2 Motion

To optimise athletic performance is training velocity. It has been suggested that training at a specific velocity improves strength mainly at that velocity and as velocity deviates from the trained velocity, the less effective training will be. Developing qualities such as strength, power and rate of force development would appear of greater importance than training at the actual movement velocity of a task. The ability of the nervous system to activate and coordinate agonist, synergist and antagonist activity would seem essential. It was suggested training techniques that simulate the velocity and acceleration profiles associated with the desired functional performance, such as throw or jump training, may optimise functional adaptation.

Mechanics, the oldest of the physical sciences, is the study of the motion of objects. The calculation of the path of a baseball or of a space probe sent to Mars is among its problems, as is the analysis of the tracks of the elementary particles. Formed following collision in our largest accelerators. When we describe motion, we are dealing with the part of mechanics called kinematics and when we analyse the cause of motion we are dealing with dynamics.

One of the most important topics in a motion is the motion of projectiles, such as a shotput. A shotput is a very ideal projectile to look at because it isn't affected much by the air it moves through. One can therefore ignore effects like air drag or aerodynamic lift in the case of a shot-put.

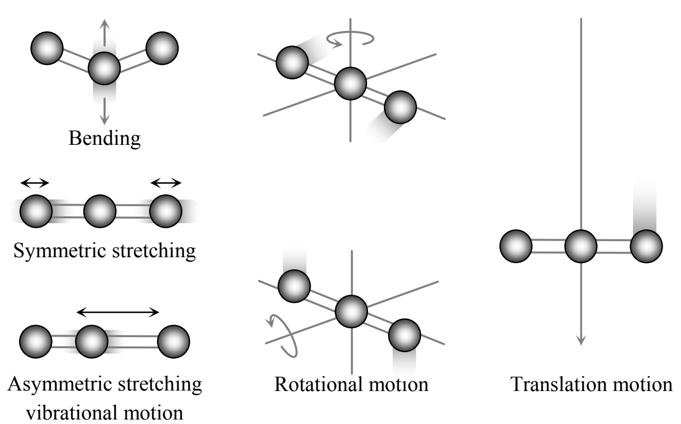


Figure: 2.1

Table: 2.1

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

Motion in One Dimension: Equations of Kinematics

$$\upsilon = u + at$$
$$s = ut + \frac{1}{2}at^2$$
$$v^2 = u^2 + 2as$$
$$s_t = u + \frac{1}{2}a(2t-1)$$

u = initial velocity

v = velocity after t se

s = displacement in t seconds

a = constant acceleration

s_t = displacement in second

The **displacement** of the jogger Δx (read as "Delta" x) is defined as his *change in position*. (We shall use the Greek letter delta, Δ, to denoted a change in any physical quantity) As he moves from one position to another, his displacement is given by the difference between his final and initial position, or $x_f - x_i$. Therefore, we write the displacement, or change in position, of the jogger as

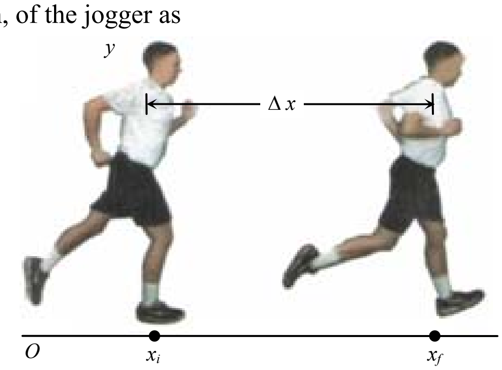


Figure: 2.2 A jogger moving along the x axis from x_i to x_f undergoes a displacement of $\Delta x = x_f - x_i$. $\Delta x \equiv x_f - x_i$

From this definition, we see that Δx is positive if x_f is greater than x_i and negative if x_f is less than x_i. If the jogger moves from an initial position of $x_i = 3\,\text{m}$ to a final position of $x_f = 15\,\text{m}$, his displacement is $\Delta x = 15\,m - 3\,m = 12\,m.$ Displacement is an example of a vector quantity.

Displacement-time graphs and their characteristics:

- If the graph is a straight line parallel to time-axis means that the body is at rest, i.e., $v = 0$.

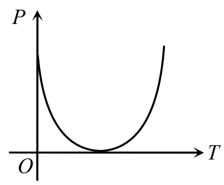


Figure: 2.3 This graph shows that at one instant the particle has two positions, which is not possible.

- A straight line inclined to x-axis shows that body is moving with a constant velocity. Remember that a straight line inclined x-axis by an angle $> 90°$ represent negative velocity.
- It is worth nothing that no line can ever be $\perp$ to the time axis because it implies infinite velocity.

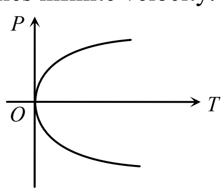


Figure: 2.4 The graph shows that particle coming towards origin initially and after that it is moving away from origin.

- If the curve is of the type whose slope decreases with time, the velocity goes on decreasing i.e., motion is retarded.
- If the curve is of the type whose slope increases with time, the velocity goes on increasing i.e., motion is accelerated. The slope of s-t graph gives velocity.

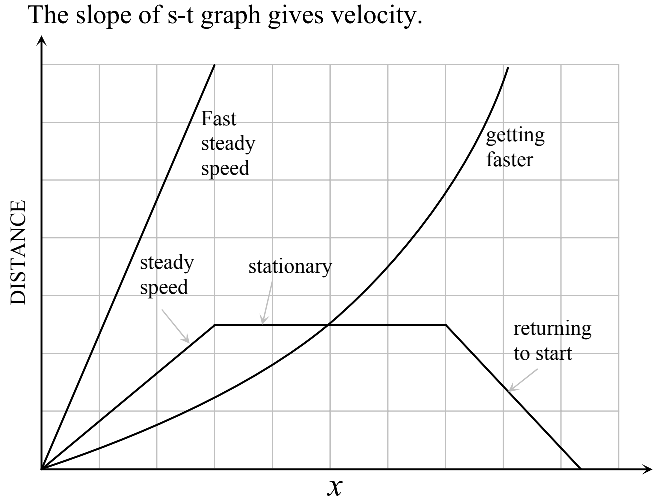


Figure: 2.5

The speed is magnitude of velocity and it can never be negative. The distance is length of actual path and it can never be negative.

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

Distance covered $\geq$ magnitude of displacement

When total journey is divided into distances s_1, s_2 which are traversed with speed v_1, v_2 respectively, then average speed v_{av} is given by $\frac{s_1 + s_2}{v_{av}} = \frac{s_1}{v_1} + \frac{s_2}{v_2}$ where $s = s_1 + s_2$

When journey is divided into time intervals t_1 and t_2 such that v_1 is the speed during time t_1 and v_2 is the speed during time t_2 then average speed $v_{av} = \frac{\text{Total distance}}{\text{Total time}} = \frac{v_1 t_1 + v_2 t_2}{t_1 + t_2}$

- 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} $\frac{v_1 \quad v_2}{2}$.
- 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} $\frac{2v_1 v_2}{v_1 \quad v_2}$.
- 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} $\frac{3v_1\, v_2\, v_3}{v_1 v_2 \quad v_2 v_3 \quad v_3 v_1}$.
- For two particles having displacement time graph with slopes θ_1 and θ_2 possesses velocities v_1 and v_2 respectively then $\frac{v_1}{v_2}$ $\frac{\tan\ _1}{\tan\ _2}$.
- Speedometer measures the instantaneous speed of a vehicle.

Velocity-time graphs and their characteristics:

- If the graph is a straight line parallel to time axis means that the body is moving with a constant velocity or acceleration (a) is zero.
- If the graph is a straight line inclined to the x-axis with $+ve$ slope means that the body is moving with constant acceleration.
- If the graph is a straight line inclined to x-axis with negative slope means that the body is under retardation. The slope of v-t graph gives acceleration.

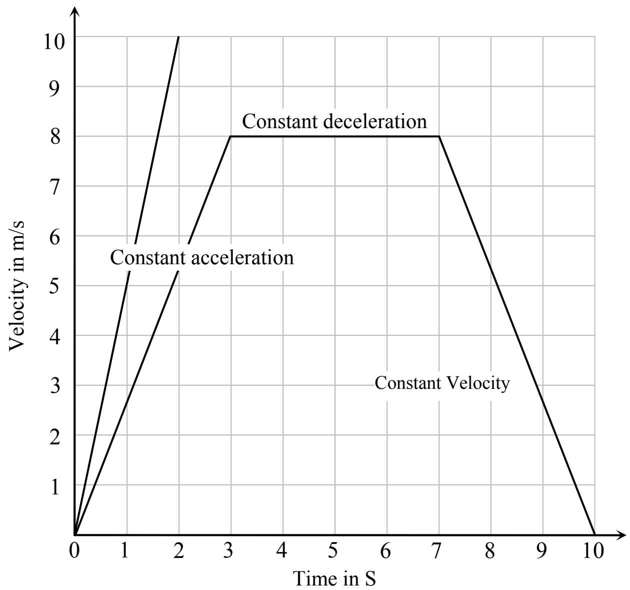


Figure: 2.6 The area enclosed by $v - t$ curve and times axis gives displacement.

Special Cases of Motion

Vertical motion

- 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 upward or downward direction.
- 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., $t = \sqrt{\frac{2h}{g}}$ and $v \quad \sqrt{2hg}$.
- 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 $(t_1) \quad \frac{u}{g}$.

$\therefore$ Total time of light $T \quad t_1 \quad t_2 \quad \frac{2u}{g}$.

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

- Change in speed $= u$
- Change in velocity $= u$
- Change in momentum $= mu$
- Change in kinetic energy = Change in potential energy $= \frac{1}{2}mu^2$

One return to the ground the changes in these quantities are as follows:

- Change in speed = 0
- change in velocity = $2u$
- Change in momentum = $2mu$
- Change in kinetic energy = Change in potential energy = 0

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

- Time taken to go up (ascent) < time taken to come down (descent)
- The speed of the object on returning to the ground is less than the initial speed. Same is true for velocity (magnitude), momentum (magnitude) and kinetic energy.
- Maximum height attained is less than $\frac{u^2}{2g}$.
- A part of the kinetic energy is used up in overcoming the fraction.
- A ball is dropped form 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 $t \quad \sqrt{t_1 t_2}$.
- A particle is dropped vertically form rest form 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., $\sqrt{1}, (\sqrt{2}-\sqrt{1}), (\sqrt{3}-\sqrt{2}), \ldots (\sqrt{4}-\sqrt{3}), \ldots$
- A body is thrown vertically upwards. If air resistance is to be taken into account, then the time of ascent is less than that time of descent, $t_2 > t_1$

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

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 works vertically downward.

So, $\quad h = \frac{1}{2}(g-a)t_2^2$

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

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

Comparing t_1 and t_2 we can say that $t_1 > t_2$, since $(g+a) > (g-a)$

Horizontal motion

- 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 $a_{av}\quad \frac{a_1t_1\quad a_2t_2}{t_1\quad t_2}$.
- If same force is applied on two bodies of different masses m_1 and m_2 separately then it produces acceleration 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 $a\quad \frac{a_1a_2}{a_1\quad a_2}$.
- If a body start from rest and moves with uniform acceleration then distance covered by the body in t sec is proportional to t^2 (i.e., $s \propto t^2$).

  So, we cay say that the ratio of distance covered in 1 sec, 2 sec and 3 sec is $1^2 : 2^2 : 3^2$ or $1 : 4 : 9$.
- A body moving with a velocity u is stopped by application of brakes after covering a distance s. If the same body moves with velocity nu and same braking force is applied on it then it will come to rest after covering a distance of n^2s.

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

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

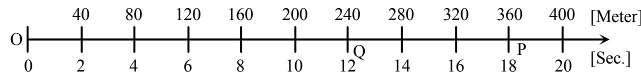
  $\Rightarrow \quad s = \frac{u^2}{2a},\ s \propto u^2$ [since a constant]

  So we cay 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 v_1 and v_2 at A and B respectively. If C is the mid-point between A and B then velocity of the particle at C is equal to $v\quad \sqrt{\frac{v_1^2\quad v_2^2}{2}}$.

Motion with Variable Acceleration:

- If acceleration is a function of time $a = f(t)$ then $v = u + \int_0^t f(t)\,dt$ and $s = ut + \int_0^t \left(\int f(t)\,dt\right) dt$
- If acceleration is a function of distance $a = f(x)$ then $v^2 = u^2 + 2\int_u^v f(x)\,dx$
- If acceleration is a function of velocity $a = f(v)$ then $t = \int_u^v \frac{dv}{f(v)}dx$ and $x = x_0 + \int_u^v \frac{vdv}{f(v)}$

Example 1. A car is moving along x-axis. As shown in figure it moves from O to P in 18 seconds and returns from P to Q in 6 seconds. What is the average velocity and average speed of the car in going from (i) O to P and (ii) from O to P and back to Q.



Solution: (i) Average velocity

$$\frac{\text{path length}}{\text{time interval}}\quad \frac{360m}{18}\quad 20\,ms^{\ 1}$$

Average speed $\frac{\text{path length}}{\text{time interval}}\quad \frac{360m}{18}\quad 20\,ms^{\ 1}$

(ii) From O to P and back to Q

Average velocity $= \frac{OQ}{18+6} = \frac{240m}{24} = 10\,ms^{-1}$

Average speed

$$= \frac{\text{path length}}{\text{time interval}} = \frac{OP+PQ}{18+6} = \frac{360+120}{24} = 20\,ms^{-1}$$

Example 2. A car covers the 1st half of the distance between two places at a speed of 40 kmh^{-1} and the 2nd half at 60 kmh^{-1}. What is the average speed of the car?

Solution: Suppose the total distance covered is 2S. Then time taken to cover first distance with speed 40 km/h, $t_1 = \frac{S}{40}h$

Time taken to cover second S distance with speed 60 km/h,

$t_2 = \frac{S}{60}h$

$$\Rightarrow \quad V_{av} = \frac{\text{total distance}}{\text{total time}} = \frac{S+S}{\left(\frac{S}{40}+\frac{S}{60}\right)}$$

$$\Rightarrow \quad V_{av} = \frac{2S}{\left(\frac{3S+2S}{120}\right)} = \frac{2S}{5S}\times 120$$

$$\Rightarrow \quad V_{av} = 48km/h$$

Example 3. A non-stop bus goes from one station to another station with a speed of 54 km/h, the same bus returns from the second station to the first station with a speed of 36 km/h. Find the average speed of the bus for the entire journey.

Solution: Suppose the distance between the stations is S. Time taken in reaching from one station to another station, $t_1 = \frac{S}{54}h$

Time taken in returning back, $t_2 = \frac{S}{36}h$

Total time, $t \quad t_1 \quad t_2$

$$t = \frac{S}{54} + \frac{S}{36} = \frac{2S + 3S}{108} = \frac{5S}{108}h$$

Average speed $V_{av} = \frac{\text{Total distance}}{\text{Total time}}$

$\Rightarrow \quad V_{av} = \frac{2S}{5S} \times 108$

$\Rightarrow \quad V_{av} = \frac{216}{5} = 43.2\, km/h$

Example 4. A car is moving at a speed of 50 km/h. Two seconds there after it is moving at 60 km/h. Calculate the acceleration of the car.

Solution: Here $u \quad 50\, km/h \quad 50 \quad \frac{5}{18} m/s$

$u \quad \frac{250}{18} m/s$

and $\quad v = 60\, km/h = 60 \times \frac{5}{18} m/s = \frac{300}{18} m/s$

Since $a \; = \frac{v-u}{t} = \frac{\frac{300}{18} - \frac{250}{18}}{2} = \frac{\frac{50}{18}}{2} = \frac{50}{36} = 1.39\, m/s^2$

Example 5. A car attains 54 km/h in 20 s after it starts. Find the acceleration of the car.

Solution: $u = 0$ (as car starts from rest)

$\Rightarrow \quad v = 54\, km/h = 54 \times \frac{5}{18} = 15\, m/s$

As, $\quad a = \frac{v-u}{t}$

$\therefore \quad a = \frac{15-0}{20} = 0.75\, m/s^2$

Example 6. A ball is thrown vertically upwards with a velocity of 20 m/s. How high did the ball go? (take $g = 9.8\, m/s^2$).

Solution: $u = 20\, ms$

$a = -g = -9.8\; m/s^2$ (moving against gravity)

$s = ?, v = 0$ (at highest point)

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

$(0)^2 - (20)^2 = 2(-g)s$

$\Rightarrow \quad -400 = 2(-9.8)s$

$\Rightarrow \quad -400 = -19.6\; s$

$\Rightarrow \quad \frac{400}{19.6} = s \quad \Rightarrow \; s = 20.4\; m$

Multiple Choice Questions

1. A body whose position with respect to surrounding does not change, is said to be in a state of:
a. Rest **b.** Motion **c.** Vibration **d.** Oscillation

2. In case of a moving body:
a. Displacement > Distance
b. Displacement < Distance
c. Displacement $\geq$ Distance
d. Displacement $\leq$ Distance

3. Vector quantities are those which have:
a. Only direction
b. Only magnitude
c. Magnitude and direction both
d. None of these

4. What is true about scalar quantities?
a. Scalars quantities have direction also.
b. Scalars can be added arithmetically.
c. There are special laws to add scalars.
d. Scalars have special method to represent.

5. A body is said to be in motion if:
a. Its position with respect to surrounding objects remains same.
b. Its position with respect to surrounding objects keeps on changing.
c. Both **a.** and **b.** .
d. Neither **a.** nor **b.**

6. A distance is always:
a. shortest length between two points.
b. path covered by an object between two points.
c. product of length and time.
d. none of the above

7. A displacement:
a. is always positive.
b. is always negative.
c. may be positive as well as negative.
d. is neither positive nor negative.

8. Examples of vector quantities are:
a. velocity, length and mass
b. speed, length and mass
c. time, displacement and mass
d. velocity, displacement and force

9. Which of the following is not characteristic of displacement?
a. It is always positive.
b. It has both magnitude and direction.
c. It can be zero.
d. Its magnitude is less than or equal the actual path length of the object.

10. S.I. unit of displacement is:

a. m **b.** ms^{-1}
c. ms^{-2} **d.** None of these

11. Which of the following is not a vector?

a. Speed **b.** Velocity
c. Weight **d.** Acceleration

12. Time is an example of:

a. Scalar **b.** Vector
c. Scalar or vector **d.** Neither scalar nor vector

13. In 5 minutes distance between a pole and a car changes progressively. What is true about the car?

a. Car is at rest.
b. Car is in motion.
c. Nothing can be said with this information.
d. None of the above

14. A distance:

a. is always positive.
b. is always negative.
c. may be positive as well as negative.
d. is neither positive nor negative.

15. When a body covers equal distance in equal intervals of time, its motion is said to be:

a. Non-uniform **b.** Uniform
c. Accelerated **d.** Back and forth

16. The motion along a straight line is called:

a. Vibratory **b.** Stationary
c. Circular **d.** Linear

17. A particle is traveling with a constant speed. This means:

a. Its position remains constant as time passes.
b. It covers equal distance in equal interval of time
c. Its acceleration is zero
d. It does not change its direction of motion

18. The rate of change of displacement is:

a. Speed **b.** Velocity
c. Acceleration **d.** Retardation

19. Speed is never:

a. zero **b.** Fraction
c. Negative **d.** Positive

20. The motion of a body covering different distances in same intervals of time is said to be:

a. Zig-Zag **b.** Fast **c.** Slow **d.** Variable

21. Unit of velocity is:

a. ms **b.** ms^{-1}
c. ms^2 **d.** none of these

22. A speed:

a. is always positive.
b. is always negative.
c. may be positive as well as negative.
d. is neither zero nor negative.

23. A particle moves with a uniform velocity:

a. The particle must be at rest.
b. The particle moves along a curved path.
c. The particle moves along a circle.
d. The particle moves along a straight line.

24. A quantity has value of $-6.0\ ms^{-1}$. It may be the

a. Speed of a particle
b. Velocity of a particle
c. Position of a particle
d. Displacement of a particle

25. In 10 minutes, a car with speed of 60 kmh^{-1} travels a distance of :

a. 6 km **b.** 600 km **c.** 10 km **d.** 7 km

26. A particle covers equal distances in equal intervals of times, it is said to be moving with uniform:

a. Speed **b.** Velocity
c. Acceleration **d.** Retardation

27. The SI unit of the average velocity is:

a. m/s **b.** km/s **c.** cm/s **d.** mm/s

28. Metre per second is not the unit of:

a. Speed **b.** Velocity
c. Displacement **d.** None of them

29. A car accelerated uniformly from 18 km/h to 36 km/h in 5 s. The accelerating is ms^{-2} is:

a. 1 **b.** 2 **c.** 3 **d.** 4

30. Out of energy and acceleration which is vector

a. Acceleration **b.** Energy
c. Both **d.** None of these

31. C.G.S. unit of acceleration is:

a. ms^{-2} **b.** cms^{-2} **c.** ms^2 **d.** cms^2

32. A train starting from a railway station and moving with uniform acceleration, attains a speed of 40 kmh^{-1} in 10 minutes, Its acceleration is:

a. 18.5 ms^{-2} **b.** 1.85 cms^{-2}
c. 18.5 cms^{-2} **d.** 1.85 ms^{-2}

33. The brakes applied to a cap produce a negative acceleration of 6 ms^{-2}. If the car stops after 2 seconds, the initial velocity of the car is:

a. 6 ms^{-1} **b.** 12 ms^{-1} **c.** 24 ms^{-1} **d.** zero

34. A body is moving with uniform velocity of 10 ms^{-1}. The velocity of the body after 10 s is:

a. 100 ms^{-1} **b.** 50 ms^{-1} **c.** 10 ms^{-1} **d.** 5 ms^{-1}

35. In 12 minutes a car whose speed is 35 kmh^{-1} travels of distance of:

a. 7 km **b.** 3.5 km **c.** 14 km **d.** 28 km

36. A body is moving along a straight line at 20 ms^{-1} undergoes an acceleration of 4 ms^{-2}. After 2 s, its speed will be:

a. 8 ms^{-2} **b.** 12 ms^{-1} **c.** 16 ms^{-2} **d.** 28 ms^{-2}

37. A car increase its speed from 20 kmh^{-1} to 50 kmh^{-1} is 10 sec, its acceleration is:

a. 30 ms^{-1} **b.** 3 ms^{-1} **c.** 18 ms^{-1} **d.** 0.83 ms^{-1}

38. When the distance travelled by an object is directly proportional to the time, it is said to travel with:

a. zero velocity **b.** constant speed

c. constant acceleration **d.** uniform velocity

39. A body freely failing from rest has a velocity V after it falls through a height h. The distance it has to fall further for its velocity to become double is:

a. 3 h **b.** 6 h **c.** 8 h **d.** 10 h

40. The velocity of bullet is reduced from 200 m/s to 100 m/s while traveling through a wooden block of thickness 10 cm. The retardation, assuming it to be uniform will be:

a. $10 \times 10^4\ m/s^2$ **b.** $10 \times 10^4\ m/s^2$

c. $13.5 \times 10^4\ m/s^2$ **d.** $15 \times 10^4\ m/s^2$

41. A body starts falling from height 'h' and travels distance h/2 during the last second of motion. The find of travel (in sec) is:

a. $\sqrt{2}-1$ **b.** $2+\sqrt{2}$ **c.** $\sqrt{2}+\sqrt{3}$ **d.** $\sqrt{3}+2$

42. Area between speed–time graph and time axis gives:

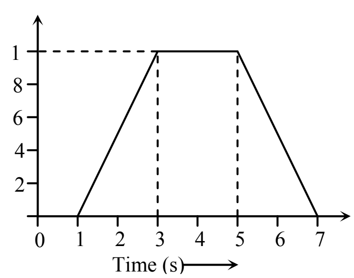
a. Distance **b.** Velocity

c. Speed **d.** None of these

43 An object undergoes an acceleration of 8 ms^{-2} starting from rest. Distance traveled is 1 s is:

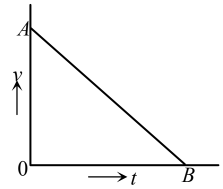
a. 2 m **b.** 4m **c.** 6m **d.** 8 m

44 For the velocity time graph shown in figure, the distance covered by the body in the last 2 seconds of its motion is what fraction is of the total distance covered in all the 7 seconds?



a. 1/2 **b.** 1/4 **c.** 1/3 **d.** 2/3

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



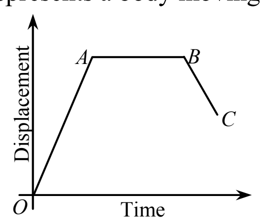
a. A uniform acceleration

b. A non-uniform retardation

c. Uniform speed

d. Initial velocity O*A* and is moving with uniform retardation

46. In figure BC represents a body moving:



a. Backward with uniform velocity

b. Forward with uniform velocity

c. Backward with non-uniform velocity

d. Forward with non-uniform velocity

47. Π Radian = ?

a. 57.3° **b.** 573° **c.** 180° **d.** 360°

48. An athlete complete one round of a circular track of diameter 200 m in 40 s. What will be the displacement at the end of 2 minutes 40 s?

a. 2200 m **b.** 220 m **c.** 22 m **d.** Zero

49. What will be the distance in the above equation?

a. 800 m **b.** 2500 m **c.** 2200 m **d.** Zero

50. The distance traveled by a body is directly proportional to the time, then the body is said to have:

a. Zero speed **b.** Zero velocity

c. Constant speed **d.** None of these

51. An athlete runs along a circular track of diameter 28 m. The displacement of the athlete after he completes one circle is:

a. 28 m **b.** 88 m **c.** 44 m **d.** Zero

52. A boy is running along a circular track of radius 7 m. He completes one circle in 10 seconds. The average velocity of the boy is:

a. 4.4 m^{-1} **b.** 0.7 ms^{-1} **c.** Zero **d.** 70 ms^{-1}

53. A body is moving with a uniform speed of 5 ms^{-1} in a circular path of radius 5 m. The acceleration of the body is:

a. 25 ms^{-2} **b.** 15 ms^{-2} **c.** 5 ms^{-2} **d.** 1 ms^{-2}

54. Unit of angular velocity is:
a. red **b.** m/s **c.** rad/s^2 **d.** rad/s

55. The bodies in circular paths of radii 1 : 2 take same time to compete their circles. The ratio of their linear speeds is:
a. 1 : 2 **b.** 2 : 1 **c.** 1 : 3 **d.** 3 : 1

56. In a circular path of radius 1m, a mass of 2kg moves with a constant speed 10 ms^{-1}. The angular speed in radian/sec. is:
a. 5 **b.** 10 **c.** 15 **d.** 20

57. The relation among v, ω and r is :
a. $\omega = \frac{v}{r}$ **b.** $v = \frac{\omega}{r}$
c. $\omega = \frac{r}{v}$ **d.** None of these

58. Uniform circular motion is an example of:
a. Variable acceleration **b.** Constant acceleration
c. **a.** and **b.** both **d.** None of these

59. Rate of change of angular velocity refer to:
a. angular speed **b.** angular displacement
c. angular acceleration **d.** None of these

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

61. 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:
a. $v_1 v_2$ **b.** $\frac{v_2^2}{v_1^2}$ **c.** $\frac{v_1 + v_2}{2}$ **d.** $\frac{2v_1 v_2}{v_1 + v_2}$

62. The displacement-time graph for two particles *A* and *B* are straight lines inclined at angles of 30°and 60° with the time axis. The ratio of velocities of $V_A : V_B$ is:
a. 1:2 **b.** $1 : \sqrt{3}$ **c.** $\sqrt{3} : 1$ **d.** 1 : 3

63. 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:
a. 25 km/hr **b.** 24 km/hr **c.** 50 km/hr **d.** 5 km/hr

64. 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:
a. 24/13 **b.** 40/13 **c.** 3 **d.** 1/2

65. 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:
a. 42.5 *km/hr* **b.** 40.0 *km/hr*
c. 37.5 *km/hr* **d.** 35.0 *km/hr*

66. One car moving on a straight road covers one-third of the distance with 20 *km/h* and the rest with 60 *km/h*. The average speed is:
a. 40 *km/h* **b.** 80 *km/h*
c. $46\frac{2}{3}$ *km/h* **d.** 36 *km/h*

67. 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?
a. 60 km/h **b.** 80 km/h
c. 120 km/h **d.** 180 km/h

68 Which of the following is a one-dimensional motion?
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

69. 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 metres is:
a. 56 sec **b.** 68 sec
c. 80 sec **d.** 92 sec

70. 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?
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.**

71. The ratio of the numerical values of the average velocity and average speed of a body is always
a. Unity **b.** Unity or less
c. Unity or more **d.** Less than unity

72. 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:

a. $\frac{2}{v}=\frac{1}{v_1}+\frac{1}{v_2}$ **b.** $v=\frac{v_1+v_2}{2}$

c. $v=\sqrt{v_1 v_2}$ **d.** $v=\sqrt{\frac{v_1}{v_2}}$

73. The correct statement from the following is:

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.

74. 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*

75. 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

a. $S_1 = S_2$ **b.** $3S_1 = S_2$ **c.** $2S_1 = S_2$ **d.** $4S_1 = S_2$

76. 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.** $10\ m$ **c.** $\frac{10}{\sqrt{2}}m$ **d.** $10 \times 2\,m$

77. A man goes 10 *m* towards North, then 20 *m* towards East then displacement is:

a. 22.5 *m* **b.** 25 *m* **c.** 25.5 *m* **d.** 30 *m*

78. 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

a. 10 *m* along North **b.** 10 *m* along South

c. 10 *m* along West **d.** Zero

79. An aeroplane flies 400 *m* North and 300 *m* South and then flies 1200 *m* upward then net displacement is:

a. 1200 *m* **b.** 1300 *m* **c.** 1400 *m* **d.** 1500 *m*

80. 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?*

a. Zero **b.** 2R **c.** $2\pi R$ **d.** $7\pi R$

81. A wheel of radius 1 metre 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:

a. 2π **b.** $\sqrt{2}\pi$ **c.** $\sqrt{\pi^2+4}$ **d.** π

82. The initial velocity of the particle is $10\ m/\sec$ and its retardation is $2\ m/\sec^2$. The distance moved by the particle in $5th$ second of its motion is:

a. $1\ m$ **b.** $19\ m$ **c.** $50\ m$ **d.** $75\ m$

83. 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:

a. $20 m/\sec^2$ **b.** $-20 m/\sec^2$

c. $-40 m/\sec^2$ **d.** $+2 m/\sec^2$

84. 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 $m/\sec$

85 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^{th} second of its motion is:

a. 25 *m* **b.** 35 *m* **c.** 50 *m* **d.** 85 *m*

ANSWERS

1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**	**10.**
a	d	c	b	b	b	c	d	a	a
11.	**12.**	**13.**	**14.**	**15.**	**16.**	**17.**	**18.**	**19.**	**20.**
a	a	b	a	b	d	b	b	c	d
21.	**22.**	**23.**	**24.**	**25.**	**26.**	**27.**	**28.**	**29.**	**30.**
b	a	d	b	c	a	a	c	a	a
31.	**32.**	**33.**	**34.**	**35.**	**36.**	**37.**	**38.**	**39.**	**40.**
b	b	b	c	a	d	d	b	a	d
41.	**42.**	**43.**	**44.**	**45.**	**46.**	**47.**	**48.**	**49.**	**50.**

b	a	b	b	d	a	c	d	a	c
51.	**52.**	**53.**	**54.**	**55.**	**56.**	**57.**	**58.**	**59.**	**60.**
d	c	c	d	a	b	a	b	c	b
61.	**62.**	**63.**	**64.**	**65.**	**66.**	**67.**	**68.**	**69.**	**70.**
d	d	b	b	c	d	a	d	c	d
71.	**72.**	**73.**	**74.**	**75.**	**76.**	**77.**	**78.**	**79.**	**80.**
b	a	a	b	b	a	a	c	a	b
81.	**82.**	**83.**	**84.**	**85.**					
c	a	b	d	a					

SOLUTIONS

25. **(c)** $d = ut$

$\Rightarrow \quad u = 60\frac{k}{h} = \frac{60k}{60kmh^{-1}}$

$\Rightarrow \quad u = 1$ k/min $t = 10$ min

$\Rightarrow \quad d = 1 \times 10 = 10\,km$

29. **(a)** $a = \frac{v_2 - v_1}{t}$

$\Rightarrow \quad v_1 = 18kh \quad \frac{5}{18} \quad 5\,\text{sec}$

$\Rightarrow v_2 = 36k/4 \times \frac{5}{18}$

$\Rightarrow \quad t = 5\,\text{sec}$

$\Rightarrow a = \frac{10-5}{5} = 1\,\text{m/sec}^2$

32. **(b)** $a = \frac{v-u}{t}$

$\Rightarrow \quad u = 0$

33. **(b)** $v = u + at$

34. **(c)** u = constant as uniform velocity

35. **(a)** $d = ut$

36. **(d)** $v = u + at$

37. **(d)** $a = \frac{v-u}{t}$

39. **(a)** $u^2 = u^2 + 2as$

$u = \sqrt{2as}$

$\frac{u_2}{u_1} \Rightarrow \sqrt{\frac{2gh_2}{2gh_1}} = 2 \Rightarrow \boxed{h_1 = 4h}$

$\therefore \quad h_2 - h_1 = 4h - h = 3h$

40. **(d)** $v^2 = u^2 + 2as$

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

41. **(b)** $s_t = u + \frac{1}{2}a(2t-1)$

44. **(b)** Area of Trapezium

47. **(a)** $180° = \Pi$ Radian

48. **(d)** Diameter = 200 m

$t = 2\,\text{min}\,40\,\text{sec}$

$t \quad 160$ sec means will complete four rounds.

$\therefore$ displacement = 0

49. **(a)** $d = 4 \times 200m \quad 800\,m$

52. **(c)** As in one round displacement is zero.

53. **(c)** $a = \frac{v^2}{r}$

$\Rightarrow \quad a = \frac{25}{5} = 5m/\text{sec}^2$

55. **(a)** $\frac{v_1}{v_2} = \frac{2\Pi r_1 \cdot t_2}{2\Pi r_2 \cdot t_1}$; As $t_1 = t_2 \Rightarrow \frac{v_1}{v_2} = \frac{r_1}{r_2}$

56. **(b)** $v = w \times r$

$\Rightarrow \quad w = \frac{v}{r} = \frac{10}{1} \Rightarrow w = 10$ rad/sec

61. **(d)** As the total distance is divided into two equal parts therefore distance averaged speed $\frac{2v_1v_2}{v_1 \quad v_2}$.

62. **(d)** $\frac{v_A}{v_B} = \frac{\tan\theta_A}{\tan\theta_B} = \frac{\tan 30°}{\tan 60°} = \frac{1/\sqrt{3}}{\sqrt{3}} = \frac{1}{3}$

63. **(b)** Distance average speed

$= \frac{2v_1v_2}{v_1+v_2} = \frac{2\times 20\times 30}{20+30} = \frac{120}{5} = 24\,km/hr$

64. **(b)** Distance average speed

$= \frac{2v_1v_2}{v_1+v_2} = \frac{2\times 2.5\times 4}{2.5+4} = \frac{200}{65} = \frac{40}{13}km/hr$

65. **(c)** Distance average speed

$= \frac{2v_1v_2}{v_1+v_2} = \frac{2\times 30\times 50}{30+50} = \frac{75}{2} = 37.5\,km/hr$

66. **(d)** Average speed $= \frac{\text{Total distance}}{\text{Total time}} = \frac{x}{t_1+t_2}$

$= \frac{x}{\frac{x/3}{v_1} + \frac{2x/3}{v_2}} = \frac{1}{\frac{1}{3\times 20} + \frac{2}{3\times 60}} = 36\,km/hr$

67. **(a)** Time average speed $= \frac{v_1+v_2}{2} = \frac{80+40}{2} = 60km/hr$.

69. **(c)** Total distance to be covered for crossing the bridge

= length of train + length of bridge

$= 150m + 850m = 1000m$

Time $= \frac{\text{Distance}}{\text{Velocity}} = \frac{1000}{45\times\frac{5}{18}} = 80\,\text{sec}$

70. **(d)** Velocity of particle $\frac{\text{Total displacement}}{\text{Total time}}$

$= \frac{\text{Diameter of circle}}{5} = \frac{2\times 10}{5} = 4\,m/s$

71. **(b)** $\frac{|\text{Average velocity}|}{|\text{Average speed}|} = \frac{|\text{displacement}|}{|\text{distance}|} \le 1$

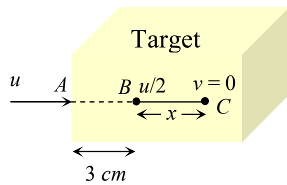
Because displacement will either be equal or less than distance. It can never be greater than distance.

73. **(a)** When the body is projected vertically upward then at the highest point its velocity is zero but acceleration is not equal to zero $(g = 9.8 m/s^2)$.

74. **(b)** Let initial velocity of the bullet = u

After penetrating 3 cm its velocity becomes $\frac{u}{2}$

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



$\Rightarrow \left(\frac{u}{2}\right)^2 = u^2 - 2a(3)$

$\Rightarrow 6a = \frac{3u^2}{4} \Rightarrow a = \frac{u^2}{8}$

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

$\Rightarrow 0 = \left(\frac{u}{2}\right)^2 - 2\left(\frac{u^2}{8}\right).x$

$\Rightarrow x = 1 \; cm$

75. **(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) $S_1 = S_2/3$

76. **(a)** $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$

$\therefore \; r = \sqrt{x^2 + y^2 + z^2}$

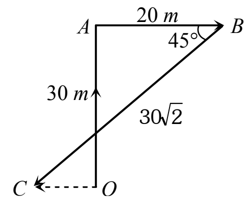
$\Rightarrow \; r = \sqrt{6^2 + 8^2 + 10^2} = 10\sqrt{2} \; m$

77. **(a)** $\vec{r} = 20\hat{i} + 10\hat{j}$

$\therefore \; r = \sqrt{20^2 + 10^2} = 22.5 \; m$

78. **(c)** From figure, $\overrightarrow{OA} = 0\vec{i} + 30\vec{j}, \overrightarrow{AB} = 20\vec{i} + 0\vec{j}$

$\overrightarrow{BC} = -30\sqrt{2}\cos 45°\vec{i} - 30\sqrt{2}\sin 45°\vec{j} = -30\vec{i} - 30\vec{j}$



$\therefore$ Net displacement,

$\overrightarrow{OC} = \overrightarrow{OA} + \overrightarrow{AB} + \overrightarrow{BC} = -10\vec{i} + 0\vec{j}$

$\Rightarrow \; |\overrightarrow{OC}| = 10 \; m.$

79. **(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.

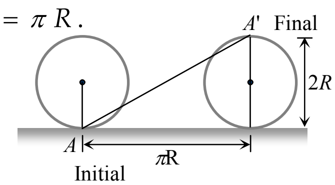
So, $r = \sqrt{(100)^2 + (1200)^2} = 1204 m \simeq 1200 m$

The option should be 1204 *m*, because this value mislead one into thinking that net displacement is in upward direction only.

80. **(b)** Total time of motion is 2 *m* in 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 = 2*R*.

81. **(c)** Horizontal distance covered by the wheel in half revolution = πR.



So, the displacement of the point which was initially in contact with ground

$= AA' = \sqrt{(\pi R)^2 + (2R)^2}$

$= R\sqrt{\pi^2 + 4} = \sqrt{\pi^2 + 4} \Rightarrow (As \; R = 1 \; m)$

82. **(a)** $S_n = u - \frac{a}{2}(2n-1) = 10 - \frac{2}{2}(2\times 5 - 1) = 1 \; metre$

83. **(b)** From $v^2 = u^2 + 2aS$

$\Rightarrow \; 0 = u^2 + 2aS$

$\Rightarrow \; a = \frac{-u^2}{2S} = \frac{-(20)^2}{2\times 10} = -20 m/s^2$

84. **(d)** $v = u + at = 10 + 2\times 4 = 18 \; m/\text{sec}$

85. **(a)** $S_n = u + \frac{a}{2}[2n-1]$

$\Rightarrow \; S_{5^{th}} = 7 + \frac{4}{2}[2\times 5 - 1] = 7 + 18 = 25m$

□ □ □