 1.
(2) Both statements 1 and 2 are true but statement 2 is not the correct explanation of statement 1
(3) Statement 1 is true but statement 2 is false
(4) Statement 1 is false but statement 2 is true

Q.23 The velocity of a particle increases from u to v in a time t during which the particle has a uniform acceleration. Which of the following equations applies to the motion ? **(NSO)**

(1) $2s = (u + v) \times t$ (2) $a = \frac{v-u}{t}$

(3) $v^2 = u^2 + 2as$ (4) $s = v \times t$

Q.24 The velocity-time graph of an object is shown in the figure. Identify the correct statement(s) regarding this graph.



(i) This is a non uniform velocity-time graph of the object

(ii) The velocity of the object is increasing at the same rate during OP and QR.

(iii) The velocity of the object is decreasing at same rate during PQ and RT. **(NSO)**

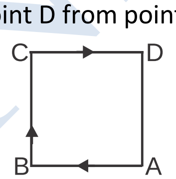
(1) Only (i) is correct

(2) Only (ii) is correct

(3) Only (iii) is correct

(4) All (i), (ii), (iii) are correct

Q.25 A boy takes 5 seconds to reach each point from A to B, B to C and C to D as shown in the diagram. If AB = BC = CD = 20 m then which of the following information is correct when the boy reaches point D from point A via BC ? **(NSO)**



	Velocity ($m\ s^{-1}$)	Speed ($m\ s^{-1}$)
(1)	4	4
(2)	1.33	1.33
(3)	4	1.33
(4)	1.33	4

Q.26 Two racing cars of masses m_1 and m_2 are moving in circles of radii r_1 and r_2 respectively. Their speeds are such that each makes a complete circle in the same length of time T. The ratio of angular speed of the first car to that of the second car is **(NSO)**

(1) $m_1 : m_2$ (2) $r_1 : r_2$

(3) $1 : 1$ (4) $m_1 r_1 : m_2 r_2$

Q.27 The speed of a train increases at a constant rate α from zero to v, and then remains constant for an interval, and finally decreases to zero at a constant rate β. If L be the total distance travelled, then the total time is **(NSO)**

(1) $\frac{L}{v}+\frac{v}{2}\left(\frac{1}{\alpha}+\frac{1}{\beta}\right)$ (2) $\frac{L}{v}+\frac{2}{v}\left(\frac{1}{\alpha}+\frac{1}{\beta}\right)$

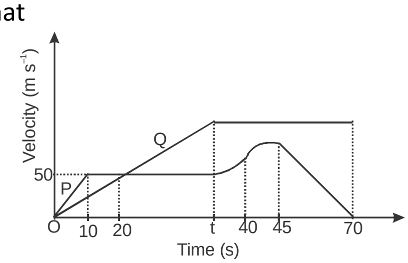
(3) $\frac{L}{v}+2v\left(\frac{1}{\alpha}+\frac{1}{\beta}\right)$ (4) $\frac{L}{v}+\frac{1}{v}\left(\frac{1}{\alpha}+\frac{1}{\beta}\right)$

Q.28 A train starts from a station P with a uniform acceleration a_1, for some distance and then goes with uniform retardation a_2 for some more distance to come to rest at the station Q. The distance between the stations P and Q is 4 km and train takes 4 minutes to complete this journey, then $\frac{1}{a_1}+\frac{1}{a_2}=$ **(NSO)**

(1) $2\ m^{-1}\ s^2$ (2) $4\ m^{-1}\ s^2$

(3) $7.2\ m^{-1}\ s^2$ (4) $72\ m^{-1}\ s^2$

Q.29 The diagram shows the velocity-time graph of two moving cars P and Q. The graph indicates that



(i) The velocity of car P is increasing at a decreasing rate from 40 s to 45 s in same direction

(ii) Car Q is moving with a constant acceleration from 0 to 20 seconds.

(iii) Acceleration of the car Q is not zero at any point during whole journey

(iv) After 20 s, P is behind Q. **(NSO)**

(1) Only (i) and (ii) (2) Only (ii) and (iii)

(3) Only (iii) and (iv) (4) Only (iv) and (i)

Q.30 After jumping out from the plane, a parachutist falls 80 m without friction. When he opens up the parachute, he declerates at 2 m s^{-2}. He reaches the ground with a speed of 4 m s^{-1}. How long did the parachutist spend his time in the air? (Take g = 10 m s^{-2}) **(NSO)**

(1) 4 s (2) 16 s (3) 18 s (4) 22 s

Q.31 A particle starts with an initial velocity and passes successively ever thetwo halves of a given distance with accelerations a_1 and a_2 respectively.

Show that the final velocity is the same as if the whole distance is covered with a uniform acceleration . $\frac{(a_1+a_2)}{2}$ **(Practise)**

Q.32 In a car race, car A takes a time t less the car B at the finish and passes the finishing point with speed v more than that of the car B.

Assuming that both the cars starts from rest and travel with constant acceleration a_1 and a_2 respectively. Show that v = $\sqrt{a_1 a_2}$ t **(Practise)**

Q.33 From an elevated point A, a stone isprojected vertically upwards. When the stone reaches a distance h below A, its velocity is double of what it was at a height h above A. Show that the greatest height attained by the stone is $\frac{5}{3}$h. **(Practise)**

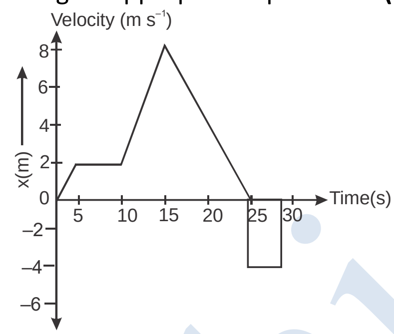
Q.34 A particle is moving in a straight line with constant acceleration. If x, y and z be the distances described by a particle during the p^{th}, q^{th} and r^{th} second respectively.

Show that (q – r)x + (r – p) y + (p – q) z = 0 **(Practise)**

Q.35 A body covers 26, 28, 30 and 32 metre in 10th, 11th, 12th and 13th seconds respectively. The body starts **(NSO 2016)**

(1) From rest and moves with uniform velocity.
(2) From rest and moves with uniform acceleration
(3) With an initial velocity and moves with uniform acceleration
(4) With an initial velocity and moves with non-uniform acceleration

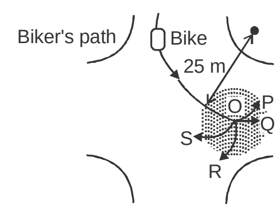
Q.36 Refer to the given graph and fill in the blanks by choosing an appropriate option **(NSO 2016)**



The displacement of the particle from its initial position at the end of 15 s and 30 s is ____(i) ____ and ____(ii)____ respectively. The average velocity of the particle between 15 s and 25 s and 0 s to 30 s is ___(iii)___ and ____ (iv) ___ respectively

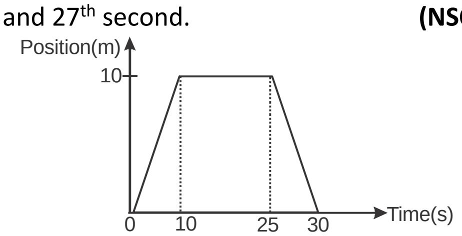
	(i)	(ii)	(iii)	(iv)
(1)	40 m	60 m	4 m s^{-1}	2 m s^{-1}
(2)	40 m	100 m	2 m s^{-1}	4 m s^{-1}
(3)	20 m	60 m	4 m s^{-1}	4 m s^{-1}
(4)	20 m	100 m	2 m s^{-1}	2 m s^{-1}

Q.37 A motorbike travelling at a constant speed turns at an intersection. The bike follows a horizontal circular path with a radius of 25 m as shown in the figure. At point O, the bike hits an area of ice and loses all frictional forces on its tyres. Which path does the bike follow on the ice ? **(NSO 2019)**



(1) Along P (2) Along R
(3) Along S (4) Along Q

Q.38 The given figure shows the position-time graph of an object. Find the ratio of the velocities at 5^{th} and 27^{th} second. **(NSO 2019)**



(1) $\frac{1}{2}$ (2) $-\frac{1}{2}$ (3) 1 (4) –1

PREVIOUS YEAR QUESTIONS

STAGE-I

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)**

(1) zero (2) 10 km/hr
(3) 48 km/hr (4) 50 km/hr

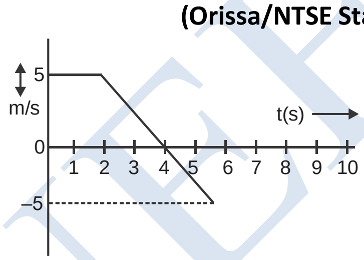
Q.2 A boy sitting on the top most berth in the compartment of a train which is just going to stop on the railway station, drops an apple aiming at the open hand of his brother situated vertically below his hands at a distance of about 2m. The apple will fall :

(Punjab/NTSE Stage-I/2013)

(1) In the hand of his brother
(2) Slightly away from the hand of his brother in the direction of the motion of the train.
(3) Slightly away from the hands of his brother in the direction opposite to the direction of the motion of the train
(4) None of these

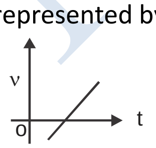
Q.3 A velocity- time graph for a moving object is shown below. What would be the total displacement during time= t=0 to t=6s?

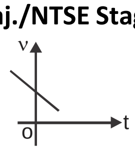
(Orissa/NTSE Stage-I/2013)

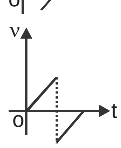


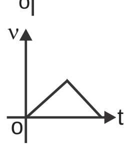
(1) 10 m (2) 20 m (3) 2.5 m (4) 0.0m

Q.4 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)**

(1)


(2)


(3)


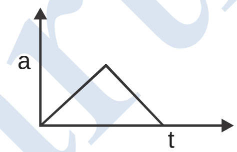
(4)


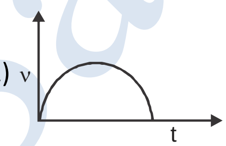
Q.5 A bullet of mass 10 g travelling horizontally with a velocity of 160 ms^{-1} strikes a stationary wooden block and comes to rest in 0.02 s The distance of penetration of the bullet into the block will be : **(Raj./NTSE Stage-I/2014)**

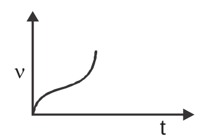
(1) 1.20 m (2) 1.60 m
(3) 2.00 m (4) 2.40 m

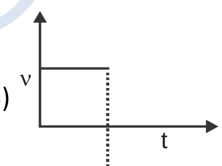
Q.6 The acceleration versus time graph of an object is as shown in figure. The corresponding velocity-time graph of the object is :

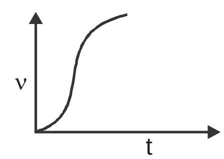
(Raj./NTSE Stage-I/2014)



(1)


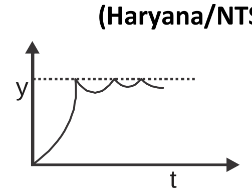
(2)


(3)


(4)


Q.7 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

(1) displacement (2) velocity
(3) acceleration (4) momentum

Q.8 Value of one Fermi is : **(M.P./NTSE Stage-I/2014)**

(1) 10^{-13} metre
(2) 10^{-14} metre
(3) 10^{-15} metre
(4) 10^{-16} metre

Q.9 A body falling from rest describes distances S_1, S_2 and S_3 in the first, second and third seconds of its fall. Then the ratio of $S_1 : S_2 : S_3$ is:

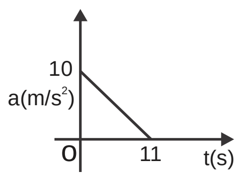
(Delhi/NTSE Stage-I/2014)

(1) 1 : 1: 1 (2) 1 :3 :5

(3) 1 : 2: 3 (4) 1 : 4 : 9

Q.10 A body starts from rest at time t=0, the acceleration time graph is shown in figure. The maximum velocity attained by the body will be:

(Delhi/NTSE Stage-I/2014)



(1) 1110 m/s (2) 55 m/s

(3) 650 m/s (4) 550 m/s

Q.11 A body covers half the distance with a speed of 20 m/s and the other half with 30 m/s. The average speed of the body during the whole journey is : **(West Bengal/NTSE Stage-I/2014)**

(1) Zero (2) 24 m/s

(3) 25 m/s (4) None of the above

Q.12 A person takes time t to go once around a circular path of diameter 2R. The speed (v) of this person would be :

(Raj./NTSE Stage-I/2015)

(1) $\frac{t}{2\pi R}$ (2) $\frac{2\pi R}{t}$

(3) $\frac{\pi R^2}{t}c$ (4) $2\pi R.t$

Q.13 A body of mass 2 kg is moving on a smooth floor in straight line with a uniform velocity of 10m/s. Resultant force acting on the body is.

(Raj./NTSE Stage-I/2015)

(1) 20 N (2) 10 N

(3) 2 N (4) zero

Q.14 Correct relation is ....

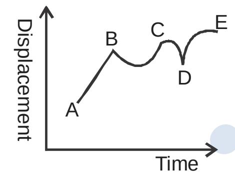
(M.P./NTSE Stage-I/2015)

(1) $v^2 = u^2 + 2a^2s^2$ (2) $v^2 = u^2 - 2a^2s^2$

(3) $v^2 = u^2 + 2as$ (4) $v^2 = u^2 + 2a^2s$

Q.15 The figure given below shows the displacement plotted time for a particle. In which regions is the force acting on the particle zero ?

(Bihar/NTSE Stage-I/2014)



(1) AB (2) BC (3) CD (4) DE

Q.16 Two cars of unequal masses use similar tyres. If they are moving with same initial speed, the minimum stopping distance :

(Jharkhand/NTSE Stage-I/2014)

(1) is smaller for the heavier car.

(2) is same for both the cars

(3) is smaller for the lighter car.

(4) depends on the volume of the car

Q.17 A ball hits a wall horizontally with a velocity of 6.0 ms^{-1}. After hitting wall it rebounds horizontally with a velocity of 4.4 ms^{-1}. If the ball remains in the contact with wall for 0.040 sec. the acceleration of ball would be :

(Uttrakhand/NTSE Stage-I/2015)

(1) -260 m/s^2 (2) +260 m/s^2

(3) -26 m/s^2 (4) +26 m/s^2

Q.18 The speed of atrain decreases from 80 km/hour to 60km/hr in 5 seconds. In this process, find out the acceleration of the train :

(Uttrakhand/NTSE Stage-I/2015)

(1) 2.22 m/sec^2 (2) -2.22 m/sec^2

(3) -1.11 m/sec^2 (4) 1.11 m/sec^2

Q.19 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^2)

(Delhi/NTSE Stage-I/2015)

(1) 2.5 s (2) 3 s (3) 4 s (4) 5 s

Q.20 A particle starts its motion from rest under the action of a constant force. If the distance covered in first 10 s is S_1 and that covered in first 20s is S_2 then : **(Delhi/NTSE Stage-I/2015)**

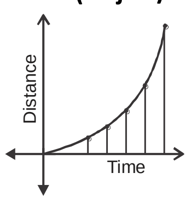
(1) $S_2 = S_1$ (2) $S_2 = 2S_1$

(3) $S_2 = 3S_1$ (4) $S_2 = 4 S_1$

Q.21 A car travels 40 km/s at an average speed of 80 km/h and then travels 40 kms 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)**

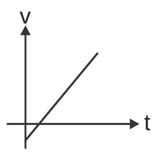
(1) 40 km/h (2) 45 km/h
(3) 48 km/h (4) 53 km/h

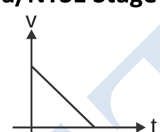
Q.22 Which motion does the graph of distance and time shows for accelerated motion ?
(Gujrat/NTSE Stage-I/2015)

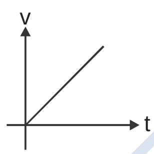


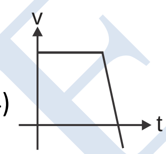
(1) non uniformly accelerated
(2) constant velocity
(3) uniformly accelerated
(4) uniformly retarded motion

Q.23 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)

(1) 

(2) 

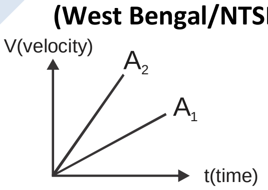
(3) 

(4) 

Q.24 A stone is dropped from the top of a tower. Its velocity after it has fallen 20 m is (take g = 10 m/s^2)
(Bihar/NTSE Stage-I/2015)

(1) –10 m/s (2) 10 m/s
(3) –20 m/s (4) 20 m/s

Q.25 In the adjacent V -T diagram what is the relation between acceleration A_1 and A_2 ?
(West Bengal/NTSE Stage-I/2015)



(1) $A_2 = A_1$ (2) $A_2 > A_1$
(3) $A_2 < A_1$ (4) Cannot be predicted

Q.26 A balloon is moving up from the ground in such a way that its acceleration is linearly decreasing with its height above the ground. It starts from the ground with acceleration 4 m/s^2 and with zero initial velocity. Its acceleration becomes zero at a height 3m. The speed of the balloon at a height 1.5 m is
(Andra Pradesh/NTSE Stage-I/2015)

(1) 4 m/s (2) 8 m/s (3) 6 m/s (4) 3 m/s

Q.27 A train can accelerate at 20 cm/s^2 and decelerate at 100 cm/s^2. Then the minimum time for the train to travel between the stations 2 km apart is... (The train should start at one station and stop at another station)
(Andra Pradesh/NTSE Stage-I/2015)

(1) 125 s (2) 100 s (3) 155 s (4) 200 s

Q.28 The brakes applied to a car produce an acceleration of 8 m/s^2 in the opposite direction to the motion. If the car takes 3 seconds to stop after the application of brakes, the distance it travels during the time will be :
(Raj./NTSE Stage-I/2017)

(1) 30 m (2) 36 m (3) 25 m (4) 40 m

Q.29 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)

(1) 30 min (2) 45 min (3) 75 min (4) 120 min

Q.30 The velocity time graph of the particle in motion is parallel to time axis shows :
(Chhatt./NTSE Stage-I/2017)

(1) Uniform motion of particle
(2) Particle is in rest
(3) Non uniform motion of particle
(4) Accelerated motion of particle

Q.31 Trippling the speed of a motor car multiplies the distance needed for stopping it by :
(Haryana/NTSE Stage-I/2017)

(1) 3 (2) 6 (3) 9 (4) 12

Q.32 Two bodies of masses m_1 and m_b are dropped from different heights 'a' and 'b'. The ratio of time taken by them to reach the ground is :
(Haryana/NTSE Stage-I/2017)

(1) $\sqrt{\mathbf{a}}:\sqrt{\mathbf{b}}$ (2) a : b (3) $\frac{1}{a}:\frac{1}{b}$ (4) $m_a : m_b$

Q.33. Two particles of masses m_1 and m_2 are allowed to fall freely from height h_1 and h_2. They reach the ground at time t_1 and t_2 respectively. Then **(West Bengal/NTSE Stage-I/2017)**

(1) $\frac{t_1}{t_2}=\sqrt{\frac{h_1}{h_2}}$ (2) $\frac{t_1}{t_2}=\sqrt{\frac{h_2}{h_1}}$

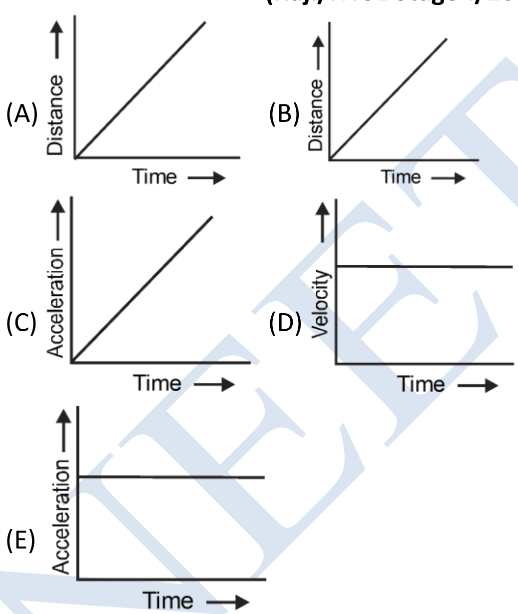
(3) $\frac{t_2}{t_1}=\frac{h_2}{h_1}c$ (4) $\frac{t_2}{t_1}=\frac{h_1}{h_2}$

Q.34 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 form t = 2 second to t = 4 second. **(West Bengal/NTSE Stage-I/2017)**

(1) 7 m/s (2) 1 m/s

(3) 13 m/s (4) 5 m/s

Q.35 Consider the following five graphs (note the axes carefully) Which of the following represents motion at constant speed? **(Raj./NTSE Stage-I/2018)**



(1) D only (2) D and E

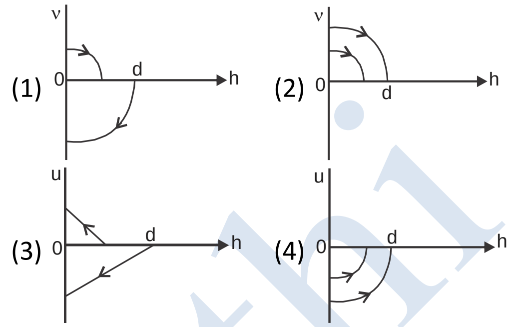
(3) A, B and C (4) A and D

Q.36 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)**

(1) 70.7 m (2) 141.4 m

(3) 200 m (4) 400 m

Q.37 A ball is dropped vertically from a height d above the ground. It hits the ground and bounces up vertically to height d/2. Neglecting air resistance, its velocity v varies with the height h above the ground as : **(Bihar/NTSE Stage-I/2018)**



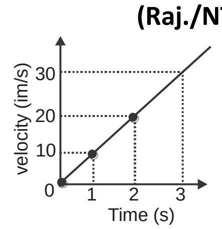
Q.38 Two objects moving along the same straight line are leaving point A with acceleration a, 2a and initial velocity 2u, u at time t = 0. The distance moved by object with respects to point A when one object, initially behind other, overtakes the other is : **(Bihar/NTSE Stage-I/2018)**

(1) $\frac{6u^2}{a}$ (2) $\frac{2u^2}{a}$ (3) $\frac{4u^2}{a}$ (4) $\frac{8u^2}{a}$

Q.39 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 m/s^{-2}): **(Delhi/NTSE Stage-I/2018)**

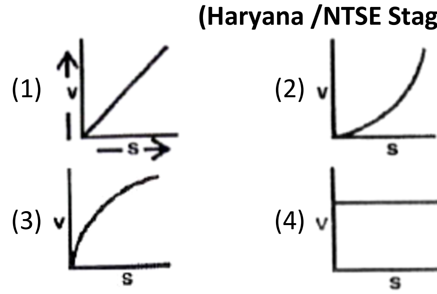
(1) 54 m (2) 45 m (3) 80 m (4) 65 m

Q.40 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)**



(1) 90 m (2) 45 m (3) zero (4) 10 m

Q.41 A body is dropped from rest. Its velocity varies with displacement covered as : **(Haryana /NTSE Stage - I/2019)**



Q.42 If work, force and time are represented by A, B and C respectively then the terma   will present **(Raj./NTSE Stage-I/2019)**

(1) displacement (2) velocity
(3) acceleration (4) momentum

Q.43 The initial velocity of a particle is 10 m/s. It is moving with an acceleration of 4 m/s^2. The distance covered by the particle after 2s is **(Raj./NTSE Stage-I/2019)**

(1) 6 m (2) 18 m (3) 22 m (4) 28 m

Q.44 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)**

(1) the lead ball reaches the ground earlier.
(2) the 1 kg iron ball reaches the ground earlier.
(3) all the balls reach the ground simultaneously.
(4) the 2 kgs steel ball reaches the ground earlier.

Q.45 The distance-time graph of a particle makes an angle 45° with the time axis. After 1second it makes an angle 60° with the time axis. What is the average acceleration of the particle during this time interval? **(West Bengal/NTSE Stage - I/2019)**

(1) $(\sqrt{3}-1)$ unit
(2) $(\sqrt{3}+1)$ unit
(3) $(\sqrt{3})$ unit
(4) (1) unit

Q.46 In the equation of motion $S = at^2 + bt$, S and t are distance and time respectively and a and b are constants. The unit of a and b are respectively given by : **(West Bengal/NTSE Stage - I/2019)**

(1) m/s^2, m/s (2) m/s^2, m/s^2
(3) m/s^2, m/s^3 (4) m/s, m/s^2

Q.47 Parsec is the unit of : **(Bihar/NTSE Stage - I/2019)**

(1) distance (2) time
(3) velocity (4) angle

Q.48 Angular velocity of hands of second in a watch will be : **(Chattisgarh/NTSE Stage - I/2019)**

(1) π radian/sec (2) 2π radian/sec
(3) $\frac{\pi}{60}$ radian/sec (4) $\frac{\pi}{30}$ radian/sec

Q.49 A particle starts its motion from rest under the action of a constant force. If the distance covered in first 10 seconds is S_1 and that covered in next 10 seconds is S_2 then : **(Delhi/NTSE Stage - I/2019)**

(1) $S_2 = 6\ S_1$ (2) $S_2 = 2\ S_1$
(3) $S_2 = 8\ S_1$ (4) $S_2 = 3\ S_1$

Q.50 A body on an inclined plane slides down $\frac{1}{4}$th of distance in 2 seconds. It will slide down the complete distance along the plane in (the inclined plane have zero friction). **(Delhi/NTSE Stage - I/2019)**

(1) 4 seconds (2) 5 seconds
(3) 2 seconds (4) 3 seconds

Q.51 Speed of bus is Increased from 36 km/hour to 72 km/hour in 10 second its acceleration is : **(Chhattisgarh/NTSE Stage - I/2020)**

(1) 3.6 meter/second^2 (2) 5 meter/second^2
(3) 2 meter/second^2 (4) 1 meter/second^2

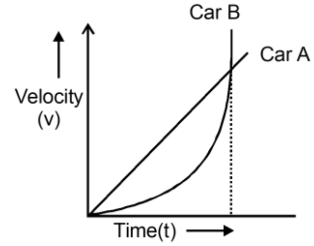
Q.52 The ratio of displacement to distance of a moving object is **(Chhattisgarh/NTSE Stage - I/2020)**

(1) More man 1
(2) Less than 1
(3) Equal to or less than 1
(4) Equal to or more than 1

Q.53 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)**

(1) m_a/m_b (2) a/b
(3) $\sqrt{(am_a/bm_b)}$ (4) $\sqrt{(a/b)}$

Q.54 An object is moving in a straight line. The velocity time graph is as shown below. Then **(Delhi/NTSE Stage - I/2020)**



(1) In part OA acceleration is increasing
(2) In opart AB acceleration is incresing
(3) In OA acceleration is decreasing
(4) In part AB acceleration is decreasing

Q.55 A car moving along straight line convers $1/5^{th}$ of total distance v_1 and remaining part of distance with speed v_2. The average speed of car over entire distance is.

(1) $\frac{5v_1v_2}{v_2+4v_1}$ (2) $\frac{4v_1v_2}{5v_1+v_2}$

(3) $\frac{5v_1v_2}{4v_2+v_1}$ (4) $\frac{4v_1v_2}{4v_1+v_2}$

Q.56 Three particles A, B and C are thrown from top of a building with same speed. A is thrown upwards, B is thrown downwards and C is thrown horizontally, they hit the ground with speed V_A, V_B and V_C respectively then.

(Delhi/NTSE Stage - I/2020)

(1) $V_A = V_B = B_C$ (2) $V_B > V_C > V_A$

(3) $V_A = V_B > V_C$ (4) $V_A > V_B = V_C$

STAGE-II

Q.1 A man running with a uniform speed 'u' on a straight road observes a stationary bus at a distance 'd' ahead of him. At that instant, the bus starts with an acceleration 'a'. The condition that he would be able to catch the bus is :

(NTSE Stage-II/2015)

(1) $d \le \frac{u^2}{a}$ (2) $d \le \frac{u^2}{2a}$

(3) $d \le \frac{u^2}{3a}$ (4) $d \le \frac{u^2}{4a}$

Q.2 A ball is thrown vertically upwards with a given velocity 'u' such that it rises for T seconds (T>1), What is the distance traversed by the ball during tha las one second of ascent (in meters) ? (Acceleration due to gravity is g m/s^2.)

(NTSE Stage-II/2015)

(1) $\frac{1}{2}gT^2$

(2) $uT+\frac{1}{2}g\left[T^2-\left(T-1^2\right)\right]$

(3) $\frac{g}{2}$

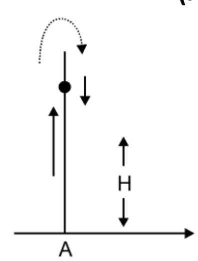
(4) $\frac{1}{2}g\left[T^2-\left(T-1^2\right)\right]$

Q.3 A cart of mass M moves at a speed u on a frictionaless surface. At regular intervals of length L, blocks of mass $= m = \frac{M}{2}$ drops vertically into the cart. How much time is taken to cover a distance of $\frac{9}{2}L$? **(NTSE Stage-II/2018)**

(1) $\frac{9L}{2u}$ (2) $\frac{5L}{2u}$ (3) $\frac{19L}{2u}$ (4) $\frac{17L}{2u}$

Q.4 A ball is thrown vertically up from the point A (see figure). A person, standing at a height H on the roof a top a building, tries to catch it, He misses the catch, the ball overshoots and simultaneously the person starts a stop- watch. The ball reaches its highest point and he manages to catch it upon itrs return. By this time, a time interval T has elapsed as recorded by the stop-watch. If g is the acceleration due to gravity at this place, the speed with which the ball was thrown from point A will be :

(NTSE Stage-II/2018)

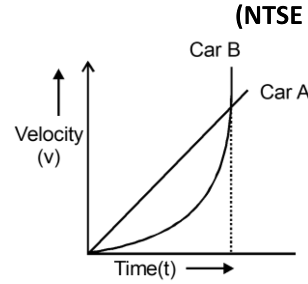


(1) $\sqrt{gH}+gT$ (2) $\left(\sqrt{g^2T^2+4gH}\right)/2$

(3) $\left(\sqrt{g^2T^2+8gH}\right)/2$ (4) $\left(\sqrt{g^2T^2+2gH}\right)$

Q.5 The velocity-time graph of motion of two cars A and B is shown in the figure

(NTSE Stage-II/2018)



Choose the correct statement.

(1) Acceleration of two cars are equal to each other at time $t = t_0$

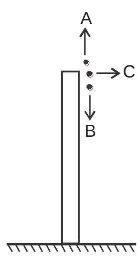
(2) Acceleration of two cars are equal to each other at an instant greater than t_0

(3) Accelerations of two cars are equal to each other at an instant earlier than t_0

(4) At no instant in the interval $0 \le t \le t_0$, the two accelerations are equal.

Q.6 Three balls A, B and C of same size but of different masses, are thrown with the same speed from the roof of a building, as shown in figure. Let V_A, V_B and V_C be the respective speeds with which the balls A, B, and C hit the ground. Neglecting air resistance, which one of the following relations is correct ?

(NTSE Stage-II/2018)

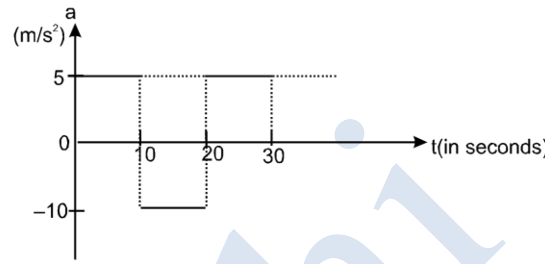


(1) $V_A > V_C > V_B$ (2) $V_C > V_A > V_B$

(3) $V_A > V_B > V_C$ (4) $V_A = V_B = V_C$

Passage (Q.7 & Q.8)

Suppose that the acceleration versus time graph of a particle that starts from rest at t = 0 is as shown in the figure. **(NTSE Stage-II/2019)**



Q.7 At what instant does the particle come to rest for the first time ?

(1) 5 sec

(2) 10 sec

(3) 15 sec

(4) the particle never comes to rest

Q.8 What is the total distance travelled by the particle during 30 seconds ?

(1) 0 m (2) 500 m (3) 750 m (4) 1000 m

Q.9 A swimmer can swim in still water at a speed of 15 km/h. A river is flowing at 5 km/h. The swimmer starts from a point and swim 1 km upstream and then returns by swimming downstream back to original position. During this, the average speed of his/her swimming is :

(NTSE Stage-II/2020)

(1) 20/3 km/h (2) 10 km/h

(3) 40/3 km/h (4) 20 km/h

ANSWER KEY

KNOWLEDGE BASKET

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	4	2	4	2	3	1	1	1	2	1	2	2	1	4	4
Que.	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Ans.	4	3	1	3	2	4	3	4	3	2	1	4	1	1	3
Que.	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**
Ans.	2	2	1	3	1	2	3	2	3	2	1	3	3	2	4
Que.	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**
Ans.	1	1	1	3	1	4	3	3	1	1	2	2	1	1	4
Que.	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**
Ans.	1	2	4	1	1	2	2	4	2	4	4	2	3	4	1
Que.	**76**	**77**	**78**	**79**	**80**	**81**	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**
Ans.	2	3	1	3	2	4	3	1	3	1	2	2	3	1	2
Que.	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**100**	**101**	**102**	**103**	**104**	**105**
Ans.	2	3	2	1	2	2	3	1	2	2	3	2	3	1	1
Que.	**106**	**107**	**108**	**109**	**110**	**111**	**112**	**113**	**114**	**115**	**116**	**117**	**118**	**119**	**120**
Ans.	2	2	4	2	2	1	1	1	1	4	2	1	3	1	4
Que.	**121**	**122**	**123**	**124**	**125**	**126**	**127**	**128**	**129**	**130**	**131**	**132**	**133**	**134**	**135**
Ans.	3	2	2	1	1	2	2	1	4	1	2	1	1	2	4
Que.	**136**	**137**	**138**	**139**	**140**	**141**	**142**	**143**	**144**	**145**	**146**	**147**	**148**	**149**	**150**
Ans.	3	4	4	2	3	4	4	3	4	2	4	1	1	2	2
Que.	**151**	**152**	**153**												
Ans.	4	2	3												

OLYMPIAD BASED EXERCISE

Que.	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Ans.	2	3	3	4	4	1	3	1	1	3	2	3	4	1	4
Que.	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**35**	**36**	**37**
Ans.	1	3	3	4	2	1	4	3	1	3	1	4	3	1	4
Que.	**38**														
Ans.	2														

PREVIOUS YEAR QUESTIONS

STAGE-I

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

STAGE-II

Que.	1	2	3	4	5	6	7	8	9
Ans.	2	3	4	3	3	4	3	3	3

NOTES

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QUOTATION FOR STUDY MATERIAL PACKAGE

Study Material	No. Of Module	Rate Per Set (Above 50 Student)	Rate Per Set (Above 100 Student)
Class 6^{th}	6	1600/Set	1400/Set
Class 7^{th}	7	1800/Set	1600/Set
Class 8^{th}	6	2000/Set	1800/Set
Class 9^{th}	8	2200/Set	2000/Set
Class 10^{th}	9	2600/Set	2400/Set
Class 11^{th} (One Year)	NEET - 13 JEE - 12	2800/Set	2500/Set
Class 12^{th} (One Year)	NEET - 11 JEE - 11	2800/Set	2500/Set

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