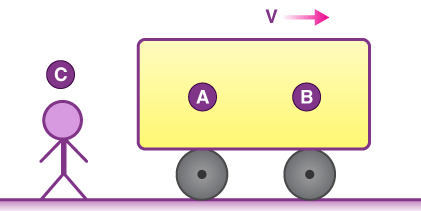
**Reference Point and Reference Frame**

* To describe the position of an object, we need a reference point or origin. An object may seem to be moving to one observer and stationary to another.
* Example: A passenger inside a bus sees the other passengers to be at rest, whereas an observer outside the bus sees the passengers to be in motion.
* In order to make observations easy, a convention or a common reference point or frame is needed. All objects must be in the same reference frame.
* **Reference Point** is used to describe the location of an object. An object can be referred to through many reference points.
* **Origin** – The reference point that is used to describe the location of an object is called Origin.
* For Example, a new restaurant is opening shortly at a distance of 5 km north of my house. Here, the house is the reference point that is used for describing where the restaurant is located

## What Is a Frame of Reference?

We have learned about velocity, acceleration, and displacement. But all these quantities need a frame of reference from which they are measured.

In physics, a frame of reference consists of an abstract coordinate system and the set of physical reference points that uniquely fix the coordinate system and standardize measurements within that frame.



**Let’s consider the figure**If we ask A what velocity of B is, he will say it is at rest. But if we ask the same question to C, he will say B is moving with a velocity V in the positive X direction. So we can see before specifying the velocity we have to specify in which frame we are or in simple terms, we need to define a frame of reference.

## Types of Frame of Reference

Once we have chosen our reference they can be of two types:

* Inertial Frame of Reference
* Non-inertial Frame of Reference

### Inertial Frame of Reference

An inertial frame of reference is a frame where Newton’s law holds true. That means if no external force is acting on a body it will stay at rest or remain in uniform motion. Suppose a body is kept on the surface of the earth, for a person on earth it is at rest while for a person on the moon it is in motion so which is my inertial frame here?

Actually, the term inertial frame is relative i.e. first we assume a reference frame to be the inertial frame of reference. So a more general definition of an inertial frame would be: Inertial frame is at rest or moves with constant velocity with respect to my assumed inertial reference frame.

### Non-inertial Frame of Reference

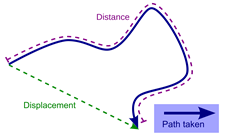
Now we can define a non-inertial frame as a frame that is accelerated with respect to the assumed inertial frame of reference. Newton’s law will not hold true in these frames. So in the above example if I assume earth to be an inertial reference frame the moon becomes a non-inertial reference frame as it is in accelerated motion with respect to earth. But if we want to make Newton’s law hold here we need to take some mysterious forces also known as pseudo forces.

## Distance and Displacement

The magnitude of the length covered by a moving object is called distance. It has no direction.

Displacement is the shortest distance between two points or the distance between the starting and final positions with respect to time. It has magnitude as well as direction.

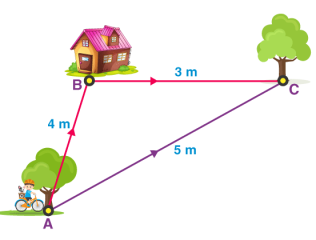
Displacement can be zero, but distance cannot.



## What Is Distance?

Distance is the total movement of an object without any regard to direction. We can define distance as to how much ground an object has covered despite its starting or ending point.

Let’s understand the concept of distance with the help of the following diagram:

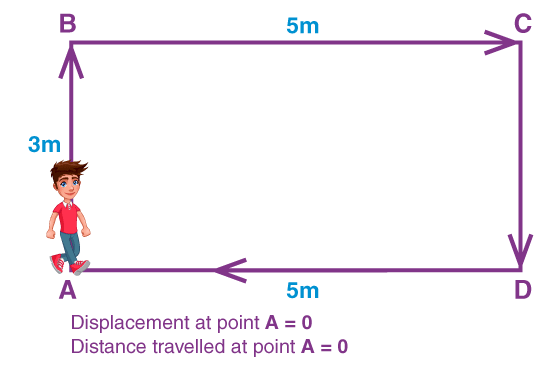


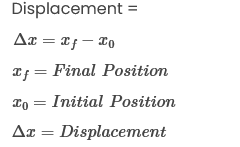
**Distance here will be = 4m + 3m + 5m = 12 m**

### Distance Formula

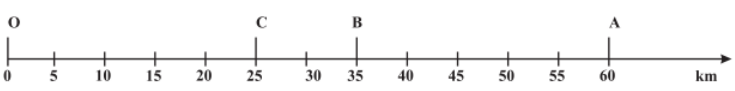
## How is Displacement defined?

Displacement is defined as the change in position of an object. It is a vector quantity and has a direction and magnitude. It is represented as an arrow that points from the starting position to the final position. For example- If an object moves from A position to B, then the object’s position changes. This change in the position of an object is known as Displacement.





**Motion in a Straight Line**



According to figure given above, if an object moves from point O to point A then the total distance travelled by the object is given as 60 km.

Displacement depends upon the direction in which the object is travelling.

## Displacement is denoted by Δx

## Δx = xf − x0

## Where,

## xf = Final position on the object

## x0 = Initial position of the object

## Consider the above figure given above, here the shortest distance between O and A is 60 km only. Hence, displacement is 60 km.

## Zero Displacement When the first and last positions of an object are the same, the displacement is zero.

## For Example, consider the diagrams given below.

## https://files.askiitians.com/cdn/images/20181026-143453758-1479-example-for-zero-displacement.png

## Displacement at point A = 0 because the shortest distance from A to A is zero.

## Negative Displacement and Positive Displacement

## https://files.askiitians.com/cdn/images/20181026-143443414-1153-example-for-negative-and-positive-displacement.png

## Here, displacement of object B is negative

## ΔB = Bf − B0 = 7–12 = – 5

## A negative sign indicates the opposite direction here.

## Also, displacement of object A is positive

## ΔA = Af − A0 = 7– 0 = 7

## Examples of Distance and Displacement

**Example John travels 250 miles to North but then back-tracks to South for 105 miles to pick up a friend. What is John’s total displacement?**

**Answer:** John’s starting position  Xi= 0.

Her final position Xf is the distance travelled N minus the distance South.

Calculating displacement, i.e.D.

D = ΔX = (Xf – Xi)

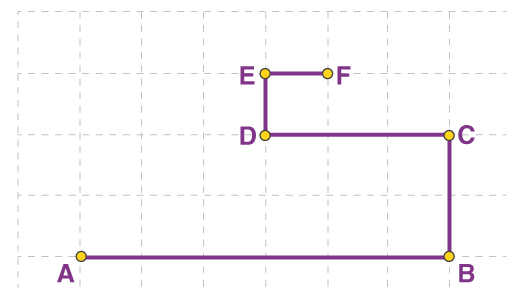
D = (250 mi N – 105 mi S) – 0

D = 145 mi N

**Example An object moves along the grid through points A, B, C, D, E, and F as shown below. The side of square tiles measures 0.5 km.**

**a) Calculate the distance covered by the moving object.**

**b) Find the magnitude of the displacement of the object.**



**Solution:**

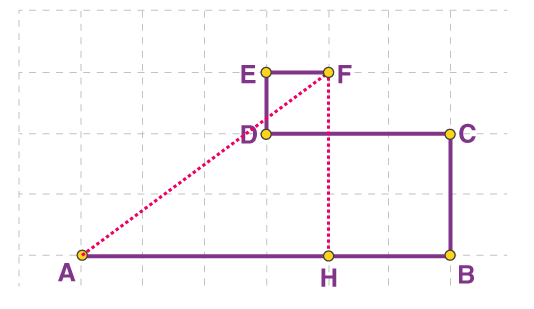
a) The distance covered by the moving object is calculated as follows:

AB + BC + CD + DE + EF

3 + 1 + 1.5 + 0.5 + 0.5 = 6.5 km

The distance covered by the moving object is 6.5 km.

b) The initial point is A and the final point is F, hence the magnitude of the displacement is equal to the distance AF which is calculated by applying Pythagoras’s theorem to the triangle AHF as shown in the figure below



Applying the Pythagorean formula, we get

Substituting the formula, we get

The magnitude of displacement is 2.5 km.

**What are Scalar and Vector Quantities?**

* A **scalar** quantity describes a magnitude or a numerical value.
* A **vector** quantity describes the magnitude as well as the direction.
* Hence, distance is a scalar quantity while displacement is a vector quantity.

## Distance vs Displacement

|  |  |
| --- | --- |
| **Distance** | **Displacement** |
| The complete length of the path between any two points is called distance | Displacement is the direct length between any two points when measured along the minimum path between them |
| Distance is a scalar quantity as it only depends upon the magnitude and not the direction | Displacement is a vector quantity as it depends upon both magnitude and direction |
| Distance can only have positive values | Displacement can be positive, negative and even zero |
| The distance between two points may not be unique | Displacement between two points is always unique |

**Magnitude**

Magnitude is the size or extent of a physical quantity. In physics, we have scalar and vector quantities.

Scalar quantities are only expressed as magnitude. E.g.: time, distance, mass, temperature, area, volume

Vector quantities are expressed in magnitude as well as the direction of the object. E.g.: Velocity, displacement, weight, momentum, force, acceleration, etc.

**What is motion**?

If the location of an object changes with time the object is said to be in motion.

### ****Time and speed****

Time is the duration of an event that is expressed in seconds. Most physical phenomena occur with respect to time. It is a scalar quantity.

Speed is the rate of change in distance. If a body covers a certain distance in a certain amount of time, its speed is given by

The instantaneous speed is the speed of an object at a particular moment in time.

Average speed is stated as the distance covered by the object within a period of time.

**Average speed** = Total distance travelled / Total time taken

The below table lists the difference between Average Speed and Instantaneous Speed.

|  |  |
| --- | --- |
| **Average Speed** | **Instantaneous Speed** |
| It is defined as the total distance travelled divided by the total time elapsed. | It is defined as the speed at a particular instant of time. |
| It is constant. | It is not constant. |
| Measured by calculating the speed for an entire journey. | It is measured by a speedometer. |
| Example: A car travelling with a speed of 60 kmph. Thus, the average speed of the car is 60 km an hour. | Example: A car travelling at a certain speed at an instant of time can be given by a speedometer. |

### ****Uniform motion and Non-uniform motion****

When an object covers equal distances in equal intervals of time, it is in uniform motion.

#### Examples of Uniform Motion

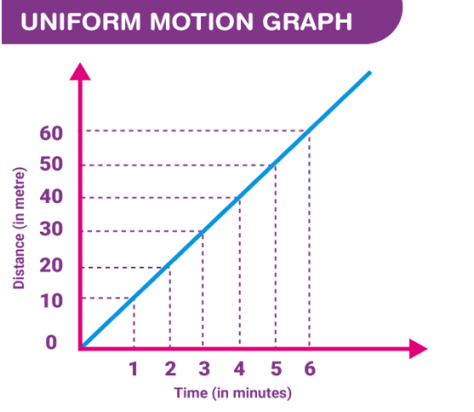
* Movement of the ceiling fan’s blades.
* Motion of Earth around the sun
* Pendulum with equivalent amplitude on either side

When an object covers unequal distances in equal intervals of time, it is said to be in non-uniform motion.

* Bouncing ball
* Running horse
* Moving train

## Uniform Motion:

**Definition:** This type of motion is defined as the motion of an object in which the object travels in a straight line, and its velocity remains constant along that line as it covers equal distances in equal intervals of time, irrespective of the duration of the time.



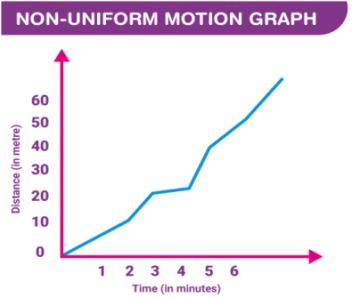
If a body is involved in rectilinear motion and the motion is consistent, then the acceleration of the body must be zero.

### Example of Uniform Motion:

1. If the speed of a car is 10 m/s, it means that the car covers 10 meters in one second. The speed is constant every second.
2. Movement of blades of a ceiling fan.

## Non Uniform Motion:

**Definition:** This type of motion is defined as the motion of an object in which the object travels with varied speed and it does not cover the same distance in equal time intervals, irrespective of the time interval duration.



If a body is involved in rectilinear motion, and if the motion is not consistent, then the acceleration of the body must be non-zero

### ****Velocity****

The Rate of change of displacement is velocity. It is a vector quantity. Here the direction of motion is specified.

Instantaneous velocity is the rate of change of position for a time interval which is very small, i.e. almost zero. In more simple words, the velocity of an object at a given instant of time is known as instantaneous velocity.

Average velocity is defined as the displacement (∆x) divided by the time intervals (∆t) in which the displacement occurs.

|  |  |
| --- | --- |
| **Average Velocity** | **Instantaneous Velocity** |
| Average velocity is defined as the displacement (∆x) divided by the time intervals (∆t) in which the displacement occurs. | Instantaneous velocity is the rate of change of position for a time interval which is very small, i.e. almost zero. |
| Average velocity is calculated by dividing the rate of displacement by the time elapsed. | Instantaneous velocity is calculated by dividing displacement by time at that instant. |
| If Jack took a total of 1 hour to travel 10 km from his house to school, then his average velocity will be 10 km/hr. | In Jack’s case, on his way to school, while he is sitting and waiting for the train to pass, his instantaneous velocity will be zero. Though the instantaneous velocity was zero for a small part of the journey, the average velocity will not be zero. |

**Average Speed and Average Velocity**

Before learning about average speed and average velocity, we must know the difference between distance and displacement.

Distance is a scalar quantity which generally implies how much ground has been covered by the object. On the other hand, displacement is a vector quantity, and it is the shortest possible distance between the start and end point.

Example: If a particle is moving in a circle, after one revolution, the distance will be the perimeter of the circle while the displacement would be zero.

Now, let us see what speed and velocity actually are.

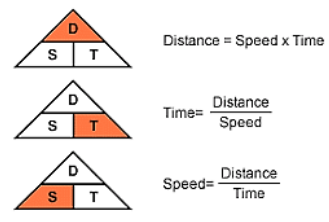
**Speed:** Speed is a scalar quantity which means it has no direction. It denotes how fast an object is moving. If the speed of the particle is high it means the particle is moving fast and if it is low,  it means the particle is moving slow.

**Velocity:** Velocity is a vector quantity which means it has both magnitude and direction. It denotes the rate at which the object is moving or changing position. The direction of the velocity vector is easy to find. Its direction is the same as the direction of the moving object. Even if the object is slowing down and the magnitude of velocity is decreasing, its direction would still be the same as the direction in which the object is moving

## Average Speed

The average speed of a body in a certain time interval is the distance covered by the body in that time interval divided by time. So if a particle covers a certain distance s in a time t1 to t2, then the average speed of the body is:

In general, average speed formula is:



Now, let us look at some of the examples to understand this concept easily

**Question** In travelling from Pune to Nagpur, Rahul drove his bike for 2 hours at 60 kmph and 3 hours at 70 kmph.

**Answer** We know that, Distance = Speed × Time

So, in 2 hours, distance covered = 2 × 60 = 120 km

in the next 3 hours, distance covered = 3 × 70 = 210 km

Total distance covered = 120 + 210 = 330 km

Total time = 2 + 3 = 5 hrs

## Average Velocity

The average velocity of a body in a certain time interval is given as the displacement of the body in that time interval divided by time. So if a particle covers a certain displacement vector AB in a time t1 to t2, then the average velocity of the particle is:

**Average Velocity (in case of uniform motion)**

**Average Velocity (in case of non-uniform motion)**

Understand the concept of average velocity through the examples given below.

**Question What is the average velocity of a person who moves 7 m in 4 seconds and 18 m in 6 seconds along x-axis?**

**Answer** Initial distance traveled by the person, xi = 7 m,

Final distance traveled, xf= 18 m,

Initial time interval ti = 4 sec,

Final time interval tf= 6 sec,

Average velocity Vav= = 5.5 m/sec.

## Acceleration

An object is said to be accelerated if there is a change in its velocity. The change in the velocity of an object could be an increase or decrease in speed or a change in the direction of motion. A few examples of acceleration are the falling of an apple, the moon orbiting around the earth, or when a car is stopped at the traffic lights. Through these examples, we can understand that when there is a change in the direction of a moving object or an increase or decrease in speed, acceleration occurs.

The rate of change of velocity is called acceleration. It is a vector quantity. In non-uniform motion, velocity varies with time, i.e., the change in velocity is not 0. It is denoted by “a”

Acceleration = Change in Velocity / Time

(OR)

Where t (time taken), v (final velocity) and u (initial velocity).

## What Is Acceleration?

Acceleration is defined as

The rate of change of velocity with respect to time.

Acceleration is a vector quantity as it has both magnitude and direction. It is also the second derivative of position with respect to time or it is the first derivative of velocity with respect to time.

## What Is the Acceleration Formula?

Acceleration formula is given as:

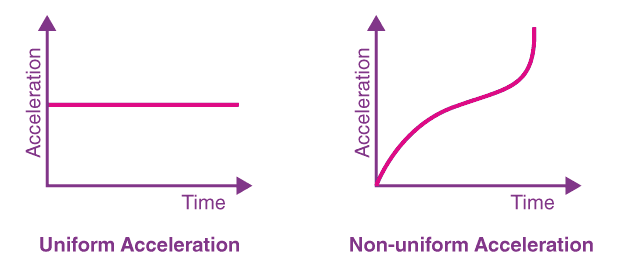
Where,

* a is the acceleration in m.s-2
* vfis the final velocity in m.s-1
* vi is the initial velocity in m.s-1
* t is the time interval in s
* Δv is the small change in the velocity in m.s-1

What Is the Unit of Acceleration?

The SI unit of acceleration is given as: **SI unit m/s2**

## Types of Acceleration



### Uniform and Non-uniform Acceleration

So can we have a situation when speed remains constant but the body is accelerated? Actually, it is possible in a circle where speed remains constant but since the direction is changing hence the velocity changes, and the body is said to be accelerated.

### Average Acceleration

The average acceleration over a period of time is defined as the total change in velocity in the given interval divided by the total time taken for the change. For a given interval of time, it is denoted as *ā*.

Mathematically,

Where *v2* and *v1* are the instantaneous velocities at time *t2* and *t1* and *ā* is the average acceleration.

**What Is Instantaneous Acceleration?**

Instantaneous acceleration is defined as

The ratio of change in velocity during a given time interval such that the time interval goes to zero.

## Equations of Motion

As we know, motion is the phenomenon in which an object changes its position. Motion is represented in terms of displacement, distance, velocity, acceleration, speed, and time. Let us know the equations of motion, and applications of the equations of motion

The motion of an object moving at uniform acceleration can be described with the help of three equations, namely

(i) v = u + at

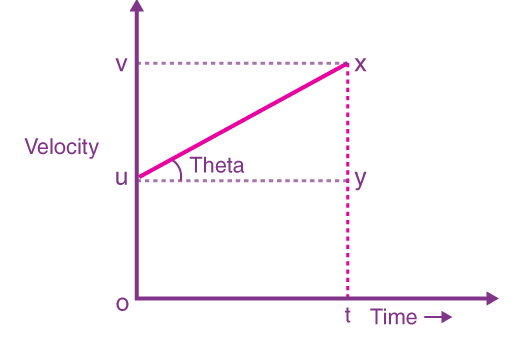
(ii) v2 – u2 = 2as

(iii) s = ut + (1/2)at2

where u is the initial velocity, v is the final velocity, t is the time, a is the acceleration and s is the displacement.

## Introduction to Equations Of Motion

In this article, we will learn how we can relate quantities like velocity, time, acceleration and displacement provided the acceleration remains constant. These relations are collectively known as the equation of motion. There are three equations of motion. There are three ways to derive the equation of motion and here we are going to derive with the help of a graph.



**First Equation of Motion**

First equation of motion relates velocity, time and acceleration. Now in ∆uxy,

We also know that tanθ is nothing but the slope, and slope of the v – t graph represents acceleration.

⇒ v = u + at ———– (1)

This is the first equation of motion where,

**v** = final velocity

**u** = initial velocity

**a** = acceleration

**t** = time taken

**Second Equation of Motion**

Now coming to the second equation of motion, it relates displacement, velocity, acceleration and time. The area under the v – t graph represents the displacement of the body.

In this case,

Displacement = Area of the trapezium (ouxt)

We can substitute v in terms of others and

get the final equation as:

Where symbols have their usual meaning.

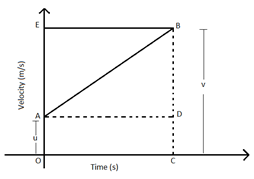
**Third Equation of Motion**

The third equation of motion relates to velocity, displacement, and acceleration. Using the same equation (2),

Using equation (1), if we replace t, we get,

The above equation represents our third equation of motion.

### ****Derivation of Velocity-Time Relation by Graphical Method****

Velocity – Time Graph

A body starts with some initial non-zero velocity at A and goes to B  with constant acceleration a.

From the graph BD = v (final velocity) – DC = u (initial velocity)…………..(eq 1).

BD = BC – DC……………..(eq 2).

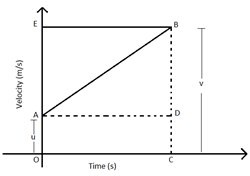
.

Therefore  BD = at………………….(eq 3).

Substitute everything we get: at = v – u.

Rearrange to get v = u + at.

### ****Derivation of Position-Time Relation by Graphical Method****

Velocity – Time Graph

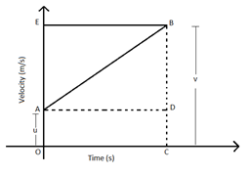
A body starts with some initial non-zero velocity at A and goes to B  with constant acceleration a

Area under the graph gives Displacement as follows:

OA = u , OC = t and BD = at

Substituting in (eq 1) we get s =

### ****Derivation of Position-Velocity Relation by Graphical Method****

Velocity – Time Graph

A body starts with some initial non-zero velocity at A and goes to B  with constant acceleration a

Displacement covered will be the area under the curve which is the trapezium OABC.

We know the area of trapezium is

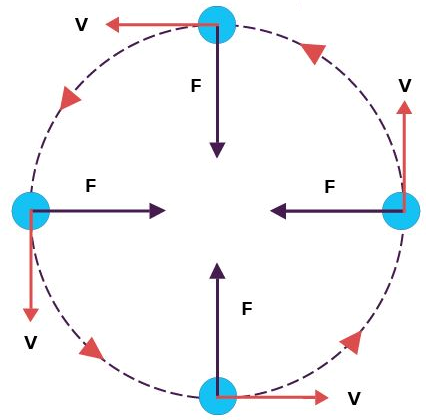
OA = u and BC = v and OC = t

Substitute (eq 2) in (eq 1) and arrange to get

v2−u2=2as

### ****Uniform Circular Motion****

* If an object moves in a circular path with uniform speed, its motion is called uniform circular motion.
* Velocity changes as direction keeps changing.
* Acceleration is constant.
* The uniform circular velocity is given by the following formula:



### Uniform Circular Motion Examples

* The motion of artificial satellites around the Earth is an example of uniform circular motion.
* The motion of electrons around its nucleus.
* The motion of blades of the windmills.
* The tip of the second hand of a watch with a circular dial shows uniform circular motion.

**Question** A particle is moving in a circular path of radius r. The displacement after half a circle would be:

(a) Zero

(b) π r

(c) 2 r

(d) 2π r

**Answer**  The answer is (c) 2 r.

**Explanation**: After half revolution

Distance travelled = X circumference= πr

Path length Displacement = Final position- Initial Position

It comes out to be the diameter of the circle = 2 r.

**Question** A body is thrown vertically upward with velocity u, the greatest height h to which it will rise is,

(a) u/g

(b) u2/2g

(c) u2/g

(d) u/2g

**Answer** The answer is (b) u2/2g.

**Explanation** V2= u2+2 as

here v = 0

a = -g

s = H

0 = u² -2gH

H = u²/2g

**Question** The numerical ratio of displacement to the distance for a moving object is

(a) always less than 1

(b) always equal to 1

(c) always more than 1

(d) equal or less than 1

**Answer** The answer is (d) equal or less than 1

**Explanation** The shortest distance between the initial and the endpoint is called displacement. Distance is the total path length.

Displacement is vector, and it may be positive or negative, whereas Distance is scalar, and it can never be negative.

The distance can be equal to or greater than displacement, which means the ratio of displacement to distance is always equal to or less than 1.

**Question** If the displacement of an object is proportional to square of time, then the object moves with

(a) uniform velocity

(b) uniform acceleration

(c) increasing acceleration

(d) decreasing acceleration

**Answer** The answer is (b) uniform acceleration

**Explanation** Velocity is measured in distance/second, and acceleration is measured in distance second2. Hence uniform acceleration is the right answer.

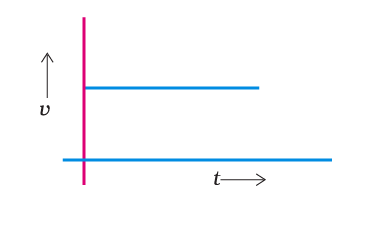
**Question** From the given v – t graph (Fig. 8.1), it can be inferred that the object is

(a) in uniform motion

(b) at rest

(c) in non-uniform motion

(d) moving with uniform acceleration



**Answer** The answer is (a) in uniform motion

**Explanation** From the above-given graph, it is clear that the velocity of the object remains constant throughout hence the object is in uniform motion.

**Question** Suppose a boy is enjoying a ride on a merry-go-round which is moving at a constant speed of 10 m/s. It implies that the boy is

(a) at rest

(b) moving with no acceleration

(c) in accelerated motion

(d) moving with uniform velocity

**Answer** The answer is (c) in accelerated motion

**Explanation**:

The boy is moving in a circular motion, and circular motion is an accelerated motion; hence C) is the right answer.

**Question** Area under a v – t graph represents a physical quantity which has the unit

(a) m2

(b) m

(c) m3

(d) m s–1

**Answer** The answer is (b) m

**Explanation** The area given in the graph represents Displacement, and its unit is meter. Hence, the answer is (b) m.

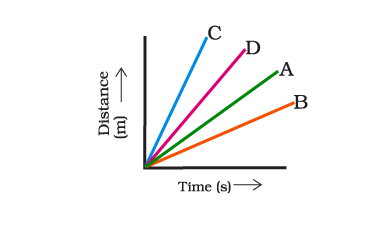
**Question** Four cars, A, B, C and D, are moving on a levelled road. Their distance versus time graphs are shown in Fig. 8.2. Choose the correct statement

(a) Car A is faster than car D.

(b) Car B is the slowest.

(c) Car D is faster than car C.

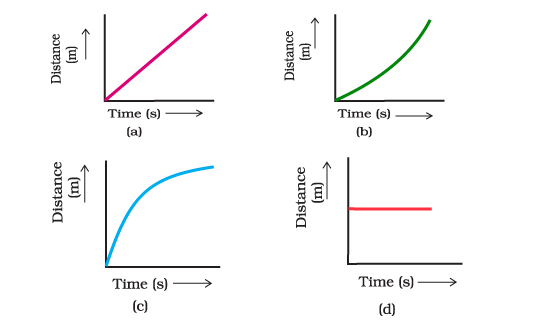
(d) Car C is the slowest.



**Answer** The answer is (b) Car B is the slowest.

**Explanation** The graph shows that Car B covers less distance in a given time than A, C and D cars hence it is the slowest.

**Question** Which of the following figures (Fig. 8.3) represents the uniform motion of a moving object correctly?



**Answer** The answer is (a)

**Explanation** Distance in graph a) is uniformly increasing with time hence it represents uniform motion.

**Question** Slope of a velocity–time graph gives

(a) the distance

(b) the displacement

(c) the acceleration

(d) the speed

**Answer** The answer is (c) the acceleration

**Question** In which of the following cases of motions the distance moved and the magnitude of displacement are equal?

(a) If the car is moving on a straight road

(b) If the car is moving in a circular path

(c) The pendulum is moving to and fro

(d) The earth is revolving around the Sun

**Answer** The answer is (a) If the car is moving on a straight road

**Explanation** In other cases given here, displacement can be less than distance; hence option (a) If the car is moving on a straight road, is the right answer.

**Question** The displacement of a moving object in a given interval of time is zero. Would the distance travelled by the object also be zero? Justify your answer.

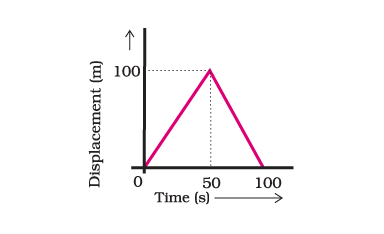
**Answer** Displacement zero does not mean zero distance. The distance can be zero when moving an object back to the place it started. Displacement is either equal to or less than distance, but the distance is always greater than one, and it cannot be a negative value.

**Question** How will the equations of motion for an object moving with a uniform velocity change?

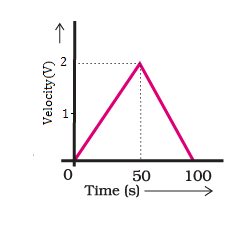
**Answer** If the object is moving with a uniform velocity, then v = µ and a = 0. In this scenario equation for distance is given below.

S= ut and V2– µ2=0

**Question** A girl walks along a straight path to drop a letter in the letterbox and comes back to her initial position. Her displacement–time graph is shown in Fig.8.4. Plot a velocity-time graph for the same.



**Answer**



**Question** A car starts from rest and moves along the x-axis with a constant acceleration of 5 m/s2 for 8 seconds. If it then continues with constant velocity, what distance will the car cover in 12 seconds since it started from the rest?

**Answer** Car Starts from rest hence Initial velocity u=o acceleration a=5 m/s2 and time t=8s

v = u+at

v = 0+5×8

v = 40ms-1

From second equation

s = ut + ½ at2

s = 0x8 + ½ x5x(8)2

s = ½ x5x(8)2

s = ½ x5x64

s = 5×32 =160 is the distance covered in 8 seconds.

Therefore, the total distance covered in 12 seconds  is 160+160=320m

**Question** A motorcyclist drives from A to B with a uniform speed of 30 km/h and returns back with a speed of 20 km h–1. Find its average speed.

**Answer** Let the distance from A to B is D kms.

Distance for the entire journey is 2D kms.

The time taken to go from A to B is D/30 hr, and that of B to A is D/20 hr. So, the total time taken T is

T = (D/30) + (D/20). By solving, we will get,

T = D/12 hrs.

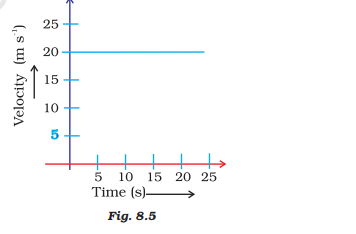
Average speed = Total distance/Total time.

Av.speed = 2D ÷ D/12

=> 2D x 12/D = 24 km/h.

Hence Average speed of the motorcycle is 24 km/h.

**Question** The velocity-time graph (Fig. 8.5) shows the motion of a cyclist. Find (i) its acceleration, (ii) its velocity, and (iii) the distance covered by the cyclist in 15 seconds



**Answer** (i) As velocity is constant, acceleration is 0 m/s2

(ii) Here, the velocity is constant, hence v=20m/s

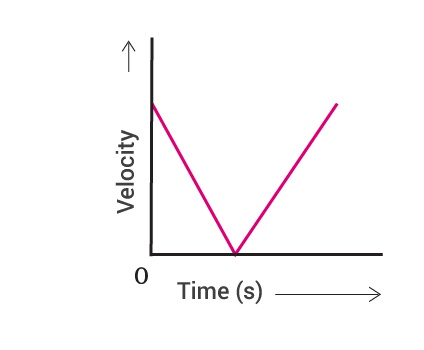
(iii) s = v x t

= 20 x 15

= 300 m

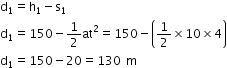
**Question** Draw a velocity versus time graph of a stone thrown vertically upwards and then coming downwards after attaining the maximum height.

**Answer** The velocity versus time graph of a stone thrown upwards vertically is as given below:



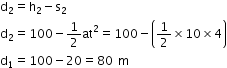
**Question** An object is dropped from rest at a height of 150 m, and simultaneously another object is dropped from rest at a height of 100 m. What is the difference in their heights after 2 s if both the objects drop with the same accelerations? How does the difference in heights vary with time?

**Answer** When two objects fall with the same acceleration simultaneously, after 2 seconds, the difference in their heights will not change, and it remains 50 m.



Therefore the height of the first object after 2 seconds is 130 m.

In the same way, the height of the second object is



Therefore, the height of the second object after 2 seconds is 80 m.

So, the difference is the same, i.e. 50 m.

This concludes that the difference in the height of the two objects does not depend on time and will always be the same.

**Question** An object starting from rest travels 20 m in first 2 s and 160 m in next 4 s. What will be the velocity after 7 s from the start?

**Answer** Here Object starts from rest hence initial velocity u=0 t =2s and s=20 m

According to the second equation of motion s= ut+at2

S = 0+ ½ ax22

20 = 2+ ½ ax22= 2a

= 20/2

a = 10m/s

According to the first equation of motion velocity after 7 s from the start

V = u+at

V = 0+10×7

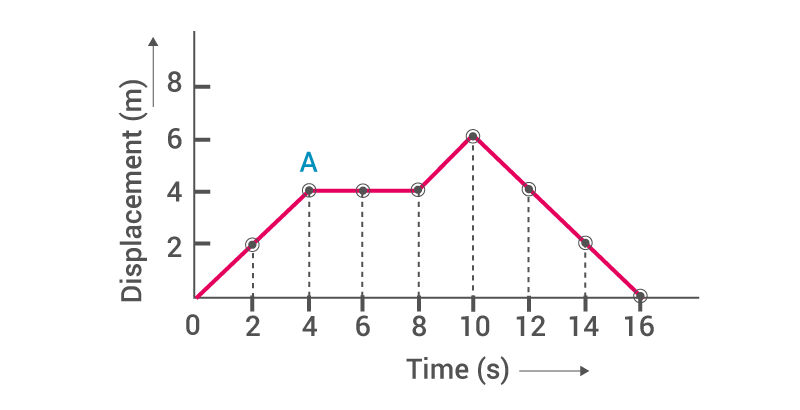
V = 70m/s

**Question** Using the following data, draw time-displacement graph for a moving object:

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Time(s) | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 |
| Displacement(m) | 0 | 2 | 4 | 4 | 4 | 6 | 4 | 2 | 0 |

Use this graph to find the average velocity for the first 4 s, for the next 4 s and for the last 6 s.

**Answer**



Average velocity for the first 4s =

= (4-0)/(4-0)=4/4 = 1ms-1

Average velocity of next 4 s = V = =0

Average velocity for last 6 s = =

= 1 ms-1

**Question** An electron moving with a velocity of 5 × 104 m/s enters into a uniform electric field and acquires a uniform acceleration of 104 ms-2 in the direction of its initial motion.

(i) Calculate the time in which the electron would acquire a velocity double of its initial velocity.

(ii) How much distance would the electron cover in this time?

**Answer** Given initial velocity, u = 5 × 104 m/s  and acceleration, a = 104ms-2

(i) final velocity = v = 2 u = 2 × 5 ×104 m/s =10 × 104 m/s

To find t,      use  v  =  at  or t = u – u / a = (5 × 104)/104

=5s

(ii)   Using s = ut + ½ at2  = (5 ×104) × 5 + ½ (10 ) × (5)2

= 25 ×104 + 25 /2 ×104

= 37.5×104 m

**Question** Obtain a relation for the distance travelled by an object moving with a uniform acceleration in the interval between the 4th and 5th seconds.

**Answer** a = dv/dt

Assume that air resistance is nil.

We can directly contain it by using Newton’s equations of motion or from the below-mentioned method:

Thus, the area under the v-t curve and the x-axis where the slope of the curve is the instantaneous acceleration.

In this case, acceleration g is constant, and due to the free-fall condition, the initial velocity is zero. Therefore the v-t curve is a straight line with a slope equal to g equal to 9.81 m/s  passing through the origin.

On dividing the total area under the curve into the interval of unit seconds, then we initially obtain a triangle followed by trapeziums of increasing height.

The ratio of the area of the first triangle to the second triangle to the third triangle is equal to the ratio of displacement in the first, second and third second. We get ratio equal to 1:3:5:7:9…  and so on.

For the 4th & 5th second, it is 7:9.

**Question** Two stones are thrown vertically upwards simultaneously with their initial velocities u1 and u2, respectively. Prove that the heights reached by them would be in the ratio of u1² :u2²

(Assume upward acceleration is –g and downward acceleration is +g ).

**Answer**

