Chapter

2

Motion In One Dimension

Any 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.

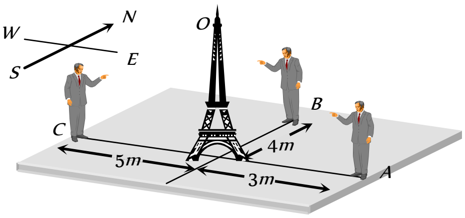


Fig. 2.1

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

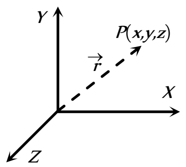
Observer 'B' says : Point O is 4 m away in south direction.

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.

That is why position is characterised by a vector known as position vector.

Consider a point P in xy plane and its coordinates are (x, y). Then position vector $(\vec{r})$ of point will be $x\hat{i} + y\hat{j}$ and if the point P is in space and its coordinates are (x, y, z) then position vector can be expressed as $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$.



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.

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

at rest. But the same passenger passing away in a train through station, observes that tree is in motion. In both conditions observer is right. But observations are different because in first situation observer stands on a platform, which is reference frame at rest and in second situation observer moving in train, which is reference frame in motion.

So rest and motion are relative terms. It depends upon the frame of references.

Table 2.1 : Types of motion

One dimensional	Two dimensional	Three dimensional
Motion of a body in a straight line is called one dimensional motion.	Motion of body in a plane is called two dimensional motion.	Motion of body in a space is called three dimensional motion.
When only one coordinate of the position of a body changes with time then it is said to be moving one dimensionally.	When two coordinates of the position of a body changes with time then it is said to be moving two dimensionally.	When all three coordinates of the position of a body changes with time then it is said to be moving three dimensionally.
Ex. (i) Motion of car on a straight road. (ii) Motion of freely falling body.	*Ex.* (i) Motion of car on a circular turn. (ii) Motion of billiards ball.	*Ex.* (i) Motion of flying kite. (ii) Motion of flying insect.

Particle or Point Mass or 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, depends upon types of motion. For example 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.

Distance and Displacement

(1) **Distance :** It is the actual length of the path covered by a moving particle in a given interval of time.

(i) If a particle starts from A and reach to C through point B as shown in the figure.

Then distance travelled by particle

$= AB + BC = 7\ m$

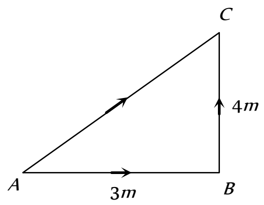


Fig. 2.2

(ii) Distance is a scalar quantity.

(iii) Dimension : $[M^0 L T^0]$

(iv) Unit : metre (S.I.)

(2) **Displacement :** Displacement is the change in position vector i.e., A vector joining initial to final position.

(i) Displacement is a vector quantity

(ii) Dimension : $[M^0 L T^0]$

(iii) Unit : metre (S.I.)

(iv) In the above figure the displacement of the particle $\overrightarrow{AC} = \overrightarrow{AB} + \overrightarrow{BC} \Rightarrow |\ AC|$

$= \sqrt{(AB)^2 + (BC)^2 + 2(AB)(BC)\cos 90^o} = 5\ m$

(v) If $\vec{S}_1, \vec{S}_2, \vec{S}_3$ .... $\vec{S}_n$ are the displacements of a body then the total (net) displacement is the vector sum of the individuals. $\vec{S} = \vec{S}_1 + \vec{S}_2 + \vec{S}_3 + ... + \vec{S}_n$

(3) **Comparison between distance and displacement :**

(i) The magnitude of displacement is equal to minimum possible distance between two positions.

So distance $\geq$ |Displacement|.

(ii) For a moving particle distance can never be negative or zero while displacement can be.

(zero displacement means that body after motion has came back to initial position)

i.e., Distance > 0 but Displacement > = or < 0

(iii) For motion between two points, displacement is single valued while distance depends on actual path and so can have many values.

(iv) For a moving particle distance can never decrease with time while displacement can. Decrease in displacement with time means body is moving towards the initial position.

(v) In general, magnitude of displacement is not equal to distance. However, it can be so if the motion is along a straight line without change in direction.

(vi) If $\vec{r}_A$ and $\vec{r}_B$ are the position vectors of particle initially and finally.

Then displacement of the particle $\vec{r}_{AB} = \vec{r}_B - \vec{r}_A$

and *s* is the distance travelled if the particle has gone through the path *APB*.

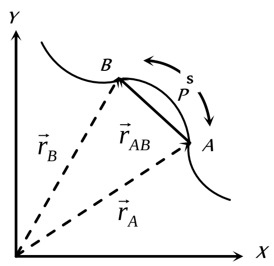


Fig. 2.3

Speed and Velocity

(1) **Speed :** The rate of distance covered with time is called speed.

(i) It is a scalar quantity having symbol υ .

(ii) Dimension : $[M^0 L T^{-1}]$

(iii) Unit : *metre/second* (S.I.), *cm/second* (C.G.S.)

(iv) Types of speed :

(a) **Uniform speed :** When a particle covers equal distances in equal intervals of time, (no matter how small the intervals are) then it is said to be moving with uniform speed. In given illustration motorcyclist travels equal distance (= 5*m*) in each second. So we can say that particle is moving with uniform speed of 5 *m/s*.

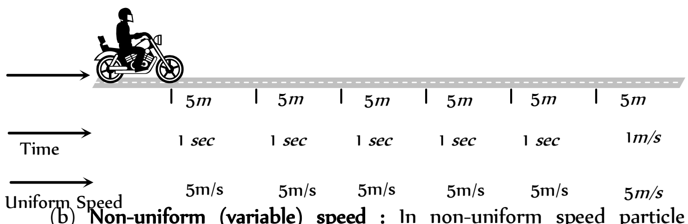


Fig. 2.4

(b) **Non-uniform (variable) speed :** In non-uniform speed particle covers unequal distances in equal intervals of time. In the given illustration motorcyclist travels 5*m* in 1st second, 8*m* in 2nd second, 10*m* in 3rd second, 4*m* in 4th second *etc.*

Therefore its speed is different for every time interval of one second. This means particle is moving with variable speed.

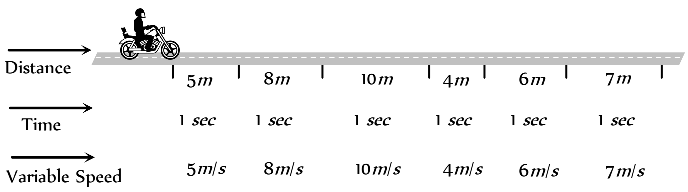


Fig. 2.5

(c) **Average speed :** The average speed of a particle for a given 'Interval of time' is defined as the ratio of total distance travelled to the time taken.

Average speed $= \dfrac{\text{Total distance travelled}}{\text{Time taken}}$; $v_{av} = \dfrac{\Delta s}{\Delta t}$

❑ Time average speed : When particle moves with different uniform speed υ_1, υ_2, υ_3 ... *etc* in different time intervals t_1, t_2, t_3, ... *etc* respectively, its average speed over the total time of journey is given as

$$v_{av} = \frac{\text{Total distance covered}}{\text{Total time elapsed}}$$

$$= \frac{d_1 + d_2 + d_3 + ...}{t_1 + t_2 + t_3 + ...} = \frac{\upsilon_1 t_1 + \upsilon_2 t_2 + \upsilon_3 t_3 + ...}{t_1 + t_2 + t_3 + ...}$$

❑ Distance averaged speed : When a particle describes different distances d_1, d_2, d_3, ... with different time intervals t_1, t_2, t_3, ... with speeds v_1, v_2, v_3...... respectively then the speed of particle averaged over the total distance can be given as

$$\upsilon_{av} = \frac{\text{Total distance covered}}{\text{Total time elapsed}} = \frac{d_1 + d_2 + d_3 + ...}{t_1 + t_2 + t_3 + ...}$$

$$= \frac{d_1 + d_2 + d_3 + ...}{\dfrac{d_1}{\upsilon_1} + \dfrac{d_2}{\upsilon_2} + \dfrac{d_3}{\upsilon_3} + ...}$$

❑ If speed is continuously changing with time then

$$v_{av} = \frac{\int v dt}{\int dt}$$

(d) **Instantaneous speed :** It is the speed of a particle at a particular instant of time. When we say "speed", it usually means instantaneous speed.

The instantaneous speed is average speed for infinitesimally small time interval (*i.e.*, $\Delta t \to 0$). Thus

Instantaneous speed $v = \lim_{\Delta t \to 0} \frac{\Delta s}{\Delta t} = \frac{ds}{dt}$

(2) **Velocity :** The rate of change of position *i.e.* rate of displacement with time is called velocity.

(i) It is a vector quantity having symbol $\vec{v}$.

(ii) Dimension : $[MLT^{-1}]$

(iii) Unit : *metre/second* (S.I.), *cm/second* (C.G.S.)

(iv) Types of velocity :

(a) **Uniform velocity :** A particle is said to have uniform velocity, if magnitudes as well as direction of its velocity remains same and this is possible only when the particles moves in same straight line without reversing its direction.

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

(c) **Average velocity** : It is defined as the ratio of displacement to time taken by the body

$$\text{Average velocity} = \frac{\text{Displacement}}{\text{Time taken}}; \quad \vec{v}_{av} = \frac{\Delta \vec{r}}{\Delta t}$$

(d) **Instantaneous velocity :** Instantaneous velocity is defined as rate of change of position vector of particles with time at a certain instant of time.

Instantaneous velocity $\vec{v} = \lim_{\Delta t \to 0} \frac{\Delta \vec{r}}{\Delta t} = \frac{d\vec{r}}{dt}$

(v) **Comparison between instantaneous speed and instantaneous velocity**

(a) instantaneous velocity is always tangential to the path followed by the particle.

When a stone is thrown from point *O* then at point of projection the instantaneous velocity of stone is $\vec{v}_1$, at point *A* the instantaneous velocity of stone is $\vec{v}_2$, similarly at point *B* and *C* are $\vec{v}_3$ and $\vec{v}_4$ respectively.

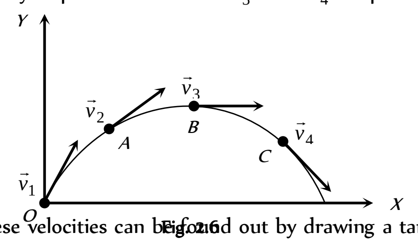


Fig. 2.6

Direction of these velocities can be found out by drawing a tangent on the trajectory at a given point.

(b) A particle may have constant instantaneous speed but variable instantaneous velocity.

Example : When a particle is performing uniform circular motion then for every instant of its circular motion its speed remains constant but velocity changes at every instant.

(c) The magnitude of instantaneous velocity is equal to the instantaneous speed.

(d) If a particle is moving with constant velocity then its average velocity and instantaneous velocity are always equal.

(e) If displacement is given as a function of time, then time derivative of displacement will give velocity.

Let displacement $\vec{x} = A_0 - A_1 t + A_2 t^2$

Instantaneous velocity $\vec{v} = \frac{d\vec{x}}{dt} = \frac{d}{dt}(A_0 - A_1 t + A_2 t^2)$

$\vec{v} = -A_1 + 2A_2 t$

For the given value of *t*, we can find out the instantaneous velocity.

e.g for $t = 0$,Instantaneous velocity $\vec{v} = -A_1$ and Instantaneous speed $|\vec{v}| = A_1$

(vi) **Comparison between average speed and average velocity**

(a) Average speed is a scalar while average velocity is a vector both having same units (*m/s*) and dimensions $[LT^{-1}]$.

(b) Average speed or velocity depends on time interval over which it is defined.

(c) For a given time interval average velocity is single valued while average speed can have many values depending on path followed.

(d) If after motion body comes back to its initial position then $\vec{v}_{av} = 0$ (as $\Delta \vec{r} = 0$) but $v_{av} > 0$ and finite as $(\Delta s > 0)$.

(e) For a moving body average speed can never be negative or zero (unless $t \to \infty$) while average velocity can be *i.e.* $v_{av} > 0$ while $\vec{v}_{av}$ = or < 0.

(f) As we know for a given time interval

Distance ≥ |displacement|

∴ Average speed ≥ |Average velocity|

Acceleration

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

(1) It is a vector quantity. It's direction is same as that of change in velocity (Not of the velocity)

Table 2.2 : Possible ways of velocity change

When only direction of velocity changes	When only magnitude of velocity changes	When both magnitude and direction of velocity changes
Acceleration perpendicular to velocity	Acceleration parallel or anti-parallel to velocity	Acceleration has two components one is perpendicular to velocity and another parallel or anti-parallel to velocity
Ex. Uniform circular motion	*Ex.* Motion under gravity	*Ex.* Projectile motion

(2) Dimension : $[MLT^{-2}]$

(3) Unit : *metre/second*^{2} (S.I.); *cm/second*^{2} (C.G.S.)

(4) Types of acceleration :

(i) **Uniform acceleration :** A body is said to have uniform acceleration if magnitude and direction of the acceleration remains constant during particle motion.

(ii) **Non-uniform acceleration :** A body is said to have non-uniform acceleration, if either magnitude or direction or both of them change during motion.

(iii) **Average acceleration :** $\vec{a}_{av} = \frac{\Delta \vec{v}}{\Delta t} = \frac{\vec{v}_2 - \vec{v}_1}{\Delta t}$

The direction of average acceleration vector is the direction of the change in velocity vector as $\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$

(iv) **Instantaneous acceleration** = $\vec{a} = \lim_{\Delta t \to 0} \frac{\Delta \vec{v}}{\Delta t} = \frac{d\vec{v}}{dt}$

(v) For a moving body there is no relation between the direction of instantaneous velocity and direction of acceleration.

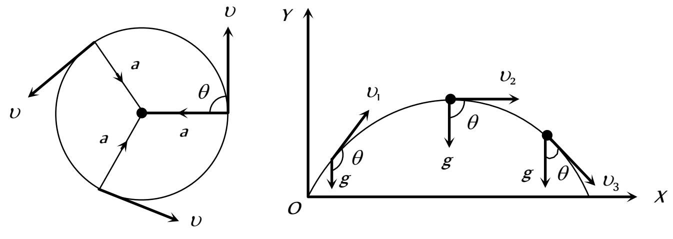


Fig. 2.7

Ex. (a) In uniform circular motion θ = 90° always

(b) In a projectile motion θ is variable for every point of trajectory.

(vi) If a force $\vec{F}$ acts on a particle of mass *m*, by Newton's 2nd law, acceleration $\vec{a} = \frac{\vec{F}}{m}$

(vii) By definition $\vec{a} = \frac{d\vec{v}}{dt} = \frac{d^2\vec{x}}{dt^2}\left[\text{As } \vec{v} = \frac{d\vec{x}}{dt}\right]$

i.e., if *x* is given as a function of time, second time derivative of displacement gives acceleration

(viii) If velocity is given as a function of position, then by chain rule

$$a = \frac{dv}{dt} = \frac{dv}{dx} \times \frac{dx}{dt} = v.\frac{d\upsilon}{dx}\left[\text{as } v = \frac{dx}{dt}\right]$$

(xi) Acceleration can be positive, zero or negative. Positive acceleration means velocity increasing with time, zero acceleration means velocity is uniform constant while negative acceleration (retardation) means velocity is decreasing with time.

(xii) For motion of a body under gravity, acceleration will be equal to "*g*", where g is the acceleration due to gravity. Its value is $9.8\ m/s^2$ or $980\ cm/s^2$ or $32\ feet/s^2$.

Position time Graph

During motion of the particle its parameters of kinematical analysis (*v*, *a*, *s*) changes with time. This can be represented on the graph.

Position time graph is plotted by taking time *t* along *x*-axis and position of the particle on *y*-axis.

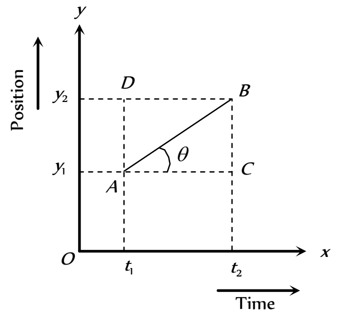


Fig. 2.8

Let *AB* is a position-time graph for any moving particle

As Velocity = $\frac{\text{Change in position}}{\text{Time taken}} = \frac{y_2 - y_1}{t_2 - t_1}$ ....(i)

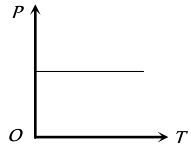
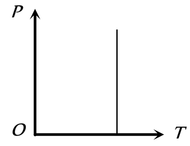
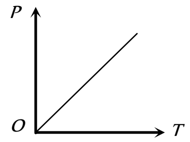
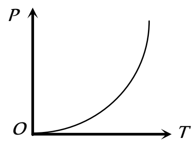
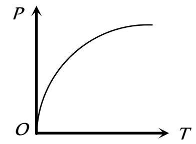
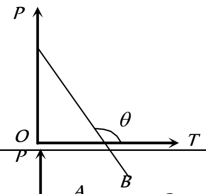
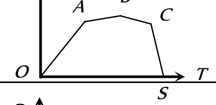
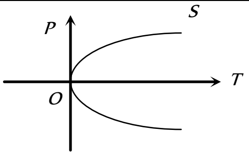
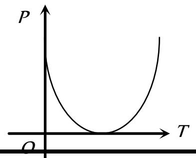
From triangle *ABC*, $\tan\theta = \frac{BC}{AC} = \frac{AD}{AC} = \frac{y_2 - y_1}{t_2 - t_1}$ ....(ii)

By comparing (i) and (ii) Velocity = tanθ

v = tanθ

It is clear that slope of tangent on position-time graph represents the velocity of the particle.

Table 2.3 : Various position -time graphs and their interpretation

	$\theta = 0°$ so $v = 0$ *i.e.*, line parallel to time axis represents that the particle is at rest.
	$\theta = 90°$ so $v = \infty$ i.e., line perpendicular to time axis represents that particle is changing its position but time does not changes it means the particle possesses infinite velocity. Practically this is not possible.
	$\theta =$ constant so $v =$ constant, $a = 0$ i.e., line with constant slope represents uniform velocity of the particle.
	θ is increasing so v is increasing, a is positive. *i.e.*, line bending towards position axis represents increasing velocity of particle. It means the particle possesses acceleration.
	θ is decreasing so v is decreasing, a is negative *i.e.*, line bending towards time axis represents decreasing velocity of the particle. It means the particle possesses retardation.
	θ constant but > 90° so v will be constant but negative *i.e.*, line with negative slope represent that particle returns towards the point of reference. (negative displacement).
	Straight line segments of different slopes represent that velocity of the body changes after certain interval of time.
	This graph shows that at one instant the particle has two positions, which is not possible.
	The graph shows that particle coming towards origin initially and after that it is moving away from origin.

Note : ❑ If the graph is plotted between distance and time then it is always an increasing curve and it never comes back towards origin because distance never decrease with time. Hence such type of distance time graph is valid up to point A only, after point *A*, it is not valid as shown in the figure.

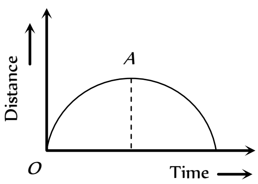


Fig. 2.9

Velocity-time Graph

The graph is plotted by taking time t along x-axis and velocity of the particle on y-axis.

Calculation of Distance and displacement : The area covered between the velocity time graph and time axis gives the displacement and distance travelled by the body for a given time interval.

Total distance $= |A_1| + |A_2| + |A_3|$

= Addition of modulus of different area. *i.e.* $s = \int |v|\, dt$

Total displacement $= A_1 + A_2 + A_3$

= Addition of different area considering their sign.

i.e. $r = \int v \, dt$

Area above time axis is taken as positive, while area below time axis is taken as negative

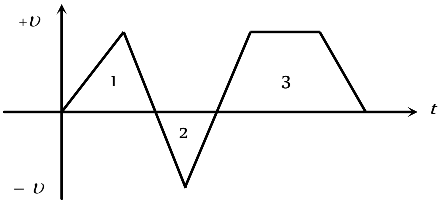


Fig. 2.10

here A_1 and A_2 are area of triangle 1 and 2 respectively and A_3 is the area of trapezium .

Calculation of Acceleration : Let *AB* is a velocity-time graph for any moving particle

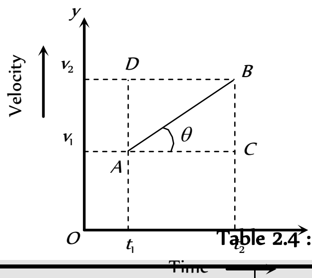


Fig. 2.11

As Acceleration = $\dfrac{\text{Change in velocity}}{\text{Time taken}}$

$$= \frac{v_2 - v_1}{t_2 - t_1} \qquad \text{...(i)}$$

From triangle *ABC*, $\tan\theta = \dfrac{BC}{AC} = \dfrac{AD}{AC}$

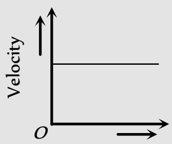
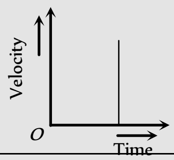
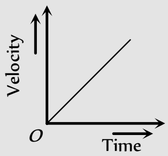
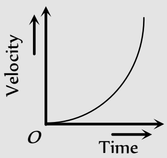
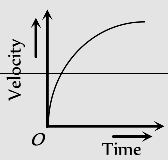
$$= \frac{v_2 - v_1}{t_2 - t_1} \qquad \text{....(ii)}$$

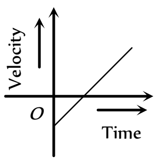
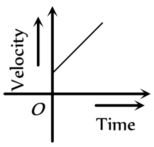
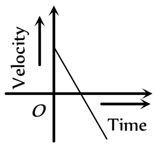
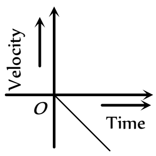
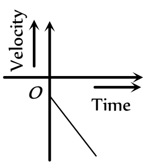
By comparing (i) and (ii)

Acceleration (a) = $\tan\theta$

It is clear that slope of tangent on velocity-time graph represents the acceleration of the particle.

Table 2.4 : Various velocity -time graphs and their interpretation

	$\theta = 0°$, $a = 0$, v = constant *i.e.*, line parallel to time axis represents that the particle is moving with constant velocity.
	$\theta = 90°$, $a = \infty$, v = increasing *i.e.*, line perpendicular to time axis represents that the particle is increasing its velocity, but time does not change. It means the particle possesses infinite acceleration. Practically it is not possible.
	θ = constant, so a = constant and v is increasing uniformly with time *i.e.*, line with constant slope represents uniform acceleration of the particle.
	θ increasing so acceleration increasing *i.e.*, line bending towards velocity axis represent the increasing acceleration in the body.
	θ decreasing so acceleration decreasing

	i.e. line bending towards time axis represents the decreasing acceleration in the body
	Positive constant acceleration because θ is constant and < 90° but initial velocity of the particle is negative.
	Positive constant acceleration because θ is constant and < 90° but initial velocity of particle is positive.
	Negative constant acceleration because θ is constant and > 90° but initial velocity of the particle is positive.
	Negative constant acceleration because θ is constant and > 90° but initial velocity of the particle is zero.
	Negative constant acceleration because θ is constant and > 90° but initial velocity of the particle is negative.

Equation of Kinematics

These are the various relations between u, v, a, t and s for the particle moving with uniform acceleration where the notations are used as :

u = Initial velocity of the particle at time t = 0 *sec*

v = Final velocity at time t *sec*

a = Acceleration of the particle

s = Distance travelled in time t *sec*

s_n = Distance travelled by the body in n *sec*

(1) **When particle moves with zero acceleration**

(i) It is a unidirectional motion with constant speed.

(ii) Magnitude of displacement is always equal to the distance travelled.

(iii) $v = u$, $s = u\,t$ [As $a = 0$]

(2) **When particle moves with constant acceleration**

(i) Acceleration is said to be constant when both the magnitude and direction of acceleration remain constant.

(ii) There will be one dimensional motion if initial velocity and acceleration are parallel or anti-parallel to each other.

(iii)

Equations of motion (in scalar from)	Equation of motion (in vector from)
$\upsilon = u + at$	$\vec{v} = \vec{u} + \vec{a}t$
$s = ut + \frac{1}{2}at^2$	$\vec{s} = \vec{u}t + \frac{1}{2}\vec{a}t^2$
$\upsilon^2 = u^2 + 2as$	$\vec{v}.\vec{v} - \vec{u}.\vec{u} = 2\vec{a}.\vec{s}$
$s = \left(\frac{u+v}{2}\right)t$	$\vec{s} = \frac{1}{2}(\vec{u} + \vec{v})t$

$s_n = u + \frac{a}{2}(2n-1)$ $\qquad \vec{s}_n = \vec{u} + \frac{\vec{a}}{2}(2n-1)$

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

(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

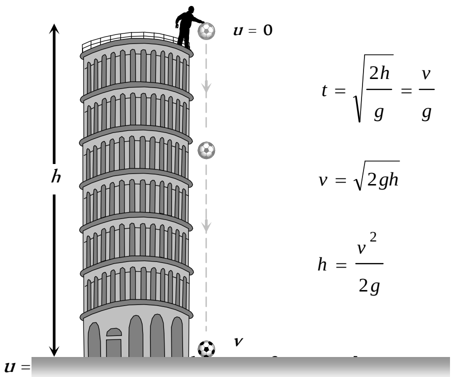


Fig. 2.12

$a = +g$ [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 :

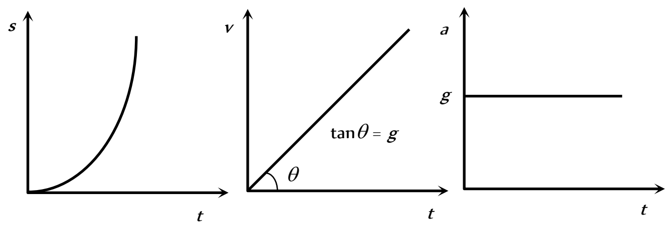


Fig. 2.13

(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*, $h_n = \frac{1}{2}g(2n-1)$

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

(2) **If a body is projected vertically downward with some initial velocity**

Equation of motion : $\quad v = u + g\,t$

$h = ut + \frac{1}{2}g\,t^2$

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

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

(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

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

(ii) For maximum height $v = 0$

So from above equation $u = gt$,

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

and $\quad u^2 = 2gh$

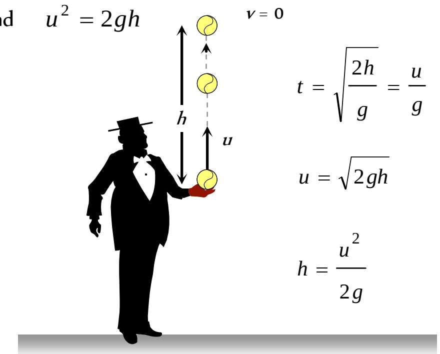


Fig. 2.14

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

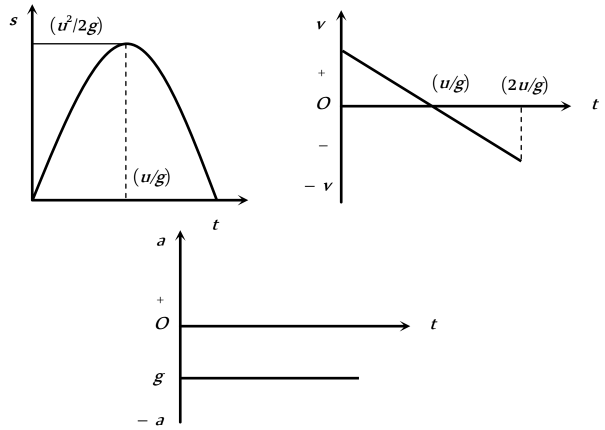


Fig. 2.15

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.

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

(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 $T = t_1 + t_2 = \dfrac{2u}{g}$

(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) 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 $t_1 = \dfrac{u}{g+a}$

and $h = \dfrac{u^2}{2(g+a)}$

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 $h = \dfrac{1}{2}(g-a)t_2^2$

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

$$\Rightarrow t_2 = \frac{u}{\sqrt{(g+a)(g-a)}}$$

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

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

Motion with Variable Acceleration

(i) If acceleration is a function of time

$a = f(t)$ then $v = u + \int_0^t f(t)\,dt$

and $s = ut + \int_0^t \left(\int f(t)\,dt\right)dt$

(ii) If acceleration is a function of distance

$a = f(x)$ then $v^2 = u^2 + 2\int_{x_0}^{x} f(x)\,dx$

(iii) If acceleration is a function of velocity

$a = f(v)$ then $t = \int_u^v \dfrac{dv}{f(v)}$ and $x = x_0 + \int_u^v \dfrac{v\,dv}{f(v)}$

Tips & Tricks

- During translational motion of the body, there is change in the location of the body.
- During rotational motion of the body, there is change in the orientation of the body, while there is no change in the location of the body from the axis of rotation.
- A point object is just a mathematical point. This concept is introduced to study the motion of a body in a simple manner.
- The choice of the origin is purely arbitrary.
- For one dimensional motion the angle between acceleration and velocity is either 0° or 180° and it does not change with time.
- For two dimensional motion, the angle between acceleration and velocity is other than 0° or 180° and also it may change with time.
- If the angle between $\vec{a}$ and $\vec{v}$ is 90°, the path of the particle is a circle.
- The particle speed up, that is the speed of the particle increases when the angle between $\vec{a}$ and $\vec{v}$ lies between –90° and +90°.
- The particle speeds down, that is the speed of the particle decreases, when the angle between $\vec{a}$ and $\vec{v}$ lies between +90° and 270°.
- The speed of the particle remains constant when the angle between $\vec{a}$ and $\vec{v}$ is equal to 90°.
- The distance covered by a particle never decreases with time, it always increases.
- Displacement of a particle is the unique path between the initial and final positions of the particle. It may or may not be the actually travelled path of the particle.
- Displacement of a particle gives no information regarding the nature of the path followed by the particle.
- Magnitude of displacement $\leq$ Distance covered.
- Since distance $\geq$ |Displacement|, so average speed of a body is equal or greater than the magnitude of the average velocity of the body.
- The average speed of a body is equal to its instantaneous speed if the body moves with a constant speed
- No force is required to move the body or an object with uniform velocity.
- Velocity of the body is positive, if it moves to the right side of the origin. Velocity is negative if the body moves to the left side of the origin.
- When a particle returns to the starting point, its displacement is zero but the distance covered is not zero.
- When a body reverses its direction of motion while moving along a straight line, then the distance travelled by the body is greater than the magnitude of the displacement of the body. In this case, average speed of

the body is greater than its average velocity.

- Speedometer measures the instantaneous speed of a vehicle.

- When particle moves with speed v_1 upto half time of its total motion and in rest time it is moving with speed v_2 then $v_{av} = \frac{v_1 + v_2}{2}$

- When particle moves the first half of a distance at a speed of v_1 and second half of the distance at speed v_2 then

$$v_{av} = \frac{2v_1v_2}{v_1 + v_2}$$

- 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

$$v_{av} = \frac{3v_1v_2v_3}{v_1v_2 + v_2v_3 + v_3v_1}$$

- For two particles having displacement time graph with slopes θ_1 and θ_2 possesses velocities v_1 and v_2 respectively then $\frac{\upsilon_1}{\upsilon_2} = \frac{\tan\theta_1}{\tan\theta_2}$

- Velocity of a particle having uniform motion = slope of displacement–time graph.

- Greater the slope of displacement-time graph, greater is the velocity and vice-versa.

- Area under $v - t$ graph = displacement of the particle.

- Slope of velocity-time graph = acceleration.

- 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

$$a_{av} = \frac{a_1t_1 + a_2t_2}{t_1 + t_2}$$

- If same force is applied on two bodies of different masses m_1 and m_2 separately then it produces accelerations a_1 and a_2 respectively. Now these bodies are attached together and form a combined system and same force is applied on that system so that a be the acceleration of the combined system, then

$$a = \frac{a_1a_2}{a_1 + a_2}$$

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

So we can say that the ratio of distance covered in 1 *sec*, 2 *sec* and 3 *sec* is $1^2 : 2^2 : 3^2$ or 1 : 4 : 9.

- If a body starts from rest and moves with uniform acceleration then distance covered by the body in nth sec is proportional to $(2n-1)$ (*i.e.* $s_n \propto (2n-1)$)

So we can say that the ratio of distance covered in 1st, 2nd and 3rd is 1 : 3 : 5.

- 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 $\upsilon^2 = u^2 - 2as \Rightarrow 0 = u^2 - 2as \Rightarrow s = \frac{u^2}{2a}$, $s \propto u^2$

[since a is constant]

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

- A particle moving with uniform acceleration from A to B along a straight line has velocities υ_1 and υ_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

$$\upsilon = \sqrt{\frac{\upsilon_1^2 + \upsilon_2^2}{2}}$$

- The body returns to its point of projection with the same magnitude of the velocity with which it was thrown vertically upward, provided air resistance is neglected.

- All bodies fall freely with the same acceleration.

- The acceleration of the falling bodies does not depend on the mass of the body.

- If two bodies are dropped from the same height, they reach the ground in the same time and with the same velocity.

- If a body is thrown upwards with velocity u from the top of a tower and another body is thrown downwards from the same point and with the same velocity, then both reach the ground with the same speed.

- When a particle returns to the starting point, its average velocity is zero but the average speed is not zero.

- If both the objects A and B move along parallel lines in the same direction, then the relative velocity of A w.r.t. B is given by $\mathbf{v}_{AB} = \mathbf{v}_A - \mathbf{v}_B$

and the relative velocity of B w.r.t. A is given by $\mathbf{v}_{BA} = \mathbf{v}_B - \mathbf{v}_A$

- If both the objects A and B move along parallel lines in the opposite direction, then the relative velocity of A w.r.t. B is given by $\mathbf{v}_{AB} = \mathbf{v}_A - (-\mathbf{v}_B) = \mathbf{v}_A + \mathbf{v}_B$

and the relative velocity of B w.r.t. A is given by $\mathbf{v}_{BA} = -\mathbf{v}_B - \mathbf{v}_A$

- Suppose a body is projected upwards from the ground and with the velocity u. It is assumed that the friction of the air is negligible. The characteristics of motion of such a body are as follows.

(i) The maximum height attained = $H = u^2/2g$.

(ii) Time taken to go up (ascent) = Time taken to come down (descent) = $t = u/g$.

(iii) Time of flight $T = 2t = 2u/g$.

(iv) The speed of the body on return to the ground = speed with which it was thrown upwards.

(v) When the height attained is not large, that is u is not large, the mass, the weight as well as the acceleration remain constant with time. But its speed, velocity, momentum, potential energy and kinetic energy change with time.

(vi) Let m be the mass of the body. Then in going from the ground to the highest point, following changes take place.

(a) Change in speed = u

(b) Change in velocity = u

(c) Change in momentum = $m\ u$

(d) Change in kinetic energy = Change in potential energy = (1/2) mu.

(vii) On return to the ground the changes in these quantities are as follows

(a) Change in speed = 0

(b) Change in velocity = $2u$

(c) Change in momentum = $2mu$

(d) Change in kinetic energy = Change in potential energy = 0

(viii) If, the friction of air be taken into account, then the motion of the object thrown upwards will have the following properties

(a) Time taken to go up (ascent) < time taken to come down (descent)

(b) The speed of the object on return to the ground is less than the initial speed. Same is true for velocity (magnitude), momentum (magnitude) and kinetic energy.

(c) Maximum height attained is less than $u/2g$.

(d) A part of the kinetic energy is used up in overcoming the friction.

✍ 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

$$t = \sqrt{t_1 t_2}$$

✍ 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.*

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

Ordinary Thinking

Objective Questions

Distance and Displacement

1. A Body moves 6 *m* north. 8 *m* east and 10*m* vertically upwards, what is its resultant displacement from initial position

(a) $10\sqrt{2}m$ (b) $10m$

(c) $\frac{10}{\sqrt{2}}m$ (d) $10 \times 2m$

2. A man goes 10*m* towards North, then 20*m* towards east then displacement is

[KCET 1999; JIPMER 1999; AFMC 2003]

(a) 22.5*m* (b) 25*m*

(c) 25.5*m* (d) 30*m*

3. A person moves 30 *m* north and then 20 *m* towards east and finally $30\sqrt{2}$ *m* in south-west direction. The displacement of the person from the origin will be

[J & K CET 2004]

(a) 10 *m* along north (b) 10 *m* long south

(c) 10 *m* along west (d) Zero

4. An aeroplane flies 400 *m* north and 300 *m* south and then flies 1200 *m* upwards then net displacement is

[AFMC 2004]

(a) 1200 *m* (b) 1300 *m*

(c) 1400 *m* (d) 1500 *m*

5. An athlete completes one round of a circular track of radius *R* in 40 *sec*. What will be his displacement at the end of 2 min. 20 *sec* [NCERT 1990; Kerala PMT 2004]

(a) Zero (b) 2*R*

(c) $2\pi R$ (d) $7\pi R$

6. A wheel of radius 1 meter rolls forward half a revolution on a horizontal ground. The magnitude of the displacement of the point of the wheel initially in contact with the ground is

[BCECE 2005]

(a) 2π (b) $\sqrt{2}\pi$

(c) $\sqrt{\pi^2 + 4}$ (d) π

Uniform Motion

1. A person travels along a straight road for half the distance with velocity v_1 and the remaining half distance with velocity v_2 The average velocity is given by [MP PMT 2001]

(a) $v_1 v_2$ (b) $\frac{v_2^2}{v_1^2}$

(c) $\frac{v_1 + v_2}{2}$ (d) $\frac{2v_1 v_2}{v_1 + v_2}$

2. The displacement-time graph for two particles *A* and *B* are straight lines inclined at angles of 30^o and 60^o with the time axis. The ratio of velocities of $V_A : V_B$ is

[CPMT 1990; MP PET 1999; MP PET 2001; Pb. PET 2003]

(a) $1:2$ (b) $1:\sqrt{3}$

(c) $\sqrt{3}:1$ (d) $1:3$

3. A car travels from *A* to *B* at a speed of $20\ km/hr$ and returns at a speed of $30\ km/hr$. The average speed of the car for the whole journey is [MP PET 1985]

(a) $25\ km/hr$ (b) $24\ km/hr$

(c) $50\ km/hr$ (d) $5\ km/hr$

4. 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*, is [DCE 2000]

(a) 24/13 (b) 40/13

(c) 3 (d) 1/2

5. A car travels the first half of a distance between two places at a speed of 30 *km/hr* and the second half of the distance at 50 *km/hr*. The average speed of the car for the whole journey is [Manipal MEE 1995; A

(a) 42.5 *km/hr* (b) 40.0 *km/hr*

(c) 37.5 *km/hr* (d) 35.0 *km/hr*

6. One car moving on a straight road covers one third of the distance with 20 *km/hr* and the rest with 60 *km/hr*. The average speed is [MP PMT 199

(a) 40 *km/hr* (b) 80 *km/hr*

(c) $46\frac{2}{3}$ *km/hr* (d) 36 *km/hr*

7. A car moves for half of its time at 80 *km/h* and for rest half of time at 40 *km/h*. Total distance covered is 60 *km*. What is the average speed of the car [RPET 1996]

(a) $60\ km/h$ (b) $80\ km/h$

(c) $120\ km/h$ (d) $180\ km/h$

8. A train has a speed of 60 *km/h*. for the first one hour and 40 *km/h* for the next half hour. Its average speed in *km/h* is

[JIPMER 1999]

(a) 50 (b) 53.33

(c) 48 (d) 70

9. Which of the following is a one dimensional motion

[BHU 2000; CBSE PMT 2001]

(a) Landing of an aircraft

(b) Earth revolving a round the sun

(c) Motion of wheels of a moving trains

(d) Train running on a straight track

10. A 150 *m* long train is moving with a uniform velocity of 45 *km/h*. The time taken by the train to cross a bridge of length 850 meters is [CBSE PMT 2001]

(a) 56 *sec* (b) 68 *sec*

(c) 80 *sec* (d) 92 *sec*

11. A particle is constrained to move on a straight line path. It returns to the starting point after 10 *sec*. The total distance covered by the particle during this time is 30 *m*. Which of the following statements about the motion of the particle is false [CBSE PMT 2000; AFMC 2001]

(a) Displacement of the particle is zero

(b) Average speed of the particle is 3 *m/s*

(c) Displacement of the particle is 30 *m*

(d) Both (a) and (b)

12. A particle moves along a semicircle of radius 10*m* in 5 seconds. The average velocity of the particle is

[Kerala (Engg.) 2001]

(a) $2\pi\ ms^{-1}$ (b) $4\pi\ ms^{-1}$

(c) $2\ ms^{-1}$ (d) $4\ ms^{-1}$

13. 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

(a) 5 *km/h* (b) $\frac{25}{4}$ *km/h*

(c) $\frac{30}{4}$ *km/h* (d) $\frac{45}{8}$ *km/h*

14. The ratio of the numerical values of the average velocity and average speed of a body is always [MP PET 2002]

(a) Unity (b) Unity or less

(c) Unity or more (d) Less than unity

15. A person travels along a straight road for the first half time with a velocity v_1 and the next half time with a velocity v_2. The mean velocity V of the man is

[RPET 1999; BHU 2002]

(a) $\frac{2}{V}=\frac{1}{v_1}+\frac{1}{v_2}$ (b) $V=\frac{v_1+v_2}{2}$

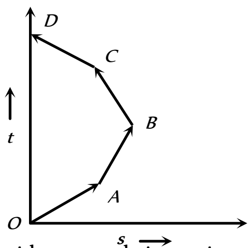
(c) $V=\sqrt{v_1v_2}$ (d) $V=\sqrt{\frac{v_1}{v_2}}$

16. If a car covers 2/5 of the total distance with v speed and 3/5 distance with v then average speed is [MP PMT 2003]

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

(c) $\frac{2v_1v_2}{v_1+v_2}$ (d) $\frac{5v_1v_2}{3v_1+2v_2}$

17. Which of the following options is correct for the object having a straight line motion represented by the following graph



(a) The object moves with constantly increasing velocity from O to A and then it moves with constant velocity.

(b) Velocity of the object increases uniformly

(c) Average velocity is zero

(d) The graph shown is impossible

18. The numerical ratio of displacement to the distance covered is always [BHU 2004]

(a) Less than one

(b) Equal to one

(c) Equal to or less than one

(d) Equal to or greater than one

19. A 100 *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 1 *km* is

(a) 58 *s* (b) 68 *s*

[AMU (Med) 2002]

(c) 78 *s* (d) 88 *s*

20. A particle moves for 20 *seconds* with velocity 3 *m/s* and then velocity 4 *m/s* for another 20 *seconds* and finally moves with velocity 5 *m/s* for next 20 *seconds*. What is the average velocity of the particle [MH CET 2004]

(a) 3 *m/s* (b) 4 *m/s*

(c) 5 *m/s* (d) Zero

21. The correct statement from the following is [MP PET 1993]

(a) A body having zero velocity will not necessarily have zero acceleration

(b) A body having zero velocity will necessarily have zero acceleration

(c) A body having uniform speed can have only uniform acceleration

(d) A body having non-uniform velocity will have zero acceleration

22. A bullet fired into a fixed target loses half of its velocity after penetrating 3 *cm*. How much further it will penetrate before coming to rest assuming that it faces constant resistance to motion?

(a) 1.5 *cm* (b) 1.0 *cm*

(c) 3.0 *cm* (d) 2.0 *cm*

23. Two boys are standing at the ends A and B of a ground where $AB=a$. The boy at B starts running in a direction perpendicular to AB with velocity v_1. The boy at A starts running simultaneously with velocity v and catches the other boy in a time *t*, where *t* is

(a) $a/\sqrt{v^2+v_1^2}$ (b) $\sqrt{a^2/(v^2-v_1^2)}$

(c) $a/(v-v_1)$ (d) $a/(v+v_1)$

24. 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

[DCE 2004] [Kerala PMT 2005]

(a) 40 (b) 45

(c) 48 (d) 50

Non-uniform Motion

1. A particle experiences a constant acceleration for 20 sec after starting from rest. If it travels a distance S_1 in the first 10 sec and a distance S_2 in the next 10 sec, then

[NCERT 1972; CPMT 1997; MP PMT 2002]

(a) $S_1=S_2$ (b) $S_1=S_2/3$

(c) $S_1=S_2/2$ (d) $S_1=S_2/4$

2. The displacement x of a particle along a straight line at time t is given by $x=a_0+a_1t+a_2t^2$. The acceleration of the particle is [NCERT 19

(a) a_0 (b) a_1

(c) $2a_2$ (d) a_2

3. The coordinates of a moving particle at any time are given by $x = at^2$ and $y = bt^2$. The speed of the particle at any moment is [DPMT 1984; CPMT 1997]

(a) $2t(a+b)$ (b) $2t\sqrt{(a^2 - b^2)}$

(c) $t\sqrt{a^2+b^2}$ (d) $2t\sqrt{(a^2+b^2)}$

4. An electron starting from rest has a velocity that increases linearly with the time that is $v = kt$, where $k = 2m/\sec^2$. The distance travelled in the first 3 seconds will be [NCERT 1982]

(a) 9 m (b) 16 m

(c) 27 m (d) 36 m

5. The displacement of a body is given to be proportional to the cube of time elapsed. The magnitude of the acceleration of the body is

(a) Increasing with time (b) Decreasing with time

(c) Constant but not zero (d) Zero

6. The instantaneous velocity of a body can be measured

(a) Graphically (b) Vectorially

(c) By speedometer (d) None of these

7. A body is moving from rest under constant acceleration and let S_1 be the displacement in the first $(p-1)$ sec and S_2 be the displacement in the first p sec. The displacement in $(p^2 - p + 1)^{th}$ sec. will be

(a) $S_1 + S_2$ (b) $S_1 S_2$

(c) $S_1 - S_2$ (d) S_1 / S_2

8. A body under the action of several forces will have zero acceleration

(a) When the body is very light

(b) When the body is very heavy

(c) When the body is a point body

(d) When the vector sum of all the forces acting on it is zero

9. A body starts from the origin and moves along the X-axis such that the velocity at any instant is given by $(4t^3 - 2t)$, where t is in sec and velocity in m/s. What is the acceleration of the particle, when it is 2 m from the origin

(a) $28\ m/s^2$ (b) $22\ m/s^2$

(c) $12 m/s^2$ (d) $10\ m/s^2$

10. The relation between time and distance is $t = \alpha x^2 + \beta x$, where α and β are constants. The retardation is [NCERT 1982; AIEEE 2005]

(a) $2\alpha v^3$ (b) $2\beta v^3$

(c) $2\alpha\beta v^3$ (d) $2\beta^2 v^3$

11. 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

(a) $(v_1 - v_2):(v_2 - v_3) = (t_1 - t_2):(t_2 + t_3)$

(b) $(v_1 - v_2):(v_2 - v_3) = (t_1 + t_2):(t_2 + t_3)$

(c) $(v_1 - v_2):(v_2 - v_3) = (t_1 - t_2):(t_1 - t_3)$

(d) $(v_1 - v_2):(v_2 - v_3) = (t_1 - t_2):(t_2 - t_3)$

12. The acceleration of a moving body can be found from [DPMT 1981]

(a) Area under velocity-time graph

(b) Area under distance-time graph

(c) Slope of the velocity-time graph

(d) Slope of distance-time graph

13. The initial velocity of a particle is u (at $t = 0$) and the acceleration f is given by at. Which of the following relation is valid [CPMT 1981; BHU 1995]

(a) $v = u + at^2$ [NCERT 1990] (b) $v = u + a\frac{t^2}{2}$

(c) $v = u + at$ (d) $v = u$

14. The initial velocity of the particle is $10\ m/\sec$ and its retardation is $2m/\sec^2$. The distance moved by the particle in $5th$ second of its motion is [CPMT 1976]

(a) $1\ m$ (b) $19\ m$

(c) $50\ m$ (d) $75 m$

15. A motor car moving with a uniform speed of $20 m/\sec$ comes to stop on the application of brakes after travelling a distance of $10 m$ Its acceleration is [EAMCET 1979]

(a) $20 m/\sec^2$ (b) $-20m/\sec^2$

(c) $-40\ m/\sec^2$ (d) $+2m/\sec^2$

16. The velocity of a body moving with a uniform acceleration of $2\ m./\sec^2$ is $10\ m/\sec$. Its velocity after an interval of 4 *sec* is

(a) $12\ m/\sec$ (b) $14\ m/\sec$

(c) $16\ m/\sec$ (d) $18\ m/\sec$

17. A particle starting from rest travels a distance x in first 2 *seconds* and a distance y in next two *seconds*, then [EAMCET 1982]

(a) $y = x$ (b) $y = 2x$

(c) $y = 3x$ (d) $y = 4x$

18. The initial velocity of a body moving along a straight line is 7 m/s. It has a uniform acceleration of $4 m/s^2$. The distance covered by the body in the 5 second of its motion is

(a) 25 m (b) 35 m

(c) 50 m (d) 85 m

19. The velocity of a body depends on time according to the equation $v = 20 + 0.1t^2$. The body is undergoing [MNR 1995; UPSEAT 2000]

(a) Uniform acceleration

(b) Uniform retardation

(c) Non-uniform acceleration [NCERT 1982]

(d) Zero acceleration

20. Which of the following four statements is false [Manipal MEE 1995]

(a) A body can have zero velocity and still be accelerated

(b) A body can have a constant velocity and still have a varying speed

(c) A body can have a constant speed and still have a varying velocity

(d) The direction of the velocity of a body can change when its acceleration is constant

21. A particle moving with a uniform acceleration travels 24 *m* and 64 *m* in the first two consecutive intervals of 4 *sec* each. Its initial velocity is [MP PET 1995]

(a) 1 *m/sec* (b) $10\, m/\sec$

(c) 5 *m/sec* (d) 2 *m/sec*

22. The position of a particle moving in the *xy*-plane at any time t is given by $x = (3t^2 - 6t)$ *metres*, $y = (t^2 - 2t)$ *metres*. Select the correct statement about the moving particle from the following

(a) The acceleration of the particle is zero at $t = 0$ second

(b) The velocity of the particle is zero at $t = 0$ second

(c) The velocity of the particle is zero at $t = 1$ second

(d) The velocity and acceleration of the particle are never zero

23. If body having initial velocity zero is moving with uniform acceleration $8\ m/\sec^2$ the distance travelled by it in fifth second will be [MP PMT 1996; DPMT 2001]

(a) 36 *metres* (b) 40 *metres*

(c) 100 *metres* (d) Zero

24. An alpha particle enters a hollow tube of 4 *m* length with an initial speed of 1 *km/s*. It is accelerated in the tube and comes out of it with a speed of 9 *km/s*. The time for which it remains inside the tube is

(a) $8 \times 10^{-3} s$ (b) $80 \times 10^{-3} s$

(c) $800 \times 10^{-3} s$ (d) $8 \times 10^{-4} s$

25. 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

(a) $d < \frac{(v_1 - v_2)^2}{2a}$ (b) $d < \frac{v_1^2 - v_2^2}{2a}$

(c) $d > \frac{(v_1 - v_2)^2}{2a}$ (d) $d > \frac{v_1^2 - v_2^2}{2a}$

26. A body of mass 10 *kg* is moving with a constant velocity of 10 *m/s*. When a constant force acts for 4 *seconds* on it, it moves with a velocity 2 *m/sec* in the opposite direction. The acceleration produced in it is [MP PET 1997]

(a) $3\, m/\sec^2$ (b) $-3m/\sec^2$

(c) $0.3\, m/\sec^2$ (d) $-0.3\, m/\sec^2$

27. A body starts from rest from the origin with an acceleration of $6\, m/s^2$ along the *x*-axis and $8\, m/s^2$ along the *y*-axis. Its distance from the origin after 4 seconds will be [MP PMT 1999]

(a) 56 *m* (b) 64 *m*

(c) 80 *m* (d) 128 *m*

28. A car moving with a velocity of 10 *m/s* can be stopped by the application of a constant force *F* in a distance of 20 *m*. If the velocity of the car is 30 *m/s*, it can be stopped by this force in

(a) $\frac{20}{3} m$ (b) 20 *m*

(c) 60 *m* (d) 180 *m*

29. The displacement of a particle is given by $y = a + bt + ct^2 - dt^4$. The initial velocity and acceleration are respectively [CPMT 1999, 2003]

(a) $b, -4d$ (b) $-b, 2c$

(c) $b, 2c$ (d) $2c, -4d$

30. A car moving with a speed of 40 *km/h* can be stopped by applying brakes after atleast 2 *m*. If the same car is moving with a speed of 80 *km/h*, what is the minimum stopping distance [MP PMT 1995][CBSE PMT 1998,1999; AFMC 2000; JIPMER 2001, 02]

(a) 8 *m* (b) 2 *m*

(c) 4 *m* (d) 6 *m*

31. An elevator car, whose floor to ceiling distance is equal to 2.7 *m*, starts ascending with constant acceleration of 1.2 *ms*. 2 *sec* after the start, a bolt begins fallings from the ceiling of the car. The free fall time of the bolt is [KCET 1994]

(a) $\sqrt{0.54}\, s$ (b) $\sqrt{6}\, s$

(c) 0.7 *s* (d) 1 *s*

32. The displacement is given by $x = 2t^2 + t + 5$, the acceleration at $t = 2s$ is [EAMCET (Engg.) 1995]

(a) $4\ m/s^2$ (b) $8\ m/s^2$

(c) $10\, m/s^2$ (d) $15\, m/s^2$

33. Two trains travelling on the same track are approaching each other with equal speeds of 40 *m/s*. The drivers of the trains begin to decelerate simultaneously when they are just 2.0 *km* apart. Assuming the decelerations to be uniform and equal, the value of the deceleration to barely avoid collision should be

(a) 11.8 m/s^2 (b) 11.0 m/s^2

(c) 2.1 m/s^2 (d) 0.8 m/s^2

34. A body moves from rest with a constant acceleration of $5\, m/s^2$. Its instantaneous speed (in m/s) at the end of 10 *sec* is [Pb. PET 2004]

(a) 50 (b) 5

(c) 2 (d) 0.5

35. 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 relation [RPET 1997]

(a) Both will be equal

(b) First will be half of second

(c) First will be 1/4 of second

(d) No definite ratio

36. A body starts from rest. What is the ratio of the distance travelled by the body during the 4th and 3rd second [CBSE PMT 1993]

(a) $\frac{7}{5}$ (b) $\frac{5}{7}$

(c) $\frac{7}{3}$ (d) $\frac{3}{7}$

37. The acceleration 'a' in m/s^2 of a particle is given by $a=3t^2+2t+2$ where t is the time. If the particle starts out with a velocity $u=2m/s$ at $t=0$, then the velocity at the end of 2 *second* is [MNR 1994; SCRA 1994]

(a) 12 *m/s* (b) 18 *m/s*
(c) 27 *m/s* (d) 36 *m/s*

38. A particle moves along a straight line such that its displacement at any time t is given by

$S=t^3-6t^2+3t+4$ *metres*

The velocity when the acceleration is zero is [CBSE PMT 1994; JIPMER 2001, 02]

(a) $3ms^{-1}$ (b) $-12ms^{-1}$
(c) $42ms^{-1}$ (d) $-9ms^{-1}$

39. For a moving body at any instant of time [NTSE 1995]

(a) If the body is not moving, the acceleration is necessarily zero
(b) If the body is slowing, the retardation is negative
(c) If the body is slowing, the distance is negative
(d) If displacement, velocity and acceleration at that instant are known, we can find the displacement at any given time in future

40. The x and y coordinates of a particle at any time t are given by $x=7t+4t^2$ and $y=5t$, where x and y are in metre and t in seconds. The acceleration of particle at $t=5$ *s* is

(a) Zero (b) $8\ m/s^2$
(c) $20\ m/s^2$ (d) $40\ m/s^2$

41. The engine of a car produces acceleration $4m/s^2$ in the car. If this car pulls another car of same mass, what will be the acceleration produced [RPET 1996]

(a) $8m/s^2$ (b) $2m/s^2$
(c) $4m/s^2$ (d) $\frac{1}{2}m/s^2$

42. If a body starts from rest and travels 120 *cm* in the 6th second, then what is the acceleration [AFMC 1997]

(a) 0.20 m/s^2 (b) 0.027 m/s^2
(c) 0.218 m/s^2 (d) 0.03 m/s^2

43. If a car at rest accelerates uniformly to a speed of 144 *km/h* in 20 *s*. Then it covers a distance of [CBSE PMT 1997]

(a) 20 *m* (b) 400 *m*
(c) 1440 *m* (d) 2880 *m*

44. The position x of a particle varies with time t as $x=at^2-bt^3$. The acceleration of the particle will be zero at time t equal to [CBSE PMT 1997; BHU 1999; DPMT 2000; KCET 2000]

(a) $\frac{a}{b}$ (b) $\frac{2a}{3b}$
(c) $\frac{a}{3b}$ (d) Zero

45. A truck and a car are moving with equal velocity. On applying the brakes both will stop after certain distance, then [CPMT 1997]

(a) Truck will cover less distance before rest
(b) Car will cover less distance before rest
(c) Both will cover equal distance
(d) None

46. If a train travelling at 72 *kmph* is to be brought to rest in a distance of 200 metres, then its retardation should be [SCRA 1998; MP PMT 2004]

(a) 20 ms^{-2} (b) 10 ms^{-2}
(c) 2 ms^{-2} (d) 1 ms^{-2}

47. The displacement of a particle starting from rest (at $t=0$) is given by $s=6t^2-t^3$. The time in seconds at which the particle will attain zero velocity again, is [SCRA 1998]

(a) 2 (b) 4
(c) 6 (d) 8

48. What is the relation between displacement, time and acceleration in case of a body having uniform acceleration [DCE 1999]

(a) $S=ut+\frac{1}{2}ft^2$ (b) $S=(u+f)t$
(c) $S=v^2-2fs$ (d) None of these

49. Two cars A and B at rest at same point initially. If A starts with uniform velocity of 40 *m/sec* and B starts in the same direction with constant acceleration of $4m/s^2$, then B will catch A after how much time [RPET 1999] [SCRA 1996]

(a) 10 *sec* (b) 20 *sec*
(c) 30 *sec* (d) 35 *sec*

50. The motion of a particle is described by the equation $x=a+bt^2$ where $a=15$ *cm* and $b=3$ *cm/s*. Its instantaneous velocity at time 3 *sec* will be [AMU (Med.) 2000]

(a) 36 *cm/sec* (b) 18 *cm/sec*
(c) 16 *cm/sec* (d) 32 *cm/sec*

51. A body travels for 15 *sec* starting from rest with constant acceleration. If it travels distances S_1, S_2 and S_3 in the first five seconds, second five seconds and next five seconds respectively the relation between S_1, S_2 and S_3 is [AMU (Engg.) 2000]

(a) $S_1=S_2=S_3$ (b) $5S_1=3S_2=S_3$
(c) $S_1=\frac{1}{3}S_2=\frac{1}{5}S_3$ (d) $S_1=\frac{1}{5}S_2=\frac{1}{3}S_3$

52. A body is moving according to the equation $x=at+bt^2-ct^3$ where $x=$ displacement and a, b and c are constants. The acceleration of the body is [BHU 2000]

(a) $a+2bt$ (b) $2b+6ct$
(c) $2b-6ct$ (d) $3b-6ct^2$

53. A particle travels 10*m* in first 5 *sec* and 10*m* in next 3 *sec*. Assuming constant acceleration what is the distance travelled in next 2 *sec*

(a) 8.3 *m* (b) 9.3 *m*
(c) 10.3 *m* (d) None of above

54. The distance travelled by a particle is proportional to the squares of time, then the particle travels with [RPET 1999; RPMT 2000]

(a) Uniform acceleration (b) Uniform velocity
(c) Increasing acceleration (d) Decreasing velocity

55. Acceleration of a particle changes when [RPMT 2000]
(a) Direction of velocity changes
(b) Magnitude of velocity changes
(c) Both of above
(d) Speed changes

56. The motion of a particle is described by the equation $u = at$. The distance travelled by the particle in the first 4 seconds
(a) $4a$ (b) $12a$
(c) $6a$ (d) $8a$

57. The relation $3t = \sqrt{3x} + 6$ describes the displacement of a particle in one direction where x is in *metres* and t in sec. The displacement, when velocity is zero, is [CPMT 2000]
(a) 24 *metres* (b) 12 *metres*
(c) 5 *metres* (d) Zero

58. A constant force acts on a body of mass 0.9 *kg* at rest for 10*s*. If the body moves a distance of 250 *m*, the magnitude of the force is
(a) $3N$ (b) $3.5N$
(c) $4.0N$ (d) $4.5N$

59. The average velocity of a body moving with uniform acceleration travelling a distance of 3.06 *m* is 0.34 ms^{-1}. If the change in velocity of the body is 0.18ms^{-1} during this time, its uniform acceleration is [EAMCET (Med.) 2000]
(a) 0.01 ms^{-2} (b) 0.02 ms^{-2}
(c) 0.03 ms^{-2} (d) 0.04 ms^{-2}

60. Equation of displacement for any particle is $s = 3t^3 + 7t^2 + 14t + 8m$. Its acceleration at time $t = 1$ sec is [CBSE PMT 2000]
(a) 10 *m/s* (b) 16 *m/s*
(c) 25 *m/s* (d) 32 *m/s*

61. 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 [AMU (Engg.) 2001]
(a) Uniform, accelerated
(b) Uniform, decelerated
(c) Non-uniform, accelerated
(d) There is not enough data for generalization

62. Consider the acceleration, velocity and displacement of a tennis ball as it falls to the ground and bounces back. Directions of which of these changes in the process [AMU (Engg.) 2001]
(a) Velocity only
(b) Displacement and velocity
(c) Acceleration, velocity and displacement
(d) Displacement and acceleration

63. The displacement of a particle, moving in a straight line, is given by $s = 2t^2 + 2t + 4$ where s is in *metres* and t in seconds. The acceleration of the particle is [CPMT 2001]
(a) 2 *m/s* (b) 4 *m/s*
(c) 6 *m/s* (d) 8 *m/s*

64. A body *A* starts from rest with an acceleration a_1. After 2 seconds, another body *B* starts from rest with an acceleration a_2. If they travel equal distances in the 5th second, after the start of A, then the ratio $a_1 : a_2$ is equal to [AIIMS 2001]
(a) 5 : 9 (b) 5 : 7
(c) 9 : 5 (d) 9 : 7

65. The velocity of a bullet is reduced from 200*m/s* to 100*m/s* while travelling through a wooden block of thickness 10*cm*. The retardation, assuming it to be uniform, will be [DCE 2000] [AIIMS 2001]
(a) 10×10^4 *m/s* (b) 12×10^4 *m/s*
(c) 13.5×10^4 *m/s* (d) 15×10^4 *m/s*

66. A body of 5 *kg* is moving with a velocity of 20 *m/s*. If a force of 100*N* is applied on it for 10*s* in the same direction as its velocity, what will now be the velocity of the body [MP PMT 2000; RPET 2001]
(a) 200 *m/s* (b) 220 *m/s*
(c) 240 *m/s* (d) 260 *m/s*
[EAMCET (Engg.) 2000]

67. A particle starts from rest, accelerates at 2 *m/s* for 10*s* and then goes for constant speed for 30*s* and then decelerates at 4 *m/s* till it stops. What is the distance travelled by it [DCE 2001; AIIMS 2002; DCE 2003]
(a) 750 *m* (b) 800 *m*
(c) 700 *m* (d) 850 *m*

68. The engine of a motorcycle can produce a maximum acceleration 5 *m/s*. Its brakes can produce a maximum retardation 10 *m/s*. What is the minimum time in which it can cover a distance of 1.5 *km*
(a) 30 *sec* (b) 15 *sec*
(c) 10 *sec* (d) 5 *sec*

69. The path of a particle moving under the influence of a force fixed in magnitude and direction is [MP PET 2002]
(a) Straight line (b) Circle
(c) Parabola (d) Ellipse

70. A car, moving with a speed of 50 *km/hr*, can be stopped by brakes after at least 6*m*. If the same car is moving at a speed of 100 *km/hr*, the minimum stopping distance is [AIEEE 2003]
(a) 6*m* (b) 12*m*
(c) 18*m* (d) 24*m*

71. A student is standing at a distance of 50metres from the bus. As soon as the bus begins its motion with an acceleration of 1ms^{-2}, the student starts running towards the bus with a uniform velocity u. Assuming the motion to be along a straight road, the minimum value of u, so that the student is able to catch the bus is [KCET 2003]
(a) 5 ms^{-1} (b) 8 ms^{-1}
(c) 10 ms^{-1} (d) 12 ms^{-1}

72. A body *A* moves with a uniform acceleration a and zero initial velocity. Another body *B*, starts from the same point moves in the same direction with a constant velocity v. The two bodies meet after a time t. The value of t is [MP PET 2003]
(a) $\frac{2v}{a}$ (b) $\frac{v}{a}$
(c) $\frac{v}{2a}$ (d) $\sqrt{\frac{v}{2a}}$

73. A particle moves along X-axis in such a way that its coordinate X varies with time t according to the equation $x = (2 - 5t + 6t^2)m$. The initial velocity of the particle is

[MNR 1987; MP PET 1996; Pb. PET 2004]

(a) $-5\,m/s$ (b) $6\,m/s$

(c) $-3\,m/s$ (d) $3\,m/s$

74. A car starts from rest and moves with uniform acceleration *a* on a straight road from time *t* = 0 to *t* = *T*. After that, a constant deceleration brings it to rest. In this process the average speed of the car is [MP PMT 2004]

(a) $\frac{aT}{4}$ (b) $\frac{3aT}{2}$

(c) $\frac{aT}{2}$ (d) aT

75. An object accelerates from rest to a velocity 27.5 *m/s* in 10 *sec* then find distance covered by object in next 10 *sec* [BCECE 2004]

(a) 550 *m* (b) 137.5 *m*

(c) 412.5 *m* (d) 275 *m*

76. If the velocity of a particle is given by $v = (180 - 16x)^{1/2}$ *m/s*, then its acceleration will be [J & K CET 2004]

(a) Zero (b) 8 *m/s*

(c) – 8 *m/s* (d) 4 *m/s*

77. The displacement of a particle is proportional to the cube of time elapsed. How does the acceleration of the particle depends on time obtained [Pb. PET 2001]

(a) $a \propto t^2$ (b) $a \propto 2t$

(c) $a \propto t^3$ (d) $a \propto t$

78. Starting from rest, acceleration of a particle is $a = 2(t-1)$. The velocity of the particle at $t = 5s$ is [RPET 2002]

(a) 15 *m/sec* (b) 25 *m/sec*

(c) 5 *m/sec* (d) None of these

79. A body is moving with uniform acceleration describes 40 *m* in the first 5 *sec* and 65 *m* in next 5 *sec*. Its initial velocity will be

(a) 4 *m/s* (b) 2.5 *m/s*

(c) 5.5 *m/s* (d) 11 *m/s*

80. Speed of two identical cars are u and $4u$ at a specific instant. The ratio of the respective distances in which the two cars are stopped from that instant is [AIEEE 2002]

(a) 1 : 1 (b) 1 : 4

(c) 1 : 8 (d) 1 : 16

81. The displacement x of a particle varies with time t, $x = ae^{-\alpha t} + be^{\beta t}$, where a, b, α and β are positive constants. The velocity of the particle will [CBSE PMT 2005]

(a) Go on decreasing with time

(b) Be independent of α and β

(c) Drop to zero when $\alpha = \beta$

(d) Go on increasing with time

82. A car, starting from rest, accelerates at the rate *f* through a distance *S*, then continues at constant speed for time *t* and then decelerates at the rate $\frac{f}{2}$ to come to rest. If the total distance traversed is 15 *S*, then [AIEEE 2005]

(a) $S = \frac{1}{2}ft^2$ (b) $S = \frac{1}{4}ft^2$

(c) $S = \frac{1}{72}ft^2$ (d) $S = \frac{1}{6}ft^2$

83. A man is 45 *m* behind the bus when the bus start accelerating from rest with acceleration 2.5 *m/s*. With what minimum velocity should the man start running to catch the bus ?

(a) 12 *m/s* (b) 14 *m/s*

(c) 15 *m/s* (d) 16 *m/s*

84. A particle moves along *x*-axis as

$x = 4(t-2) + a(t-2)^2$

Which of the following is true ? [J&K CET 2005]

(a) The initial velocity of particle is 4

(b) The acceleration of particle is 2*a*

(c) The particle is at origin at *t* = 0

(d) None of these

85. A body starting from rest moves with constant acceleration. The ratio of distance covered by the body during the 5th *sec* to that covered in 5 *sec* is [Kerala PET 2005]

(a) 9/25 (b) 3/5

(c) 25/9 (d) 1/25

86. What determines the nature of the path followed by the particle

(a) Speed (b) Velocity

(c) Acceleration (d) None of these

Relative Motion

1. Two trains, each 50 *m* long are travelling in opposite direction with velocity 10 *m/s* and 15 *m/s*. The time of crossing is [CPMT 1999; JIPMER 2000;

(a) $2s$ (b) $4\,s$

(c) $2\sqrt{3}s$ (d) $4\sqrt{3}\,s$

2. A 120 *m* long train is moving in a direction with speed 20 *m/s*. A train *B* moving with 30 *m/s* in the opposite direction and 130 *m* long crosses the first train in a time

[CPMT 1996; Kerala PET 2002]

(a) 6 *s* (b) 36 *s*

[Pb. PET 2003]

(c) 38 *s* (d) None of these

3. A 210 meter long train is moving due North at a of 25 *m/s*. A small bird is flying due South a little above the train with speed 5 *m/s*. The time taken by the bird to cross the train is

[AMU (Med.) 2001]

(a) $6s$ (b) $7s$

(c) $9s$ (d) $10s$

4. A police jeep is chasing with, velocity of 45 *km/h* a thief in another jeep moving with velocity 153 *km/h*. Police fires a bullet with muzzle velocity of 180 *m/s*. The velocity it will strike the car of the thief is [BHU 2003

(a) 150 *m/s* (b) 27 *m/s*

(c) 450 *m/s* (d) 250 *m/s*

5. A boat is sent across a river with a velocity of 8 *km/hr*. If the resultant velocity of boat is 10 *km/hr*, then velocity of the river is :

(a) 10 *km/hr* (b) 8 *km/hr*

(c) 6 *km/hr* (d) 4 *km/hr*

6. A train of 150 *meter* length is going towards north direction at a speed of $10 m/\sec$. A parrot flies at the speed of $5\ m/\sec$ towards south direction parallel to the railway track. The time taken by the parrot to cross the train is

[CBSE PMT 1992; BHU 1998]

(a) 12 *sec* (b) 8 *sec*

(c) 15 *sec* (d) 10 *sec*

7. A boat is moving with velocity of $3\hat{i}+4\hat{j}$ in river and water is moving with a velocity of $-3\hat{i}-4\hat{j}$ with respect to ground. Relative velocity of boat with respect to water is : **[Pb. PET 2002]**

(a) $-6\hat{i}-8\hat{j}$ (b) $6\hat{i}+8\hat{j}$

(c) $8\hat{i}$ (d) $6\hat{i}$

8. The distance between two particles is decreasing at the rate of 6 *m/sec*. If these particles travel with same speeds and in the same direction, then the separation increase at the rate of 4 *m/sec*. The particles have speeds as **[RPET 1999]**

(a) 5 *m/sec* ; 1 *m/sec* (b) 4 *m/sec* ; 1 *m/sec*

(c) 4 *m/sec* ; 2 *m/sec* (d) 5 *m/sec* ; 2 *m/sec*

9. A boat moves with a speed of 5 *km/h* relative to water in a river flowing with a speed of 3 *km/h* and having a width of 1 *km*. The minimum time taken around a round trip is **[J&K CET 2005]**

(a) 5 min (b) 60 min

(c) 20 min (d) 30 min

10. For a body moving with relativistic speed, if the velocity is doubled, then **[Orissa JEE 2005]**

(a) Its linear momentum is doubled

(b) Its linear momentum will be less than double

(c) Its linear momentum will be more than double

(d) Its linear momentum remains unchanged

11. A river is flowing from W to E with a speed of 5 *m/min*. A man can swim in still water with a velocity 10 *m/min*. In which direction should the man swim so as to take the shortest possible path to go to the south. **[BHU 2005]**

(a) 30° with downstream (b) 60° with downstream

(c) 120° with downstream (d) South

12. A train is moving towards east and a car is along north, both with same speed. The observed direction of car to the passenger in the train is **[J & K CET 2004]**

(a) East-north direction (b) West-north direction

(c) South-east direction (d) None of these

13. An express train is moving with a velocity v_1. Its driver finds another train is moving on the same track in the same direction with velocity v_2. To escape collision, driver applies a retardation a on the train. the minimum time of escaping collision will be

(a) $t=\dfrac{v_1-v_2}{a}$ (b) $t_1=\dfrac{v_1^2-v_2^2}{2}$

(c) None (d) Both

Motion Under Gravity

1. A stone falls from a balloon that is descending at a uniform rate of $12\ m/s$. The displacement of the stone from the point of release after 10 *sec* is

(a) 490 m (b) 510 m

(c) 610 m (d) 725 m

2. A ball is dropped on the floor from a height of 10 *m*. It rebounds to a height of 2.5 *m*. If the ball is in contact with the floor for 0.01 *sec*, the average acceleration during contact is

(a) 2100 $m/\sec^2$ downwards (b) 2100 $m/\sec^2$ upwards

(c) 1400 $m/\sec^2$ (d) 700 $m/\sec^2$

3. A body A is projected upwards with a velocity of $98\,m/s$. The second body B is projected upwards with the same initial velocity but after 4 *sec*. Both the bodies will meet after

(a) 6 sec (b) 8 sec

(c) 10 sec (d) 12 sec

4. Two bodies of different masses m_a and m_b are dropped from two different heights a and b. The ratio of the time taken by the two to cover these distances are **[NCERT 1972; MP PMT 1993]**

(a) $a:b$ (b) $b:a$

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

5. A body falls freely from rest. It covers as much distance in the last second of its motion as covered in the first three seconds. The body has fallen for a time of **[MNR 1998]**

(a) $3\ s$ (b) $5\ s$

(c) $7\ s$ (d) $9\ s$

6. A stone is dropped into water from a bridge $44.1\ m$ above the water. Another stone is thrown vertically downward 1 *sec* later. Both strike the water simultaneously. What was the initial speed of the second stone

(a) $12.25\ m/s$ (b) $14.75\ m/s$

(c) $16.23\ m/s$ (d) $17.15\ m/s$

7. An iron ball and a wooden ball of the same radius are released from the same height in vacuum. They take the same time to reach the ground. The reason for this is

(a) Acceleration due to gravity in vacuum is same irrespective of the size and mass of the body

(b) Acceleration due to gravity in vacuum depends upon the mass of the body

(c) There is no acceleration due to gravity in vacuum

(d) In vacuum there is a resistance offered to the motion of the body and this resistance depends upon the mass of the body

8. A body is thrown vertically upwards. If air resistance is to be taken into account, then the time during which the body rises is **[RPET 2000; KCET 2001; DPMT 2001]**

(a) Equal to the time of fall

(b) Less than the time of fall

(c) Greater than the time of fall **[RPET 2002]**

(d) Twice the time of fall

9. A ball P is dropped vertically and another ball Q is thrown horizontally with the same velocities from the same height and at the same time. If air resistance is neglected, then **[MNR 1986; BHU 1994]**

(a) Ball P reaches the ground first

(b) Ball Q reaches the ground first

(c) Both reach the ground at the same time

(d) The respective masses of the two balls will decide the time

10. A body is released from a great height and falls freely towards the earth. Another body is released from the same height exactly one second later. The separation between the two bodies, two seconds after the release of the second body is **[CPMT 1983; Kerala PMT 20**

(a) $4.9\,m$ (b) $9.8\,m$

(c) $19.6\,m$ **[BHU 1997; CPMT 1997]** (d) $24.5\,m$

11. An object is projected upwards with a velocity of 100 m/s. It will strike the ground after (approximately) [NCERT 1981; AFMC 1995]

(a) 10 sec (b) 20 sec

(c) 15 sec (d) 5 sec

12. A stone dropped from the top of the tower touches the ground in 4 sec. The height of the tower is about [MP PET 1986; AFMC 1994; CPMT 1997; BHU 1998; DPMT 1999; RPET 1999; MH CET 2003]

(a) $80\,m$ (b) $40\,m$

(c) $20\ m$ (d) $160\ m$

13. A body is released from the top of a tower of height h. It takes t *sec* to reach the ground. Where will be the ball after time $t/2$ sec [NCERT 1981; MP PMT 2004]

(a) At $h/2$ from the ground

(b) At $h/4$ from the ground

(c) Depends upon mass and volume of the body

(d) At $3h/4$ from the ground

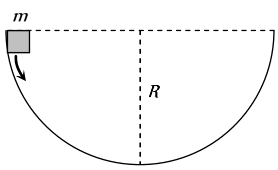
14. A mass m slips along the wall of a semispherical surface of radius R. The velocity at the bottom of the surface is [MP PMT 1993]

(a) $\sqrt{Rg}$

(b) $\sqrt{2Rg}$

(c) $2\sqrt{\pi Rg}$

(d) $\sqrt{\pi Rg}$



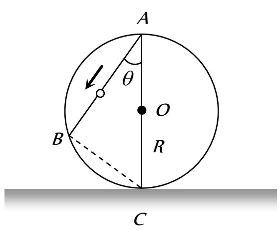
15. A frictionless wire *AB* is fixed on a sphere of radius *R*. A very small spherical ball slips on this wire. The time taken by this ball to slip from *A* to *B* is

(a) $\dfrac{2\sqrt{gR}}{g\cos\theta}$

(b) $2\sqrt{gR}.\dfrac{\cos\theta}{g}$

(c) $2\sqrt{\dfrac{R}{g}}$

(d) $\dfrac{gR}{\sqrt{g\cos\theta}}$



16. A body is slipping from an inclined plane of height h and length l. If the angle of inclination is θ, the time taken by the body to come from the top to the bottom of this inclined plane is

(a) $\sqrt{\dfrac{2h}{g}}$ (b) $\sqrt{\dfrac{2l}{g}}$

(c) $\dfrac{1}{\sin\theta}\sqrt{\dfrac{2h}{g}}$ (d) $\sin\theta\sqrt{\dfrac{2h}{g}}$

17. A particle is projected up with an initial velocity of $80\,ft/\sec$. The ball will be at a height of $96\,ft$ from the ground after

(a) 2.0 and 3.0 *sec* (b) Only at 3.0 *sec*

(c) Only at 2.0 *sec* (d) After 1 and 2 *sec*

18. A body falls from rest, its velocity at the end of first second is $(g = 32\,ft/\sec)$ [AFMC 1980]

(a) $16\ ft/\sec$ (b) $32\ ft/\sec$

(c) $64\ ft/\sec$ (d) $24\ ft/\sec$

19. A stone thrown upward with a speed u from the top of the tower reaches the ground with a velocity $3u$. The height of the tower is [EAMCET 1983; RPET 2003]

(a) $3u^2/g$ (b) $4u^2/g$

(c) $6u^2/g$ (d) $9u^2/g$

20. Two stones of different masses are dropped simultaneously from the top of a building [EAMCET 1978]

(a) Smaller stone hit the ground earlier

(b) Larger stone hit the ground earlier

(c) Both stones reach the ground simultaneously

(d) Which of the stones reach the ground earlier depends on the composition of the stone

21. A body thrown with an initial speed of $96\,ft/\sec$ reaches the ground after $(g = 32\,ft/\sec^2)$ [EAMCET 1980]

(a) 3 *sec* (b) 6 *sec*

(c) 12 *sec* (d) 8 *sec*

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

(a) 2 *sec* (b) 3 *sec*

(c) 4 *sec* (d) None of these

23. A man in a balloon rising vertically with an acceleration of $4.9\,m/\sec^2$ releases a ball 2 *sec* after the balloon is let go from the ground. The greatest height above the ground reached by the ball is $(g = 9.8\,m/\sec^2)$ [MNR 1986]

(a) 14.7 *m* (b) 19.6 *m*

(c) 9.8 *m* (d) 24.5 *m*

24. A particle is dropped under gravity from rest from a height $h(g = 9.8\,m/\sec^2)$ and it travels a distance $9h/25$ in the last second, the height h is [MNR 1987]

(a) 100 *m* (b) 122.5 *m*

(c) 145 *m* (d) 167.5 *m*

25. A balloon is at a height of 81 *m* and is ascending upwards with a velocity of 12 *m/s*. A body of $2kg$ weight is dropped from it. If $g = 10\,m/s^2$, the body will reach the surface of the earth in

(a) 1.5 *s* (b) 4.025 *s*

(c) 5.4 *s* (d) 6.75 *s*

26. An aeroplane is moving with a velocity u. It drops a packet from a height h. The time t taken by the packet in reaching the ground will be [MP PMT 1985]

(a) $\sqrt{\left(\dfrac{2g}{h}\right)}$ (b) $\sqrt{\left(\dfrac{2u}{g}\right)}$

(c) $\sqrt{\left(\dfrac{h}{2g}\right)}$ (d) $\sqrt{\left(\dfrac{2h}{g}\right)}$

27. Water drops fall at regular intervals from a tap which is $5\ m$ above the ground. The third drop is leaving the tap at the instant the first drop touches the ground. How far above the ground is the second drop at that instant [CBSE PMT 1995]

(a) 2.50 *m* (b) 3.75 *m*

(c) 4.00 *m* (d) 1.25 *m*

28. A ball is thrown vertically upwards from the top of a tower at $4.9\ ms^{-1}$. It strikes the pond near the base of the tower after 3 *seconds*. The height of the tower is

[Manipal MEE 1995]

(a) 73.5 *m* (b) 44.1 *m*

(c) 29.4 *m* (d) None of these

29. An aeroplane is moving with horizontal velocity u at height h. The velocity of a packet dropped from it on the earth's surface will be (g is acceleration due to gravity)

[MP PET 1995]

(a) $\sqrt{u^2+2gh}$ (b) $\sqrt{2gh}$

(c) $2gh$ (d) $\sqrt{u^2-2gh}$

30. A rocket is fired upward from the earth's surface such that it creates an acceleration of 19.6 *m/sec*. If after 5 *sec* its engine is switched off, the maximum height of the rocket from earth's surface would be

(a) 245 *m* (b) 490 *m*

(c) 980 *m* (d) 735 *m*

31. A bullet is fired with a speed of $1000\ m/\sec$ in order to hit a target 100 *m* away. If $g=10\ m/s^2$, the gun should be aimed

(a) Directly towards the target

(b) 5 *cm* above the target

(c) 10 *cm* above the target

(d) 15 *cm* above the target

32. A body starts to fall freely under gravity. The distances covered by it in first, second and third *second* are in ratio

[MP PET 1997; RPET 2001]

(a) $1:3:5$ (b) $1:2:3$

(c) $1:4:9$ (d) $1:5:6$

33. P, Q and R are three balloons ascending with velocities $U, 4U$ and $8U$ respectively. If stones of the same mass be dropped from each, when they are at the same height, then

(a) They reach the ground at the same time

(b) Stone from P reaches the ground first

(c) Stone from R reaches the ground first

(d) Stone from Q reaches the ground first

34. A body is projected up with a speed 'u' and the time taken by it is T to reach the maximum height H. Pick out the correct statement [EAMCET (Engg.) 1995]

(a) It reaches $H/2$ in $T/2$ *sec*

(b) It acquires velocity $u/2$ in $T/2\sec$

(c) Its velocity is $u/2$ at $H/2$

(d) Same velocity at $2T$

35. A body falling for 2 seconds covers a distance S equal to that covered in next second. Taking $g=10\,m/s^2, S=$

[EAMCET (Engg.) 1995]

(a) 30 *m* (b) 10 *m*

(c) 60 *m* (d) 20 *m*

36. A body dropped from a height h with an initial speed zero, strikes the ground with a velocity $3\,km/h$. Another body of same mass is dropped from the same height h with an initial speed $-u'=4km/h$. Find the final velocity of second body with which it strikes the ground [CBSE PMT 1996]

(a) 3 *km/h* (b) 4 *km/h*

(c) 5 *km/h* (d) 12 *km/h*

37. A ball of mass m_1 and another ball of mass m_2 are dropped from equal height. If time taken by the balls are t_1 and t_2 respectively, then [BHU 1997]

(a) $t_1=\frac{t_2}{2}$ (b) $t_1=t_2$

(c) $t_1=4t_2$ (d) $t_1=\frac{t_2}{4}$

38. With what velocity a ball be projected vertically so that the distance covered by it in 5th second is twice the distance it covers in its 6th second $(g=10\,m/s^2)$

[CPMT 1997; MH CET 2000]

(a) 58.8 *m/s* [MP PET 1995] (b) 49 *m/s*

(c) 65 *m/s* (d) 19.6 *m/s*

39. A body sliding on a smooth inclined plane requires 4 seconds to reach the bottom starting from rest at the top. How much time does it take to cover one-fourth distance starting from rest at the top

(a) 1 *s* (b) 2 *s*

(c) 4 *s* [MP PET 1996] (d) 16 *s*

40. 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 [BHU 1998]

(a) 25 *m* (b) 20 *m*

(c) 50 *m* (d) 9.8 *m*

41. A stone is thrown with an initial speed of 4.9 *m/s* from a bridge in vertically upward direction. It falls down in water after 2 *sec*. The height of the bridge is [AFMC 1999; Pb. PMT 2003]

(a) 4.9 *m* (b) 9.8 *m*

(c) 19.8 *m* (d) 24.7 *m*

42. A stone is shot straight upward with a speed of 20 *m/sec* from a tower 200 *m* high. The speed with which it strikes the ground is approximately [AMU (Engg.) 1999]

(a) 60 *m/sec* (b) 65 *m/sec*

(c) 70 *m/sec* [ISM Dhanbad 1994] (d) 75 *m/sec*

43. A body freely falling from the rest has a velocity '*v*' after it falls through a height '*h*'. The distance it has to fall down for its velocity to become double, is [BHU 1999]

(a) $2h$ (b) $4h$

(c) $6h$ (d) $8h$

44. The time taken by a block of wood (initially at rest) to slide down a smooth inclined plane 9.8 *m* long (angle of inclination is 30^o) is

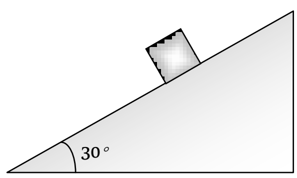
[JIPMER 1999]

(a) $\frac{1}{2}\sec$

(b) 2 sec

(c) 4 sec

(d) 1 sec



45. Velocity of a body on reaching the point from which it was projected upwards, is [AIIMS 1999; Pb. PMT 1999]

(a) $v = 0$ (b) $v = 2u$

(c) $v = 0.5u$ (d) $v = u$

46. A body projected vertically upwards with a velocity u returns to the starting point in 4 seconds. If $g = 10$ *m/sec*, the value of u is [KCET 1999]

(a) 5 *m/sec* (b) 10 *m/sec*

(c) 15 *m/sec* (d) 20 *m/sec*

47. Time taken by an object falling from rest to cover the height of h_1 and h_2 is respectively t_1 and t_2 then the ratio of t_1 to t_2 is [RPMT 1996; RPET 2002]

(a) $h_1 : h_2$ (b) $\sqrt{h_1} : \sqrt{h_2}$

(c) $h_1 : 2h_2$ (d) $2h_1 : h_2$

48. A body is thrown vertically up from the ground. It reaches a maximum height of 100*m* in 5*sec*. After what time it will reach the ground from the maximum height position [Pb. PMT 2000]

(a) 1.2 *sec* (b) 5 *sec*

(c) 10 *sec* (d) 25 *sec*

49. A body thrown vertically upwards with an initial velocity u reaches maximum height in 6 seconds. The ratio of the distances travelled by the body in the first second and the seventh second is [EAMCET (Engg.) 2000]

(a) 1 : 1 (b) 11 : 1

(c) 1 : 2 (d) 1 : 11

50. A particle is thrown vertically upwards. If its velocity at half of the maximum height is 10 *m/s*, then maximum height attained by it is (Take $g = 10$ *m/s*) [CBSE PMT 2001, 2004]

(a) 8 *m* (b) 10 *m*

(c) 12 *m* (d) 16 *m*

51. A body, thrown upwards with some velocity, reaches the maximum height of 20*m*. Another body with double the mass thrown up, with double initial velocity will reach a maximum height of [KCET 2001]

(a) 200 *m* (b) 16 *m*

(c) 80 *m* (d) 40 *m*

52. A balloon starts rising from the ground with an acceleration of 1.25 *m/s* after 8s, a stone is released from the balloon. The stone will ($g = 10$ *m/s*) [KCET 2001]

(a) Reach the ground in 4 second

(b) Begin to move down after being released

(c) Have a displacement of 50 *m*

(d) Cover a distance of 40 *m* in reaching the ground

53. A body is thrown vertically upwards with a velocity u. Find the true statement from the following [Kerala 2001]

(a) Both velocity and acceleration are zero at its highest point

(b) Velocity is maximum and acceleration is zero at the highest point

(c) Velocity is maximum and acceleration is g downwards at its highest point

(d) Velocity is zero at the highest point and maximum height reached is $u^2/2g$

54. A man throws a ball vertically upward and it rises through 20 *m* and returns to his hands. What was the initial velocity (u) of the ball and for how much time (T) it remained in the air $[g = 10 m/s^2]$ [MP PET 2001]

(a) u = 10 *m/s*, T = 2*s* (b) u = 10 *m/s*, T = 4*s*

(c) u = 20 *m/s*, T = 2*s* (d) u = 20 *m/s*, T = 4*s*

55. A particle when thrown, moves such that it passes from same height at 2 and 10*s*, the height is [UPSEAT 2001]

(a) g (b) $2g$

(c) $5g$ (d) $10g$

56. Three different objects of masses m_1, m_2 and m_3 are allowed to fall from rest and from the same point '*O*' along three different frictionless paths. The speeds of the three objects, on reaching the ground, will be in the ratio of [AIIMS 2002]

(a) $m_1 : m_2 : m_3$ (b) $m_1 : 2m_2 : 3m_3$

(c) 1 : 1 : 1 (d) $\frac{1}{m_1} : \frac{1}{m_2} : \frac{1}{m_3}$

57. 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 3rd and 2nd seconds of the motion is (Take $g = 10 m/s^2$) [AIIMS 2000; CBSE PMT 2002]

(a) 5 : 7 (b) 7 : 5

(c) 3 : 6 (d) 6 : 3

58. Two balls *A* and *B* of same masses are thrown from the top of the building. *A*, thrown upward with velocity *V* and *B*, thrown downward with velocity *V*, then [AIEEE 2002]

(a) Velocity of *A* is more than *B* at the ground

(b) Velocity of *B* is more than *A* at the ground

(c) Both *A* & *B* strike the ground with same velocity

(d) None of these

59. A ball is dropped from top of a tower of 100*m* height. Simultaneously another ball was thrown upward from bottom of the tower with a speed of 50 *m/s* ($g = 10 m/s^2$). They will cross each other after [Orissa JEE 2002]

(a) 1*s* (b) 2*s*

(c) 3*s* (d) 4*s*

60. A cricket ball is thrown up with a speed of 19.6 ms^{-1}. The maximum height it can reach is [Kerala PMT 2002]

(a) 9.8 *m* (b) 19.6 *m*

(c) 29.4 *m* (d) 39.2 *m*

61. 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 5*m*, the number of ball thrown per minute is (take $g = 10 ms^{-2}$) [KCET 200

(a) 120 (b) 80

(c) 60 (d) 40

62. A body falling from a high Minaret travels 40 meters in the last 2 seconds of its fall to ground. Height of Minaret in meters is (take $g = 10 m/s^2$) [MP PMT 2002]

(a) 60 (b) 45

(c) 80 (d) 50

63. A body falls from a height $h = 200m$ (at New Delhi). The ratio of distance travelled in each 2 *sec* during t = 0 to $t = 6$ second of the journey is [BHU 2003; CPMT 2004]

(a) 1 : 4 : 9 (b) 1 : 2 : 4

(c) 1 : 3 : 5 (d) 1 : 2 : 3

64. A man drops a ball downside from the roof of a tower of height 400 meters. At the same time another ball is thrown upside with a velocity 50 *meter/sec.* from the surface of the tower, then they will meet at which height from the surface of the tower

(a) 100 meters (b) 320 meters

(c) 80 meters (d) 240 meters

65. Two balls are dropped from heights h and $2h$ respectively from the earth surface. The ratio of time of these balls to reach the earth is [CPMT 2003]

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

(c) 2 : 1 (d) 1 : 4

66. The acceleration due to gravity on the planet *A* is 9 times the acceleration due to gravity on planet *B*. A man jumps to a height of $2m$ on the surface of *A*. What is the height of jump by the same person on the planet *B* [CBSE PMT 2003]

(a) $18m$ (b) $6m$

(c) $\frac{2}{3}m$ (d) $\frac{2}{9}m$

67. A body falls from rest in the gravitational field of the earth. The distance travelled in the fifth second of its motion is $(g = 10 m/s^2)$ [MP PET 2003]

(a) $25m$ (b) $45m$

(c) $90m$ (d) $125m$

68. If a body is thrown up with the velocity of 15 *m/s* then maximum height attained by the body is (g = 10 *m/s*) [MP PMT 2003]

(a) 11.25 *m* (b) 16.2 *m*

(c) 24.5 *m* (d) 7.62 *m*

69. A balloon is rising vertically up with a velocity of 29 ms^{-1}. 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 is (g = 9.8 ms^{-2})

(a) 100 *m* (b) 200 *m*

(c) 400 *m* (d) 150 *m*

70. A ball is released from the top of a tower of height *h* meters. It takes *T* seconds to reach the ground. What is the position of the ball in *T*/3 seconds [AIEEE 2004]

(a) *h*/9 *meters* from the ground

(b) 7*h*/9 *meters* from the ground

(c) 8*h*/9 *meters* from the ground

(d) 17*h*/18 *meters* from the ground

71. Two balls of same size but the density of one is greater than that of the other are dropped from the same height, then which ball will reach the earth first (air resistance is negligible)

(a) Heavy ball

(b) Light ball

(c) Both simultaneously

(d) Will depend upon the density of the balls

72. A packet is dropped from a balloon which is going upwards with the velocity 12 *m/s*, the velocity of the packet after 2 seconds will be

(a) –12 *m/s* (b) 12 *m/s*

(c) –7.6 *m/s* (d) 7.6 *m/s*

73. If a freely falling body travels in the last second a distance equal to the distance travelled by it in the first three second, the time of the travel is [Pb. PMT 2004; MH CET 2003]

(a) 6 *sec* (b) 5 *sec*

(c) 4 *sec* (d) 3 *sec*

74. The effective acceleration of a body, when thrown upwards with acceleration *a* will be : [Pb. PMT 2004]

(a) $\sqrt{a-g^2}$ (b) $\sqrt{a^2+g^2}$

(c) $(a-g)$ (d) $(a+g)$

75. A body is thrown vertically upwards with velocity *u*. The distance travelled by it in the fifth and the sixth seconds are equal. The velocity *u* is given by (g = 9.8 *m/s*) [UPSEAT 2004]

(a) 24.5 *m/s* (b) 49.0 *m/s*

(c) 73.5 *m/s* (d) 98.0 *m/s*

76. A body, thrown upwards with some velocity reaches the maximum height of 50 *m*. Another body with double the mass thrown up with double the initial velocity will reach a maximum height of [CPMT 2003]

(a) 100 *m* (b) 200 *m*

(c) 300 *m* (d) 400 *m*

77. A parachutist after bailing out falls 50 *m* without friction. When parachute opens, it decelerates at 2 *m/s*. He reaches the ground with a speed of 3 *m/s*. At what height, did he bail out ?

(a) 293 *m* (b) 111 *m*

(c) 91 *m* (d) 182 *m*

78. Three particles *A, B* and *C* are thrown from the top of a tower with the same speed. *A* is thrown up, *B* is thrown down and *C* is horizontally. They hit the ground with speeds V_A, V_B and V_C respectively. [Orissa JEE 2005]

(a) $V_A = V_B = V_C$ (b) $V_A = V_B > V_C$

(c) $V_B > V_C > V_A$ (d) $V_A > V_B = V_C$

79. From the top of a tower two stones, whose masses are in the ratio 1 : 2 are thrown one straight up with an initial speed *u* and the second straight down with the same speed *u*. Then, neglecting air resistance [KCET 2005]

(a) The heavier stone hits the ground with a higher speed

(b) The lighter stone hits the ground with a higher speed

(c) Both the stones will have the same speed when they hit the ground.

(d) The speed can't be determined with the given data.

80. When a ball is thrown up vertically with velocity V_o, it reaches a maximum height of '*h*'. If one wishes to triple the maximum height then the ball should be thrown with velocity [KCET 2004]

(a) $\sqrt{3}V_o$ (b) $3V_o$

(c) $9V_o$ (d) $3/2V_o$

81. An object start sliding on a frictionless inclined plane and from same height another object start falling freely [RPET 2000]

(a) Both will reach with same speed

(b) Both will reach with same acceleration

(c) Both will reach in same time

(d) None of above [J & K CET 2004]

Critical Thinking

Objective Questions

[Pb. PMT 2004]

1. A particle moving in a straight line covers half the distance with speed of 3 *m/s*. The other half of the distance is covered in two equal time intervals with speed of 4.5 *m/s* and 7.5 *m/s* respectively. The average speed of the particle during this motion is

(a) 4.0 *m/s* (b) 5.0 *m/s*

(c) 5.5 *m/s* (d) 4.8 *m/s*

2. The acceleration of a particle is increasing linearly with time t as bt. The particle starts from the origin with an initial velocity v_0 The distance travelled by the particle in time t will be

(a) $v_0 t + \frac{1}{3}bt^2$ (b) $v_0 t + \frac{1}{3}bt^3$

(c) $v_0 t + \frac{1}{6}bt^3$ (d) $v_0 t + \frac{1}{2}bt^2$

3. The motion of a body is given by the equation $\frac{dv(t)}{dt} = 6.0 - 3v(t)$. where $v(t)$ is speed in m/s and t in $\sec$. If body was at rest at $t = 0$ [IIT-JEE 1995]

(a) The terminal speed is 2.0 m/s

(b) The speed varies with the time as $v(t) = 2(1 - e^{-3t})m/s$

(c) The speed is $0.1m/s$ when the acceleration is half the initial value

(d) The magnitude of the initial acceleration is $6.0m/s^2$

4. A particle of mass m moves on the *x*-axis as follows : it starts from rest at $t = 0$ from the point $x = 0$ and comes to rest at $t = 1$ at the point $x = 1$. No other information is available about its motion at intermediate time $(0 < t < 1)$. If α denotes the instantaneous acceleration of the particle, then [IIT-JEE 1993]

(a) α cannot remain positive for all t in the interval $0 \le t \le 1$

(b) $|\alpha|$ cannot exceed 2 at any point in its path

(c) $|\alpha|$ must be ≥ 4 at some point or points in its path

(d) α must change sign during the motion but no other assertion can be made with the information given

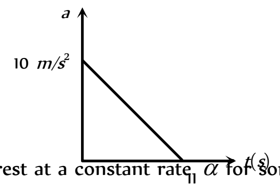
5. A particle starts from rest. Its acceleration (*a*) versus time (*t*) is as shown in the figure. The maximum speed of the particle will be [IIT-JEE (Screening) 2004]

(a) 110 *m/s*

(b) 55 *m/s*

(c) 550 *m/s*

(d) 660 *m/s*



6. A car accelerates from rest at a constant rate α for some time, after which it decelerates at a constant rate β and comes to rest. If the total time elapsed is *t*, then the maximum velocity acquired by the car is [IIT 1978; CBSE PMT 1994]

(a) $\left(\frac{\alpha^2 + \beta^2}{\alpha\beta}\right)t$ (b) $\left(\frac{\alpha^2 - \beta^2}{\alpha\beta}\right)t$

(c) $\frac{(\alpha + \beta)t}{\alpha\beta}$ (d) $\frac{\alpha\beta t}{\alpha + \beta}$

7. A stone dropped from a building of height h and it reaches after t seconds on earth. From the same building if two stones 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 [CPMT 1997; UPSEAT 2002; KCET 2002]

(a) $t = t_1 - t_2$ (b) $t = \frac{t_1 + t_2}{2}$

(c) $t = \sqrt{t_1 t_2}$ (d) $t = t_1^2 t_2^2$

8. A ball is projected upwards from a height h above the surface of the earth with velocity v. The time at which the ball strikes the ground is

(a) $\frac{v}{g} + \frac{2hg}{\sqrt{2}}$ (b) $\frac{v}{g}\left[1 - \sqrt{1 + \frac{2h}{g}}\right]$

(c) $\frac{v}{g}\left[1 + \sqrt{1 + \frac{2gh}{v^2}}\right]$ (d) $\frac{v}{g}\left[1 + \sqrt{v^2 + \frac{2g}{h}}\right]$

9. 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 [Kurukshetra CEE 1996]

(a) All equal, being equal to $\sqrt{2/g}$ second

(b) In the ratio of the square roots of the integers 1, 2, 3.....

(c) In the ratio of the difference in the square roots of the integers *i.e.* $\sqrt{1}, (\sqrt{2} - \sqrt{1}), (\sqrt{3} - \sqrt{2}), (\sqrt{4} - \sqrt{3})$....

(d) In the ratio of the reciprocal of the square roots of the integers *i.e.*,. $\frac{1}{\sqrt{1}}, \frac{1}{\sqrt{2}}, \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{4}}$

10. A man throws balls with the same speed vertically upwards one after the other at an interval of 2 seconds. What should be the speed of the throw so that more than two balls are in the sky at any time (Given $g = 9.8m/s^2$) [CBSE PMT 2003]

(a) At least 0.8 *m/s*

(b) Any speed less than 19.6 *m/s*

(c) Only with speed 19.6 *m/s*

(d) More than 19.6 *m/s*

11. If a ball is thrown vertically upwards with speed u, the distance covered during the last t seconds of its ascent is [CBSE PMT 2003]

(a) $\frac{1}{2}gt^2$ (b) $ut - \frac{1}{2}gt^2$

(c) $(u - gt)t$ (d) ut d

12. 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 $\frac{S_n}{S_{n+1}}$ is [IIT-JEE (Screening) 2004]

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

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

GQ Graphical Questions

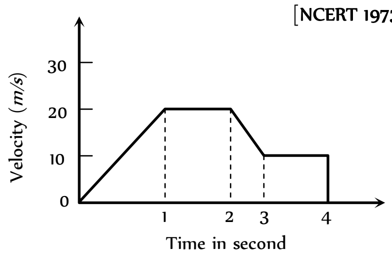
1. The variation of velocity of a particle with time moving along a straight line is illustrated in the following figure. The distance travelled by the particle in four seconds is [NCERT 1973]

(a) 60 m

(b) 55 m

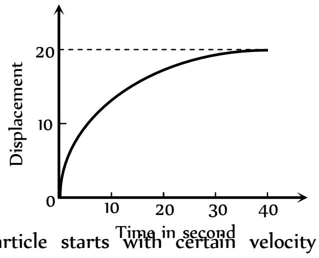
(c) 25 m

(d) 30 m



2. The displacement of a particle as a function of time is shown in the figure. The figure shows that

[CPMT 1970, 86]



(a) The particle starts with certain velocity but the motion is retarded and finally the particle stops

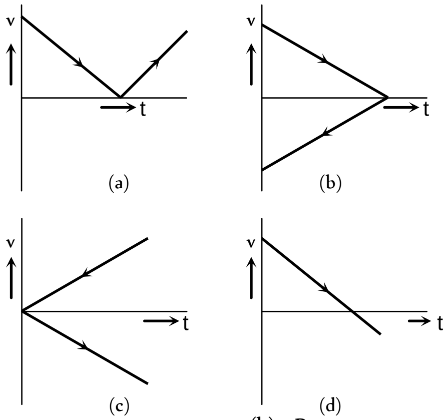
(b) The velocity of the particle is constant throughout

(c) The acceleration of the particle is constant throughout.

(d) The particle starts with constant velocity, then motion is accelerated and finally the particle moves with another constant velocity

3. A ball is thrown vertically upwards. Which of the following graph/graphs represent velocity-time graph of the ball during its flight (air resistance is neglected)

[CPMT 1993; AMU (Engg.) 2000]

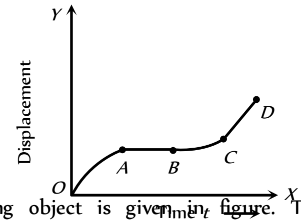


(a) A (b) B

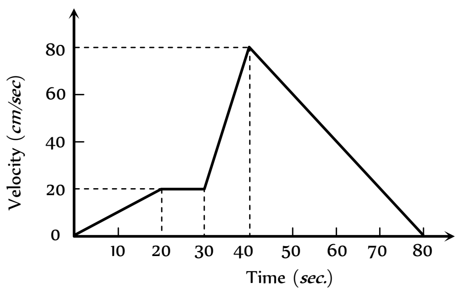
(c) C (d) D

4. The graph between the displacement x and time t for a particle moving in a straight line is shown in figure. During the interval OA, AB, BC and CD, the acceleration of the particle is

	OA,	AB,	BC,	CD
(a)	+	0	+	+
(b)	–	0	+	0
(c)	+	0	–	+
(d)	–	0	–	0



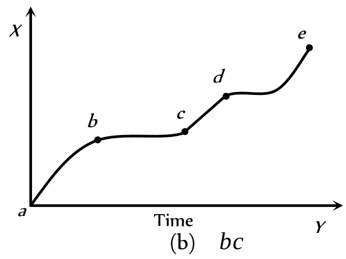
5. The $v-t$ graph of a moving object is given in figure. The maximum acceleration is [NCERT 1972]



(a) $1 cm/sec^2$ (b) $2 cm/sec^2$

(c) $3\ cm/sec^2$ (d) $6\ cm/sec^2$

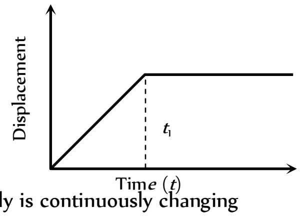
6. The displacement versus time graph for a body moving in a straight line is shown in figure. Which of the following regions represents the motion when no force is acting on the body



(a) ab (b) bc

(c) cd (d) de

7. The $x-t$ graph shown in figure represents [CPMT 1984]



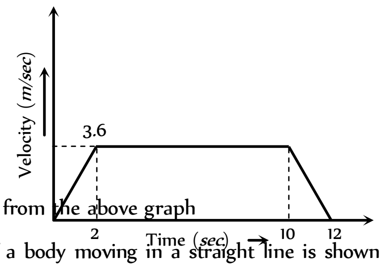
(a) Constant velocity

(b) Velocity of the body is continuously changing

(c) Instantaneous velocity

(d) The body travels with constant speed upto time t_1 and then stops

8. 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



(a) 3.6 m

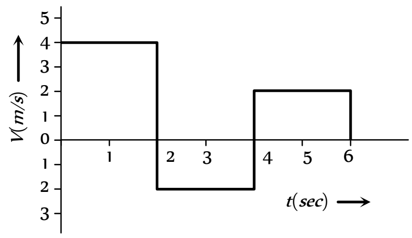
(b) 28.8 m

(c) 36.0 m

[CPMT 1986]

(d) Cannot be calculated from the above graph

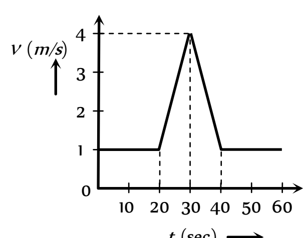
9. The velocity-time graph of a body moving in a straight line is shown in the figure. The displacement and distance travelled by the body in 6 *sec* are respectively [MP PET 1994]



(a) 8 m, 16 m (b) 16 m, 8 m

(c) 16 m, 16 m (d) 8 m, 8 m

10. Velocity-time (v-t) graph for a moving object is shown in the figure. Total displacement of the object during the time interval when there is non-zero acceleration and retardation is



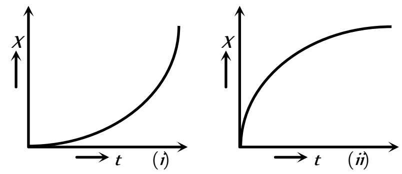
(a) 60 m

(b) 50 m

(c) 30 m

(d) 40 m

11. Figures (i) and (ii) below show the displacement-time graphs of two particles moving along the x-axis. We can say that



(a) Both the particles are having a uniformly accelerated motion

(b) Both the particles are having a uniformly retarded motion

(c) Particle (i) is having a uniformly accelerated motion while particle (ii) is having a uniformly retarded motion

(d) Particle (i) is having a uniformly retarded motion while particle (ii) is having a uniformly accelerated motion

[Kurukshetra CEE 1996]

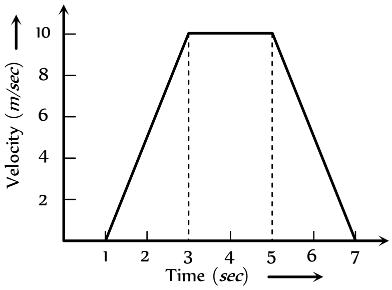
12. For the velocity-time graph shown in figure below the distance covered by the body in last two seconds of its motion is what fraction of the total distance covered by it in all the seven seconds [MP PMT/PET 1998; RPET 2001]

(a) $\frac{1}{2}$

(b) $\frac{1}{4}$

(c) $\frac{1}{3}$

(d) $\frac{2}{3}$



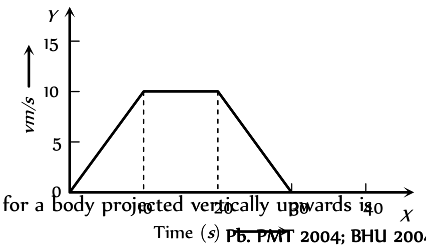
13. In the following graph, distance travelled by the body in metres is [EAMCET 1994]

(a) 200

(b) 250

(c) 300

(d) 400

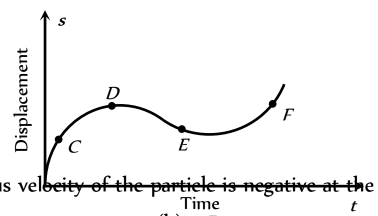


14. Velocity-time curve for a body projected vertically upwards is [EAMCET (Med.) 1995; AIIMS 1999; Pb. PMT 2004; BHU 2004]

(a) Parabola (b) Ellipse

(c) Hyperbola (d) Straight line

15. The displacement-time graph of moving particle is shown below



The instantaneous velocity of the particle is negative at the point [CBSE PMT 1994]

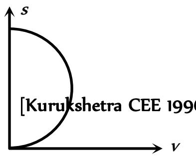
(a) D (b) F

(c) C (d) E

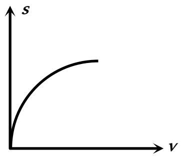
16. An object is moving with a uniform acceleration which is parallel to its instantaneous direction of motion. The displacement (s) – velocity (v) graph of this object is

[SCRA 1998; DCE 2000; AIIMS 2003; Orissa PMT 2004]

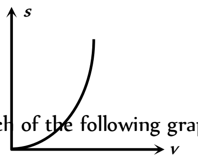
(a)



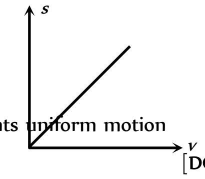
(b)



(c)

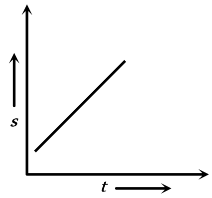


(d)

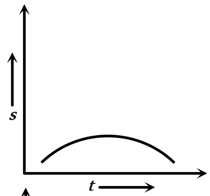


17. Which of the following graph represents uniform motion [DCE 1999]

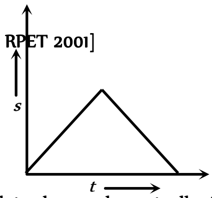
(a)



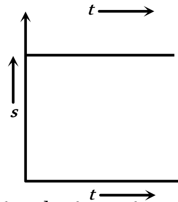
(b)



(c)

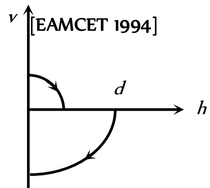


(d)

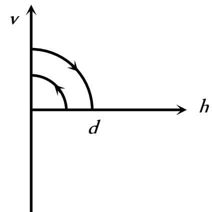


18. A ball is dropped vertically from a height d above the ground. It hits the ground and bounces up vertically to a height $d/2$. Neglecting subsequent motion and air resistance, its velocity v varies with the height h above the ground is

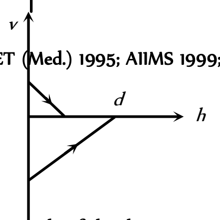
(a)



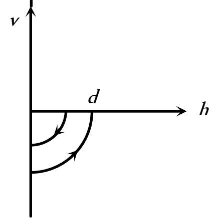
(b)



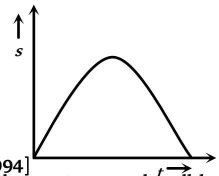
(c)



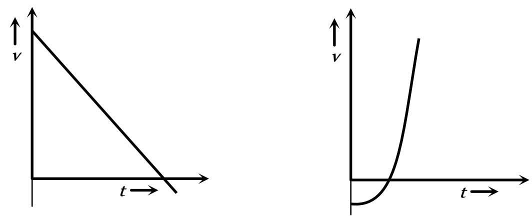
(d)



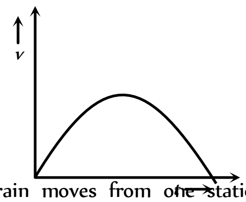
19. The graph of displacement v/s time is

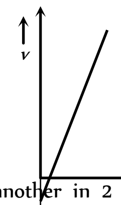


Its corresponding velocity-time graph will be [DCE 2001]



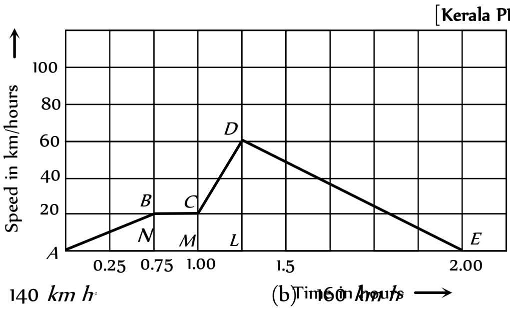
(a) (b)

(c) 

(d) 

20. A train moves from one station to another in 2 hours time. Its speed-time graph during this motion is shown in the figure. The maximum acceleration during the journey is

[Kerala PET 2002]



(a) 140 $km\ h^{-1}$ (b) 160 $km\ h^{-1}$
(c) 100 $km\ h^{-1}$ (d) 120 $km\ h^{-1}$

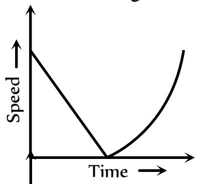
21. The area under acceleration-time graph gives

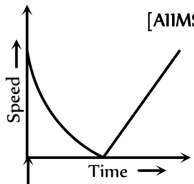
[Kerala PET 2005]

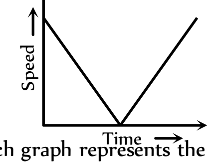
(a) Distance travelled (b) Change in acceleration
(c) Force acting (d) Change in velocity

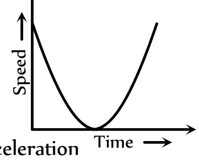
22. A ball is thrown vertically upwards. Which of the following plots represents the speed-time graph of the ball during its height if the air resistance is not ignored

[AIIMS 2003]

(a) 

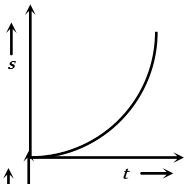
(b) 

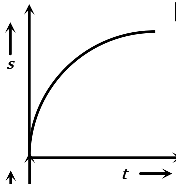
(c) 

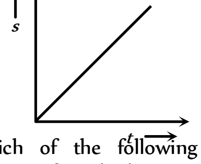
(d) 

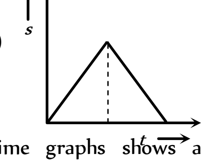
23. Which graph represents the uniform acceleration

[DCE 2003]

(a) 

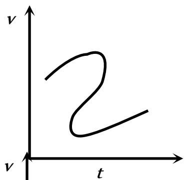
(b) 

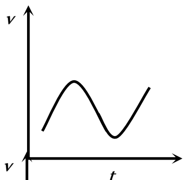
(c) 

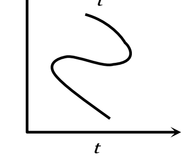
(d) 

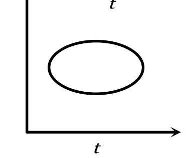
24. Which of the following velocity-time graphs shows a realistic situation for a body in motion

[AIIMS 2004]

(a) 

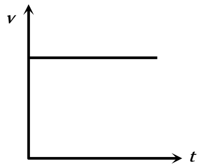
(b) 

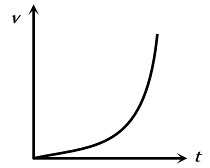
(c) 

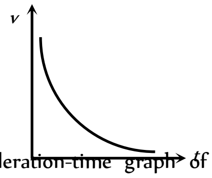
(d) 

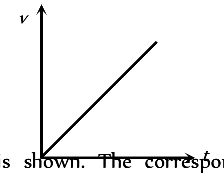
25. Which of the following velocity-time graphs represent uniform motion

[Kerala PMT 2004]

(a) 

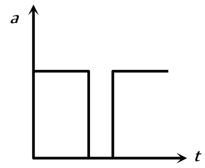
(b) 

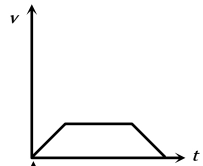
(c) 

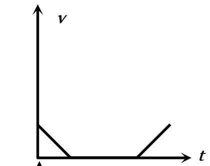
(d) 

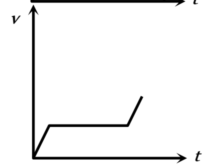
26. Acceleration-time graph of a body is shown. The corresponding velocity-time graph of the same body is

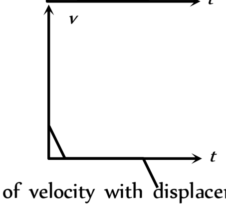
[DPMT 2004]



(a) 

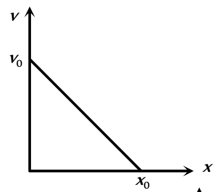
(b) 

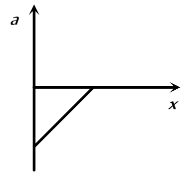
(c) 

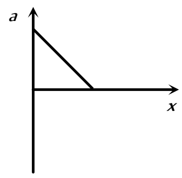
(d) 

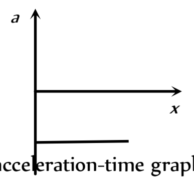
27. The given graph shows the variation of velocity with displacement. Which one of the graph given below correctly represents the variation of acceleration with displacement

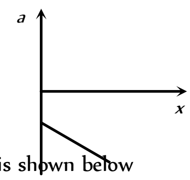
[IIT-JEE (Screening) 2005]



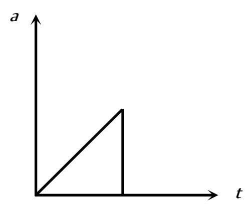
(a) 

(b) 

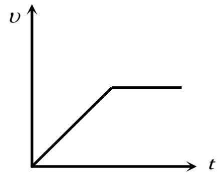
(c) 

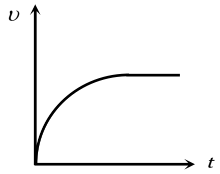
(d) 

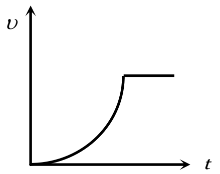
28. The acceleration-time graph of a body is shown below

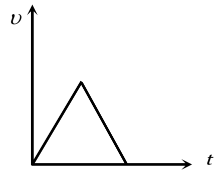


The most probable velocity-time graph of the body is

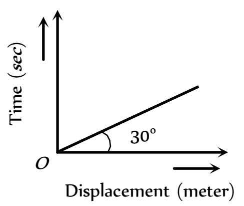
(a) 

(b) 

(c) 

(d) 

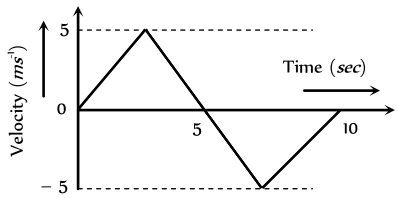
29. From the following displacement-time graph find out the velocity of a moving body



(a) $\frac{1}{\sqrt{3}}$ *m/s* (b) 3 *m/s*

(c) $\sqrt{3}$ *m/s* (d) $\frac{1}{3}$

30. The $\upsilon - t$ plot of a moving object is shown in the figure. The average velocity of the object during the first 10 seconds is



(a) 0 (b) 2.5 ms^{-1}

(c) 5 ms^{-1} (d) 2 ms^{-1}

AR Assertion & Reason

For AIIMS Aspirants

Read the assertion and reason carefully to mark the correct option out of the options given below:

Read the assertion and reason carefully to mark the correct option out of the options given below:

(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.
(c) If assertion is true but reason is false.
(d) If the assertion and reason both are false.
(e) If assertion is false but reason is true.

1. Assertion : A body can have acceleration even if its velocity is zero at a given instant of time.

Reason : A body is momentarily at rest when it reverses its direction of motion.

2. Assertion : Two balls of different masses are thrown vertically upward with same speed. They will pass through 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.

3. Assertion : If the displacement of the body is zero, the distance covered by it may not be zero.

Reason : Displacement is a vector quantity and distance is a scalar quantity.

4. Assertion : The average velocity of the object over an interval of time is either smaller than or equal to the average speed of the object over the same interval.

Reason : Velocity is a vector quantity and speed is a scalar quantity.

5. Assertion : An object can have constant speed but variable velocity.

Reason : Speed is a scalar but velocity is a vector quantity.

6. Assertion : The speed of a body can be negative.

Reason : If the body is moving in the opposite direction of positive motion, then its speed is negative.

7. Assertion : The position-time graph of a uniform motion in one dimension of a body can have negative slope.

Reason : When the speed of body decreases with time, the position-time graph of the moving body has negative slope.

8. Assertion : A positive acceleration of a body can be associated with a '*slowing down*' of the body.

Reason : Acceleration is a vector quantity.

9. Assertion : A negative acceleration of a body can be associated with a '*speeding up*' of the body.

Reason : Increase in speed of a moving body is independent of its direction of motion.

10. Assertion : When a body is subjected to a uniform acceleration, it always move in a straight line.

Reason : Straight line motion is the natural tendency of the body.

11. Assertion : Rocket in flight is not an illustration of projectile.

Reason : Rocket takes flight due to combustion of fuel and does not move under the gravity effect alone.

12. Assertion : The average speed of a body over a given interval of time is equal to the average velocity of the body in the same interval of time if a body moves in a straight line in one direction.

Reason : Because in this case distance travelled by a body is equal to the displacement of the body.

13. Assertion : Position-time graph of a stationary object is a straight line parallel to time axis.

Reason : For a stationary object, position does not change with time.

14. Assertion : The slope of displacement-time graph of a body moving with high velocity is steeper than the slope of displacement-time graph of a body with low velocity.

Reason : Slope of displacement-time graph = Velocity of the body.

15. Assertion : Distance-time graph of the motion of a body having uniformly accelerated motion is a straight line inclined to the time axis.

Reason : Distance travelled by a body having uniformly accelerated motion is directly proportional to the square of the time taken.

16. Assertion : A body having non-zero acceleration can have a constant velocity.

Reason : Acceleration is the rate of change of velocity.

17. Assertion : A body, whatever its motion is always at rest in a frame of reference which is fixed to the body itself.

Reason : The relative velocity of a body with respect to itself is zero.

18. Assertion : Displacement of a body may be zero when distance travelled by it is not zero.

Reason : The displacement is the longest distance between initial and final position.

19. Assertion : The equation of motion can be applied only if acceleration is along the direction of velocity and is constant.

Reason : If the acceleration of a body is constant then its motion is known as uniform motion.

20. Assertion : A bus moving due north takes a turn and starts moving towards east with same speed. There will be no change in the velocity of bus.

Reason : Velocity is a vector-quantity.

21. Assertion : The relative velocity between any two bodies moving in opposite direction is equal to sum of the velocities of two bodies.

Reason : Sometimes relative velocity between two bodies is equal to difference in velocities of the two.

22. Assertion : The displacement-time graph of a body moving with uniform acceleration is a straight line.

Reason : The displacement is proportional to time for uniformly accelerated motion.

23. Assertion : Velocity-time graph for an object in uniform motion along a straight path is a straight line parallel to the time axis.

Reason : In uniform motion of an object velocity increases as the square of time elapsed.

24. Assertion : A body may be accelerated even when it is moving uniformly.

Reason : When direction of motion of the body is changing then body may have acceleration.

25. Assertion : A body falling freely may do so with constant velocity.

Reason : The body falls freely, when acceleration of a body is equal to acceleration due to gravity.

26. Assertion : Displacement of a body is vector sum of the area under velocity-time graph.

Reason : Displacement is a vector quantity.

27. Assertion : The position-time graph of a body moving uniformly is a straight line parallel to position-axis.

Reason : The slope of position-time graph in a uniform motion gives the velocity of an object.

28. Assertion : The average speed of an object may be equal to arithmetic mean of individual speed.

Reason : Average speed is equal to total distance travelled per total time taken.

29. Assertion : The average and instantaneous velocities have same value in a uniform motion.

Reason : In uniform motion, the velocity of an object increases uniformly.

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

Reason : Average velocity is equal to total displacement per total time taken.

Answers

Distance and Displacement

1	a	2	a	3	c	4	a	5	b
6	c								

Uniform Motion

1	d	2	d	3	b	4	b	5	c
6	d	7	a	8	b	9	d	10	c
11	c	12	d	13	d	14	b	15	b
16	d	17	c	18	c	19	d	20	b
21	a	22	b	23	b	24	c		

Non-uniform Motion

1	b	2	c	3	d	4	a	5	a
6	ac	7	a	8	d	9	b	10	a
11	b	12	c	13	b	14	a	15	b
16	d	17	c	18	a	19	c	20	b
21	a	22	c	23	a	24	d	25	c
26	b	27	c	28	d	29	c	30	a
31	c	32	a	33	d	34	a	35	b
36	a	37	b	38	d	39	d	40	b
41	b	42	c	43	b	44	c	45	b
46	d	47	b	48	a	49	b	50	b

51	c	52	c	53	a	54	a	55	c
56	d	57	d	58	d	59	b	60	d
61	c	62	b	63	b	64	a	65	d
66	b	67	a	68	a	69	a	70	d
71	c	72	a	73	a	74	c	75	c
76	c	77	d	78	a	79	c	80	d
81	d	82	c	83	c	84	b	85	a
86	d								

Relative Motion

1	b	2	d	3	b	4	a	5	c
6	d	7	b	8	a	9	d	10	c
11	c	12	b	13	a				

Motion Under Gravity

1	c	2	b	3	d	4	c	5	b
6	a	7	a	8	b	9	c	10	d
11	b	12	a	13	d	14	b	15	c
16	c	17	a	18	b	19	b	20	c
21	b	22	c	23	a	24	b	25	c
26	d	27	b	28	c	29	a	30	d
31	b	32	a	33	b	34	b	35	a
36	c	37	b	38	c	39	b	40	a
41	b	42	b	43	b	44	b	45	d
46	d	47	b	48	b	49	b	50	b
51	c	52	a	53	d	54	d	55	d
56	c	57	b	58	c	59	b	60	b
61	c	62	b	63	c	64	c	65	a
66	a	67	b	68	a	69	b	70	c
71	c	72	c	73	b	74	c	75	b
76	b	77	a	78	a	79	c	80	a
81	a								

Critical Thinking Questions

1	a	2	c	3	abd	4	ad	5	b
6	d	7	c	8	c	9	c	10	d
11	a	12	c						

Graphical Questions

1	b	2	a	3	d	4	b	5	d
6	c	7	d	8	c	9	a	10	b
11	c	12	b	13	a	14	d	15	d
16	c	17	a	18	a	19	a	20	b
21	d	22	c	23	a	24	b	25	a
26	c	27	a	28	c	29	c	30	a

Assertion and Reason

1	a	2	a	3	a	4	a	5	a
6	d	7	c	8	b	9	b	10	e
11	a	12	a	13	a	14	a	15	e
16	e	17	a	18	c	19	d	20	e
21	b	22	d	23	c	24	e	25	e
26	a	27	e	28	b	29	c	30	e

Answers and Solutions

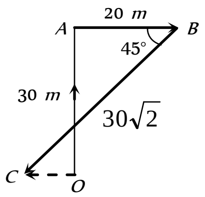
Distance and Displacement

1. (a) $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$ $\therefore r = \sqrt{x^2 + y^2 + z^2}$

$r = \sqrt{6^2 + 8^2 + 10^2} = 10\sqrt{2}\ m$

2. (a) $\vec{r} = 20\hat{i} + 10\hat{j}$ $\therefore r = \sqrt{20^2 + 10^2} = 22.5\ m$

3. (c) From figure, $\overrightarrow{OA} = 0\hat{i} + 30\hat{j}$, $\overrightarrow{AB} = 20\hat{i} + 0\hat{j}$



$\overrightarrow{BC} = -30\sqrt{2}\ cos 45^o \hat{i} - 30\sqrt{2}\ \sin 45^o \hat{j} = -30\hat{i} - 30\hat{j}$

$\therefore$ Net displacement, $\overrightarrow{OC} = \overrightarrow{OA} + \overrightarrow{AB} + \overrightarrow{BC} = -10\hat{i} + 0\hat{j}$

$|\overrightarrow{OC}| = 10\ m.$

4. (a) An aeroplane flies 400 *m* north and 300 *m* south so the net displacement is 100 *m* towards north.

Then it flies 1200 *m* upward so $r = \sqrt{(100)^2 + (1200)^2}$

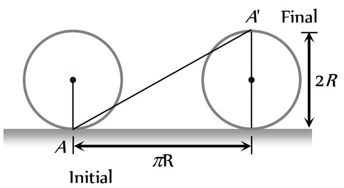
$= 1204 m \simeq 1200 m$

The option should be 1204 *m*, because this value mislead one into thinking that net displacement is in upward direction only.

5. (b) Total time of motion is 2 *min* 20 *sec* = 140 *sec.*

As time period of circular motion is 40 *sec* so in 140 *sec.* athlete will complete 3.5 revolution *i.e.,* He will be at diametrically opposite point *i.e.,* Displacement = $2R$.

6. (c) Horizontal distance covered by the wheel in half revolution = πR.



So the displacement of the point which was initially in contact with ground = $AA' = \sqrt{(\pi R)^2 + (2R)^2}$

$= R\sqrt{\pi^2 + 4} = \sqrt{\pi^2 + 4}$ $(As\ R = 1m)$

Uniform Motion

1. (d) As the total distance is divided into two equal parts therefore distance averaged speed $= \dfrac{2v_1 v_2}{v_1 + v_2}$

2. (d) $\dfrac{v_A}{v_B} = \dfrac{\tan\theta_A}{\tan\theta_B} = \dfrac{\tan 30°}{\tan 60°} = \dfrac{1/\sqrt{3}}{\sqrt{3}} = \dfrac{1}{3}$

3. (b) Distance average speed $= \dfrac{2v_1 v_2}{v_1 + v_2} = \dfrac{2 \times 20 \times 30}{20 + 30}$

$= \dfrac{120}{5} = 24\ km/hr$

4. (b) Distance average speed $= \dfrac{2v_1 v_2}{v_1 + v_2} = \dfrac{2 \times 2.5 \times 4}{2.5 + 4}$

$= \dfrac{200}{65} = \dfrac{40}{13} km/hr$

5. (c) Distance average speed $= \dfrac{2v_1 v_2}{v_1 + v_2} = \dfrac{2 \times 30 \times 50}{30 + 50}$

$= \dfrac{75}{2} = 37.5\ km/hr$

6. (d) Average speed $= \dfrac{\text{Total distance}}{\text{Total time}} = \dfrac{x}{t_1 + t_2}$

$= \dfrac{x}{\dfrac{x/3}{v_1} + \dfrac{2x/3}{v_2}} = \dfrac{1}{\dfrac{1}{3 \times 20} + \dfrac{2}{3 \times 60}} = 36\ km/hr$

7. (a) Time average speed $= \dfrac{v_1 + v_2}{2} = \dfrac{80 + 40}{2} = 60 km/hr$.

8. (b) Distance travelled by train in first 1 *hour* is 60 *km* and distance in next 1/2 *hour* is 20 *km.*

So Average speed $= \dfrac{\text{Total distance}}{\text{Total time}} = \dfrac{60 + 20}{3/2}$

$= 53.33\ km/hour$

9. (d)

10. (c) Total distance to be covered for crossing the bridge

= length of train + length of bridge

$= 150m + 850m = 1000m$

$\text{Time} = \dfrac{\text{Distance}}{\text{Velocity}} = \dfrac{1000}{45 \times \dfrac{5}{18}} = 80\ sec$

11. (c) Displacement of the particle will be zero because it comes back to its starting point

$\text{Average speed} = \dfrac{\text{Total distance}}{\text{Total time}} = \dfrac{30m}{10\ sec} = 3\ m/s$

12. (d) Velocity of particle $= \dfrac{\text{Total diplacement}}{\text{Total time}}$

$= \dfrac{\text{Diameter of circle}}{5} = \dfrac{2 \times 10}{5} = 4\ m/s$

13. (d) A man walks from his home to market with a speed of $5\ km/h$. Distance $= 2.5\ km$ and time $= \dfrac{d}{v} = \dfrac{2.5}{5} = \dfrac{1}{2} hr$.

and he returns back with speed of $7.5\ km/h$ in rest of time of 10 *minutes*.

Distance $= 7.5 \times \frac{10}{60} = 1.25\ km$

So, Average speed $= \frac{\text{Total distance}}{\text{Total time}}$

$= \frac{(2.5+1.25)km}{(40/60)hr} = \frac{45}{8} km/hr$.

14. (b) $\frac{|\text{Average velocity}|}{|\text{Average speed}|} = \frac{|\text{displacement}|}{|\text{distance}|} \le 1$

because displacement will either be equal or less than distance. It can never be greater than distance.

15. (b)

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

$= \frac{x}{\frac{2x/5}{v_1} + \frac{3x/5}{v_2}} = \frac{5v_1v_2}{3v_1 + 2v_2}$

17. (c) From given figure, it is clear that the net displacement is zero. So average velocity will be zero.

18. (c) Since displacement is always less than or equal to distance, but never greater than distance. Hence numerical ratio of displacement to the distance covered is always equal to or less than one.

19. (d) Length of train = 100 *m*

Velocity of train $= 45\ km/hr = 45 \times \frac{5}{18} = 12.5\ m/s$

Length of bridge = 1 *km* = 1000 *m*

$\therefore$ Total length covered by train = 1100 *m*

Time taken by train to cross the bridge $= \frac{1100}{12.5} = 88$ *sec*

20. (b) Time average velocity $= \frac{v_1 + v_2 + v_3}{3} = \frac{3+4+5}{3} = 4m/s$

21. (a) When the body is projected vertically upward then at the highest point its velocity is zero but acceleration is not equal to zero $(g = 9.8 m/s^2)$.

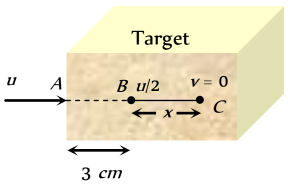
22. (b) Let initial velocity of the bullet = *u*

After penetrating 3 *cm* its velocity becomes $\frac{u}{2}$

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

$\left(\frac{u}{2}\right)^2 = u^2 - 2a(3)$

$\Rightarrow 6a = \frac{3u^2}{4} \Rightarrow a = \frac{u^2}{8}$

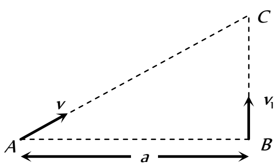


Let further it will penetrate through distance *x* and stops at point *C*.

For distance *BC*, $v = 0, u = u/2, s = x, a = u^2/8$

From $v^2 = u^2 - 2as \Rightarrow 0 = \left(\frac{u}{2}\right)^2 - 2\left(\frac{u^2}{8}\right).x \Rightarrow x = 1$ *cm.*

23. (b) Let two boys meet at point *C* after time '*t*' from the starting. Then $AC = vt$, $BC = v_1 t$



$(AC)^2 = (AB)^2 + (BC)^2 \Rightarrow v^2t^2 = a^2 + v_1^2t^2$

By solving we get $t = \sqrt{\frac{a^2}{v^2 - v_1^2}}$

24. (c) $v_{av} = \frac{2v_1v_2}{v_1 + v_2} = \frac{2 \times 40 \times 60}{100} = 48 kmph.$

Non-uniform Motion

1. (b) As $S = ut + \frac{1}{2}at^2 \therefore S_1 = \frac{1}{2}a(10)^2 = 50a$ .....(i)

As $v = u + at \therefore$ velocity acquired by particle in 10 *sec*

$v = a \times 10$

For next 10 *sec* , $S_2 = (10a) \times 10 + \frac{1}{2}(a) \times (10)^2$

$S_2 = 150a$ .....(ii)

From (i) and (ii) $S_1 = S_2/3$

2. (c) Acceleration $= \frac{d^2x}{dt^2} = 2a_2$

3. (d) Velocity along *X*-axis $v_x = \frac{dx}{dt} = 2at$

Velocity along *Y*-axis $v_y = \frac{dy}{dt} = 2bt$

Magnitude of velocity of the particle,

$v = \sqrt{v_x^2 + v_y^2} = 2t\sqrt{a^2 + b^2}$

4. (a) $S = \int_0^3 v\, dt = \int_0^3 kt\, dt = \left[\frac{1}{2}kt^2\right]_0^3 = \frac{1}{2} \times 2 \times 9 = 9m$

5. (a) $S = kt^3 \therefore a = \frac{d^2S}{dt^2} = 6kt$ *i.e.* $a \propto t$

6. (a,c)

7. (a) From $S = ut + \frac{1}{2}a\,t^2$

$S_1 = \frac{1}{2}a(P-1)^2$ and $S_2 = \frac{1}{2}a\,P^2$ $[As\ u = 0]$

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

$S_{(P^2-P+1)^{th}} = \frac{a}{2}\left[2(P^2 - P + 1) - 1\right] = \frac{a}{2}\left[2P^2 - 2P + 1\right]$

It is clear that $S_{(P^2-P+1)^{th}} = S_1 + S_2$

8. (d) $\vec{a} = \frac{\vec{F}}{m}$. If $\vec{F} = 0$ then $\vec{a} = 0$.

9. (b) $v = 4t^3 - 2t$ (given) $\therefore a = \frac{dv}{dt} = 12t^2 - 2$

and $x = \int_0^t v\, dt = \int_0^t (4t^3 - 2t)\, dt = t^4 - t^2$

When particle is at 2*m* from the origin $t^4 - t^2 = 2$

$\Rightarrow t^4 - t^2 - 2 = 0 \quad (t^2 - 2)(t^2 + 1) = 0 \Rightarrow t = \sqrt{2}$ sec

Acceleration at $t = \sqrt{2}$ sec given by,

$a = 12t^2 - 2 = 12 \times 2 - 2 = 22\ m/s^2$

10. (a) $\frac{dt}{dx} = 2\alpha x + \beta \Rightarrow v = \frac{1}{2\alpha x + \beta}$

$\because \quad a = \frac{dv}{dt} = \frac{dv}{dx}.\frac{dx}{dt}$

$a = v\frac{dv}{dx} = \frac{-v.2\alpha}{(2\alpha x + \beta)^2} = -2\alpha.v.v^2 = -2\alpha v^3$

$\therefore$ Retardation $= 2\alpha v^3$

11. (b) Let u_1, u_2, u_3 and u_4 be velocities at time $t = 0, t_1, (t_1 + t_2)$ and $(t_1 + t_2 + t_3)$ respectively and acceleration is a then $v_1 = \frac{u_1 + u_2}{2}, v_2 = \frac{u_2 + u_3}{2}$ and $v_3 = \frac{u_3 + u_4}{2}$

Also $u_2 = u_1 + at_1$, $u_3 = u_1 + a(t_1 + t_2)$

and $u_4 = u_1 + a(t_1 + t_2 + t_3)$

By solving, we get $\frac{v_1 - v_2}{v_2 - v_3} = \frac{(t_1 + t_2)}{(t_2 + t_3)}$

12. (c) Acceleration $a = \tan\theta$, where θ is the angle of tangent drawn on the graph with the time axis.

13. (b) If acceleration is variable (depends on time) then

$v = u + \int (f)\, dt = u + \int (a\, t)\, dt = u + \frac{a\, t^2}{2}$

14. (a) $S_n = u - \frac{a}{2}(2n - 1) = 10 - \frac{2}{2}(2 \times 5 - 1) = 1\ meter$

15. (b) From $v^2 = u^2 + 2aS \Rightarrow 0 = u^2 + 2aS$

$\Rightarrow a = \frac{-u^2}{2S} = \frac{-(20)^2}{2 \times 10} = -20 m/s^2$

16. (d) $v = u + at = 10 + 2 \times 4 = 18\ m/\text{sec}$

17. (c) If particle starts from rest and moves with constant acceleration then in successive equal interval of time the ratio of distance covered by it will be

$1 : 3 : 5 : 7$ ..... $(2n - 1)$

i.e. ratio of x and y will be $1 : 3$ *i.e.* $\frac{x}{y} = \frac{1}{3} \Rightarrow y = 3x$

18. (a) $S_n = u + \frac{a}{2}[2n - 1]$

$S_{5^{th}} = 7 + \frac{4}{2}[2 \times 5 - 1] = 7 + 18 = 25m$.

19. (c) Acceleration $a = \frac{dv}{dt} = 0.1 \times 2t = 0.2t$

Which is time dependent *i.e.* non-uniform acceleration.

20. (b) Constant velocity means constant speed as well as same direction throughout.

21. (a) Distance travelled in 4 *sec*

$24 = 4u + \frac{1}{2}a \times 16$ ...(i)

Distance travelled in total 8 *sec*

$88 = 8u + \frac{1}{2}a \times 64$ ...(ii)

After solving (i) and (ii), we get $u = 1$ *m/s.*

22. (c) $v_x = \frac{dx}{dt} = \frac{d}{dt}(3t^2 - 6t) = 6t - 6$. At $t = 1, v_x = 0$

$v_y = \frac{dy}{dt} = \frac{d}{dt}(t^2 - 2t) = 2t - 2$. At $t = 1, v_y = 0$

Hence $v = \sqrt{v_x^2 + v_y^2} = 0$

23. (a) Distance travelled in n^{th} second $= u + \frac{a}{2}(2n - 1)$

Distance travelled in 5^{th} second $= 0 + \frac{8}{2}(2 \times 5 - 1) = 36m$

24. (d) $v^2 = u^2 + 2as \Rightarrow (9000)^2 - (1000)^2 = 2 \times a \times 4$

$\Rightarrow a = 10^7 m/s^2$ Now $t = \frac{v - u}{a}$

$\Rightarrow t = \frac{9000 - 1000}{10^7} = 8 \times 10^{-4}\ sec$

25. (c) Initial relative velocity $= v_1 - v_2$, Final relative velocity $= 0$

From $v^2 = u^2 - 2as \Rightarrow 0 = (v_1 - v_2)^2 - 2 \times a \times s$

$\Rightarrow s = \frac{(v_1 - v_2)^2}{2a}$

If the distance between two cars is '*s*' then collision will take place. To avoid collision $d > s \quad \therefore d > \frac{(v_1 - v_2)^2}{2a}$

where $d =$ actual initial distance between two cars.

26. (b) $v = u + at \Rightarrow -2 = 10 + a \times 4 \Rightarrow a = -3m/sec^2$

27. (c) $S_x = u_x t + \frac{1}{2}a_x t^2 \Rightarrow S_x = \frac{1}{2} \times 6 \times 16 = 48\ m$

$S_y = u_y t + \frac{1}{2}a_y t^2 \Rightarrow S_y = \frac{1}{2} \times 8 \times 16 = 64\ m$

$S = \sqrt{S_x^2 + S_y^2} = 80m$

28. (d) $S \propto u^2$. If u becomes 3 times then S will become 9 times *i.e.* $9 \times 20 = 180m$

29. (c) $y = a + bt + ct^2 - dt^4$

$\therefore v = \frac{dy}{dt} = b + 2ct - 4dt^3$ and $a = \frac{dv}{dt} = 2c - 12dt^2$

Hence, at $t = 0$, $v_{initial} = b$ and $a_{initial} = 2c$.

30. (a) $S \propto u^2 \quad \therefore \frac{S_1}{S_2} = \left(\frac{u_1}{u_2}\right)^2 \Rightarrow \frac{2}{S_2} = \frac{1}{4} \Rightarrow S_2 = 8\ m$

31. (c) $t = \sqrt{\frac{2h}{(g + a)}} = \sqrt{\frac{2 \times 2.7}{(9.8 + 1.2)}} = \sqrt{\frac{5.4}{11}} = \sqrt{0.49} = 0.7\,\text{sec}$

As $u = 0$ and lift is moving upward with acceleration

32. (a) Displacement $x = 2t^2 + t + 5$

Velocity $= \frac{dx}{dt} = 4t + 1$

Acceleration $= \frac{d^2x}{dt^2} = 4$ *i.e.* independent of time

Hence acceleration $= 4\ m/s^2$

33. (d) Both trains will travel a distance of 1 *km* before to come in rest. In this case by using $v^2 = u^2 + 2as$

$\Rightarrow 0 = (40)^2 + 2a \times 1000 \Rightarrow a = -0.8\ m/s^2$

34. (a) $v = u + at \Rightarrow v = 0 + 5 \times 10 = 50\ m/s$

35. (b) 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)

$v^2 = u^2 + 2as \Rightarrow 0 = u^2 - 2as \Rightarrow s_b = \frac{u^2}{2a}$

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 $= s_t = ut = \frac{u^2}{a}$

Hence ratio $\frac{s_b}{s_t} = \frac{1}{2}$

36. (a) $S_n = u + \frac{a}{2}(2n-1) = \frac{a}{2}(2n-1)$ because $u = 0$

Hence $\frac{S_4}{S_3} = \frac{7}{5}$

37. (b) $v = u + \int a dt = u + \int (3t^2 + 2t + 2)dt$

$= u + \frac{3t^3}{3} + \frac{2t^2}{2} + 2t = u + t^3 + t^2 + 2t$

$= 2 + 8 + 4 + 4 = 18\ m/s$ (As $t = 2$ *sec*)

38. (d) $v = \frac{ds}{dt} = 3t^2 - 12t + 3$ and $a = \frac{dv}{dt} = 6t - 12$

For $a = 0$, we have $t = 2$ and at $t = 2, v = -9\ ms^{-1}$

39. (d)

40. (b) $a = \sqrt{a_x^2 + a_y^2} = \left[\left(\frac{d^2x}{dt^2}\right)^2 + \left(\frac{d^2y}{dt^2}\right)^2\right]^{\frac{1}{2}}$

Here $\frac{d^2y}{dt^2} = 0$. Hence $a = \frac{d^2x}{dt^2} = 8m/s^2$

41. (b) $F = m \times a$, If force is constant then $a \propto \frac{1}{m}$. So If mass is doubled then acceleration becomes half.

42. (c) $S_n = u + \frac{a}{2}(2n-1) \Rightarrow 1.2 = 0 + \frac{a}{2}(2 \times 6 - 1)$

$\Rightarrow a = \frac{1.2 \times 2}{11} = 0.218\ m/s^2$

43. (b) Here $v = 144\ km/h = 40m/s$

$v = u + at \Rightarrow 40 = 0 + 20 \times a \Rightarrow a = 2\ m/s^2$

$\therefore s = \frac{1}{2}at^2 = \frac{1}{2} \times 2 \times (20)^2 = 400\ m$

44. (c) $\frac{dx}{dt} = 2at - 3bt^2 \Rightarrow \frac{d^2x}{dt^2} = 2a - 6bt = 0 \Rightarrow t = \frac{a}{3b}$

45. (b) Stopping distance $= \frac{\text{Kinetic energy}}{\text{Retardins force}} = \frac{\frac{1}{2}mu^2}{F}$

If retarding force (*F*) and velocity (*v*) are equal then stopping distance $\propto m$ (mass of vehicle)

As $m_{car} < m_{truck}$ therefore car will cover less distance before coming to rest.

46. (d) $u = 72\ kmph = 20m/s,\ v = 0$

By using $v^2 = u^2 - 2as \Rightarrow a = \frac{u^2}{2s} = \frac{(20)^2}{2 \times 200} = 1\ m/s^2$

47. (b) $v = \frac{ds}{dt} = 12t - 3t^2$

Velocity is zero for $t = 0$ and $t = 4$ sec

48. (a)

49. (b) Let *A* and *B* will meet after time *t sec*. it means the distance travelled by both will be equal.

$S_A = ut = 40t$ and $S_B = \frac{1}{2}at^2 = \frac{1}{2} \times 4 \times t^2$

$S_A = S_B \Rightarrow 40t = \frac{1}{2}4t^2 \Rightarrow t = 20$ *sec*

50. (b) $x = a + bt^2, v = \frac{dx}{dt} = 2bt$

Instantaneous velocity $v = 2 \times 3 \times 3 = 18\ cm/\text{sec}$

51. (c) If the body starts from rest and moves with constant acceleration then the ratio of distances in consecutive equal time interval $S_1 : S_2 : S_3 = 1 : 3 : 5$

52. (c) $x = at + bt^2 - ct^3, a = \frac{d^2x}{dt^2} = 2b - 6ct$

53. (a) Let initial $(t = 0)$ velocity of particle $= u$

For first 5 *sec* motion $s_5 = 10$ *metre*

$s = ut + \frac{1}{2}at^2 \Rightarrow 10 = 5u + \frac{1}{2}a(5)^2$

$2u + 5a = 4$ ...(i)

For first 8 *sec* of motion $s_8 = 20$ *metre*

$20 = 8u + \frac{1}{2}a(8)^2 \Rightarrow 2u + 8a = 5$ ...(ii)

By solving $u = \frac{7}{6}m/s$ and $a = \frac{1}{3}m/s^2$

Now distance travelled by particle in Total 10 *sec.*

$s_{10} = u \times 10 + \frac{1}{2}a(10)^2$

By substituting the value of *u* and *a* we will get $s_{10} = 28.3\ m$

so the distance in last 2 sec $= s_{10} - s_8$

$= 28.3 - 20 = 8.3m$

54. (a) $s \propto t^2$ (given) $\therefore\ s = Kt^2$

Acceleration $a = \frac{d^2s}{dt^2} = 2k$ (constant)

It means the particle travels with uniform acceleration.

55. (c) Because acceleration is a vector quantity

56. (d) $u = at, x = \int u\ dt = \int at\ dt = \frac{at^2}{2}$

For $t = 4$ sec, $x = 8a$

57. (d) $3t = \sqrt{3x} + 6 \Rightarrow 3x = (3t-6)^2$

$\Rightarrow x = 3t^2 - 12t + 12$

$v = \frac{dx}{dt} = 6t - 12$, for $v = 0, t = 2\,\text{sec}$

$x = 3(2)^2 - 12\times 2 + 12 = 0$

58. (d) $u = 0, S = 250m, t = 10\,\text{sec}$

$S = ut + \frac{1}{2}at^2 \Rightarrow 250 = \frac{1}{2}a[10]^2 \Rightarrow a = 5m/s^2$

So, $F = ma = 0.9\times 5 = 4.5N$

59. (b) $\text{Time} = \frac{\text{Distance}}{\text{Average velocity}} = \frac{3.06}{0.34} = 9\text{ sec}$

$\text{Acceleration} = \frac{\text{Change in velocity}}{\text{Time}} = \frac{0.18}{9} = 0.02\, m/s^2$

60. (d) $s = 3t^3 + 7t^2 + 14t + 8\, m$

$a = \frac{d^2s}{dt^2} = 18t + 14$ at $t = 1$ sec $\Rightarrow a = 32m/s^2$

61. (c) Instantaneous velocity $v = \frac{\Delta x}{\Delta t}$

By using the data from the table

$v_1 = \frac{0-(-2)}{1} = 2m/s,\quad v_2 = \frac{6-0}{1} = 6\, m/s$

$v_3 = \frac{16-6}{1} = 10\, m/s$

So, motion is non-uniform but accelerated.

62. (b) Only direction of displacement and velocity gets changed, acceleration is always directed vertically downward.

63. (b) $s = 2t^2 + 2t + 4,\ a = \frac{d^2s}{dt^2} = 4\, m/s^2$

64. (a) According to problem

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

$0 + \frac{a_1}{2}(2\times 5 - 1) = 0 + \frac{a_2}{2}[2\times 3 - 1]$

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

65. (d) $u = 200\, m/s, v = 100\, m/s, s = 0.1\, m$

$a = \frac{u^2 - v^2}{2s} = \frac{(200)^2 - (100)^2}{2\times 0.1} = 15\times 10^4\, m/s^2$

66. (b) $v = u + at = u + \left(\frac{F}{m}\right)t = 20 + \left(\frac{100}{5}\right)\times 10 = 220\ m/s$

67. (a) Velocity acquired by body in 10*sec*

$v = 0 + 2\times 10 = 20m/s$

and distance travelled by it in 10 *sec*

$S_1 = \frac{1}{2}\times 2\times (10)^2 = 100\, m$

then it moves with constant velocity (20 *m/s*) for 30 sec

$S_2 = 20\times 30 = 600\, m$

After that due to retardation $(4m/s^2)$ it stops

$S_3 = \frac{v^2}{2a} = \frac{(20)^2}{2\times 4} = 50m$

Total distance travelled $S_1 + S_2 + S_3 = 750m$

68. (a) If a body starts from rest with acceleration α and then retards with retardation β and comes to rest. The total time taken for this journey is t and distance covered is S

then $S = \frac{1}{2}\frac{\alpha\beta t^2}{(\alpha+\beta)} = \frac{1}{2}\frac{5\times 10}{(5+10)}\times t^2$

$\Rightarrow\ 1500 = \frac{1}{2}\frac{5\times 10}{(5+10)}\times t^2\ \Rightarrow t = 30\,\text{sec}$.

69. (a)

70. (d) $S \propto u^2$. Now speed is two times so distance will be four times $S = 4\times 6 = 24m$

71. (c) Let student will catch the bus after t *sec.* So it will cover distance *ut.*

Similarly distance travelled by the bus will be $\frac{1}{2}at^2$ for the given condition

$ut = 50 + \frac{1}{2}at^2 = 50 + \frac{t^2}{2}\qquad [a = 1\, m/s^2]$

$\Rightarrow u = \frac{50}{t} + \frac{t}{2}$

To find the minimum value of u

$\frac{du}{dt} = 0$, so we get $t = 10\,\text{sec}$, then $u = 10\, m/s$

72. (a) $\frac{1}{2}at^2 = vt \Rightarrow t = \frac{2v}{a}$

73. (a) The velocity of the particle is

$\frac{dx}{dt} = \frac{d}{dt}(2 - 5t + 6t^2) = (0 - 5 + 12t)$

For initial velocity $t = 0$, hence $v = -5\, m/s$.

74. (c) For First part,

$u = 0,\ t = T$ and acceleration $= a$

$\therefore v = 0 + aT = aT$ and $S_1 = 0 + \frac{1}{2}aT^2 = \frac{1}{2}aT^2$

For Second part,

$u = aT$, retardation$=a$, $v = 0$ and time taken $= T$ (let)

$\therefore\ 0 = u - a_1T_1 \Rightarrow aT = a_1T_1$

and from $v^2 = u^2 - 2aS_2\ \Rightarrow S_2 = \frac{u^2}{2a_1} = \frac{1}{2}\frac{a^2T^2}{a_1}$

$S_2 = \frac{1}{2}aT\times T_1\qquad \left(As\ a_1 = \frac{aT}{T_1}\right)$

$\therefore\ v_{av} = \frac{S_1 + S_2}{T + T_1} = \frac{\frac{1}{2}aT^2 + \frac{1}{2}aT\times T_1}{T + T_1}$

$= \frac{\frac{1}{2}aT\,(T + T_1)}{T + T_1} = \frac{1}{2}aT$

75. (c) $u = 0,\ v = 27.5\, m/s$ and $t = 10$ *sec*

$\therefore a = \frac{27.5 - 0}{10} = 2.75\, m/s^2$

Now, the distance traveled in next 10 *sec*,

$S = ut + \frac{1}{2}at^2 = 27.5\times 10 + \frac{1}{2}\times 2.75\times 100$

$= 275 + 137.5 = 412.5\ m$

76. (c) $v = (180 - 16x)^{1/2}$

As $a = \frac{dv}{dt} = \frac{dv}{dx}.\frac{dx}{dt}$

$\therefore a = \frac{1}{2}(180 - 16x)^{-1/2} \times (-16)\left(\frac{dx}{dt}\right)$

$= -8\,(180 - 16x)^{-1/2} \times v$

$= -8\,(180 - 16x)^{-1/2} \times (180 - 16x)^{1/2} = -8\ m/s^2$

77. (d) $x \propto t^3 \ \therefore\ x = Kt^3$

$\Rightarrow v = \frac{dx}{dt} = 3\ Kt^2$ and $a = \frac{dv}{dt} = 6\ Kt$

i.e. $a \propto t$

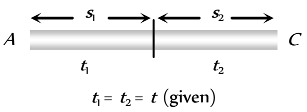
78. (a) $\because a = \frac{dv}{dt} = 2(t-1) \Rightarrow dv = 2(t-1)\,dt$

$\Rightarrow v = \int_0^5 2\,(t-1)dt = 2\left[\frac{t^2}{2} - t\right]_0^5 = 2\left[\frac{25}{2} - 5\right]$ = 15 *m/s*

79. (c) $\because S_1 = ut + \frac{1}{2}at^2$ .....(i)

and velocity after first *t sec*

$v = u + at$



Now, $S_2 = vt + \frac{1}{2}at^2$

$= (u + at)t + \frac{1}{2}at^2$ ..... (ii)

Equation (ii) – (i) $\Rightarrow S_2 - S_1 = at^2$

$\Rightarrow a = \frac{S_2 - S_1}{t^2} = \frac{65 - 40}{(5)^2} = 1\ m/s^2$

From equation (i), we get,

$S_1 = ut + \frac{1}{2}at^2 \Rightarrow 40 = 5u + \frac{1}{2} \times 1 \times 25$

$\Rightarrow 5u = 27.5 \ \therefore\ u = 5.5\ m/s$

80. (d) $S \propto u^2 \Rightarrow \frac{S_1}{S_2} = \left(\frac{1}{4}\right)^2 = \frac{1}{16}$

81. (d) $x = ae^{-\alpha t} + be^{\beta t}$

Velocity $v = \frac{dx}{dt} = \frac{d}{dt}(ae^{-\alpha t} + be^{\beta t})$

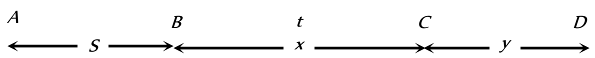
$= a.e^{-\alpha t}(-\alpha) + be^{\beta t}.\beta) = -a\alpha e^{-\alpha t} + b\beta e^{\beta t}$

Acceleration $= -a\alpha e^{-\alpha t}(-\alpha) + b\beta e^{bt}.\beta$

$= a\alpha^2 e^{-\alpha t} + b\beta^2 e^{\beta t}$

Acceleration is positive so velocity goes on increasing with time.

82. (c) Let car starts from point *A* from rest and moves up to point *B* with acceleration *f*



Velocity of car at point *B*, $v = \sqrt{2fS}$

$[\text{As } v^2 = u^2 + 2as]$

Car moves distance *BC* with this constant velocity in time *t*

$x = \sqrt{2fS}.t$ ......(i) [As $s = ut$]

So the velocity of car at point *C* also will be $\sqrt{2fs}$ and finally car stops after covering distance *y*.

Distance $CD \Rightarrow y = \frac{(\sqrt{2fS})^2}{2(f/2)} = \frac{2fS}{f} = 2S$ ....(ii)

$[\text{As}\, v^2 = u^2 - 2as \Rightarrow s = u^2/2a]$

So, the total distance $AD = AB + BC + CD = 15S$ (given)

$\Rightarrow \quad S + x + 2S = 15S \Rightarrow x = 12S$

Substituting the value of *x* in equation (i) we get

$x = \sqrt{2fS}.t \Rightarrow 12S = \sqrt{2fS}.t \Rightarrow 144S^2 = 2fS.t^2$

$\Rightarrow S = \frac{1}{72}ft^2.$

83. (c) Let man will catch the bus after '*t*' *sec* . So he will cover distance *ut*.

Similarly distance travelled by the bus will be $\frac{1}{2}at^2$. For the given condition

$u\,t = 45 + \frac{1}{2}a\,t^2 = 45 + 1.25\,t^2$ $[As\ a = 2.5m/s^2]$

$\Rightarrow u = \frac{45}{t} + 1.25\,t$

To find the minimum value of *u*

$\frac{du}{dt} = 0$ so we get $t = 6$ sec then,

$u = \frac{45}{6} + 1.25 \times 6 = 7.5 + 7.5 = 15m/s$

84. (b) $x = 4(t-2) + a(t-2)^2$

At $t = 0, x = -8 + 4a = 4a - 8$

$v = \frac{dx}{dt} = 4 + 2a(t-2)$

At $t = 0,\ v = 4 - 4a = 4(1-a)$

But acceleration, $a = \frac{d^2x}{dt^2} = 2a$

85. (a) Distance covered in 5th second,

$S_{5^{th}} = u + \frac{a}{2}(2n-1) = 0 + \frac{a}{2}(2 \times 5 - 1) = \frac{9a}{2}$

and distance covered in 5 second,

$S_5 = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2} \times a \times 25 = \frac{25a}{2}$

$\therefore \frac{S_{5^{th}}}{S_5} = \frac{9}{25}$

86. (d) The nature of the path is decided by the direction of velocity, and the direction of acceleration. The trajectory can be a straight line, circle or a parabola depending on these factors.

Relative Motion

1. (b) Time $= \dfrac{\text{Total length}}{\text{Relativevelocity}} = \dfrac{50+50}{10+15} = \dfrac{100}{25} = 4\ sec$

2. (d) Total distance $= 130 + 120 = 250\ m$

Relative velocity $= 30 - (-20) = 50\ m/s$

Hence $t = 250/50 = 5s$

3. (b) Relative velocity of bird *w.r.t* train $= 25 + 5 = 30\ m/s$

time taken by the bird to cross the train $t = \dfrac{210}{30} = 7\ sec$

4. (a) Effective speed of the bullet

= speed of bullet + speed of police jeep

$= 180\ m/s + 45\ km/h = (180 + 12.5)\ m/s = 192.5\ m/s$

Speed of thief's jeep $= 153 km/h = 42.5 m/s$

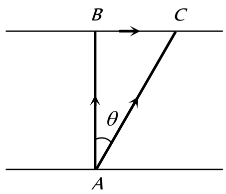
Velocity of bullet *w.r.t* thief's car $= 192.5 - 42.5 = 150 m/s$

5. (c) Given $\overrightarrow{AB}$ = Velocity of boat = 8 *km/hr*

$\overrightarrow{AC}$ = Resultant velocity of boat = 10 *km/hr*

$\overrightarrow{BC}$ = Velocity of river $= \sqrt{AC^2 - AB^2}$

$= \sqrt{(10)^2 - (8)^2} = 6\ km/hr$



6. (d) Relative velocity

$= 10 + 5 = 15\ m/sec$

$\therefore\ t = \dfrac{150}{15} = 10\ sec$

7. (b) The relative velocity of boat *w.r.t.* water

$= v_{\text{boat}} - v_{\text{water}} = (3\hat{i} + 4\hat{j}) - (-3\hat{i} - 4\hat{j}) = 6\hat{i} + 8\hat{j}$

8. (a) When two particles moves towards each other then $v_1 + v_2 = 6$ ...(i)

When these particles moves in the same direction then $v_1 - v_2 = 4$ ...(ii)

By solving $v_1 = 5$ and $v_2 = 1\ m/s$

9. (d) For the round trip he should cross perpendicular to the river

$\therefore$ Time for trip to that side $= \dfrac{1km}{4km/hr} = 0.25hr$

To come back, again he take 0.25 *hr* to cross the river.

Total time is 30 min, he goes to the other bank and come back at the same point.

10. (c) Relativistic momentum $= \dfrac{m_0 v}{\sqrt{1 - v^2/c^2}}$

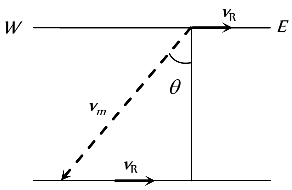
If velocity is doubled then the relativistic mass also increases. Thus value of linear momentum will be more than double.

11. (c) For shortest possible path man should swim with an angle $(90+\theta)$ with downstream.

From the fig,

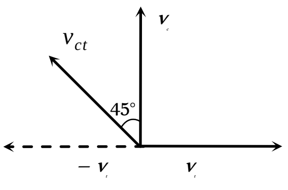
$\sin\theta = \dfrac{v_r}{v_m} = \dfrac{5}{10} = \dfrac{1}{2}$

$\Rightarrow\ \therefore\ \theta = 30°$



So angle with downstream $= 90° + 30° = 120°$

12. (b) $\overrightarrow{v_{ct}} = \overrightarrow{v_c} - \overrightarrow{v_t}$



$\overrightarrow{v_{ct}} = \overrightarrow{v_c} + (-\overrightarrow{v_t})$

Velocity of car *w.r.t.* train (v_{ct}) is towards West – North

13. (a) As the trains are moving in the same direction. So the initial relative speed $(v_1 - v_2)$ and by applying retardation final relative speed becomes zero.

From $v = u - at \Rightarrow 0 = (v_1 - v_2) - at \Rightarrow t = \dfrac{v_1 - v_2}{a}$

Motion Under Gravity

1. (c) $u = 12\ m/s$, $g = 9.8\ m/\sec^2$, $t = 10$ sec

Displacement $= ut + \dfrac{1}{2}gt^2$

$= 12 \times 10 + \dfrac{1}{2} \times 9.8 \times 100 = 610m$

2. (b) Velocity at the time of striking the floor,

$u = \sqrt{2gh_1} = \sqrt{2 \times 9.8 \times 10} = 14 m/s$

Velocity with which it rebounds.

$v = \sqrt{2gh_2} = \sqrt{2 \times 9.8 \times 2.5} = 7\ m/s$

$\therefore$ Change in velocity $\Delta v = 7 - (-14) = 21 m/s$

$\therefore$ Acceleration $= \dfrac{\Delta v}{\Delta t} = \dfrac{21}{0.01} = 2100\ m/s^2$ (upwards)

3. (d) Let t be the time of flight of the first body after meeting, then $(t-4)$ *sec* will be the time of flight of the second body. Since $h_1 = h_2$

$\therefore\ 98t - \dfrac{1}{2}gt^2 = 98(t-4) - \dfrac{1}{2}g(t-4)^2$

On solving, we get $t = 12$ *seconds*

4. (c) $h = \dfrac{1}{2}gt^2 \Rightarrow t = \sqrt{2h/g}$

$t_a = \sqrt{\dfrac{2a}{g}}$ and $t_b = \sqrt{\dfrac{2b}{g}} \Rightarrow \dfrac{t_a}{t_b} = \sqrt{\dfrac{a}{b}}$

5. (b) $\dfrac{1}{2}g(3)^2 = \dfrac{g}{2}(2n-1) \Rightarrow n = 5\ s$

6. (a) Time taken by first stone to reach the water surface from the bridge be t, then

$h = ut + \dfrac{1}{2}gt^2 \Rightarrow 44.1 = 0 \times t + \dfrac{1}{2} \times 9.8t^2$

$t = \sqrt{\dfrac{2 \times 44.1}{9.8}} = 3\ sec$

Second stone is thrown 1 *sec* later and both strikes simultaneously. This means that the time left for second stone $= 3 - 1 = 2\ sec$

Hence $44.1 = u \times 2 + \dfrac{1}{2}9.8(2)^2$

$\Rightarrow 44.1 - 19.6 = 2u \Rightarrow u = 12.25\ m/s$

7. (a)

8. (b) Let the initial velocity of ball be u

Time of rise $t_1 = \dfrac{u}{g+a}$ and height reached $= \dfrac{u^2}{2(g+a)}$

Time of fall t_2 is given by

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

$\Rightarrow t_2 = \frac{u}{\sqrt{(g+a)(g-a)}} = \frac{u}{(g+a)}\sqrt{\frac{g+a}{g-a}}$

$\therefore t_2 > t_1$ because $\frac{1}{g+a} < \frac{1}{g-a}$

9. (c) Vertical component of velocities of both the balls are same and equal to zero. So $t = \sqrt{\frac{2h}{g}}$

10. (d) The separation between the two bodies, two seconds after the release of second body

$= \frac{1}{2} \times 9.8[(3)^2 - (2)^2] = 24.5\ m$

11. (b) Time of flight $= \frac{2u}{g} = \frac{2 \times 100}{10} = 20\ sec$

12. (a) $h = \frac{1}{2}gt^2 = \frac{1}{2} \times 10 \times (4)^2 = 80\ m$

13. (d) Let the body after time $t/2$ be at x from the top, then

$x = \frac{1}{2}g\frac{t^2}{4} = \frac{gt^2}{8}$ ...(i)

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

Eliminate t from (i) and (ii), we get $x = \frac{h}{4}$

$\therefore$ Height of the body from the ground $= h - \frac{h}{4} = \frac{3h}{4}$

14. (b) By applying law of conservation of energy

$mgR = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{2Rg}$

15. (c) Acceleration of body along AB is $g\cos\theta$

Distance travelled in time t sec $= AB = \frac{1}{2}(g\cos\theta)t^2$

From ΔABC, $AB = 2R\cos\theta$; $2R\cos\theta = \frac{1}{2}g\cos\theta t^2$

$\Rightarrow t^2 = \frac{4R}{g}$ or $t = 2\sqrt{\frac{R}{g}}$

16. (c) Force down the plane $= mg\sin\theta$

$\therefore$ Acceleration down the plane $= g\sin\theta$

Since $l = 0 + \frac{1}{2}g\sin\theta t^2$

$\therefore t^2 = \frac{2l}{g\sin\theta} = \frac{2h}{g\sin^2\theta} \Rightarrow t = \frac{1}{\sin\theta}\sqrt{\frac{2h}{g}}$

17. (a) $h = ut - \frac{1}{2}gt^2 \Rightarrow 96 = 80t - \frac{32}{2}t^2$

$\Rightarrow t^2 - 5t + 6 = 0 \Rightarrow t = 2$ sec or 3 sec

18. (b) $v = g \times t = 32 \times 1 = 32\ ft/\text{sec}$

19. (b) $v^2 = u^2 + 2gh \Rightarrow (3u)^2 = (-u)^2 + 2gh \Rightarrow h = \frac{4u^2}{g}$

20. (c) $t = \sqrt{\frac{2h}{g}}$ and h and g are same.

21. (b) Time of flight $= \frac{2u}{g} = \frac{2 \times 96}{32} = 6\ sec$

22. (c) Total distance $= \frac{1}{2}gt^2 = \frac{25}{2}g$

Distance moved in 3 sec $= \frac{9}{2}g$

Remaining distance $= \frac{16}{2}g$

If t is the time taken by the stone to reach the ground for the remaining distance then

$\Rightarrow \frac{16}{2}g = \frac{1}{2}gt^2 \Rightarrow t = 4$ sec

23. (a) Height travelled by ball (with balloon) in 2 sec

$h_1 = \frac{1}{2}a\,t^2 = \frac{1}{2} \times 4.9 \times 2^2 = 9.8\ m$

Velocity of the balloon after 2 sec

$v = a\,t = 4.9 \times 2 = 9.8\ m/s$

Now if the ball is released from the balloon then it acquire same velocity in upward direction.

Let it move up to maximum height h_2

$v^2 = u^2 - 2gh_2 \Rightarrow 0 = (9.8)^2 - 2 \times (9.8) \times h_2 \therefore h_2 = 4.9m$

Greatest height above the ground reached by the ball $= h_1 + h_2 = 9.8 + 4.9 = 14.7\ m$

24. (b) Let h distance is covered in n sec

$\Rightarrow h = \frac{1}{2}gn^2$ ...(i)

Distance covered in n^{th} sec $= \frac{1}{2}g(2n-1)$

$\Rightarrow \frac{9h}{25} = \frac{g}{2}(2n-1)$ ...(ii)

From (i) and (ii), $h = 122.5\ m$

25. (c) $h = ut + \frac{1}{2}gt^2 \Rightarrow 81 = -12t + \frac{1}{2} \times 10 \times t^2 \Rightarrow t = 5.4\ sec$

26. (d) The initial velocity of aeroplane is horizontal, then the vertical component of velocity of packet will be zero.

So $t = \sqrt{\frac{2h}{g}}$

27. (b) Time taken by first drop to reach the ground $t = \sqrt{\frac{2h}{g}}$

$\Rightarrow t = \sqrt{\frac{2 \times 5}{10}} = 1$ sec

As the water drops fall at regular intervals from a tap therefore time difference between any two drops $= \frac{1}{2}$ sec

In this given time, distance of second drop from the tap $= \frac{1}{2}g\left(\frac{1}{2}\right)^2 = \frac{5}{5} = 1.25\,m$

Its distance from the ground $= 5 - 1.25 = 3.75\ m$

28. (c) $h = ut + \frac{1}{2}gt^2$, $t = 3$ sec, $u = -4.9\ m/s$

$\Rightarrow h = -4.9 \times 3 + 4.9 \times 9 = 29.4\ m$

29. (a) Horizontal velocity of dropped packet $= u$

Vertical velocity $= \sqrt{2gh}$

$\therefore$ Resultant velocity at earth $= \sqrt{u^2 + 2gh}$

30. (d) Given $a = 19.6\ m/s^2 = 2g$

Resultant velocity of the rocket after 5 *sec*

$v = 2g \times 5 = 10g\ m/s$

Height achieved after 5 *sec*, $h_1 = \frac{1}{2} \times 2g \times 25 = 245m$

On switching off the engine it goes up to height h_2 where its velocity becomes zero.

$0 = (10g)^2 - 2gh_2 \Rightarrow h_2 = 490m$

$\therefore$ Total height of rocket $= 245 + 490 = 735\ m$

31. (b) Bullet will take $\frac{100}{1000} = 0.1$ *sec* to reach target.

During this period vertical distance (downward) travelled by the bullet $= \frac{1}{2}gt^2$

$= \frac{1}{2} \times 10 \times (0.1)^2 m = 5\ cm$

So the gun should be aimed 5 *cm* above the target.

32. (a) $S_n = u + \frac{g}{2}(2n-1)$; when $u = 0$, $S_1 : S_2 : S_3 = 1 : 3 : 5$

33. (b) It has lesser initial upward velocity.

34. (b) At maximum height velocity $v = 0$

We know that $v = u + at$, hence

$0 = u - gT \Rightarrow u = gT$

When $v = \frac{u}{2}$, then

$\frac{u}{2} = u - gt \Rightarrow gt = \frac{u}{2} \Rightarrow gt = \frac{gT}{2} \Rightarrow t = \frac{T}{2}$

Hence at $t = \frac{T}{2}$, it acquires velocity $\frac{u}{2}$

35. (a) If u is the initial velocity then distance covered by it in 2 *sec*

$S = ut + \frac{1}{2}at^2 = u \times 2 + \frac{1}{2} \times 10 \times 4 = 2u + 20$ ...(i)

Now distance covered by it in 3 *sec*

$S_{3^{rd}} = u + \frac{g}{2}(2 \times 3 - 1)10 = u + 25$ ...(ii)

From(i) and (ii), $2u + 20 = u + 25 \Rightarrow u = 5$

$\therefore S = 2 \times 5 + 20 = 30\ m$

36. (c) For first case $v^2 - 0^2 = 2gh \Rightarrow (3)^2 = 2gh$

For second case $v^2 = (-u)^2 + 2gh = 4^2 + 3^2$ $\therefore v = 5$*km/h*

37. (b) The time of fall is independent of the mass.

38. (c) $h_{n^{th}} = u - \frac{g}{2}(2n-1)$

$h_{5^{th}} = u - \frac{10}{2}(2 \times 5 - 1) = u - 45$

$h_{6^{th}} = u - \frac{10}{2}(2 \times 6 - 1) = u - 55$

Given $h_{5^{th}} = 2 \times h_{6^{th}}$. By solving we get $u = 65\ m/s$

39. (b) $S = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2}at^2$

Hence $t \propto \sqrt{S}$ *i.e.*, if S becomes one-fourth then t will become half *i.e.*, 2 *sec*

40. (a) Distance between the balls = Distance travelled by first ball in 3 seconds –Distance travelled by second ball in 2 seconds

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

41. (b) Speed of stone in a vertically upward direction is 4.9 *m/s*. So for vertical downward motion we will consider $u = -4.9\ m/s$

$h = ut + \frac{1}{2}gt^2 = -4.9 \times 2 + \frac{1}{2} \times 9.8 \times (2)^2 = 9.8\ m$

42. (b) Speed of stone in a vertically upward direction is 20*m/s*. So for vertical downward motion we will consider $u = -20\ m/s$

$v^2 = u^2 + 2gh = (-20)^2 + 2 \times 9.8 \times 200 = 4320\ m/s$

$\therefore v \simeq 65\, m/s$.

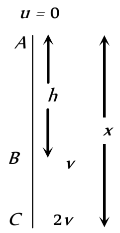
43. (b) Let at point A initial velocity of body is equal to zero

for path AB: $v^2 = 0 + 2gh$ ...(i)

for path AC: $(2v)^2 = 0 + 2gx$

$4v^2 = 2gx$ ...(ii)

Solving (i) and (ii) $x = 4h$



44. (b) For one dimensional motion along a plane

$S = ut + \frac{1}{2}at^2 \Rightarrow 9.8 = 0 + \frac{1}{2}\ g\sin 30^o\, t^2 \Rightarrow t = 2\sec$

45. (d) Body reaches the point of projection with same velocity.

46. (d) Time of flight $T = \frac{2u}{g} = 4\ \sec \Rightarrow u = 20\ m/s$

47. (b) $t = \sqrt{\frac{2h}{g}} \Rightarrow \frac{t_1}{t_2} = \sqrt{\frac{h_1}{h_2}}$

48. (b) Time of ascent = Time of descent = 5 *sec*

49. (b) Time of ascent $= \frac{u}{g} = 6\ \sec \Rightarrow u = 60\ m/s$

Distance in first second $h_{\text{first}} = 60 - \frac{g}{2}(2 \times 1 - 1) = 55\ m$

Distance in seventh second will be equal to the distance in first second of vertical downward motion

$h_{\text{seventh}} = \frac{g}{2}(2 \times 1 - 1) = 5\ m \Rightarrow h_{\text{first}} / h_{\text{seventh}} = 11:1$

50. (b) Let particle thrown with velocity u and its maximum height is H then $H = \frac{u^2}{2g}$

When particle is at a height $H/2$, then its speed is 10 *m/s*

From equation $v^2 = u^2 - 2gh$

$(10)^2 = u^2 - 2g\left(\frac{H}{2}\right) = u^2 - 2g\frac{u^2}{4g} \Rightarrow u^2 = 200$

Maximum height $\Rightarrow H = \frac{u^2}{2g} = \frac{200}{2 \times 10} = 10\ m$

51. (c) Mass does not affect on maximum height.

$H = \frac{u^2}{2g} \Rightarrow H \propto u^2$, So if velocity is doubled then height will become four times. *i.e.* $H = 20 \times 4 = 80m$

52. (a) When the stone is released from the balloon. Its height $h = \frac{1}{2}at^2 = \frac{1}{2} \times 1.25 \times (8)^2 = 40\ m$ and velocity

$v = at = 1.25 \times 8 = 10\ m/s$

Time taken by the stone to reach the ground

$$t = \frac{v}{g}\left[1 + \sqrt{1 + \frac{2gh}{v^2}}\right] = \frac{10}{10}\left[1 + \sqrt{1 + \frac{2 \times 10 \times 40}{(10)^2}}\right] = 4\ sec$$

53. (d) At highest point $v = 0$ and $H_{max} = \frac{u^2}{2g}$

54. (d) $u = \sqrt{2gh} = \sqrt{2 \times 10 \times 20} = 20\ m/s$

and $T = \frac{2u}{g} = \frac{2 \times 20}{10} = 4\ sec$

55. (d) If t_1 and t_2 are the time, when body is at the same height then, $h = \frac{1}{2} g\, t_1 t_2 = \frac{1}{2} \times g \times 2 \times 10 = 10\ g$

56. (c) Speed of the object at reaching the ground $v = \sqrt{2gh}$

If heights are equal then velocity will also be equal.

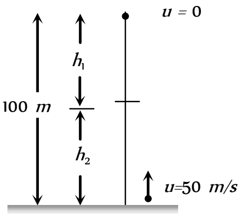
57. (b) $S_{3^{rd}} = 10 + \frac{10}{2}(2 \times 3 - 1) = 35\ m$

$S_{2^{nd}} = 10 + \frac{10}{2}(2 \times 2 - 1) = 25m \Rightarrow \frac{S_{3^{rd}}}{S_{2^{nd}}} = \frac{7}{5}$

58. (c) $v^2 = u^2 + 2gh \Rightarrow v = \sqrt{u^2 + 2gh}$

so for both the cases velocity will be equal.

59. (b) $h_1 = \frac{1}{2}gt^2$, $h_2 = 50t - \frac{1}{2}gt^2$



Given $h_1 + h_2 = 100m \Rightarrow 50t = 100 \Rightarrow t = 2$ sec

60. (b) $H_{max} = \frac{u^2}{2g} = \frac{19.6 \times 19.6}{2 \times 9.8} = 19.6\ m$

61. (c) Maximum height of ball = 5 *m*

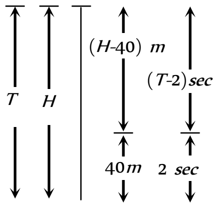
So velocity of projection $\Rightarrow u = \sqrt{2gh} = 10\ m/s$

Time interval between two balls (time of ascent)

$= \frac{u}{g} = 1\ sec = \frac{1}{60} min$.

So number of ball thrown per min. = 60

62. (b) Let height of minaret is *H* and body take time *T* to fall from top to bottom.



$H = \frac{1}{2}gT^2$ ...(i)

In last 2 *sec.* body travels distance of 40*meter* so in $(T-2)$ *sec* distance travelled $= (H - 40)\ m$.

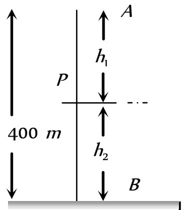
$(H - 40) = \frac{1}{2}g(T-2)^2$ ...(ii)

By solving (i) and (ii) $T = 3$ *sec* and $H = 45\ m$.

63. (c) $S_n \propto (2n-1)$. In equal time interval of 2 *seconds*

Ratio of distance $= 1 : 3 : 5$

64. (c) Let both balls meet at point *P* after time *t*.



The distance travelled by ball *A*, $h_1 = \frac{1}{2}gt^2$

The distance travelled by ball *B*, $h_2 = ut - \frac{1}{2}gt^2$

$h_1 + h_2 = 400\ m \Rightarrow ut = 400,\ t = 400/50 = 8\ sec$

$\therefore\ h_1 = 320\ m$ and $h_2 = 80\ m$

65. (a) $t = \sqrt{\frac{2h}{g}} \Rightarrow \frac{t_1}{t_2} = \sqrt{\frac{h_1}{h_2}} = \sqrt{\frac{1}{2}} = \frac{1}{\sqrt{2}}$

66. (a) $H_{max} = \frac{u^2}{2g} \Rightarrow H_{max} \propto \frac{1}{g}$

On planet *B* value of *g* is $1/9$ times to that of *A*. So value of H_{max} will become 9 times *i.e.* $2 \times 9 = 18\ metre$

67. (b) $h_n = \frac{g}{2}(2n-1) \Rightarrow h_{5^{th}} = \frac{10}{2}(2 \times 5 - 1) = 45\ m$.

68. (a) $h_{max} = \frac{u^2}{2g} = \frac{(15)^2}{2 \times 10} = 11.25\ m$.

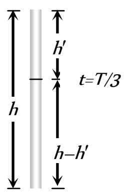
69. (b) For stone to be dropped from rising balloon of velocity 29 *m/s*.

$u = -29\ m/s$, $t = 10$ *sec.*

$\therefore h = -29 \times 10 + \frac{1}{2} \times 9.8 \times 100$

$= -290 + 490 = 200$ *m*.

70. (c) $\because\ h = ut + \frac{1}{2}gt^2 \Rightarrow h = \frac{1}{2}gT^2$



After $\frac{T}{3}$ seconds, the position of ball,

$$h' = 0 + \frac{1}{2}g\left(\frac{T}{3}\right)^2 = \frac{1}{2}\times\frac{g}{9}\times T^2$$

$$h' = \frac{1}{2}\times\frac{g}{9}\times T^2 = \frac{h}{9}m \text{ from top}$$

$\therefore$ Position of ball from ground $= h - \frac{h}{9} = \frac{8h}{9}m.$

71. (c) Since acceleration due to gravity is independent of mass, hence time is also independent of mass (or density) of object.

72. (c) When packet is released from the balloon, it acquires the velocity of balloon of value 12 *m/s*. Hence velocity of packet after 2 *sec*, will be

$v = u + gt = 12 - 9.8\times 2 = -7.6$ *m/s*.

73. (b) The distance traveled in last second.

$$S_{\text{Last}} = u + \frac{g}{2}(2t-1) = \frac{1}{2}\times 9.8(2t-1) = 4.9(2t-1)$$

and distance traveled in first three second,

$$S_{\text{Three}} = 0 + \frac{1}{2}\times 9.8\times 9 = 44.1\ m$$

According to problem $S_{\text{Last}} = S_{\text{Three}}$

$\Rightarrow 4.9(2t-1) = 44.1 \Rightarrow 2t-1 = 9 \Rightarrow t = 5$ *sec.*

74. (c) Net acceleration of a body when thrown upward

= acceleration of body – acceleration due to gravity

$= a - g$

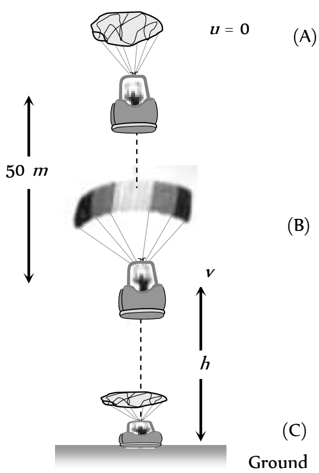
75. (b) The given condition is possible only when body is at its highest position after 5 seconds

It means time of ascent = 5 *sec*

and time of flight $T = \frac{2u}{g} = 10 \Rightarrow u = 50\ m/s$

76. (b) $H_{\max} \propto u^2$, It body projected with double velocity then maximum height will become four times *i.e.* 200 *m.*

77. (a) After bailing out from point *A* parachutist falls freely under gravity. The velocity acquired by it will '*v*'



From $v^2 = u^2 + 2as = 0 + 2\times 9.8\times 50 = 980$

[As $u = 0$, $a = 9.8 m/s^2$, $s = 50\ m$]

At point *B*, parachute opens and it moves with retardation of $2\ m/s^2$ and reach at ground (Point *C*) with velocity of $3m/s$

For the part '*BC*' by applying the equation $v^2 = u^2 + 2as$

$v = 3m/s$, $u = \sqrt{980}\ m/s$, $a = -2m/s^2$, $s = h$

$\Rightarrow (3)^2 = (\sqrt{980})^2 + 2\times(-2)\times h \Rightarrow 9 = 980 - 4h$

$$\Rightarrow h = \frac{980-9}{4} = \frac{971}{4} = 242.7 \cong 243\ m.$$

So, the total height by which parachutist bail out = $50 + 243 = 293\ m.$

78. (a)

79. (c)

80. (a) $H_{\max} \propto u^2 \ \therefore u \propto \sqrt{H_{\max}}$

i.e. to triple the maximum height, ball should be thrown with velocity $\sqrt{3}\,u$.

81. (a)

Critical Thinking Questions

1. (a) If t_1 and $2t_2$ are the time taken by particle to cover first and second half distance respectively.

$t_1 = \frac{x/2}{3} = \frac{x}{6}$ ...(i)

$x_1 = 4.5\ t_2$ and $x_2 = 7.5\ t_2$

So, $x_1 + x_2 = \frac{x}{2} \Rightarrow 4.5t_2 + 7.5t_2 = \frac{x}{2}$

$t_2 = \frac{x}{24}$ ...(ii)

Total time $t = t_1 + 2t_2 = \frac{x}{6} + \frac{x}{12} = \frac{x}{4}$

So, average speed $= 4\ m/sec$.

2. (c) $\frac{dv}{dt} = bt \Rightarrow dv = bt\,dt \Rightarrow v = \frac{bt^2}{2} + K_1$

At $t = 0, v = v_0 \Rightarrow K_1 = v_0$

We get $v = \frac{1}{2}bt^2 + v_0$

Again $\frac{dx}{dt} = \frac{1}{2}bt^2 + v_0 \Rightarrow x = \frac{1}{2}\frac{bt^2}{3} + v_0t + K_2$

At $t = 0, x = 0 \Rightarrow K_2 = 0$

$\therefore x = \frac{1}{6}bt^3 + v_0t$

3. (a,b,d) $\frac{dv}{dt} = 6 - 3v \Rightarrow \frac{dv}{6-3v} = dt$

Integrating both sides, $\int \frac{dv}{6-3v} = \int dt$

$\Rightarrow \dfrac{\log_e(6-3v)}{-3} = t + K_1$

$\Rightarrow \log_e(6-3v) = -3t + K_2$ ...(i)

At $t = 0, v = 0$ $\therefore$ $\log_e 6 = K_2$

Substituting the value of K_2 in equation (i)

$\log_e(6-3v) = -3t + \log_e 6$

$\Rightarrow \log_e\left(\dfrac{6-3v}{6}\right) = -3t \Rightarrow e^{-3t} = \dfrac{6-3v}{6}$

$\Rightarrow 6 - 3v = 6e^{-3t} \Rightarrow 3v = 6(1 - e^{-3t})$

$\Rightarrow v = 2(1 - e^{-3t})$

$\therefore$ $v_{\text{trminal}} = 2\ m/s$ (When $t = \infty$)

Acceleration $a = \dfrac{dv}{dt} = \dfrac{d}{dt}\left[2\left(1 - e^{-3t}\right)\right] = 6e^{-3t}$

Initial acceleration = $6\ m/s^2$.

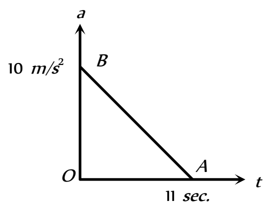
4. (a,d) The body starts from rest at $x = 0$ and then again comes to rest at $x = 1$. It means initially acceleration is positive and then negative.

So we can conclude that α can not remains positive for all t in the interval $0 \le t \le 1$ *i.e.* α must change sign during the motion.

5. (b) The area under acceleration time graph gives change in velocity. As acceleration is zero at the end of 11 *sec*

i.e. $v_{\max}$ = Area of ΔOAB

$= \dfrac{1}{2} \times 11 \times 10 = 55\ m/s$



6. (d) Let the car accelerate at rate α for time t_1 then maximum velocity attained, $v = 0 + \alpha t_1 = \alpha t_1$

Now, the car decelerates at a rate β for time $(t - t_1)$ and finally comes to rest. Then,

$0 = v - \beta(t - t_1) \Rightarrow 0 = \alpha t_1 - \beta t + \beta t_1$

$\Rightarrow t_1 = \dfrac{\beta}{\alpha + \beta} t$

$\therefore$ $v = \dfrac{\alpha\beta}{\alpha + \beta} t$

7. (c) If a stone is dropped from height h

then $h = \dfrac{1}{2} g t^2$ ...(i)

If a stone is thrown upward with velocity u then

$h = -u\ t_1 + \dfrac{1}{2} g\ t_1^2$ ...(ii)

If a stone is thrown downward with velocity u then

$h = ut_2 + \dfrac{1}{2} g t_2^2$ ...(iii)

From (i) (ii) and (iii) we get

$-ut_1 + \dfrac{1}{2} g t_1^2 = \dfrac{1}{2} g t^2$ ...(iv)

$ut_2 + \dfrac{1}{2} g t_2^2 = \dfrac{1}{2} g t^2$ ...(v)

Dividing (iv) and (v) we get

$\therefore$ $\dfrac{-ut_1}{ut_2} = \dfrac{\frac{1}{2} g(t^2 - t_1^2)}{\frac{1}{2} g(t^2 - t_2^2)}$

or $-\dfrac{t_1}{t_2} = \dfrac{t^2 - t_1^2}{t^2 - t_2^2}$

By solving $t = \sqrt{t_1 t_2}$

8. (c) Since direction of v is opposite to the direction of g and h so from equation of motion

$h = -vt + \dfrac{1}{2} gt^2$

$\Rightarrow gt^2 - 2vt - 2h = 0$

$\Rightarrow t = \dfrac{2v \pm \sqrt{4v^2 + 8gh}}{2g}$

$\Rightarrow t = \dfrac{v}{g}\left[1 + \sqrt{1 + \dfrac{2gh}{v^2}}\right]$

9. (c) $h = ut + \dfrac{1}{2} gt^2 \Rightarrow 1 = 0 \times t_1 + \dfrac{1}{2} gt_1^2 \Rightarrow t_1 = \sqrt{2/g}$

Velocity after travelling 1m distance

$v^2 = u^2 + 2gh \Rightarrow v^2 = (0)^2 + 2g \times 1 \Rightarrow v = \sqrt{2g}$

For second 1 meter distance

$1 = \sqrt{2g} \times t_2 + \dfrac{1}{2} gt_2^2 \Rightarrow gt_2^2 + 2\sqrt{2g} t_2 - 2 = 0$

$t_2 = \dfrac{-2\sqrt{2g} \pm \sqrt{8g + 8g}}{2g} = \dfrac{-\sqrt{2} \pm 2}{\sqrt{g}}$

Taking +ve sign $t_2 = (2 - \sqrt{2})/\sqrt{g}$

$\therefore$ $\dfrac{t_1}{t_2} = \dfrac{\sqrt{2/g}}{(2 - \sqrt{2})/\sqrt{g}} = \dfrac{1}{\sqrt{2} - 1}$ and so on.

10. (d) Interval of ball throw = 2 *sec.*

If we want that minimum three (more than two) ball remain in air then time of flight of first ball must be greater than 4 *sec.*

$T > 4\ sec$

$\dfrac{2u}{g} > 4\ sec \Rightarrow u > 19.6\ m/s$

for u =19.6. First ball will just strike the ground(in sky)

Second ball will be at highest point (in sky)

Third ball will be at point of projection or at ground (not in sky)

11. (a) The distance covered by the ball during the last t seconds of its upward motion = Distance covered by it in first t seconds of its downward motion

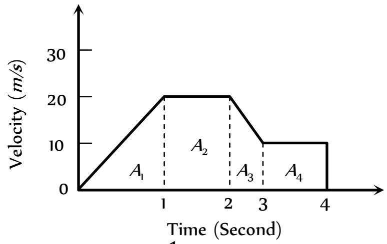
From $h = ut + \dfrac{1}{2} g t^2$

$h = \frac{1}{2} g t^2$ [As $u = 0$ for it downward motion]

12. (c)

Graphical Questions

1. (b) Distance = Area under $v - t$ graph $= A_1 + A_2 + A_3 + A_4$



$= \frac{1}{2} \times 1 \times 20 + (20 \times 1) + \frac{1}{2}(20+10) \times 1 + (10 \times 1)$

$= 10 + 20 + 15 + 10 = 55\ m$

2. (a) The slope of displacement-time graph goes on decreasing, it means the velocity is decreasing *i.e.* It's motion is retarded and finally slope becomes zero *i.e.* particle stops.

3. (d) In the positive region the velocity decreases linearly (during rise) and in the negative region velocity increases linearly (during fall) and the direction is opposite to each other during rise and fall, hence fall is shown in the negative region.

4. (b) Region *OA* shows that graph bending toward time axis *i.e.* acceleration is negative.

Region *AB* shows that graph is parallel to time axis *i.e.* velocity is zero. Hence acceleration is zero.

Region *BC* shows that graph is bending towards displacement axis *i.e.* acceleration is positive.

Region *CD* shows that graph having constant slope *i.e.* velocity is constant. Hence acceleration is zero.

5. (d) Maximum acceleration means maximum change in velocity in minimum time interval.

In time interval $t = 30$ to $t = 40\,\text{sec}$

$a = \frac{\Delta v}{\Delta t} = \frac{80-20}{40-30} = \frac{60}{10} = 6\ cm/\text{sec}^2$

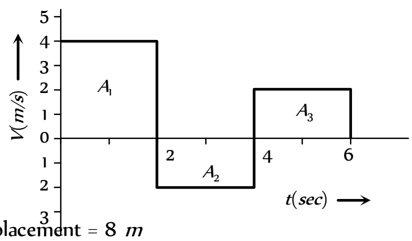
6. (c) In part *cd* displacement-time graph shows constant slope *i.e.* velocity is constant. It means no acceleration or no force is acting on the body.

7. (d) Up to time t_1 slope of the graph is constant and after t_1 slope is zero *i.e.* the body travel with constant speed up to time t_1 and then stops.

8. (c) Area of trapezium $= \frac{1}{2} \times 3.6 \times (12+8) = 36.0\ m$

9. (a) Displacement = Summation of all the area with sign

$= (A_1) + (-A_2) + (A_3) = (2 \times 4) + (-2 \times 2) + (2 \times 2)$



$\therefore$ Displacement = 8 *m*

Distance =Summation of all the areas without sign

$= |A_1| + |-A_2| + |A_3| = |8| + |-4| + |4| = 8 + 4 + 4$

$\therefore$ Distance = 16 *m*.

10. (b) Between time interval 20 *sec* to 40 *sec*, there is non-zero acceleration and retardation. Hence distance travelled during this interval

= Area between time interval 20 *sec* to 40 *sec*

$= \frac{1}{2} \times 20 \times 3 + 20 \times 1 = 30 + 20 = 50\ m.$

11. (c)

12. (b) $\frac{(S)_{(last\ 2s)}}{(S)_{7s}} = \frac{\frac{1}{2} \times 2 \times 10}{\frac{1}{2} \times 2 \times 10 + 2 \times 10 + \frac{1}{2} \times 2 \times 10} = \frac{1}{4}$

13. (a) Distance = Area covered between graph and displacement axis $= \frac{1}{2}(30+10)10 = 200\ meter$.

14. (d) Because acceleration due to gravity is constant so the slope of line will be constant *i.e.* velocity time curve for a body projected vertically upwards is straight line.

15. (d) Slope of displacement time graph is negative only at point *E*.

16. (c) $v^2 = u^2 + 2aS$, If $u = 0$ then $v^2 \propto S$

i.e. graph should be parabola symmetric to displacement axis.

17. (a) This graph shows uniform motion because line having a constant slope.

18. (a) For the given condition initial height $h = d$ and velocity of the ball is zero. When the ball moves downward its velocity increases and it will be maximum when the ball hits the ground & just after the collision it becomes half and in opposite direction. As the ball moves upward its velocity again decreases and becomes zero at height $d/2$. This explanation match with graph (*A*).

19. (a) We know that the velocity of body is given by the slope of displacement – time graph. So it is clear that initially slope of the graph is positive and after some time it becomes zero (corresponding to the peak of graph) and then it will becomes negative.

20. (b) Maximum acceleration will be represented by *CD* part of the graph

Acceleration $= \frac{dv}{dt} = \frac{(60-20)}{0.25} = 160\ km/h^2$

21. (d)

22. (c) For upward motion

Effective acceleration $= -(g + a)$

and for downward motion

Effective acceleration $= (g - a)$

But both are constants. So the slope of speed-time graph will be constant.

23. (a) Since slope of graph remains constant for velocity-time graph.

24. (b) Other graph shows more than one velocity of the particle at single instant of time which is not practically possible.

25. (a) Slope of velocity-time graph measures acceleration. For graph (a) slope is zero. Hence $a = 0$ *i.e.* motion is uniform.

26. (c) From acceleration time graph, acceleration is constant for first part of motion so, for this part velocity of body increases uniformly with time and as $a = 0$ then the velocity becomes constant. Then again increased because of constant acceleration.

27. (a) Given line have positive intercept but negative slope. So its equation can be written as

$$v = -mx + v_0 \quad .....(i) \qquad [\text{where } m = \tan\theta = \frac{v_0}{x_0}]$$

By differentiating with respect to time we get

$$\frac{dv}{dt} = -m\frac{dx}{dt} = -mv$$

Now substituting the value of v from eq. (i) we get

$$\frac{dv}{dt} = -m[-mx + v_0] = m^2x - mv_0 \quad \therefore \quad a = m^2x - mv_0$$

i.e. the graph between a and x should have positive slope but negative intercept on a-axis. So graph (a) is correct.

28. (c) From given $a - t$ graph it is clear that acceleration is increasing at constant rate

$$\therefore \frac{da}{dt} = k \text{ (constant)} \Rightarrow a = kt \text{ (by integration)}$$

$$\Rightarrow \frac{dv}{dt} = kt \Rightarrow dv = ktdt$$

$$\Rightarrow \int dv = k\int tdt \Rightarrow v = \frac{kt^2}{2}$$

i.e. v is dependent on time parabolically and parabola is symmetric about v-axis.

and suddenly acceleration becomes zero. *i.e.* velocity becomes constant.

Hence (c) is most probable graph.

29. (c) In first instant you will apply $\upsilon = \tan\theta$ and say, $\upsilon = \tan 30^o = \frac{1}{\sqrt{3}}$ *m/s.*

But it is wrong because formula $\upsilon = \tan\theta$ is valid when angle is measured with time axis.

Here angle is taken from displacement axis. So angle from time axis $= 90^o - 30^o = 60^o$

Now $\upsilon = \tan 60^o = \sqrt{3}$

30. (a) Since total displacement is zero, hence average velocity is also zero.

Assertion and Reason

1. (a) When body going vertically upwards, reaches at the highest point, then it is momentarily at rest and it then reverses its direction. At the highest point of motion, its velocity is zero but its acceleration is equal to acceleration due to gravity.

2. (a) As motion is governed by force of gravity and acceleration due to gravity (g) is independent of mass of object.

3. (a) As distance being a scalar quantity is always positive but displacement being a vector may be positive, zero and negative depending on situation.

4. (a) As displacement is either smaller or equal to distance but never be greater than distance.

5. (a) Since velocity is a vector quantity, hence as its direction changes keeping magnitude constant, velocity is said to be changed. But for constant speed in equal time interval distance travelled should be equal.

6. (d) Speed can never be negative because it is a scalar quantity.

7. (c) Negative slope of position time graph represents that the body is moving towards the negative direction and if the slope of the graph decrease with time then it represents the decrease in speed *i.e.* retardation in motion.

8. (b) A body having positive acceleration can be associated with slowing down, as time rate of change of velocity decreases, but velocity increases with time, from graph it is clear that slope with time axis decreases, but velocity increases with time.

9. (b) A body having negative acceleration can be associated with a speeding up, if object moves along negative X-direction with increasing speed.

10. (e) It is not necessary that an object moving under uniform acceleration have straight path. *eg.* projectile motion.

11. (a) Motion of rocket is based on action reaction phenomena and is governed by rate of fuel burning causing the change in momentum of ejected gas.

12. (a) When a body moves on a straight path in one direction value of distance & displacement remains same so that average speed equals the average velocity for a given time interval.

13. (a) Position-time graph for a stationary object is a straight line parallel to time axis showing that no change in position with time.

14. (a) Since slope of displacement-time graph measures velocity of an object.

15. (e) For distance-time graph, a straight line inclined to time axis measures uniform speed for which acceleration is zero and for uniformly accelerated motion $S \propto t^2$.

16. (e) As per definition, acceleration is the rate of change of velocity, *i.e.* $\vec{a} = \frac{d\vec{v}}{dt}$.

If velocity is constant $d\vec{v}/dt = 0, \quad \therefore \vec{a} = 0$.

Therefore, if a body has constant velocity it cannot have non zero acceleration.

17. (a) A body has no relative motion with respect to itself. Hence if a frame of reference of the body is fixed, then the body will be always at relative rest in this frame of reference.

18. (c) The displacement is the shortest distance between initial and final position. When final position of a body coincides with its initial position, displacement is zero, but the distance travelled is not zero.

19. (d) Equation of motion can be applied if the acceleration is in opposite direction to that of velocity and uniform motion mean the acceleration is zero.

20. (e) As velocity is a vector quantity, its value changes with change in direction. Therefore when a bus takes a turn from north to east its velocity will also change.

21. (b) When two bodies are moving in opposite direction, relative velocity between them is equal to sum of the velocity of bodies. But if the bodies are moving in same direction their relative velocity is equal to difference in velocity of the bodies.

22. (d) The displacement of a body moving in straight line is given by, $s = ut + \frac{1}{2}at^2$. This is a equation of a parabola, not straight line. Therefore the displacement-time graph is a parabola. The displacement time graph will be straight line, if acceleration of body is zero or body moving with uniform velocity.

23. (c) In uniform motion the object moves with uniform velocity, the magnitude of its velocity at different instant *i.e.* at $t = 0$, $t = 1sec$, $t = 2sec$,.... will always be constant. Thus velocity-time graph for an object in uniform motion along a straight path is a straight line parallel to time axis.

24. (e) The uniform motion of a body means that the body is moving with constant velocity, but if the direction of motion is changing (such as in uniform circular motion), its velocity changes and thus acceleration is produced in uniform motion.

25. (e) When a body falling freely, only gravitational force acts on it in vertically downward direction. Due to this downward acceleration the velocity of a body increases and will be maximum when the body touches the ground.

26. (a) According to definition,displacement = velocity × time Since displacement is a vector quantity so its value is equal to the vector sum of the area under velocity-time graph.

27. (e) If the position-time graph of a body moving uniformly in a straight line parallel to position axis, it means that the position of body is changing at constant time. The statement is abrupt and shows that the velocity of body is infinite.

28. (b) Average speed = Total distance /Total time

Time average speed $= \dfrac{v_1 + v_2 + v_3 + ...}{n}$

29. (c) An object is said to be in uniform motion if it undergoes equal displacement in equal intervals of time.

$$\therefore v_{av} = \frac{s_1 + s_2 + s_3 + ...}{t_1 + t_2 + t_3 + ...} = \frac{s + s + s + ...}{t + t + t + ...} = \frac{ns}{nt} = \frac{s}{t}$$

and $v_{ins} = \dfrac{s}{t}$.

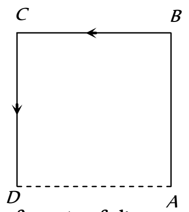
Thus, in uniform motion average and instantaneous velocities have same value and body moves with constant velocity.

30. (e) Speedometer measures instantaneous speed of automobile.

Motion In One Dimension

SET Self Evaluation Test - 2

1. A car travels a distance S on a straight road in two hours and then returns to the starting point in the next three hours. Its average velocity is
   (a) $S/5$ (b) $2S/5$
   (c) $S/2+S/3$ (d) None of the above
2. A particle moves along the sides AB, BC, CD of a square of side 25 m with a velocity of 15 ms^{-1}. Its average velocity is



   (a) 15 ms^{-1}
   (b) 10 ms^{-1}
   (c) 7.5 ms^{-1}
   (d) 5 ms^{-1}
3. A body has speed V, $2V$ and $3V$ in first 1/3 of distance S, seconds 1/3 of S and third 1/3 of S respectively. Its average speed will be
   (a) V (b) $2V$
   (c) $\frac{18}{11}V$ (d) $\frac{11}{18}V$
4. If the body covers one-third distance at speed v_1 next one third at speed v_2 and last one third at speed v_3 then average speed will be
   (a) $\frac{\upsilon_1\upsilon_2+\upsilon_2\upsilon_3+\upsilon_3\upsilon_1}{\upsilon_1+\upsilon_2+\upsilon_3}$ (b) $\frac{\upsilon_1+\upsilon_2+\upsilon_3}{3}$
   (c) $\frac{\upsilon_1\upsilon_2\upsilon_3}{\upsilon_1\upsilon_2+\upsilon_2\upsilon_3+\upsilon_3\upsilon_1}$ (d) $\frac{3\upsilon_1\upsilon_2\upsilon_3}{\upsilon_1\upsilon_2+\upsilon_2\upsilon_3+\upsilon_3\upsilon_1}$
5. The displacement of the particle varies with time according to the relation $x=\frac{k}{b}[1-e^{-bt}]$. Then the velocity of the particle is
   (a) $k(e^{-bt})$ (b) $\frac{k}{b^2e^{-bt}}$
   (c) $k\,b\,e^{-bt}$ (d) None of these
6. The acceleration of a particle starting from rest, varies with time according to the relation $A = -a\omega \sin\omega t$. The displacement of this particle at a time t will be
   (a) $-\frac{1}{2}(a\omega^2\sin\omega t)t^2$ (b) $a\omega\sin\omega t$
   (c) $a\omega\cos\omega t$ (d) $a\sin\omega t$
7. If the velocity of a particle is $(10 + 2t)$ m/s, then the average acceleration of the particle between $2s$ and $5s$ is
   (a) 2 m/s^2 (b) 4 m/s^2
   (c) 12 m/s^2 (d) 14 m/s^2
8. A bullet moving with a velocity of 200 cm/s penetrates a wooden block and comes to rest after traversing 4 cm inside it. What velocity is needed for travelling distance of 9 cm in same block
   (a) 100 cm/s (b) 136.2 cm/s
   (c) 300 cm/s (d) 250 cm/s
9. A thief is running away on a straight road in jeep moving with a speed of 9 ms^{-1}. A police man chases him on a motor cycle moving at a speed of 10 ms^{-1}. If the instantaneous separation of the jeep from the motorcycle is 100 m, how long will it take for the police to catch the thief
   (a) 1 s (b) 19 s
   (c) 90 s (d) 100 s
10. A car A is travelling on a straight level road with a uniform speed of 60 km/h. It is followed by another car B which is moving with a speed of 70 km/h. When the distance between them is 2.5 km, the car B is given a deceleration of 20 km/h^2. After how much time will B catch up with A
    (a) 1 hr (b) 1/2 hr
    (c) 1/4 hr (d) 1/8 hr
11. The speed of a body moving with uniform acceleration is u. This speed is doubled while covering a distance S. When it covers an additional distance S, its speed would become
    (a) $\sqrt{3}\,u$ (b) $\sqrt{5}\,u$
    (c) $\sqrt{11}\,u$ (d) $\sqrt{7}\,u$
12. Two trains one of length 100 m and another of length 125 m, are moving in mutually opposite directions along parallel lines, meet each other, each with speed 10 m/s. If their acceleration are 0.3 m/s^2 and 0.2 m/s^2 respectively, then the time they take to pass each other will be
    (a) 5 s (b) 10 s
    (c) 15 s (d) 20 s
13. A body starts from rest with uniform acceleration. If its velocity after n second is υ, then its displacement in the last two seconds is
    (a) $\frac{2\upsilon(n+1)}{n}$ (b) $\frac{\upsilon(n+1)}{n}$
    (c) $\frac{\upsilon(n-1)}{n}$ (d) $\frac{2\upsilon(n-1)}{n}$
14. A point starts moving in a straight line with a certain acceleration. At a time t after beginning of motion the acceleration suddenly becomes retardation of the same value. The time in which the point returns to the initial point is
    (a) $\sqrt{2t}$
    (b) $(2+\sqrt{2})\,t$
    (c) $\frac{t}{\sqrt{2}}$

(d) Cannot be predicted unless acceleration is given

15. A particle is moving in a straight line and passes through a point O with a velocity of $6\ ms^{-1}$. The particle moves with a constant retardation of $2\ ms^{-2}$ for 4 s and there after moves with constant velocity. How long after leaving O does the particle return to O

(a) $3s$ (b) $8s$

(c) Never (d) $4s$

16. A bird flies for 4 s with a velocity of $|t-2|\ m/s$ in a straight line, where t is time in seconds. It covers a distance of

(a) $2\ m$ (b) $4\ m$

(c) $6\ m$ (d) $8\ m$

17. A particle is projected with velocity υ_0 along $x-axis$. The deceleration on the particle is proportional to the square of the distance from the origin i.e., $a=\alpha x^2$. The distance at which the particle stops is

(a) $\sqrt{\frac{3\upsilon_0}{2\alpha}}$ (b) $\left(\frac{3v_o}{2\alpha}\right)^{\frac{1}{3}}$

(c) $\sqrt{\frac{3\upsilon_0^2}{2\alpha}}$ (d) $\left(\frac{3\upsilon_0^2}{2\alpha}\right)^{\frac{1}{3}}$

18. A body is projected vertically up with a velocity v and after some time it returns to the point from which it was projected. The average velocity and average speed of the body for the total time of flight are

(a) $\vec{v}/2$ and $v/2$ (b) 0 and $v/2$

(c) 0 and 0 (d) $\vec{v}/2$ and 0

19. A stone is dropped from a height h. Simultaneously, another stone is thrown up from the ground which reaches a height 4 h. The two stones cross each other after time

(a) $\sqrt{\frac{h}{8g}}$ (b) $\sqrt{8gh}$

(c) $\sqrt{2gh}$ (d) $\sqrt{\frac{h}{2g}}$

20. 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 forth will be respectively

(a) 35, 25 and 15 m (b) 30, 20 and 10 m

(c) 20, 10 and 5 m (d) 40, 30 and 20 m

21. A balloon rises from rest with a constant acceleration $g/8$. A stone is released from it when it has risen to height h. The time taken by the stone to reach the ground is

(a) $4\sqrt{\frac{h}{g}}$ (b) $2\sqrt{\frac{h}{g}}$

(c) $\sqrt{\frac{2h}{g}}$ (d) $\sqrt{\frac{g}{h}}$

22. Two bodies are thrown simultaneously from a tower with same initial velocity v_0 : one vertically upwards, the other vertically downwards. The distance between the two bodies after time t is

(a) $2v_0t+\frac{1}{2}gt^2$ (b) $2v_0t$

(c) $v_0t+\frac{1}{2}gt^2$ (d) v_0t

23. A body falls freely from the top of a tower. It covers 36% of the total height in the last second before striking the ground level. The height of the tower is

(a) 50 m (b) 75 m

(c) 100 m (d) 125 m

24. A particle is projected upwards. The times corresponding to height h while ascending and while descending are t_1 and t_2 respectively. The velocity of projection will be

(a) gt_1 (b) gt_2

(c) $g(t_1+t_2)$ (d) $\frac{g(t_1+t_2)}{2}$

25. A projectile is fired vertically upwards with an initial velocity u. After an interval of T seconds a second projectile is fired vertically upwards, also with initial velocity u.

(a) They meet at time $t=\frac{u}{g}$ and at a height $\frac{u^2}{2g}+\frac{gT^2}{8}$

(b) They meet at time $t=\frac{u}{g}+\frac{T}{2}$ and at a height $\frac{u^2}{2g}+\frac{gT^2}{8}$

(c) They meet at time $t=\frac{u}{g}+\frac{T}{2}$ and at a height $\frac{u^2}{2g}-\frac{gT^2}{8}$

(d) They never meet

AS Answers and Solutions

(SET -2)

1. (d) Average velocity $=\frac{\text{Total displacement}}{\text{Time}}=\frac{0}{2+3}=0$

2. (d) Average velocity $=\frac{\text{Total displacement}}{\text{Time taken}}=\frac{25}{75/15}=5\ m/s$

3. (c) $v_{av}=\frac{\text{Total distance}}{\text{Time taken}}=\frac{x}{\frac{x/3}{v}+\frac{x/3}{2v}+\frac{x/3}{3v}}=\frac{18}{11}v$

4. (d) $v_{av}=\frac{x}{\frac{x/3}{v_1}+\frac{x/3}{v_2}+\frac{x/3}{v_3}}=\frac{3v_1v_2v_3}{v_1v_2+v_2v_3+v_1v_3}$

5. (a) $v = \frac{dx}{dt} = \frac{d}{dt}\left[\frac{k}{b}\left(1 - e^{-bt}\right)\right] = \frac{k}{b}\left[0 - (-b)e^{-bt}\right] = ke^{-bt}$.

6. (d) Velocity $v = \int A\, dt = \int (-a\omega^2 \sin\omega t)\, dt = a\omega \cos\omega t$

Displacement $x = \int v\, dt = \int a\omega \cos\omega t\, dt = a \sin\omega t$

7. (d) Average acceleration $= \frac{\text{Change in velocity}}{\text{Time taken}} = \frac{v_2 - v_1}{t_2 - t_1}$

$= \frac{\left[10 + 2(5)^2\right] - \left[10 + 2(2)^2\right]}{3} = \frac{60 - 18}{3} = 14\ m/s^2$.

8. (c) As $v^2 = u^2 - 2as \Rightarrow u^2 = 2as \quad (\because v = 0)$

$\Rightarrow u^2 \propto s \quad \Rightarrow \frac{u_2}{u_1} = \left(\frac{s_2}{s_1}\right)^{1/2}$

$\Rightarrow u_2 = \left(\frac{9}{4}\right)^{1/2} u_1 = \frac{3}{2} u_1 = 300 cm/s$.

9. (d) The relative velocity of policeman *w.r.t.* thief $= 10 - 9 = 1 m/s$.

$\therefore$ Time taken by police to catch the thief $= \frac{100}{1}$ =100 *sec*

10. (b) Let car *B* catches, car A after '*t*' sec, then

$60t + 2.5 = 70t - \frac{1}{2} \times 20 \times t^2$

$\Rightarrow 10t^2 - 10t + 2.5 = 0 \Rightarrow t^2 - t + 0.25 = 0$

$\therefore \ t = \frac{1 \pm \sqrt{1 - 4 \times (0.25)}}{2} = \frac{1}{2} hr$

11. (d) As $v^2 = u^2 + 2as \Rightarrow (2u)^2 = u^2 + 2as \Rightarrow 2as = 3u^2$

Now, after covering an additional distance *s*, if velocity becomes *v*, then,

$v^2 = u^2 + 2a(2s) = u^2 + 4as = u^2 + 6u^2 = 7u^2$

$\therefore \ v = \sqrt{7} u$.

12. (b) Relative velocity of one train *w.r.t.* other

=10+10=20 *m/s*.

Relative acceleration =0.3+0.2=0.5 *m/s*

If trains cross each other then from $s = ut + \frac{1}{2}at^2$

$As,\ s = s_1 + s_2 = 100 + 125 = 225$

$\Rightarrow 225 = 20t + \frac{1}{2} \times 0.5 \times t^2 \Rightarrow 0.5t^2 + 40t - 450 = 0$

$\Rightarrow t = -\frac{40 \pm \sqrt{1600 + 4.(005) \times 450}}{1} = -40 \pm 50$

$\therefore \ t = 10 \sec$ (Taking +ve value).

13. (d) $\because v = 0 + na \Rightarrow a = v/n$

Now, distance travelled in *n sec.* $\Rightarrow S_n = \frac{1}{2}an^2$ and distance travelled in $(n-2)\sec \Rightarrow S_{n-2} = \frac{1}{2}a(n-2)^2$

$\therefore$ Distance travelled in last two seconds,

$= S_n - S_{n-2} = \frac{1}{2}an^2 - \frac{1}{2}a(n-2)^2$

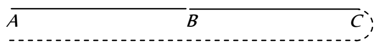
$= \frac{a}{2}\left[n^2 - (n-2)^2\right] = \frac{a}{2}[n + (n-2)][n - (n-2)]$

$= a(2n-2) = \frac{v}{n}(2n-2) = \frac{2v(n-1)}{n}$

14. (b) In this problem point starts moving with uniform acceleration *a* and after time *t* (Position *B*) the direction of acceleration get reversed *i.e.* the retardation of same value works on the point. Due to this velocity of points goes on decreasing and at position *C* its velocity becomes zero. Now the direction of motion of point reversed and it moves from *C* to *A* under the effect of acceleration *a*.

We have to calculate the total time in this motion. Starting velocity at position *A* is equal to zero.

Velocity at position $B \Rightarrow v = at$ [As $u = 0$]



Distance between *A* and *B*, $S_{AB} = \frac{1}{2}at^2$

As same amount of retardation works on a point and it comes to rest therefore $S_{BC} = S_{AB} = \frac{1}{2}a\,t^2$

$\therefore \ S_{AC} = S_{AB} + S_{BC} = a\,t^2$ and time required to cover this distance is also equal to *t*.

$\therefore$ Total time taken for motion between *A* and *C* = 2*t*

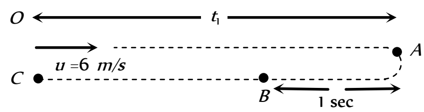
Now for the return journey from *C* to *A* $\left(S_{AC} = a\,t^2\right)$

$S_{AC} = u\,t + \frac{1}{2}at^2 \Rightarrow a\,t^2 = 0 + \frac{1}{2}a\,t_1^2 \Rightarrow t_1 = \sqrt{2}\ t$

Hence total time in which point returns to initial point

$T = 2t + \sqrt{2}\ t = (2 + \sqrt{2})t$

15. (b) Let the particle moves toward right with velocity 6 *m/s*. Due to retardation after time t_1 its velocity becomes zero.



From $v = u - a\,t \Rightarrow 0 = 6 - 2 \times t_1 \Rightarrow t_1 = 3 \sec$

But retardation works on it for 4 *sec.* It means after reaching point *A* direction of motion get reversed and acceleration works on the particle for next one second.

$$S_{OA} = ut_1 - \frac{1}{2}at_1^2 = 6\times 3 - \frac{1}{2}(2)(3)^2 = 18 - 9 = 9m$$

$$S_{AB} = \frac{1}{2}\times 2\times (1)^2 = 1m$$

$$\therefore\ S_{BC} = S_{0A} - S_{AB} = 9 - 1 = 8m$$

Now velocity of the particle at point B in return journey

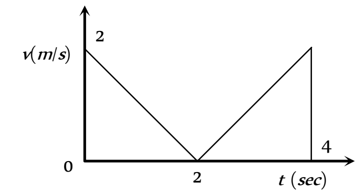
$v = 0 + 2\times 1 = 2m/s$

In return journey from B to C, particle moves with constant velocity 2 m/s to cover the distance $8m$.

Time taken $= \dfrac{\text{Distance}}{\text{Velocity}} = \dfrac{8}{2} = 4$ sec

Total time taken by particle to return at point O is $\Rightarrow T = t_{0A} + t_{AB} + t_{BC} = 3 + 1 + 4 = 8$ sec .

16. (b) The velocity time graph for given problem is shown in the figure.



Distance travelled S = Area under curve= 2+2=4m

17. (d) $a = \dfrac{dv}{dt} = \dfrac{dv}{dx}\dfrac{dx}{dt} = v\dfrac{dv}{dx} = -\alpha x^2$ (given)

$$\Rightarrow \int_{v_0}^{0} v dv = -\alpha\int_0^S x^2 dx \Rightarrow \left[\frac{v^2}{2}\right]_{v_0}^{0} = -\alpha\left[\frac{x^3}{3}\right]_0^S$$

$$\Rightarrow \frac{v_0^2}{2} = \frac{\alpha S^3}{3} \Rightarrow S = \left(\frac{3v_0^2}{2\alpha}\right)^{\frac{1}{3}}$$

18. (b) Average velocity =0 because net displacement of the body is zero.

Average speed $= \dfrac{\text{Total distance covered}}{\text{Time of flight}} = \dfrac{2H_{\max}}{2u/g}$

$$\Rightarrow v_{av} = \frac{2u^2/2g}{2u/g} \Rightarrow v_{av} = u/2$$

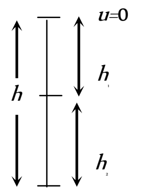
Velocity of projection = v (given)

$\therefore\ v_{\text{av}} = v/2$

19. (a) For first stone $u = 0$ and

For second stone $\dfrac{u^2}{2g} = 4h \Rightarrow u^2 = 8gh$

$\therefore\ u = \sqrt{8gh}$



Now, $h_1 = \dfrac{1}{2}gt^2$

$h_2 = \sqrt{8gh}t - \dfrac{1}{2}gt^2$

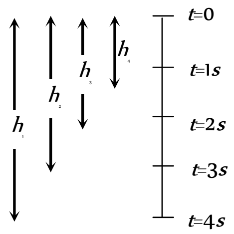
$u = \sqrt{8gh}$

where, t =time to cross each other.

$\because h_1 + h_2 = h$

$$\Rightarrow \frac{1}{2}gt^2 + \sqrt{8gh}t - \frac{1}{2}gt^2 = h \Rightarrow t = \frac{h}{\sqrt{8gh}} = \sqrt{\frac{h}{8g}}$$

20. (a) For first marble, $h_1 = \dfrac{1}{2}g\times 16 = 8g$



For Second marble, $h_2 = \dfrac{1}{2}g\times 9 = 4.5g$

For third marble, $h_3 = \dfrac{1}{2}g\times 4 = 2g$

For fourth marble, $h_4 = \dfrac{1}{2}g\times 1 = 0.5g$

$\therefore\ h_1 - h_2 = 8g - 4.5g = 3.5g = 35m.$

$h_2 - h_3 = 4.5g - 2g = 2.5g = 25m$ and

$h_3 - h_4 = 2g - 0.5g = 1.5g = 15m$.

21. (b) The velocity of balloon at height h, $v = \sqrt{2\left(\dfrac{g}{8}\right)h}$

When the stone released from this balloon, it will go upward with velocity $v = \dfrac{\sqrt{gh}}{2}$ (Same as that of balloon). In this condition time taken by stone to reach the ground

$$t = \frac{v}{g}\left[1 + \sqrt{1 + \frac{2gh}{v^2}}\right] = \frac{\sqrt{gh}/2}{g}\left[1 + \sqrt{1 + \frac{2gh}{gh/4}}\right]$$

$$= \frac{2\sqrt{gh}}{g} = 2\sqrt{\frac{h}{g}}$$

22. (b) For vertically upward motion, $h_1 = v_0t - \dfrac{1}{2}gt^2$ and for vertically down ward motion, $h_2 = v_0t + \dfrac{1}{2}gt^2$

$\therefore$ Total distance covered in t sec $h = h_1 + h_2 = 2v_o t$.

23. (d) Let height of tower is h and body takes t time to reach to ground when it fall freely.

$\therefore\ h = \dfrac{1}{2}gt^2$ ...(i)

In last second *i.e.* t^{th} *sec* body travels = 0.36 h

It means in rest of the time *i.e.* in $(t-1)$ *sec* it travels

$= h - 0.36h = 0.64h$

Now applying equation of motion for $(t-1)$ *sec*

$0.64h = \dfrac{1}{2}g(t-1)^2$ ...(ii)