Motion

Motion, Position, distance & displacement.

Q.1 What do you mean by a body is at rest?

A body is said to be at rest, if it does not change its position with respect to a fixed point in it surroundings.

Q.2 What do you mean by a body is in Motion?

Movement of any object from one position to another position with respect to the observer is called as Motion.

Q.3 Define position of an object and reference point?

Position : Position is the location of the object.

Reference point : It is the point from which the location of object is measured. It is often called as origin.

An object can be located only with the help of reference point and its direction.

Q.4 What do you mean by the motion in Straight line?

When an object moves in Straight line with respect to the observer then the motion is called straight line motion.

Ex. Motion of lift.

Q.5 What do you understand by the Distance and Displacement?

Distance : It is the actual path travelled by an object from its initial position to final position. It is a scalar quantity.

Displacement : It is the shortest straight line path between initial and final position.

If the initial and final points are same then displacement will be zero.

Distance is always greater than or equal to displacement.

Q.6 Define Uniform and Non-uniform Motion?

Uniform motion : It is a motion, in which equal distance is covered in equal time intervals.

Non - uniform motion : It is a motion, in which unequal distance is covered in equal intervals of time.

Q.7 Is displacement a scalar quantity?

No, displacement is not scalar quantity. It is vector quantity.

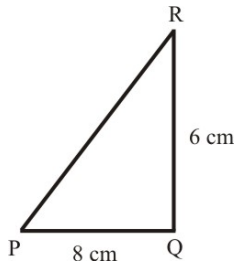
Q.8 Under what conditions can a body travel a certain distance and yet its resultant displacement be zero?

If the initial and final points are same then displacement will be zero. Then, a body can travel a certain distance.

Q.9 What type of motion is exhibited by a freely falling body?

The **motion** is non-uniform but a **freely falling body** is uniformly accelerated because while falling it is not covering the equal amount of distance at equal intervals.

Q.10 An ant travels a distance of 8 cm fro P to Q and then moves a distance of 6 cm at right angles to PQ. Find its resultant displacement.



The Ant starts from point P and moves to Q covering 8cms.

Now, turns right angles and moves to R covering 6cm.

The resultant displacement PR is the shortest distance from initial(P) and final position(R).

$PR^2 = PQ^2 + QR^2$

$= (8)^2 + (6)^2$

$= 64 + 36$

Hence PR = 10cm

Q.11 If on a round trip you travel 6 cm and then arrive back home.

(a) What distance have you travelled?

(b) What is your final displacement?

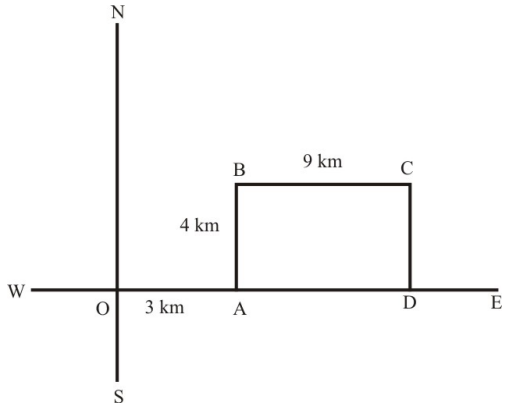
(a) Distance travelled is 6 km

(b) Final and initial position same. So that final displacement is zero.

Q.12 A body travels a distance of 3 km towards East then 4 km towards North and finally 9 km towards East.

(a) What is the total distance traveled?

(b) What is the resultant displacement?



(a) The total traveled distance is

3km + 4km + 9 km = 16 km

(b) The resultant displacement is OC (as shown in fig)

OA= 3km; AB=CD= 4km; BC=AD= 9km

OD= OA+ AD= 3+9= 12 km.shortest distance = 3 + 9 = 12 km.

In triangle OCD,

$OC^2 = OD^2 + CD^2$

$$OC = \sqrt{(12)^2 + (4)^2} = 12.65\,km$$

Q.13 A particle is moving in a circular path of radius r. The displacement after half a circle would be?

The displacement after half a circle would be 2r.

SPEED, VELOCITY AND ACCELERATION

Q.14 Define speed and Velocity with their S.I. Unit?

Speed : It is the distance traveled by an object in unit time. It is scalar quantity. It's SI unit is metre/sec.

Speed = Distance traveled / taken time

Velocity : It is the displacement of a body in unit time.

Velocity = displacement of object/time taken.

It is vector quantity. It's S.I. unit is meter/sec.

Q.15 Define acceleration with its S.I. unit?

Acceleration is measure of change of velocity with time. It is also called rate of change of velocity. S.I. Unit is metre/sec^2. It is a Vector quantity.

Acceleration = Change in velocity / Total time taken

If u is initial velocity and v is final velocity of an object and taken time t. then

Acceleration = (v – u) / t

Q.16 Define average speed and average velocity?

Average speed : The ratio of total distance travelled to total time taken by the body gives its average speed.

Average speed = Total distance travelled / Total time taken

Average velocity : The ratio of total displacement over total time taken by the body gives its average velocity.

Average velocity = Total displacement \ Total time taken

Average speed is always greater than average velocity except in case of straight line motion without U-turn when both are equal.

When direction of motion changes, velocity also changes.

Q.17 What are the Instantaneous speed and velocity?

Instantaneous speed : It is the speed of an object at a particular moment (instant) in time.

Instantaneous velocity : It is the velocity of an object in motion at a specific point in time.

Q.18 What is Retardation?

If the velocity of an object decreases with time and its direction is opposite to the direction of velocity, then that motion is called retardation or negative acceleration. For example, when we apply breaks to the vehicle then its velocity will decrease and the vehicle will decelerate.

Q.19 What are the uniform and non-uniform acceleration?

Uniform acceleration : When velocity of body changes by equal amounts in equal time intervals, acceleration is said to be uniform.

Non uniform acceleration : When velocity of body changes by unequal amounts in equal intervals, acceleration is said to be non-uniform.

Q.20 A train travels at a speed of 60 km/h for 0.52 h, at 30 km/h for next 0.24 h and then at 70 km/h for next 0.71h. What is the average speed of the train?

In given problem, we need calculate distances traveled by the train under three different conditions of speed and time.

(i) In the first case, the train travels at speed of 60 km/h for a time of 0.52 hours.

Speed = {Distance}/{Time}

60 = {Distance} / {.52}= 31.2km

(ii) In the second case, the train travels at a speed of 30 km/h for a time of 0.24 hours.

Speed = {Distance}/{Time}

30 = {Distance}/ {.24}

Distance = 30 × 0.24 = 7.2 km

(iii) In the third, the train travels speed of 70 km/h for a time of 0.7/hours.

Speed = {Distance}/{Time}

70 = {Distance}/{.71}

Distance = 70 × 0.71 = 49.7 km

Then total distance traveled = 31.2 + 7.2 + 49.7 = 88.1 km

Total time taken = 0.52 + 0.24 + 0.71 = 1.47 h

Average speed = {Total distance traveled}/{Total time taken}

= {88.1}/ {1.47}= 59.9 km/h

Q.21 A bus between Visakhapatnam and Hyderabad passed the 100 km, 160 km and 220 km points at 10.30 a.m., 11.30 a.m. and 1.30 p.m. Find the average speed of the bus during each of the following intervals :

(a) 10.30 a.m. to 11.30 a.m.

(b) 11.30 am to 1.30 p.m. and 10.30 am to 1.30 pm.

(a) The distance covered between 10.30 a.m. and 11.30 a.m. is 160 km – 100 km = 60 km. The time interval is 1 hours.

The average speed during this interval is

Distance/time = 60km/ 1h

Distance = 60 km/h

(b) The distance covered between 11.30 a.m. and 1.30 p.m. is 220 km – 160 km = 60 km. The time interval is 2 hours. The average speed during this interval is

Distance/time = 60km / 2h

Distance = 30 km/h

(c) The distance covered between 10.30 a.m. and 1.30 p.m. is 220 km – 100 km = 120 km. The time interval is 3 hours. The average speed during this interval is

V_3 = 120km/ {3h}= 40km/h

Q.22 A Car covers 30 km at a uniform speed of 60 km/h and the next 30 km at a uniform speed of 40 km/h. Find the total time taken.

For uniform speed.

s = n.t

If the Car takes time t_1 to cover the first 30 km

30 km = (60 km/h) × t_1

t_1 = 30km/ 60km/h

t_1= 1 / 2= 30 min

Similarly, if it takes time t_2 cover the next 30 km

30 km = (40 km/h) × t_2

t_2 = 30km/40km/h = 3 / 4 = 45 min

The total time taken is t_1 + t_2 = 30 min + 45 min = 75 min = 1h 15 min

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Q.23 Convert 15 m/s into km/h ?

1,000 meters = 1 km.

60 seconds =1 minute,

and 60 minutes =1 hour.

Therefore, 3600 s=1hr

Now, multiply it with 3600/1000 i.e. 18/5

Therefore,

15m/s= 15x 18/5 km/hr

= 54 km/h

Q.24 The average speeds of a bicycle, an athlete and a car are 18 km/h, 7 m/s and 3 km/min respectively. Which of the three is the fastest and which is the slowest?

18 km/h = 18km/ 1h= 18000m/ 3600s = 5m/sec

3km/min = 3km/1 min = 3000m/ 60s = 50 m/sec

Thus, the average speeds of the bicycle, the athlete and the Car are 5 m/s, 7 m/s and 50 m/s respectively. So, the Car is the fastest and the bicycle is the slowest.

Q.25 An object is sliding down an inclined plane. The velocity changes at a constant rate from 10 cm/s to 15 cm/s in two seconds. What is its acceleration?

The initial velocity at t = 0 is

u = +10 cm/sec

and t = 2 final velocity is v = +15 cm/sec

a = v – u/ t= (15 cm/s -10 cm/s) / 2s = 2.5 cm/s^2

Q.26 A boy throws a ball up and catches it when the ball falls back. In which part of the motion is the ball decelerating?

As the ball goes up, its speed decreases and as its comes down, its speed increases. Thus, it decelerates while going up.

Q.27 What name is given to the speed in a specified direction?

Velocity is the name given to the speed in particular direction.

Q.28 Name the physical quantity obtained by dividing 'Distance' traveled by 'Time taken' to travel that distance?

Speed is the physical quantity obtained by dividing 'Distance traveled' by 'Time taken' to travel that distance.

Q.29 What do the following measure in a Car?

(a) Speedometer (b) Odometer

(a) Speedometer is used to measure the instantaneous speed of the Car.

(b) Odometer of the Car is used to record and measure the total distance travelled by the car.

Q.30 What is the S.I. unit of retardation?

S.I. unit of retardation is m/sec^2 or metre per sec^2.

Q.31 Give one example of a situation in which a body has a certain average speed but its average velocity is zero?

Motion of a Car from home to market and back to home is an example of a situation in which an object has a certain average speed but its average velocity is zero because total displacement is zero.

Q.32 (a) What term is used to denote the change of velocity with time?

(b) Give one word which means the same as 'moving with a negative acceleration'.

(c) The displacement of a moving object in a given interval of time is zero. Would the distance travelled by the object also be zero? Give reason for your answer.

(a) Acceleration the term is used to denote the change of velocity with time.

(b) Retardation is the same as 'moving with a negative acceleration.

(c) When the object comes back to its initial position. Then, the displacement is zero and distance travelled is non-zero.

Q.33 A motorcyclist drives from place A to B with a uniform speed of 30 m/s and returns from place B to A with a uniform speed of 20 m/sec. Find his average speed.

Given :

Speed from A to B, V_1 = 30 m/s

Let the distance from A to B be = d metre

also let the time taken to travel from A to B be = t_1 sec

Time = Distance/ Speed

We have t_1 = d/ 30……. . . . (1)

Now, Speed from B to A, V_2 = 20 m/s

Let the time taken to travel from B to A be = t_2 sec

Then, t_2 = d/ 20

Then total time of journey

$t = t_1 + t_2$

= d/30 + d /20

= d/12

Therefore, average speed = Total distance traveled/Time = 2d/(d/12) = 24 m/sec

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Q.34 An aircraft traveling at 600 km/h accelerates steadily at 10 km/h per second. Taking the speed of sound as 1100 km/h at the aircraft's altitude, how long will it take to reach the 'sound barrier'

You can use equations of motion to solve

Let initial velocity (u) = 600km/h

Acceleration (a) = +10km/h per second = 36000km/h²

Final velocity (v) = 1100 km/h

v = u + at

Plugging the respective values

1100 = 600 + 36000(t)

1100 - 600 = 36000t

Solving for t

t = 0.1388 hrs = 0.8333 minutes = 50 seconds

So time taken to reach barrier = 50 seconds

Q.35 If a bus traveling at 20 m/sec is subjected to a steady deceleration of 5m/sec^2, how long will it take to come to rest?

Given :

Initial velocity (u) = 20 m/s

Final velocity (v) = 0 m/s

Acceleration (a) = – 5 m/s^2

a= v-u/t

Now, Time taken t = v – u / a

t = 0 – 20/– 5 = 4 sec

Q.36 (a) What is the difference between speed and velocity?

(b) Convert a speed of 5u km/h into m/s.

(a)

Speed	Velocity
(i) Speed is a scalar quantity	(i) Velocity is a vector quantity
(ii) Speed of a object is the distance travelled by it per unit time	(ii) The velocity of an object is displacement travelled by it per unit time in a given direction
(iii) Speed is always positive	(iii) Velocity can be positive, negative or zero depending upon the direction

(b) Convert 54 km/h into ms.

54km/hr = 54 x 1000 / 3600 m/s = 15 m/sec

Q.37 A car is moving along a straight road at a steady speed. It travels 150 m in 5 seconds.

(a) What is its average speed?

(b) How far does it travel in a second?

(c) How far does it travel in 6 seconds?

(d) How long does it take to travel 240 m?

Given Distance = 150 m

Time t = 5s

(a) Then average speed = Total distance traveled /Time taken

= 150/ 5 = 30 m/sec

(b) Traveled distance in 1 second

Distance = Speed × time = 30 m/s × 1 = 30 m

(c) Traveled distance in 6s

Distance = Speed × time = 30 × 6 =180m

(d) Time taken to travel 240 m

Time = Distance/ Speed = 240/ 30 = 8 sec

Q.38 The distance between Delhi and Agra is 200 km. A train travels the first 100 km at a speed of 50 km/h. How fast must the train travel the next 100 km. So as to get the average 70km/h for whole journey?

Given :

Total traveled distance D = 200 km

Average speed required (V_{avg})= 70 km/h

Then time required for total distance traveled

Time = Total distance traveled /Average speed

T = 200km/ 70 km/hr= 20/ 7 hr

Now, for first part of the distance

Distance traveled d_1 = 100 km

Speed V_1 = 50 km/hr

Time taken = (t_1) = Distance traveled/ Speed = d/ v

t_1 = 100km/ 50kmhr^{-1} = 2 hr

For the second part of the trip

Distance traveled d_2 = 100 km

Time taken for second part

$t_2 = T - t_1$

= 20/7 -2= 2.85-2 = 0.85 hr=

Speed for second part

V= distance traveled/ time

= 100/ 0.85

= 117.64km/hr

Topic : Equations of Uniformly accelerated Motion

Q.39 Define the term ‘Uniform acceleration. Give one example of a uniformly accelerated motion?

An object has uniform acceleration if it travels in a straight line and its velocity increases by equal amount in equal time period.

Ex. A freely falling body has Uniform acceleration.

Q.40 What are equations of Uniform accelerated Motion?

Relation among velocity, distance, time and acceleration is called equations of motion. There are three equations of motion for bodies moving with uniform acceleration.

First equation of Motion

$V = u + at$ . . . (1)

Second Equation of Motion

$S = ut + \frac{1}{2} at^2$ . . . (2)

Third equation of Motion

$V^2 = u^2 + 2as$ . . . (3)

Where, u = initial velocity of body

v = Final velocity of body

a = acceleration of body

t = time taken by body

s = distance traveled by body in time t

Q.41 Derive expression for Average velocity in Uniform accelerated Motion :

Let,

Initial velocity of the object = u

Final velocity of the object = v

Acceleration = a

Time = t

Distance covered in given time = s

We know that,

Average velocity = (Initial Velocity (u) + Find Velocity (v)) / 2

Therefore,

Average velocity = u + v / 2 ……(ii)

This is the formula of average velocity.

Q.42 Derive the formula : v = u + at

Where the symbols have usual meanings.

The final velocity (v) of a moving object with uniform acceleration (a) after time, t.

Let

The initial velocity = u.

Final velocity = v.

Time = t

Acceleration = a

We know that, Acceleration = $\frac{Change\ in\ velocity}{Time\ taken}$

$\Rightarrow Acceleration\ (a)\ \frac{Final\ velocity(v) - Initial\ velocity(u)}{Time\ taken}$

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

$\Rightarrow at = v - u$

$\Rightarrow at - v = -u$

$\Rightarrow -v = -u - at$

$\Rightarrow v = u + at \ldots\ldots\ldots (i)$

This equation is known as first equation of motion.

Q.43 Derive the formula :

$s = ut + \frac{1}{2}at^2$, where the symbols have usual meanings.

Suppose an object has an initial velocity ‘u’ and a uniform acceleration ‘a’ for time ‘t’ so that its final velocity becomes ‘v’ and covering a distance s. Then distance ‘s’ traveled by a moving object can be calculated by considering its average velocity for time t.

Since Average velocity = $\frac{Initial\ velocity + final\ velocity}{2}$

So, Average velocity = $\frac{v+u}{2}$

the distance traveled = Average velocity × time

$$S = \left(\frac{u+v}{2}\right) \times t$$

Now using Ist equation of motion V = u + at

Now using Ist equation of motion V = u + at

$$S = \left(\frac{2u+at}{2}\right) t$$

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

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

Where,

S = Displacement

u = Initial Velocity

a = Acceleration

t = Time

This equation is known as second equation of motion.

Q.44 Derive the formula $V^2 = u^2 + 2as$, where the symbols have usual meanings.

The third equation of motion is derived by substituting the value of time (t) from first equation of motion.

We know from first equation of motion,v = u + at

$$\Rightarrow v - u = at$$

$$\Rightarrow at = v - u$$

$$\Rightarrow t = \frac{v-u}{a} \ldots\ldots\ldots\ldots (v)$$

We know that the second equation of motion is, $s = ut + \frac{1}{2}at^2$

By substituting the value of ' t ' from equation (v) we get

$$s = u\left(\frac{v-u}{a}\right) + \frac{1}{2}a\left(\frac{v-u}{a}\right)^2$$

$$\Rightarrow s = u \times \frac{v-u}{a} + \frac{1}{2}a \times \frac{(v-u)^2}{a^2}$$

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

$$\Rightarrow s = \frac{uv-u^2}{a} + \frac{a(v-u)^2}{2 \times a \times a}$$

$$\Rightarrow \frac{2(uv-u^2)+(v-u)^2}{2a}$$

$$\Rightarrow 2as = 2uv - 2u^2 + v^2 + u^2 - 2uv$$

$$\Rightarrow 2as = -2u^2 + v^2 + u^2$$

$$\Rightarrow 2as = -u^2 + v^2$$

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

$$\Rightarrow v^2 = u^2 + 2as \ldots\ldots\ldots (vi)$$

This is called the Third equation of motion.

This equation gives us the velocity acquired by a body in traveling a distance.

Q.45 Find the initial velocity of a Car which is stopped is 10 seconds by applying brakes. The retardation due to brakes is 2.5 m/s^2.

Given :

Find velocity as the car stops after sometime (v) = 0 m/sec.

Retardation = – 2.5 m/sec

Time taken (t) = 10s

Let the initial velocity be u

Now from 1st equation of motion

u = v – at

u = 0 – (–2.5)(10)

u = 25 m/s

Q.46 Describe the motion of a body which is accelerating at a constant rate of 10 m/sec^2. If the body starts from rest, how much distance will it cover in 2s?

Given initial velocity (u) = 0 m/s

Acceleration (a) = 10 m/s^2

Time taken (t) = 2s

We can calculate the distance traveled by using the 2nd equation of motion.

$s = ut + 1/2at^2$

By substituting the values, we get

$s = 0(2) + 1 / 2 \times (10) (2)^2$ s = 20 m

Q.47 A motorcycle moving with a speed of 5 m/s is subjected to an acceleration of 0.2 m/s^2. Calculate the speed of the motorcycle after 10 seconds and the distance travelled in this time.

We need to find the distance travelled and final velocity of the object.

Given:

Initial velocity (u) = 5 m/s

Acceleration (a) = 0.2 m/s^2

Time taken (t) = 10 s

So, we can find the final velocity using the relation

V = u + at

So, final velocity

V = 5 + (0.2)(10) = 7 m/sec

Now distance from 2nd equation of motion

$s = ut + 1 / 2at^2$

$s = 5(10) + ½ \times (0.2) (10)^2$

= (50 + 10)m = 60m

Q.48 A train traveling at 20 ms^{-1} accelerates at 0.5 ms^{-2} for 30s. How far will it travel in this time?

Given :

Initial velocity (u) = 20 m/sec

Acceleration (a) = 0.5 m/sec^2

Time taken (t) = 30 sec

Distance travelled using 2^n equation of motion

$s = ut + ½ \times at^2$

$s = 20(30) + ½ \times (0.5) (30)^2$

= (600 + 225)m

S = 825 m

Q.49 A car acquires a velocity of 72 km per hour in 10 seconds starting from rest. Find

(i) The acceleration,

(ii) The average velocity

(iii) Distance traveled in this time.

Given :

Initial velocity (u) = 0 m/s

Final velocity (V) = 72 km/hr

Initial velocity (u) = 0 m/s

Final velocity (V) = 72 km/hr

= 72km/hr = 72 × 1000/3600
= 72000 m/3600s
Velocity = 20m/s

Time taken t = 10 s

(i) Acceleration

$= 20 – 0/ 10= 2m/s^2$

(ii) Average velocity

Average velocity = (Initial velocity + Final velocity) /2

Average velocity = v + u/2

= 20 + 0/2 m/s = 10 m/s

(iii) Distance traveled = (average velocity) × time

= (10) × (10)m

= 100 m

Q.50 A scooter moving at a speed of 10 m/s is stopped by applying brakes which produce a Uniform acceleration of – 0.5 m/s^2. How much distance will be covered by the Scooter before it stops?

Given :

Initial speed u = 10 m/s

Final speed v = 0

Acceleration a = – 0.5m/s^2

then Distance traveled by using the third equation of motion

$V^2 = u^2 + 2as$

$0^2 = (10)^2 + 2 \times (– 0.5) \times 5$

0 = 100 – s

s = 100 m

Q.51 A Car covers 30 km at a uniform speed of 30 km/h. What should be its speed for next 90 km if the average speed for the entire journey is 60 km/h?

The total distance = 30 km + 90 km = 120 km

The average speed for the entire journey = 60 km/h

using s = vt

t = s / v = 120km/ 60km/h = 2hr

Thus, it takes 2 hours to complete the entire journey.

The first 30 km is covered at a speed of 30 km/h.

Suppose the time taken to cover the first 30 km is t_1,

Using s = vt

t_1 = 30km/ 30km/h= 1h

Thus, the remaining 90 km must be covered in (2h – 1h) = 1h.

The speed during this 90 km should be

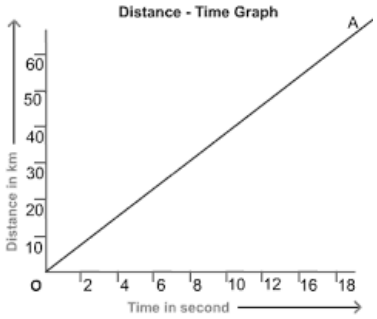
v = s /t = 90km/ 1h = 90 km/h

Topic : Graphical Representation of Motion and Circular Motion

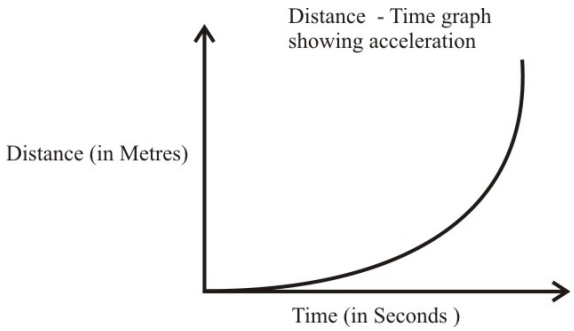
Q.52 Describe distance – Time graph?

The change in the position of an object with time can be represented on the distance time graph. The distance time graph for a moving body can be used to calculated speed of the body.

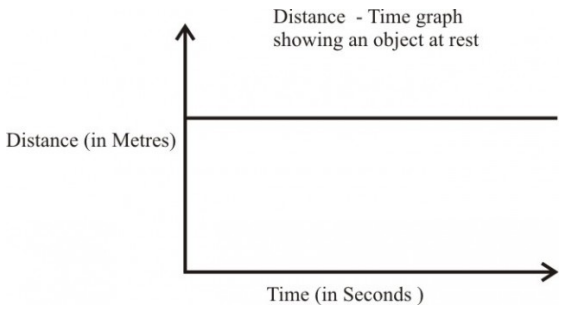
(a) **Straight line graph :** The distance time graph for a body moving at Uniform speed is always a straight line as the body is in Uniform motion, body moves equal distance in equal time interval.



(b) **Curved graph :** When graph of distance vs time is plotted for an object moving with non uniform speed, the slope of graph will not be a straight line. The rising trend of slope shows the increasing trend of velocity.



(c) The distance time graph is parallel to time axis when the body is at rest.



Slope of the graph shows the speed of body.

Q.53 Describe the velocity time graph or speed – time graphs?

There are three types of speed – time graphs for a moving body. These three cases are :

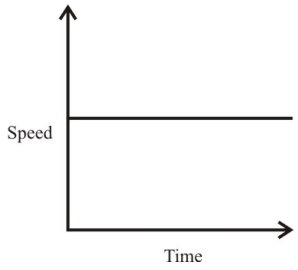
(i) When the velocity of the body remains constant (and there is no acceleration)

(ii) When the velocity of the body changes at a uniform rate (there is uniform acceleration)

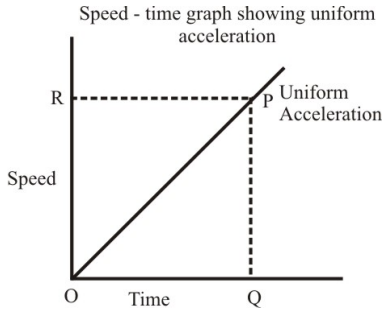
(iii) When the velocity of body changes in a non-Uniform way (there is non-uniform acceleration)

Case I : Velocity time graph when the velocity remains constant:

If a body moves with a Uniform velocity (no acceleration) then velocity time graph for this body would be straight line parallel to time axis.



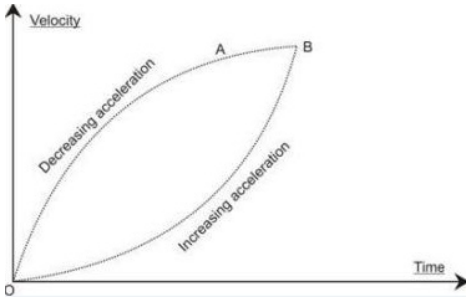
Case II : Velocity-time graph when velocity of body changes at a uniform rate (there is uniform acceleration).



If body moves with a non-uniform velocity (Uniform acceleration) then speed time graph would be a straight line. The pattern of slope of the graph depends on sign of velocity.

(iii) Velocity time graph when velocity changes at a non-uniform Rate (Non-uniform acceleration)

Zigzag graph and curved graph shows that the object is moving with non-uniform velocity.

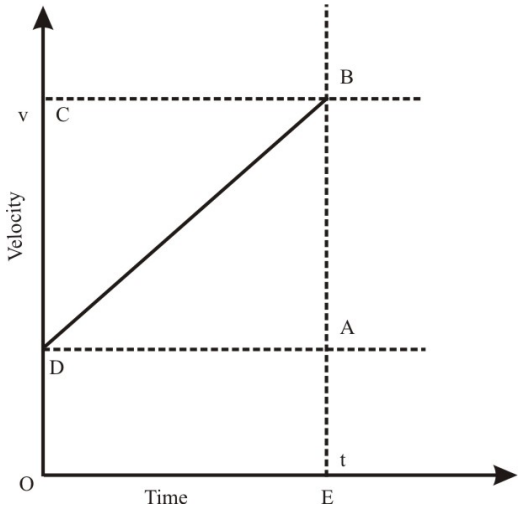


The distance traveled by moving body in a given time will be equal to area under speed time graph.

Q.54 Derive the equations of Motion by Graphical method.

There are three equation of motion : v = u + at, s = ut + 1/2at^2 and v^2 = u^2 + 2as can be derived with help of the graph.

Let an object is moving with uniform acceleration.



Let the initial velocity of the object = u

Let the object is moving with uniform acceleration, a.

Let object reaches at point B after time, t and its final velocity becomes, v

Draw a line parallel to x-axis DA from point, D from where object starts moving.

Draw another line BA from point B parallel to y-axis which meets at E at y-axis.

Let OE = time, t

Now, from the graph,

BE = AB + AE

⇒ v = DC + OD (Since, AB = DC and AE = OD)

⇒ v = DC + u (Since, OD = u)

⇒ v = DC + u ---------- (i)

$$Now, Acceleration\,(a) = \frac{Change\ in\ velocity}{Time\ taken}$$

$$\Rightarrow a = \frac{v-u}{t} = \frac{OC-OD}{t} = \frac{DC}{t}$$

$$\Rightarrow at = DC.....(ii)$$

By substituting the value of DC from (ii) in (i) we get

v = at +u

⇒ v = u + at

Above equation is the relation among initial velocity (u), final velocity (u), acceleration (a) and time (t). It is called first equation of motion.

2nd equation of Motion :

Equation for distance –time relation:

Distance covered by the object in the given time 't' is given by the area of the trapezium ABDOE

Let in the given time, t the distance covered by the moving object = s

The area of trapezium, ABDOE

= Distance (s) = Area of ΔABD + Area of ADOE

$$\Rightarrow \frac{1}{2} \times AB \times AD + (OD \times OE)$$

$$\Rightarrow s = \frac{1}{2} \times DC \times AD + (u + t) \quad [Since,\ AB = DC]$$

$$\Rightarrow s = \frac{1}{2} \times at \times t + ut\ [Since, DC = at\ from\ equation\ (ii)]$$

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

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

The above expression gives the distance covered by the object moving with uniform acceleration. This expression is known as second equation of motion.

Equation for Distance Velocity Relation: Third equation of Motion:

The distance covered by the object moving with uniform acceleration is given by the area of trapezium ABDO

Therefore,

Area of trapezium ABDOE

$=\frac{1}{2}$ sum of parallel sides + distance between parallel sides

⇒Distance (s)

$$\Rightarrow s = \frac{1}{2}(u + v) \times t \ldots\ldots\ldots\ldots\ldots (iii)$$

$$Now,\ from\ equation\ (ii)\ a = \frac{v-u}{t}$$

$$Therefore,\ t = \frac{v-u}{a} \ldots\ldots\ldots (iv)$$

After substituting the value of t from equation (iv) in equation (iii)

$$\Rightarrow s = \frac{1}{2}(u+v) \times \frac{(v-u)}{a}$$

$$\Rightarrow s = \frac{1}{2a}(v+u)(v-u)$$

$$\Rightarrow 2as = (v+u)(v-u)$$

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

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

The above expression gives the relation between position and velocity and is called the third equation of motion.

Q.55 Define circular motion? Also derive expression for it.

When an object moves on a circular path this motion is known as circular motion.

Uniform Circular motion: Motion in which an object moves on a circular path with constant speed. For example: Moon revolving round the earth etc.

Non-Uniform Circular Motion: Motion in which an object is moves on a circular path with varying speed.

When an object is in circular motion, direction of its velocity keeps on changing.

Velocity in the case of circular motion:
If the radius of circle is 'r'

Therefore, circumference = 2πr

Let time 't' is taken to complete one rotation over a circular path by any object

$$\text{Therefore, velocity (v)} = \frac{Distance}{time}$$

$$\Rightarrow v = \frac{Circumference}{t}$$

$$\Rightarrow v = \frac{2\pi r}{t}$$

Where, v = velocity, r = radius of circular path and t = time

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Q.56 (a) What remains constant in Uniform Circular motion?

(b) What changes continuously in Uniform Circular Motion?

(a) Speed remains constant in Uniform circular motion.

(b) Direction of motion changes continuously in uniform Circular motion.

Q.57 Name the quantity which is measured by the area occupied under the velocity time graph.

Displacement is measured by the area occupied under the velocity-time graph.

Q.58 What does the slope of a speed-time graph and a distance-time graph indicates.

Slope of a speed – time graph indicates acceleration.

Slope of a distance – time graph indicates speed.

Q.59 Give an example of a motion where an object does not change its speed but its direction of motion changes continuously.

The motion of an artificial satellite around the earth is an example of a motion (uniform circular motion) where an object does not change its speed but its direction of motion changes continuously.

Q.60 Name the type of motion in which a body has a constant speed but not constant velocity.

Uniform circular motion, in which a body has a constant speed but not constant velocity.

Q.61 A cyclist goes around a circular track once every 2 minutes. If the radius of the circular track is 105 metre. Calculate his speed ? (Given π= 22/ 7)

An object moving in a circular path

Speed (V) = 2πr/t …….. . . (1)

π= 22/ 7

Radius of circular track r = 105m

Time taken for 1 round, t = 2 minutes

= 2 × 60 = 120s

put in equation (1)

V = 2 x (22/7x 105) / 120 = 5.5m/s

Q.62 What can you say about the motion of a body if its speed-time graph is a straight line parallel to the time axis?

If the speed-time graph is a straight line parallel to the time axis then the body is moving with a constant speed.

Q.63 What can you about the motion of a body whose distance-time graph is a straight line parallel to

the time axis?

The object is not moving it is not changing its position with respect to any stationary object.

Q.64 Is the Uniform circular motion accelerated? Give reasons for your answer.

Yes, the Uniform circular motion is accelerated because the velocity changes due to continuous change in the direction.

Q.65 What is the difference between Uniform linear motion and Uniform circular motion? Explain with examples.

Uniform linear motion : The speed and direction of motion is fixed and so, it is not accelerated.

Ex. A car running on a straight road.

Uniform Circular motion : The speed is constant but direction of motion changes continuously and hence, it is accelerated.

Example : Motion of earth around the sun.

Q.66 Name the two quantities the slope of whose graph gives
(a) speed
(b) acceleration

(a) Slope of graph of distance and time given speed

(b) Slope of graph of velocity and time gives acceleration.

Q.67 State an important characteristic of Uniform Circular motion. Name the force which brings about Uniform Circular motion.

Characteristic:

(i) Speed remains constant while the direction of motion changes continuously with time, so it is accelerated.

(ii) Centripetal force brings about uniform circular motion. This force is always directed towards the center of the circular path and it is along the radius of the circular path.

Q.68 A bus was moving with a speed of 54 km/h on applying brakes it stopped in 8 seconds. Calculate the acceleration.

Given :

Initial Velocity u = 54 km/r

Converting km/hr to m/s

54x1000m/3600s

54000/3600 m/s

15m/s

Final velocity =0m/s(since the bus has come to a stop)

Time taken by the bus to come to a stop= 8sec

Acceleration(a)= v-u/t

=0-15/8

= -1.87 m/s^2

Q.69 A train starting from stationary position and moving with uniform acceleration attains a speed of 36 km per hour in 10 minutes. find its acceleration?

Given :
Initial velocity u = 0.m/sec

Final velocity v = 36 km/hr

= 36 x 1000m /3600= 36000/3600 = 10 m/s

Time taken (t) = 10 × 60s

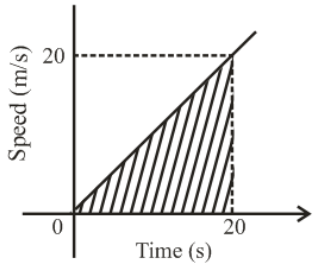
=600 s

Therefore, acceleration a = v – u/ t

=10 – 0/600

a = 0.0167 m/s^2

Q.70 Find the distance covered by a particle during the time interval t = 0 to t = 20s for which the speed-time graph is shown in figure.



Distance traveled is equal to the area under the speed-time graph and time axis.

Then, area of the shaded triangle is

S = ½ × base × height

S = ½ × (20s)× (20m/s)

=200 m

Q.71 A particle moving with an initial velocity of 5.0 m/s is subjected to a uniform acceleration of –2.5m/s^2. Find the displacement in the next 4.0s.

The displacement from the 2nd equation of motion

$s = ut + 1/2at^2$

Given:

Initial velocity u = 5.0 m/s

Acceleration a = –2.5 m/sec^2

Time t = 4.0 sec

Substitute the given values in the equation-

= 5x4 + ½ -2.5x16

= (20 – 20) = 0

The particle will be back its initial position.

Q.72 (a) What is meant by uniform circular motion? Give two examples of uniform circular motion.

(b) The tip of the second's hand of a clock takes 60 seconds to move once on the circular dial of the clock. The radius of the clock be 10.5 cm. Calculate the speed of the tip of the seconds hand of the clock (Given π= 22/ 7)

(a) When an object moves in a circular path with uniform speed, this motion is called uniform circular motion.

Ex.

(i) A satellite goes around the earth in a circular orbit.

(ii) Motion of a Cyclist on a circular track.

(b) Given time t = 60s

Radius of circular path, r = 0.105

Speed (V) = 2πr/t …….. . . (1)

π= 22/ 7

= 2x (22/7 x0.105)/ 60 =

= 6.285 x0.105/60

= 0.66/60

= .011 m/s

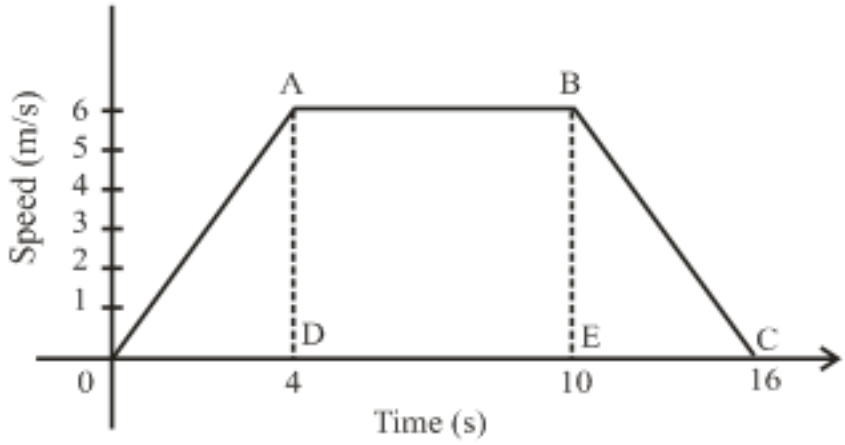
Value based Questions

Q.1 Study the speed–time graph of a body.

Given here and answer the following questions :

(i) Find out the acceleration of the body.

(ii) Calculate the retardation of the body.



From the graph :

OA shows acceleration :

then slope of speed – time graph OA will give us acceleration

Acceleration = AD/OD

Where AD = 6 m/s

OD = 4 sec.

Acceleration = 6m/s/4s

= 1.5 m/sec^2

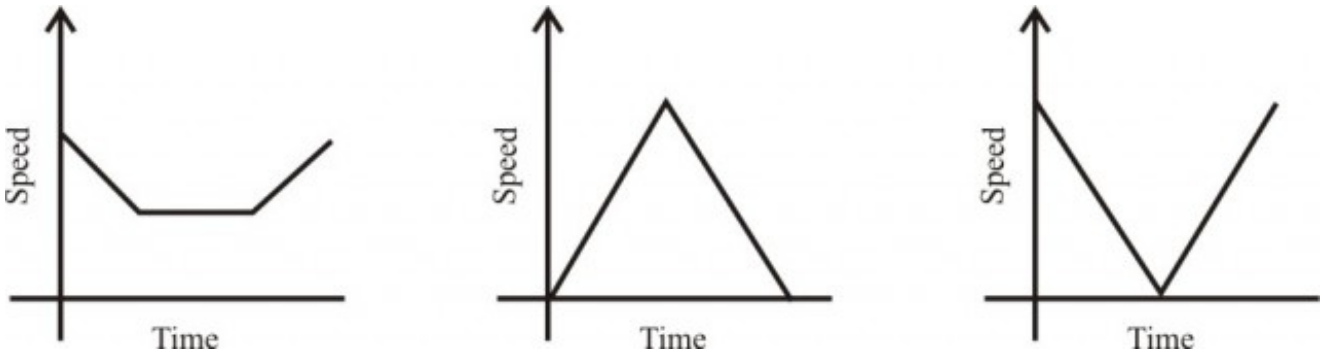
(b) Now for retardation –

from graph, BC show the retardation

Retardation = BE/ EC

= 6m/sec /6 sec = 1m/sec^2

Q.2 Three speed-time graphs are given below



Which graph represents the case of

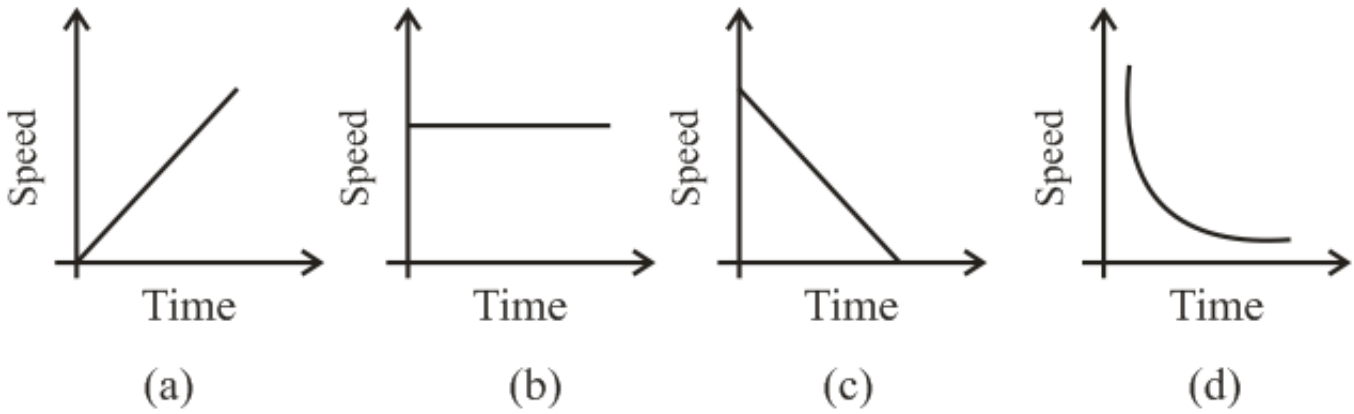
(a) A cricket ball thrown vertically upwards and returning to the hands of the thrower?

(b) A trolley decelerating to a constant speed and then accelerating uniformly?

(a) Graph C shows a cricket ball thrown vertically upwards and decreases its velocity. At maximum height, its velocity is zero. When returning to the hands of the thrower its velocity increases.

(b) Graph A shows a trolley decelerating to a constant speed and then accelerating uniformly.

Q.3 What types of motion is represented by each one of the following graphs?



(a) Graphs shows uniformly accelerating motion because there is equal change in speed at equal intervals of time.

(b) Graph shows constant speed because no change in speed with time.

(c) Graph shows uniformly retarding motion because there is an equal decrease in speed at equal intervals of time and the graph also has a negative slope.

(d) Graph shows non-uniformly retarding motion because speed is changing unequally in equal time period. Graph as varying slope.