MOTION

1
CHAPTER

CONTENTS

Introduction

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

Type ofMotions

(a) According toDirections

- **One Dimensional motion or Straight line motion** is the motion of a particle moving along a straightline.
- **Two dimensional motion or Planer motion** A particle moving along a curved path in a plane has 2-dimensionalmotion.

(b) According to state ofmotion

UniformMotion

- Abodyissaidtobeinastateofuniformmotionifittravelsequaldistancesinequalintervalsoftime.
- Ifthetimedistancegraphisastraightlinethemotionissaidtobeuniformmotion.

Non-uniformmotion

- A body has a non-uniform motion if it travels unequal distances in equal intervals of time. e.g. a freely fallingbody.
- Time-distancegraphforabodywithnon-uniformmotionisacurvedline.

Distance & Displacement

- The path length between the initial and final positions of the particle gives the **distance** covered by theparticle.
- The minimum distance between the initial and final positions of a body during that time interval is called**displacement**.

2 Difference between distance and displacement.

- Distancetravelledisascalarquantitywhiledisplacementisavectorquantity.

  eg. if a body moves along the circumference of a circle of radius r, then the distance travelled is given by $2\pi r$, while the displacement is given byzero.
- When a body continuously moves in the same straight line and in the same direction then displacement will be equal to the distance travelled. But if the body changes its direction while moving, then the displacement is smaller than the distancetravelled.

  Displacement ≤Distance
- Displacementinanyintervaloftimemaybezero,positiveornegative.

Ex. A person travels a distance of 5 m towards east, then 4 m towards north and then 2 m towards west.

(i) Calculate the total distancetravelled.

(ii) Calculate the resultantdisplacement.

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

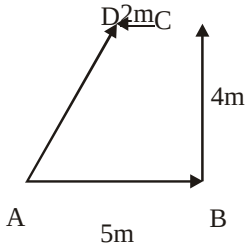
(ii)To calculate the resultant displacement, we choose a convenient scale, where 1 cm represents 1 m. We draw a 5 cm long line AB towards east and then 4 cm long line BC towards north. Finally, a 2 cm long line CD towards west. The resultant displacement is calculatedby joining the initial position A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

Since 1 cm = 1m

$\therefore$ 5 cm = 5m

Hence, the displacement of the person

= 5m towards AD.

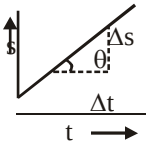


Speed and Velocity

- The 'distance' travelled by a body in unit time interval is called its **speed**. When the position of a body changes in particular direction, then speed is denoted by 'velocity'. i.e. the rate of change of displacementofabodyiscalledits**velocity**.
- Speed is a scalar quantity while velocity is a vectorquantity.
- Speed= $\frac{s_2 - s_1}{t_2 - t_2} = \frac{\Delta s}{\Delta t}$ = $\frac{\text{Distance Travelled}}{\text{Time Taken}}$

  Where Δs = displacement in time interval Δt.
- Velocity = $\frac{\Delta s}{\Delta t}$, Where$\Delta s$=distancetravelledintimeintervalΔt.
- Unit : In M.K.S.system =ms^{-1}; In C.G.S. system =ms^{-1}
- Iftimedistancegraphisastraightline,thenspeedcanbegivenbytheslopeoftheline,i.e.

$$v = \frac{\Delta s}{\Delta t} = \text{slope} = \frac{s_2 - s_1}{t_2 - t_1}$$



If θis more velocity will be more.

- The area of velocity time graph gives distancetravelled.

Ex. The distance between two points A and B is 100 m. A person moves from A to B with a speed of 20m/sandfromBtoAwithaspeedof25m/s.Calculateaveragespeedandaveragevelocity.

Sol. (i) Distance from A to B = 100 m

Distance from B to A = 100 m

Thus, total distance = 200 m

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

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

TimetakenfromBtoA,isgivenby

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

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

$\therefore$ Average speed of the person = $\frac{\text{Total distance covered}}{\text{Totaltime taken}} = \frac{200}{9}$ m/s = 22.2m/s

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

Ex. Acarmoveswithaspeedof40km/hrforfirsthour,thenwithaspeedof60km/hrfornexthalfhour and finally with a speed of 30 km/hr for next $1\frac{1}{2}$ hours. Calculate the average speed of the car.

Sol. Distancetravelledinfirsthour,isgivenby

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

Distance travelled in next half an hour, is given by

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

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

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

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

= 40 + 30 + 45 = 115 km

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

$\therefore$ Average speed = $\frac{\text{Total distance covered}}{\text{Total time taken}} = \frac{115\text{km}}{3\text{hrs}} = 38.33$ km/hr

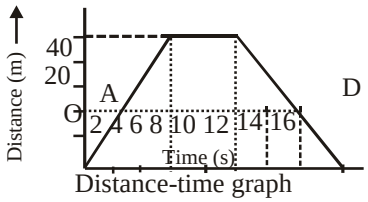
Ex. Figureshowstimedistancegraphofanobject.Calculatethefollowing:

(i) Whichpartofthegraphshowsthatthebodyisatrest?

(ii) Averagespeedinfirst10s.

(iii) Speeds in different parts ofmotion.

100 B C_{80}
60



Distance-time graph

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

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

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

(iii) Speed of the object in part AB is given byslope= $\frac{100}{6} = 50/3$ m/s

Speed of object in part BC = 0 m/s

Speed of object in part CD= $\frac{100-0}{16-10} = \frac{100}{6} = 50/3$ m/s

Ex. Figure shows the time-displacement graph of an object. Calculate thefollowing:

(i) Average velocity in the first4s.

(ii) Displacement at the end of10s.

(iii) After how much time, the object reaches its original position?

(iv) Velocity at t = 2 s, and at t =6s

Sol. (i) Average velocity in first 4 s, is given by

$$v = \frac{\text{Totaldisplacement(in4seconds)}}{4\text{s}} = \frac{20}{4} = 5\text{m/s}$$

(ii) Displacement at the end of 10 s = 20m

(iii) It is clear from the graph that the object comes toits original position.

i.e. displacement = 0, after 7 seconds and again after 13 seconds.

(iv) At t = 2 s, v = slope = $\frac{0-20}{3-1} = \frac{-20}{2} = -10$ m/s

At t =6s, $v = \frac{0-20}{7-5} = \frac{-20}{2} = -10$ m/s

➢ Acceleration

- Rateofchangeofvelocityiscalledacceleration
- Thechangeinvelocitymaybeinmagnitudeorindirectionorboth.i.e. $a = \frac{v-u}{t}$
- Unit of acceleration = m/s^2 or ms^{-2}

2 Types of acceleration : Uniform & Non uniform acceleration

- **Uniform acceleration :** If a body travels in a straight line and its velocity increases by equal amounts in equal intervals of time then it is said to be in state of uniform acceleration e.g. motion of a freely fallingbody.
- **Non uniform acceleration :** A body has a non-uniform acceleration if its velocity increases by unequal amounts in equal intervals oftime.

- **Average acceleration** : $a_{av} = \dfrac{v_2 - v_1}{t_2 - t_1} = \dfrac{\Delta v}{\Delta t}$

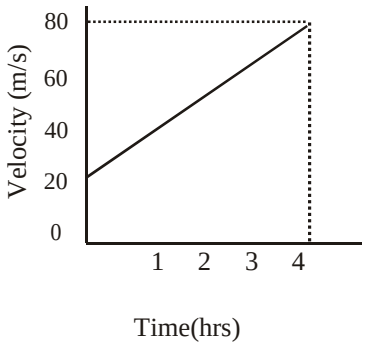
[here it is assumed that acceleration remains the same during the time i

m/s^2.

Sol. As it is clear from thefigure,

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

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



$\therefore$ Acceleration, $a = \frac{\text{Changeinvelocity}}{\text{Time in terval}}$

$$= \frac{\Delta v \quad v - v}{\Delta t = t_2 - t_1} = \frac{(80-20)\text{m/s}}{(4-0)} = 15\text{m/s}^2$$

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

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

Using the equation v = u + at,

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

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

$$a = \frac{6-0}{30} = 0.2\text{m/s}^2;$$ which is positiveacceleration.

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

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

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

➢Equations of Motion

2 Motion under uniformacceleration

Suppose a body starts with initial velocity u, moving with an acceleration attains a velocity v after time t travels a distance s, then motion can be described by followingequations.

(a) $v = u + at$

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

(c) $v^2 = u^2 + 2as$

- The equations of motion under gravity can be obtained by replacing acceleration by acceleration due togravity(g)andcanbewrittenasfollows:
- When the body is coming towards the centreof earth

(a) $v = u + gt$;

(b) $h = ut + \frac{1}{2}gt^2$;

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

- When a body is thrown upwards with some initial velocity, then a retardation produced due to attractionoftheearth.Inequationsofmotion,aisreplacedby(–g)andthusequationsbecome.

(a) v=u–gt;

(b) $h = ut - \frac{1}{2}gt^2$;

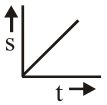
(c) $v^2 = u^2 - 2gh$

- Distance covered by a body in n^{th} sec. i.e.$s_n = u + \frac{1}{2}a(2n - 1)$

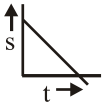
➢ Various Graphs Related to Motion

² Displacement- time graph:

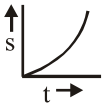
- Thestraightlineinclinedtotimeaxisins-tgraphrepresentsconstantvelocity.



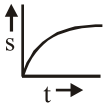
- Thestraightlineinclinedtotimeaxisins-tgraphrepresentsconstantnegativevelocity.



- Body with accelerated motion (velocityincreasing)

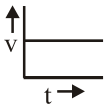


- Body with decelerated motion (velocitydecreasing)

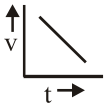


² Velocity -time graph:

- For the body having constant velocity or zero acceleration.

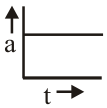


- Thebodyismovingwithconstantretardationanditsinitialvelocityisnotzero.

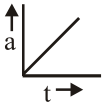


² Acceleration time graph:

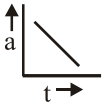
- Acceleration isconstant



- Acceleration is increasing and is+ve



- Acceleration is decreasing and is–ve



➢Circular Motion

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

² Uniform circular motion:

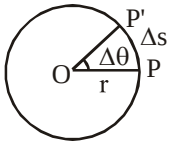
- If the partical travels out equal angles in equal times, then its motion is said to be uniform circularmotion.
- In uniform circular motion speed remainsconst.

² Linear velocity (v):

It is defined as distance travelled per unit time on a circular path.

² Angular velocity (ω):

It is defined as angle travelled per unit time on a circular path.



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

- Unit is Radian/sec. orrad/s
- v =rωwhere r = radius ofthe circle.
  v = Linear velocity
  w = Angularvelocity

² Centripetalacceleration

- In uniform circular motion the particle experiences an acceleration called the centripetalacceleration.
- $a_c = \frac{v^2}{r}$
- The direction of centripetal acceleration is along the radius towards thecentre.

² Centripetal force:

- Always acts towardscentre.
- Centripetal force is required to move a particle in acircle.
- Because F_c is always perpendicular to velocity or displacement, hence the work done by this force will always bezero.

Note :

- Circularmotioninhorizontalplaneisusuallyuniformcircularmotion.
- Remember that equations of motion are not applicable for circularmotion.

² Time period:

- It is the time taken to complete one completerevolution.
- Inonerevolution,anglesubtendedis2πandifTistimeperiod,thentheangularvelocityisgivenby

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

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

2 Frequency:

- Frequencyisdefinedastheno.ofrevolutionspersecond.

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

Ex. Thelengthofsecond'sneedleinawatchis1.2cm.Calculatethefollowing:

(i) Angular velocityand

(ii) Linear velocity of the tip of theneedle.

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

$\therefore$ Time period, T = 60 s

Angular velocity,

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

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

Linear velocity of the tip of the needle is given by

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

$$\text{or } v = \frac{\pi}{25} = 1.266 \times 10^{-1} \text{cm/sec.}$$

Ex. Earthrevolvesaroundthesunin365days.Calculateitsangularvelocity.

Sol. Time period,

T = 365 days

= 365 × 24 × 60 × 60seconds

$\therefore$ Angular velocity,

$$\omega = \frac{2\pi}{T} = \frac{2\pi}{365 \times 24 \times 60 \times 60} \text{ rad/s} = 1.99 \times 10^{-7} \text{ rad/s.}$$

EXERCISE - 1

A. Very Short Answer TypeQuestion.

Q.1 What does the slope of time distance graph represent?

Q.2 What does the slope of time-velocity graph represent?

Q.3 What is the acceleration of a body moving with constant velocity?

Q.4 What is the unit of acceleration in MKS system?

Q.5 What does area under time-velocity graph represent?

Q.6 Define uniform circularmotion.

Q.7 What is the relation between linear velocity and angular velocity?

Q.8 Definevelocity.

B. Short Answer TypeQuestion

Q.9 A body falls from a height of 500 m. In how muchtime,willitstriketheground?

Q.10 Differentiate between the following:

(i) speed andvelocity,

(ii) distance anddisplacement

Q.11 A body starts moving with an initial velocity 50 m/s and acceleration 20 m/s^2. How much distance it will cover in 4s ? Also, calculate its average speed during this timeinterval.

Q.12 A body is moving with a speed of 20 m/s. When certainforceis applied, an acceleration of 4 m/s^2 is produced. After howmuchtimeitsvelocitywillbe80m/s?

Q.13 A body starts from rest and moves with a constant acceleration. It travels a distance s_1 in first 10 s, and a distance s_2 in next10 s. Find the relation between s_2 and s_1.

Q.14 A train is moving with a velocity 400 m/s. With the application of brakes a retardation of 10 m/s^2 is produced. Calculate the following:

(i) After how much time it will stop?

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

Q.15 A body is thrown vertically upwards with an initial velocity of 19.6 m/s. If g = –9.8 m/s^2. Calculate the following:

(i) Themaximumheightattainedbythebody.

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

Q.16 From the top of a tower of height 490 m, a shell is fired horizontally with a velocity 100 m/s. At what distance from the bottom ofthetower,theshellwillhittheground?

Q.17 The brakes applied to a car produce a negative acceleration of 6 m/s^2. If the car takes 2 seconds to stop after applying the brakes, calculate the distance it travelsduring thistime.

Q.18 A particle moves in a circle of radius 2 m and completes 5 revolutions in 10 seconds. Calculate the following:

(i) Angular velocityand

(ii) Linearvelocity.

EXERCISE- 2

A Single Correct Answer type Questions

Q.1 A car increases its speed from 36 km/hr to 72 km/hr in 10 s. Its accelerationis

(A)1m/s^2 (B) 2m/s^2

(C)3.6m/s^2 (D) 5m/s^2

Q.2 The rate of change of displacement with time iscalled

(A) speed (B)velocity

(C)angularvelocity (D)acceleration

Q.3 Thevelocityofanobjectisdirectlyproportional to the time elapsed. The objecthas

(A) uniformspeed

(B) uniformvelocity

(C) uniformacceleration

(D) variableacceleration

Q.4 A body whose speed isconstant

(A) has a constantvelocity

(B) must beaccelerated

(C) might beaccelerated

(D) can not beaccelerated

Q.5 An object is moving with a constant velocity of 10 m/s, then itsacceleration is

(A) zero (B) 10m/s^2

(C)5m/s^2 (D) 20m/s^2

Q.6 A particle moves with a uniform positive acceleration. Its velocity-time graph isa

(A) straight line parallel to timeaxis

(B) straight line parallel to velocityaxis

(C) straightlineinclinedtotimeaxis

(D) parabola

Q.7 A ball is thrown vertically upwards, It rises to a height of 20 m and comes back to the same place, thenthe

(A) total distance covered by the ball iszero

Q.8 A body moves with a constantacceleration upto 10s. It travels a distance s, in first 5s and a distance s_2 in next 5s,then

(A) $s_2 = s_1$ (B) $s_2 = 2s_1$

(C) $s_2 = 3s_1$ (D) $s_2 = 4s_1$

Q.9 The slope of speed-time graphgives

(A) displacement (B) velocity

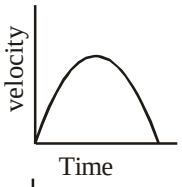
(C) acceleration (D)momentum

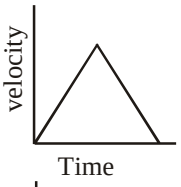
Q.10 A particle moves in a straight line. It travels for first half time with a velocity v_1 and for next half time with a velocity v_2. The averagevelocityoverthecompletepathis

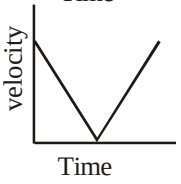
(A) $\frac{\overline{v_1+v_2}}{2}$ (B) $\overline{\frac{2v_1v_2}{v_1+v_2}}$

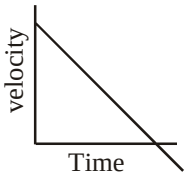
(C) $\frac{v_1-v_2}{2}$ (D) $v_1 + v_2$

Q.11 A particle is thrown vertically up with some initial velocity and comes back to theground. Its velocity-time graph is representedby

(A) 

(B) 

(C) 

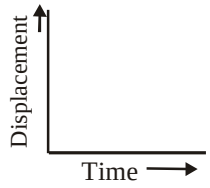
(D) 

(B) netdisplacementoftheballiszero

(C) displacement is 40m

(D) both distance moved and displacement are 40 meach

Q.12 The following time-displacement graph (fig.) represents



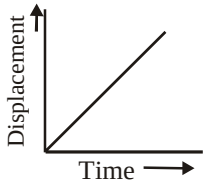
(A) zerovelocity

(B) constantvelocity

(C) increasingvelocity

(D) decreasingvelocity

Q.13 The following time-displacement graph(fig.)



(A) zerovelocity

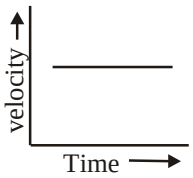
(B) constantvelocity

(C) increasingvelocity

(D) decreasingvelocity

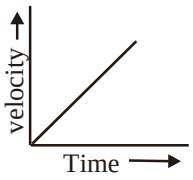
Q.14 The following time-velocity graph (fig.) represents

(A) zeroacceleration
(B) constantacceleration
(C) increasingacceleration
(D) decreasingacceleration



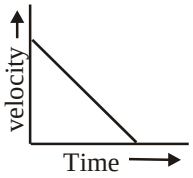
Q.15 The following time-velocity graph (fig) represents

(A) zeroacceleration
(B) positiveacceleration
(C) negativeacceleration
(D) variableacceleration



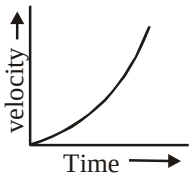
Q.16 The following time-velocity graph (fig.) represents

(A) zeroacceleration
(B) positiveacceleration
(C) negativeacceleration
(D) variableacceleration



Q.17 The following time-velocity graph (fig.) represents

(A) zeroacceleration
(B) constant acceleration
(C) increasingacceleration
(D) decreasingacceleration



Q.18 Which of the following quantities is a vector quantity?

(A) time (B)distance
(C)speed (D)velocity

Q.19 Which of the following quantities is/are a vector quantity?

(A) Mass (B)Length
(C)work (D)Momentum

Q.20 Which ofthe following is incorrect statement?

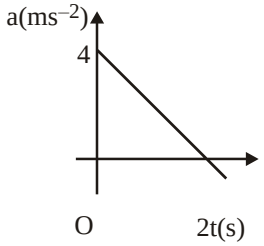
(A) speed is a scalar quantity while velocity is a vectorquantity

(B) speed may be positive or negative but velocity is alwayspositive.

(C) The change in the position of a body in a particular direction is called displacement.

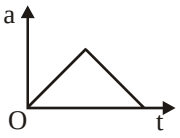
(D) displacement can be positive as well as negative.

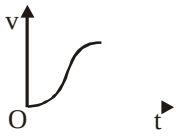
Q.21 The acceleration versus time graph of a particle moving in a straight line is shown in the figure. The velocity-time graph of the particle would be–

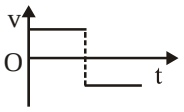


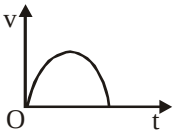
(A) a straight line (B) aparabola
(C)acircle (D) anellipse

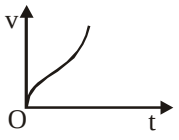
Q.22 The acceleration versus time graph of a particle is as shown in figure. The respective v–t graph of the particle is–



(A) 

(B) 

(C) 

(D) 

Q.23 The displacement of a particle isproportional to the cube of time. Then magnitude of its acceleration–

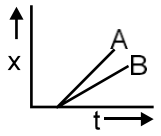
(A) increases withtime

(B) decreases withtime

(C) constant but not zero

(D) zero

Q.24 Figure shows two displacement-time graphs for particles A and B. Their relativevelocity-



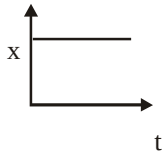
(A) zero

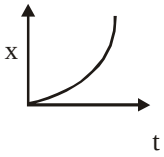
(B) non-zero butconstant

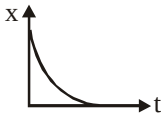
(C) continuouslydecreases

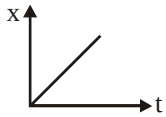
(D) continuouslyincreases

Q.25 Which of the following distance-time graphs represents one dimensional uniformmotion?

(A) 

(B) 

(C) 

(D) 

Q.26 A stone falls from the top of the towerin 8 sec. How much time will it take to cover the first quarter of the distance starting from the top?

(A) 4s (B) 2s (C) 1s (D) none

Q.27 The slope of the velocity-time graph for retarded motionis–

(A) positive (B) negative

(C)zero (D)infinite

Q.28 A car travels along a straight line with speed V_1 from A to B and returns back from B to A with speed V_2. The average speed of the carduringitsjourneyisgivenby–

(A) $\frac{V_1+V_2}{2}$ (B)(B) $\frac{2V_1V_2}{V_1+V_2}$

(C) $\frac{V_1V_2}{V_1+V_2}$ (D) $\sqrt{V_1V_2}$

Q.29 A particle moves on a circular path with constant speed. What is the nature of its acceleration– (A) it iszero

(B) it isuniform

(C) its directionchanges

(D) its magnitudechanges

Q.30 A stone thrown upward with a speed u from the top of the tower reaches the groundwith the velocity 3u. The height of the tower is–

(A)$3u^2/g$ (B)$4u^2/g$

(C)$6u^2/g$ (D)$9u^2/g$

Q.31 The velocity of a body depends on time according to the equation $v = 20 + 0.1t^2$.The body isundergoing–

Q.32 A driver applies the brakes on seeing traffic signal 400 m ahead. At the time ofapplying the brakes vehicle was moving with 15 $ms^{-1}$and retarding with 0.3 ms^{-2}. The distance of vehicle after 1 minute from the traffic light is–

(A)25m (B)375m

(C)360m (D) 40m

Q.33 Choose the wrongstatement–

(A) zero velocity of a particle does not necessarily mean that its acceleration is zero.

(B) zero acceleration of a particle does not necessarily mean that its velocity iszero.

(C) if speed of a particle is constant, its acceleration must be zero.

(D) none ofthese

Q.34 Which statements can be impossible cases in one/two dimensionalmotion–

(A) A body has zero velocity and still be accelerating

(B) The velocity of an object reverses direction when acceleration isconstant

(C) An object be increasing in speed as its acceleration decreases.

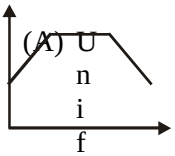
(D) None of these

Q.35 A body falling for 2 sec covers a distance 'S' which is equal to that covered in next 1 sec. If g = 10 m/sec^2 the distance S is–

(A)30m (B) 10m

(C)60m (D) 20m

Q.36 Which of the following graphs represents the uniformmotion–

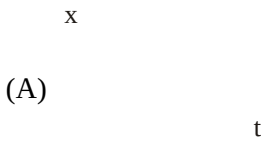
(A) 

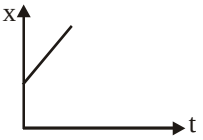
(B) Uniformretardation

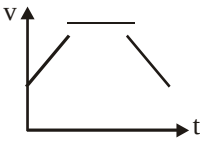
(C) Non-uniformacceleration

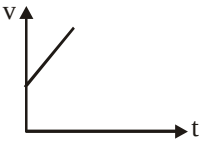
(D) Zeroaccelera

tion

(A) 

(B) 

(C) 

(D) 

ANSWER KEY

EXERCISE- 1

A. Very Short Answer TypeQuestion

Sol.1 The slope of time distance graph represents speed.

Sol.2 The slope of time-velocity graph represents acceleration.

Sol.3 The acceleration of a body moving with constant velocity iszero.

Sol.4 The unit of acceleration inM.K.S ismetre per secondm/s²

Sol.5 The area under time – velocity graph represents the displacement.

Sol.6 When a body moves in a circular path with uniform speed or constant speed, its motion is called uniform circular motion.

Sol.7 The relation between linear velocity & angular velocity is :

Linearvelocity=angularvelocity×Radiusof the circularpath.

$v = \omega \times r$

where, v = linear velocity

ω= angular velocity

r = radius of circular path

Sol.8 The distance travelled in a unit time in a particular direction or displacement per unit time or rate of change of displacement.

B. Short Answer TypeQuestion

Sol.9 S(h) = 500m

$a(g) = 9.8 m/s^2$ or $10 m/s^2$

u =0m/s; v =0m/s

t = ?

as $S = ut + \frac{1}{2}at^2$ $\Rightarrow 500 = 0 + \frac{1}{2}(10)t^2$

$500 = 5t^2$ $\Rightarrow 100 = t^2$

(b) Distance is always greater than displacement.

(c) Distance is always positive & increasing with time whereas displacement may be positive,negativeorzero.

(d) Distance is path depended where as displacementalwaysdependsoninitial&final pointsonly

(ii) Speed &velocity

(a) Speedisscalerwhereasvelocityisvector.

(b) Speedispathdependent,velocitydoesn't.

(c) Bothspeed&velocitymayincreaseordecrease but speed is always ≤ 0 whereas velocitymaybepositive,negative&zero.

Sol.11 Given : u = 50 m/s, $a = 20 m/s^2$,

t = 4s, s = ?

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

= 200 + 160 = 360 m

Average speed during this interval,

$\bar{v} = \frac{\text{distancetravelled}}{\text{timeinterval}} = \frac{360}{4} = 90 m/s$

Sol.12 Given : u =20m/s, $a = 4 m/s^2$,

v = 80 m/s, t =?

Using equation, v = u + at, we get

$80 = 20 + 4 \times t$

or $4t = 80 - 20 = 60$ or $t = 15$ s

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

Sol.13 Given : u = 0, t_1 = 10s

∴ Distance travelled in first 10 seconds, is given by

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

t = 10 s

Sol.10 (i) (a) Distance is scalar & displacement is vector.

$=50a$ ...(1)

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

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

$$= 200a \quad ...(2)$$

$\therefore$ Distance travelled in 10th second interval,

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

or $s_2 = 150a$

$$\frac{s_2}{s_1} = \frac{150a}{50a} = \frac{3}{1} \quad \text{or} \quad s_2 = 3s_1$$

Sol.14 (i) Given: $u = 400$ m/s, $a = -10$ m/s^2, $v = 0$, $t = ?$

Using equation, $v = u + at$, we get

$0 = 400 + (-10) \times t$ or $t = 40$s

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

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

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

or $20s = 400 \times 400$

or $s = 8000$ m $= 8$km

Sol.15 (i) Given: $u = 19.6$ m/s, $g = -9.8$ m/s^2, $v = 0$, $h = ?$

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

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

or $h = \frac{19.6 \times 19.6}{2 \times 9.8} = 19.6$ m

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

$v = u + gt$

or $0 = 19.6 + (-9.8) \times t$

or $t = 2$s

In the same time, it will come back to its original position.

$\therefore$ Total time $= 2 \times 2 = 4$s

Sol.16 We know that the horizontal motion and the vertical motion are independent of each other. Now for vertical motion, we have $u = 0$, $h = 490$ m, $g = 9.8$ m/s^2, $t = ?$

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

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

or $t^2 = \frac{490}{4.9} = 100$ or $t = 10$ s

$\therefore$ It takes 10 seconds to reach the ground.

Now, horizontal distance

= horizontal velocity $\times$ time

$= 100$ m/s $\times$ 10 s $= 1000$ m

$\therefore$ The shell will strike the ground at a distance of 100 m from the bottom of thetower.

Sol.17 Given: $a = -6$ m/s^2, $t = 2$ s and $v = 0$ m/s

Using theequation,

$v = u + at$, we get

$0 = u + (-6) \times 2$

[ΘSince final velocity, $v = 0$]

or $u = 12$m/s

Now by using the equation

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

we get

or $s = 12 \times 2 + \frac{1}{2} \times (-6) \times (2)^2 = 12$ m

Thus, the car will move 12 m before it stops after applying the brakes.

Sol. 18 Since, it completes 5 revolutions in 10 seconds.

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

(i) Now angularvelocity,

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

(ii) Linear velocity is givenby

$v = r\omega = 2\pi \therefore$ $v = 2\pi$m/s

EXERCISE - 2

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	A	B	C	C	A	C	B	C	C	A	D	A	B	A	B
Ques.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ans.	C	C	D	D	B	B	A	A	B	D	A	B	B	C	B
Ques.	31	32	33	34	35	36									
Ans.	C	A	C	D	A	B									