NAVODAYA VIDYALAYA SAMITI, NOIDA

E-CONTENT PREPARATION FOR CLASS 9TH SCIENCE

CHAPTER-8: MOTION AND ITS DESCRIPTION (*PART-1)*

BY

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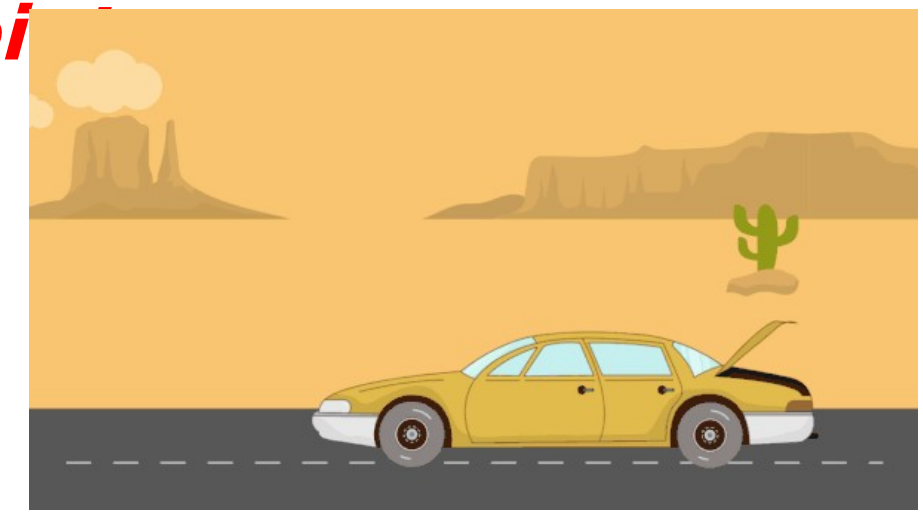
Motion

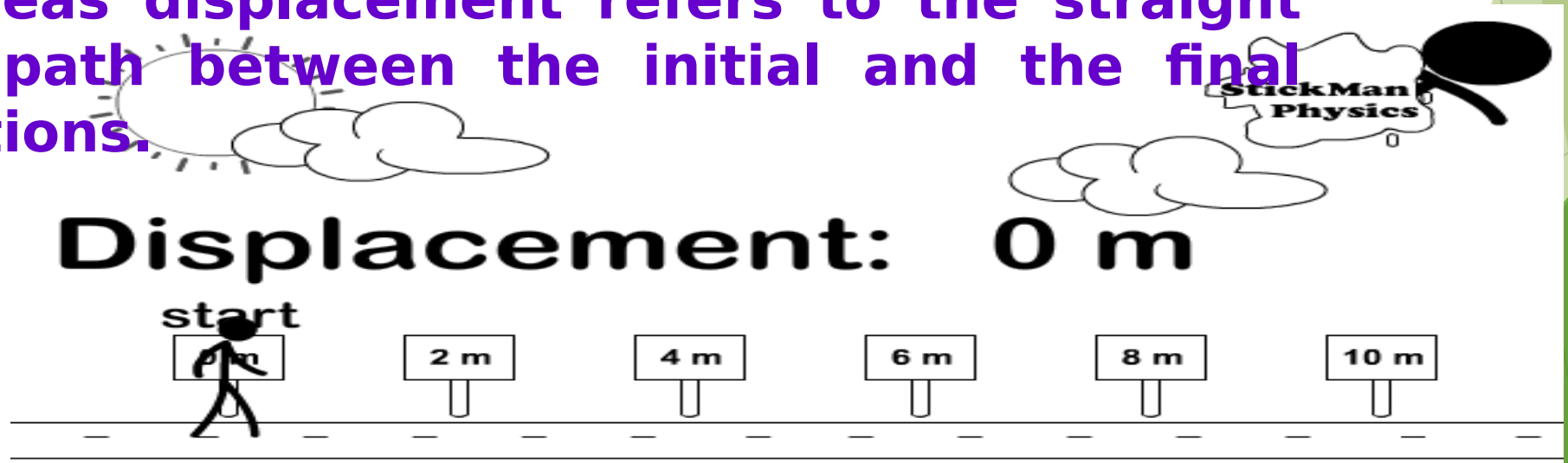
Motion- ***A body is said to be in motion when its position changes continuously with respect to a stationary object taken as reference poi***



Ex.- When the position of a car changes continuously with respect to a stationary objects like houses and trees, ect., we say

Distance Travelled And Displacement-

- ***Distance*- The distance travelled by a body is the actual length of the path covered by a moving body irrespective of the direction in which the body travels.**
- ***Displacement*- When a body moves from one point to another, the distance travelled refers to the actual length of the indirect path whereas displacement refers to the straight line path between the initial and the final positions.**



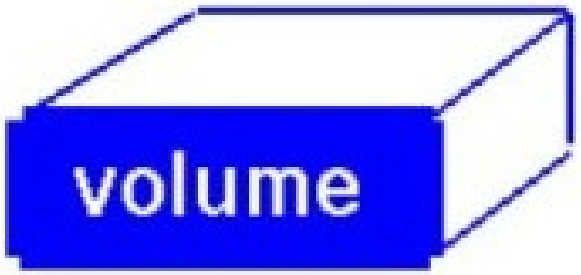
Scalars and Vectors

A scalar quantity has only magnitude.

A vector quantity has both magnitude and direction.

Scalar Quantities

length, area, volume
speed
mass, density
pressure
temperature
energy, entropy
work, power



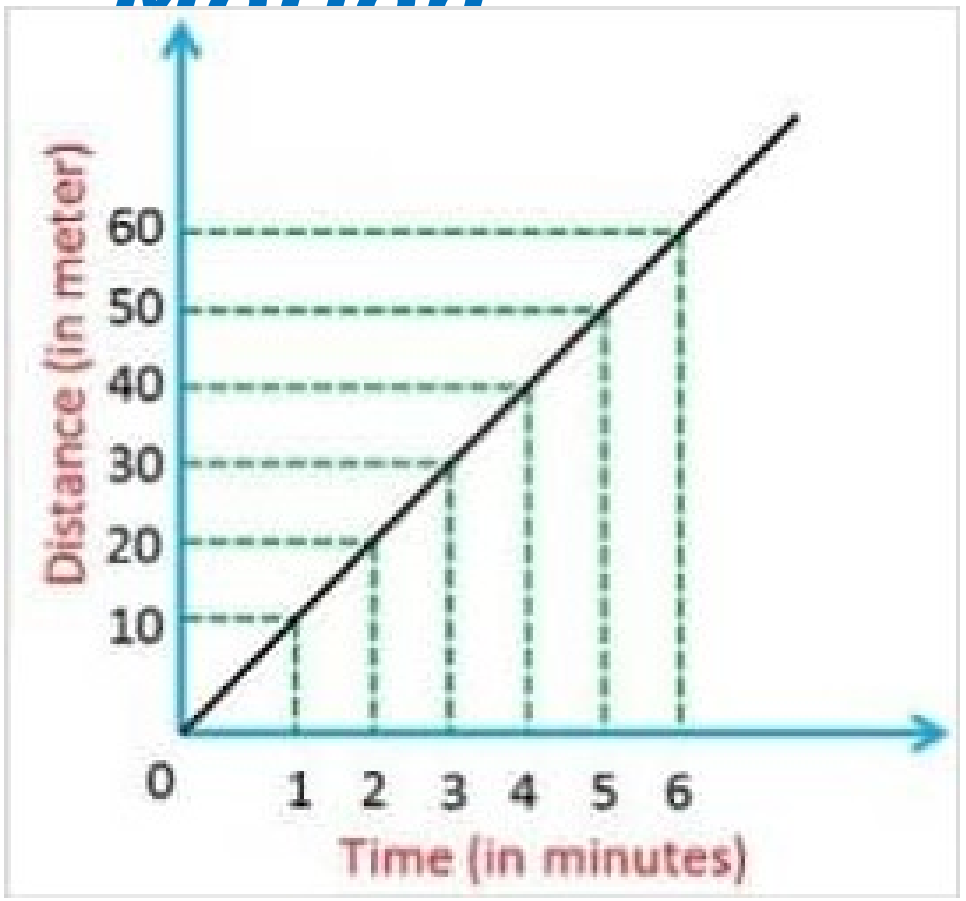
Vector Quantities

displacement
velocity
acceleration
momentum
force
lift , drag , thrust
weight

- **1- Distance is a scalar quantity (because it has magnitude only, it has no specified direction).**
- **2- Displacement is a vector quantity (because it has magnitude as well as a direction).**
- **3- Distance travelled by a moving body cannot be zero but the final displacement of a moving body can be zero**
- **The displacement of a moving body will be zero if, after travelling a certain distance, the moving body**

animation

Uniform Motion

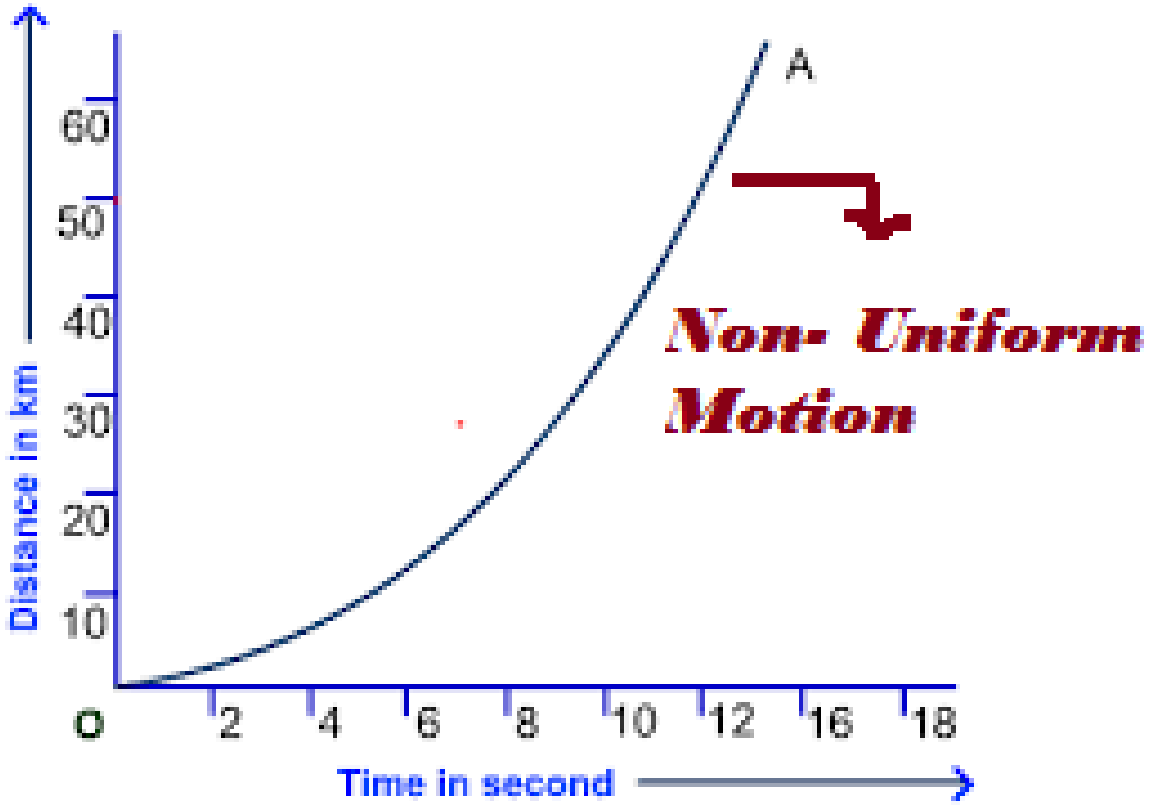


Uniform motion- **A body has a uniform motion if it travels equal distances in equal intervals of time, no matter how small these time intervals may be.**

The distance-time graph for uniform motion is a straight line.

Ex.- the motion of a car in a straight-line with constant speed

Non-Uniform motion



- **A body has a non-uniform motion if it travels unequal distance in equal intervals of time.**

The distance-time graph for a having non-uniform motion is a curved line.

animation

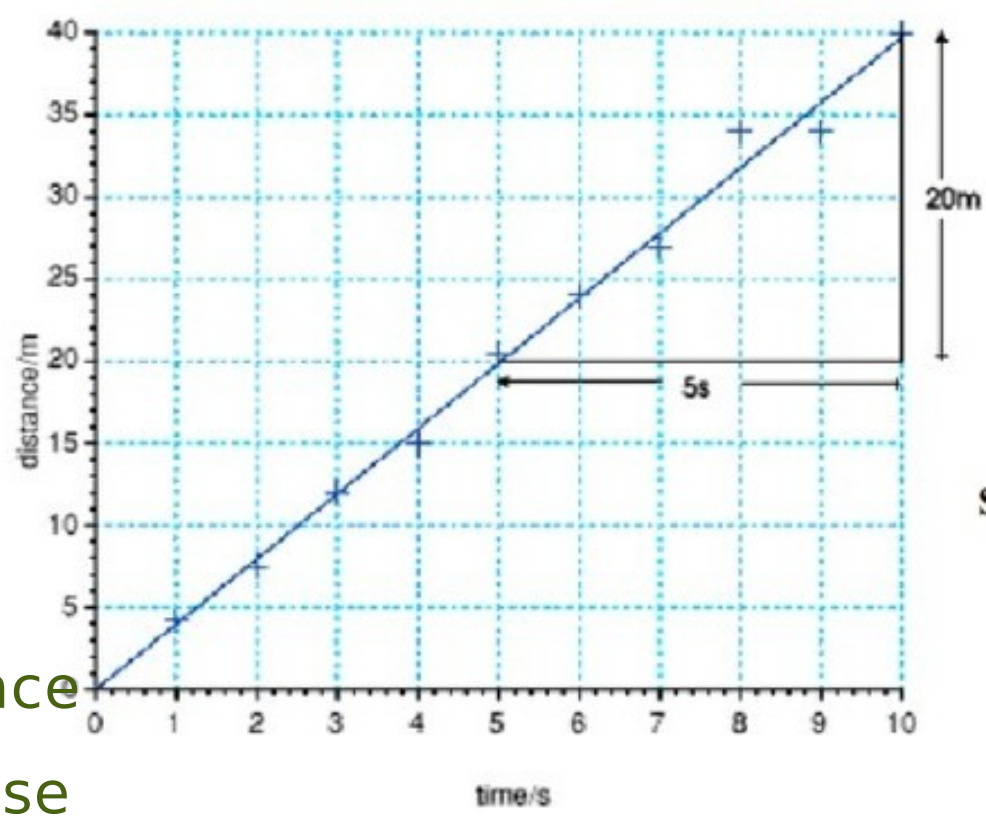
Speed, Velocity and Acceleration

Speed

Speed of a body gives us an idea of how slow and fast that body is moving. Speed of a body is = distance travelled / time taken.

$$v = s/t$$

Where v = speed, s = distance travelled,
t = time taken unit of speed is m/s

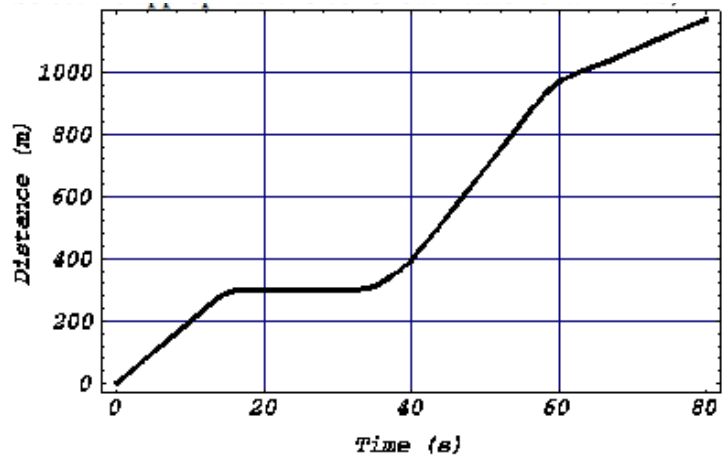


Uniform Speed

A body has uniform speed if it travels equal distance in equal intervals of time, no matter how small these time intervals may be.

Average Speed

The average speed of a body is the total distance travelled divided by the total time taken to cover this distance.



Velocity

Velocity of a body is the distance travelled by it per unit time in a given direction.

Velocity = displacement / time taken

$V = s / t$

Where V = velocity of the body, s = displacement of the body and t = time taken

The SI unit of velocity is the same as that, (m/s or $m\ s^{-1}$). We can use the bigger unit of kilometers per hour .

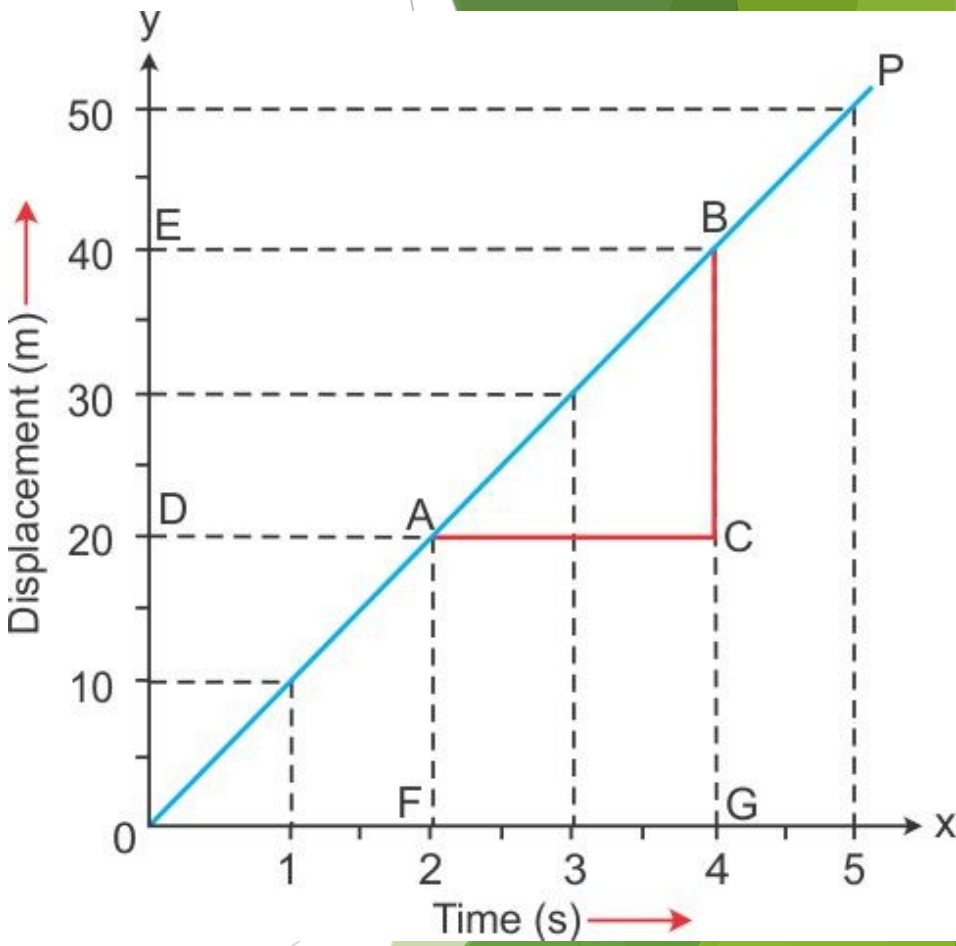
Uniform Velocity

A body has a uniform velocity if it travels in a specified direction in a straight line and moves over equal distances in equal intervals of time, no matter how small these time intervals may be .

The velocity of a body can be changed in two ways –

1- by changing the speed of the body, and

2- by keeping the speed constant but by changing



How to calculate

Speed And Velocity Are Not Always Equal In Magnitude

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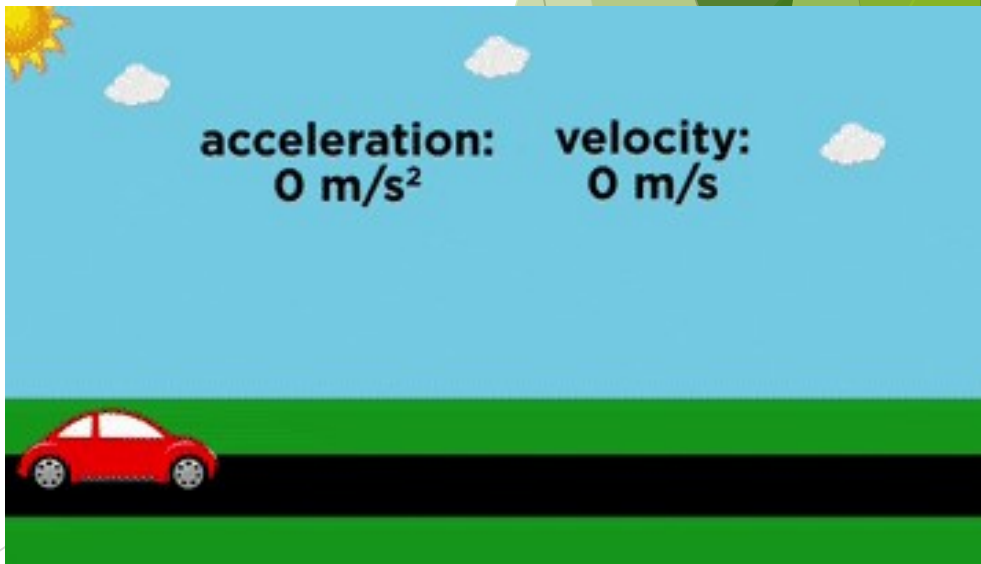
The magnitude of speed and velocity of a moving body is equal only *if the body moves in a single straight line* .

If , however, a body doesn't move in a single straight line , then the speed and velocity of the body are not equal .



The average speed of a moving body can never be zero, but the average velocity of a body can be zero.

Try these

Acceleration

Acceleration of a body is defined as the rate of change of its velocity with time .

Acceleration = change in velocity / time taken for change

Acceleration = final velocity – initial velocity / time taken

$$a = (v-u) / t$$

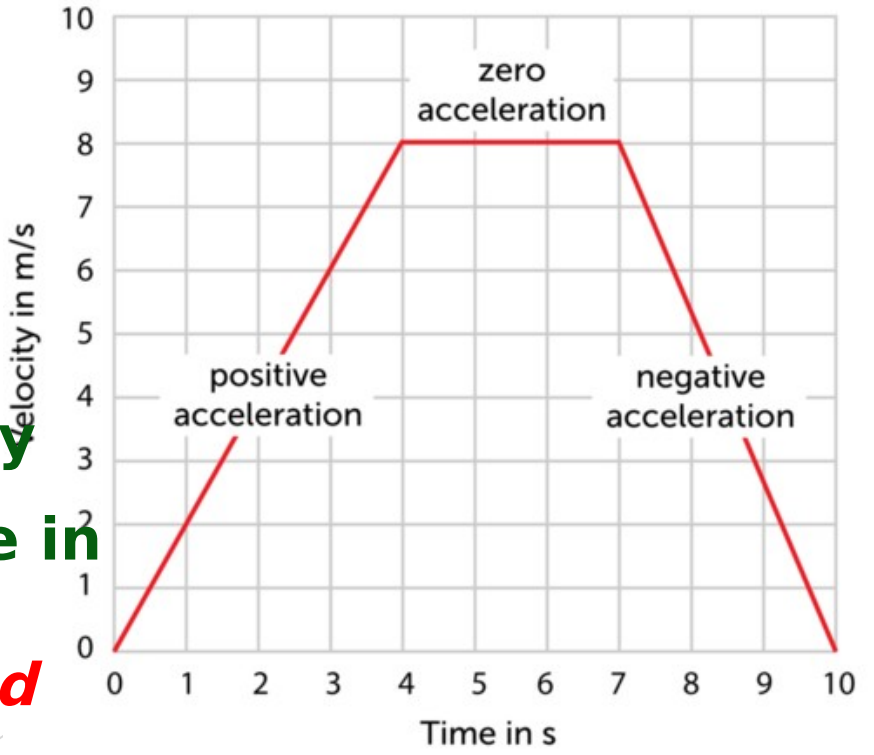
Where, a = acceleration of the body

v = final velocity of the body

u= initial velocity of the body

And t = time taken for the change in velocity

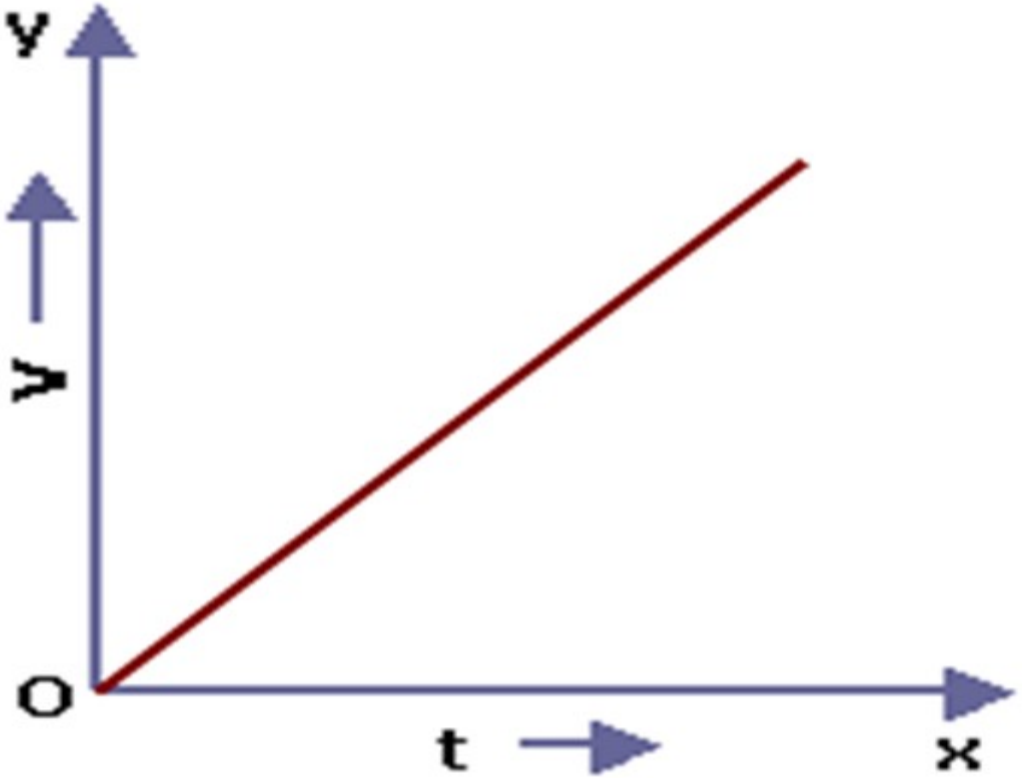
The SI unit of acceleration is meters per second square .



Uniform Acceleration

velocity increases by equal amounts in equal intervals of time.

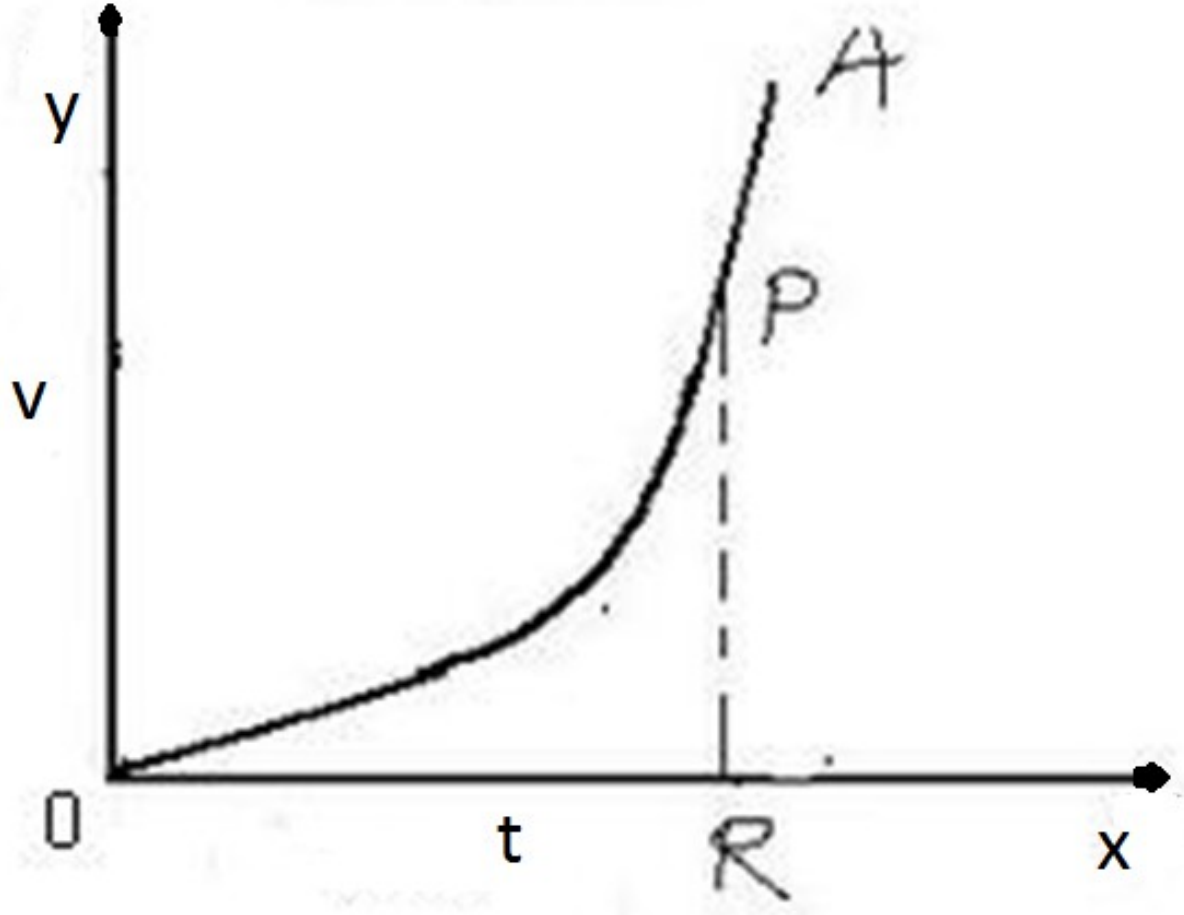
The velocity -time graph of a body having uniformly accelerated motion is a straight line.



Non- Uniform Acceleration

velocity increase by unequal amounts in equal intervals of time.

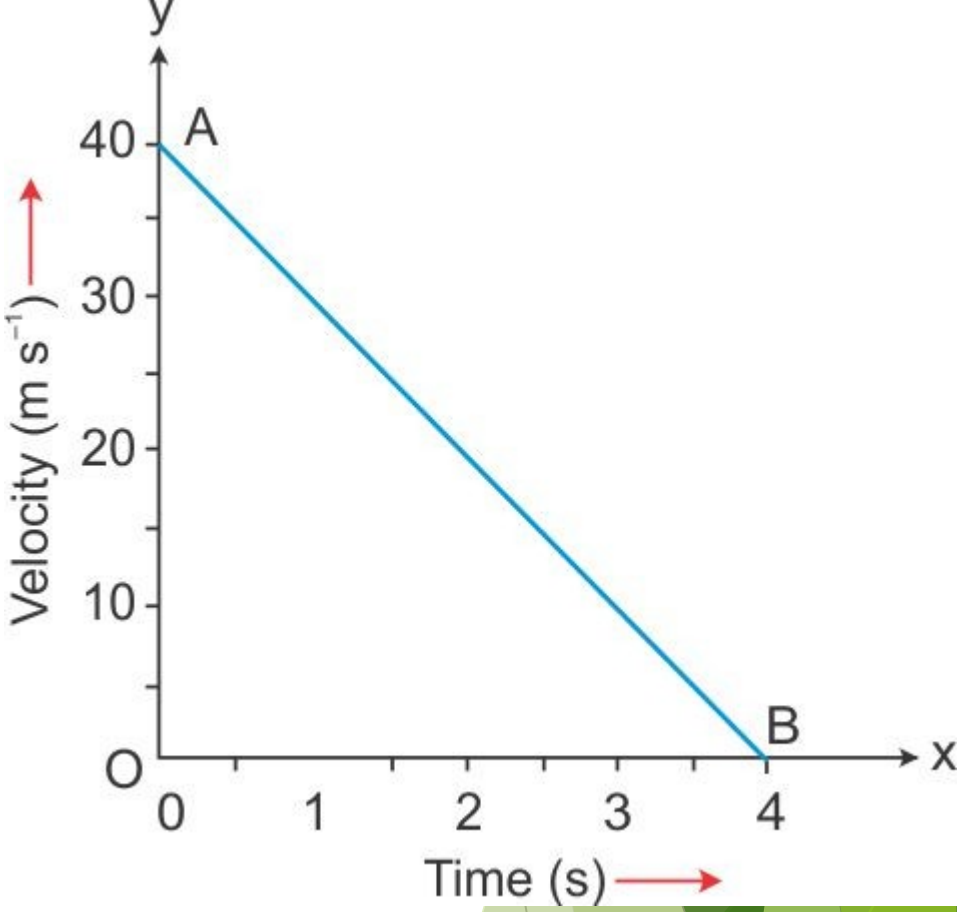
- The velocity -time graph for a body having non-uniform acceleration is a curved line.



See the change in velocity

Retardation (Deceleration or Negative Acceleration)

If the velocity of a body increases, the acceleration is positive, and if the velocity of the body decreases, the acceleration is negative. Retardation is measured in the same way as acceleration. Retardation is actually acceleration with the negative sign .



Average Velocity

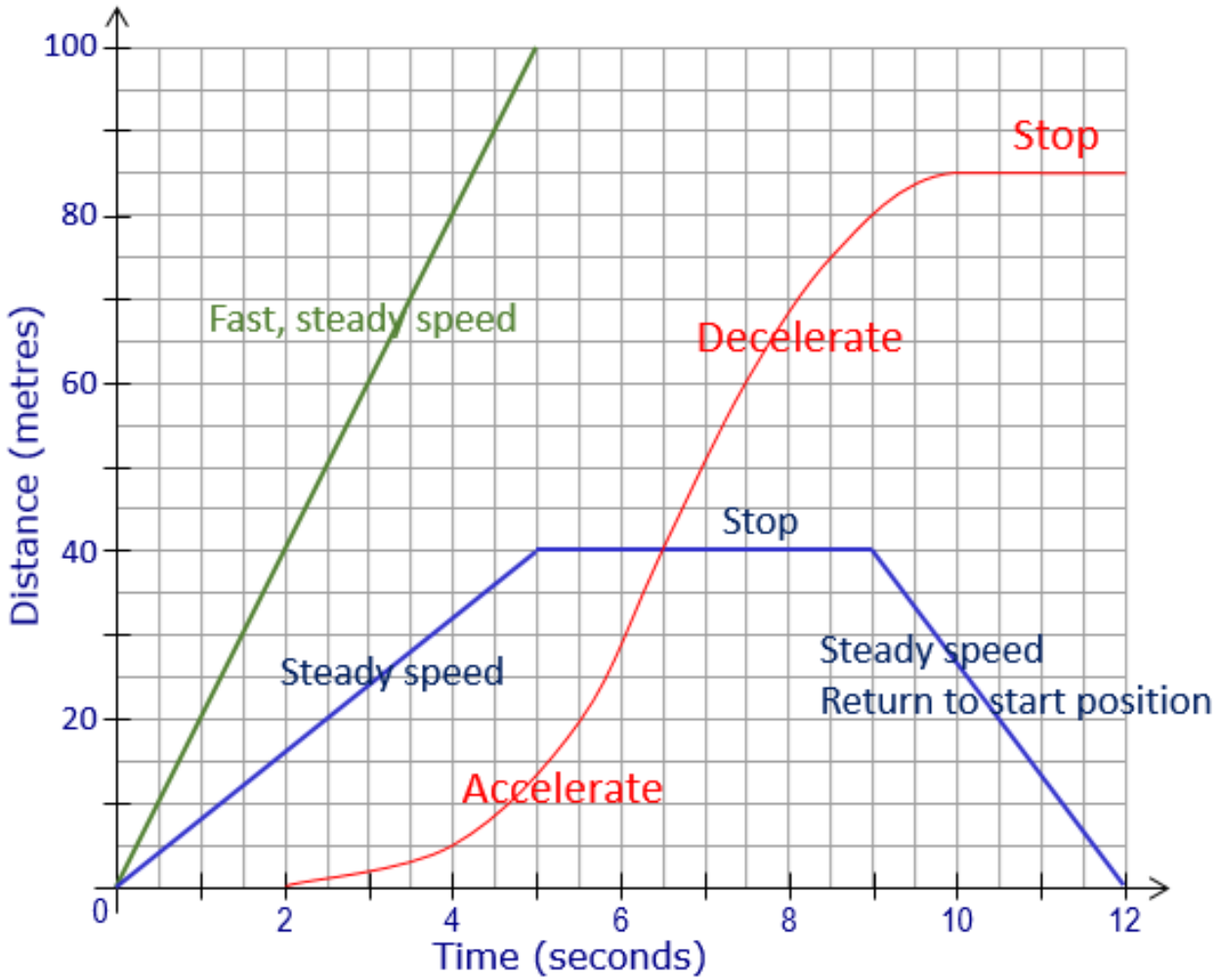
Average velocity =(Initial velocity + Final velocity) / 2

$$v = (u + v)/2$$

When a bar on the v denotes the average velocity, u is the initial velocity and v is the final velocity

Positive negative and zero accelerat

Distance-Time Graph



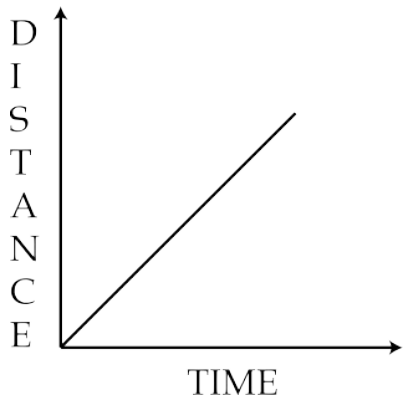
The **green line** shows a fast, steady speed, moving from 0 to 100 m in 5 seconds.

The **blue line** shows a journey with a stop and a return to the starting position.

The **red line** shows a journey starting 2 seconds later than the other two, with an initial acceleration, then a deceleration and then a stop.

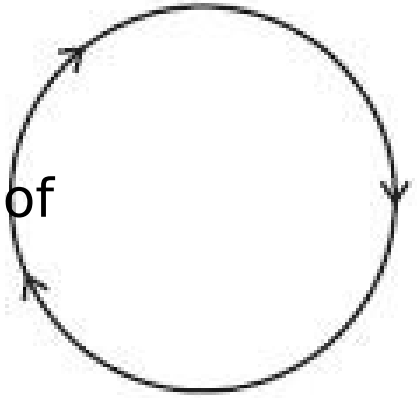
Questions

1. State the type of motion represented by the given graph.



Ans: Uniform motion

2. A stone describes a circular path with a constant speed. State the type of motion of the stone.

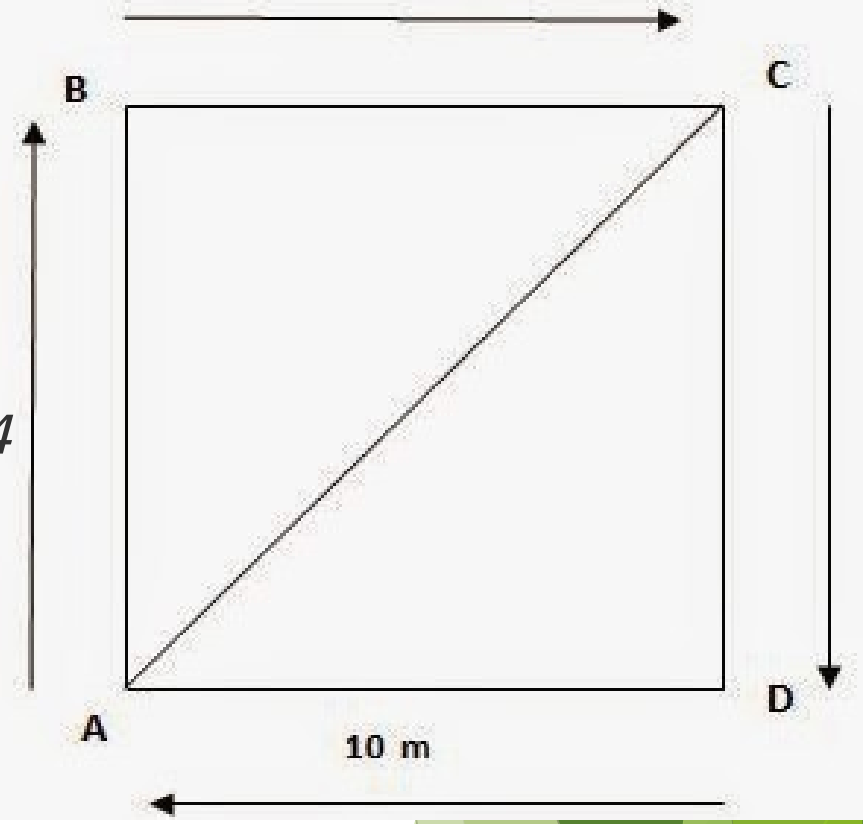


Ans: Accelerated motion since the direction of velocity changes

3. Under what conditions is the magnitude of average velocity of an object equal to its average speed ?

Ans: when object moves in a straight line

2. *A farmer moves along the boundary of a square field of side 10 m in 40 s. What will be the magnitude of displacement of the farmer at the end of 2 minutes 20 seconds from his initial position?*



Side of the given square field = 10m so, perimeter = 10 m x 4 = 40 m

Farmer takes 40 s to move along the boundary.

Displacement after 2 minutes 20 s = 2 x 60 s + 20 s = 140s

Therefore, in 1s the distance covered by farmer = 40 / 40 m = 1m

Therefore, in 140s distance covered by farmer = 140 m. Now, number of rotation to cover 140 al boundary= Total Distance / Perimeter = 140 m / round

Thus, after 2 min 20 seconds the displacement of farmer will be equal to 14.14 m, northeast from initial position.

Thus, after 3.5 round farmer will at point C of th

Therefore. Displacement $AC = \sqrt{(10m)^2 + (10m)^2}$

$= \sqrt{100m^2 + 100m^2}$

$= \sqrt{200m^2}$

$= 10\sqrt{2}\,\text{m}$

$= 10 \times 1.414 = 14.14\ \text{m}$

aphical Representation of Motion

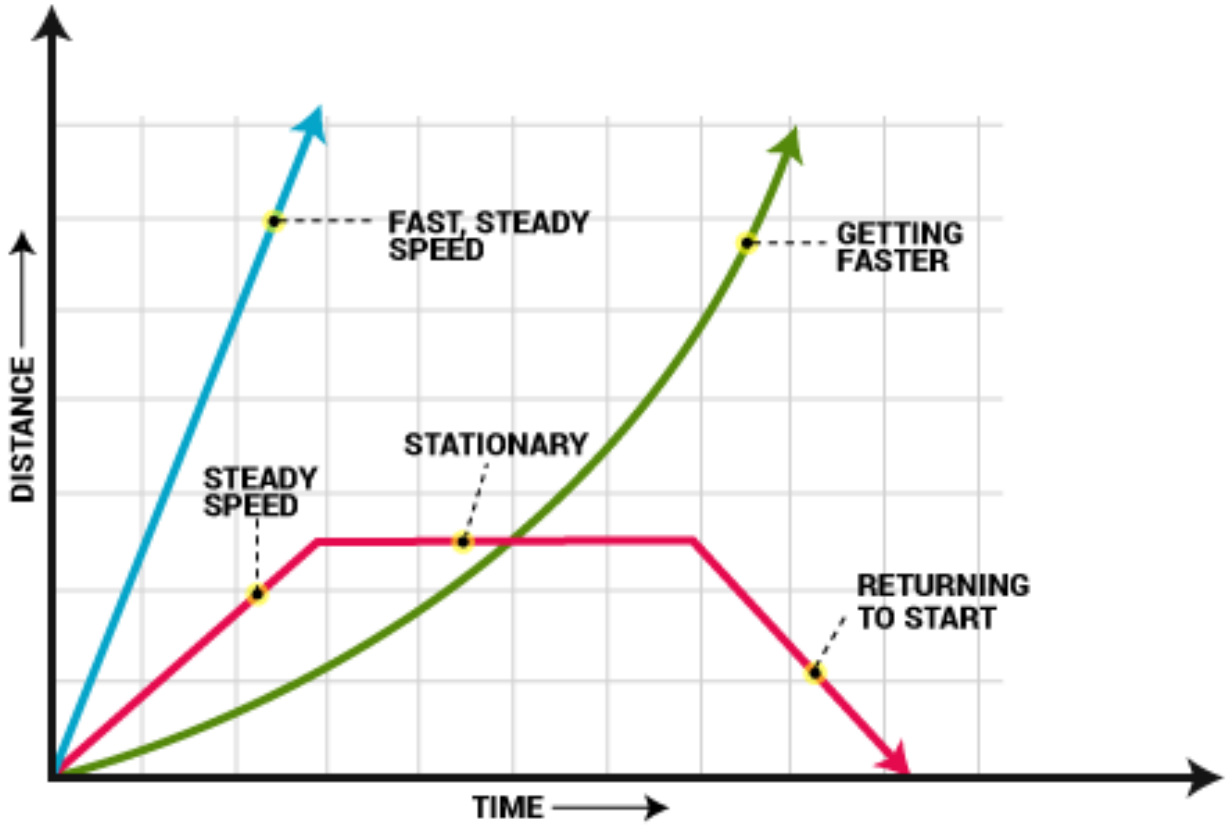
Remember-‘time’ is always taken along the x-axis whereas ‘distance’ or ‘speed’ (or velocity) is taken along the y-axis .

1- Distance – Time Graphs

- **The slope of a distance – time graph indicates speed .**

I- if the distance – time graph of a body is a straight line, then its speed is uniform .

II – if the distance – time graph of a body is a curved line, then its speed is non – uniform .



2- Speed – Time Graphs (Or Velocity – Time Graphs)

Three types

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

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

iii) When the speed of the body changes in a non- uniform way

(there is non-uniform acceleration)

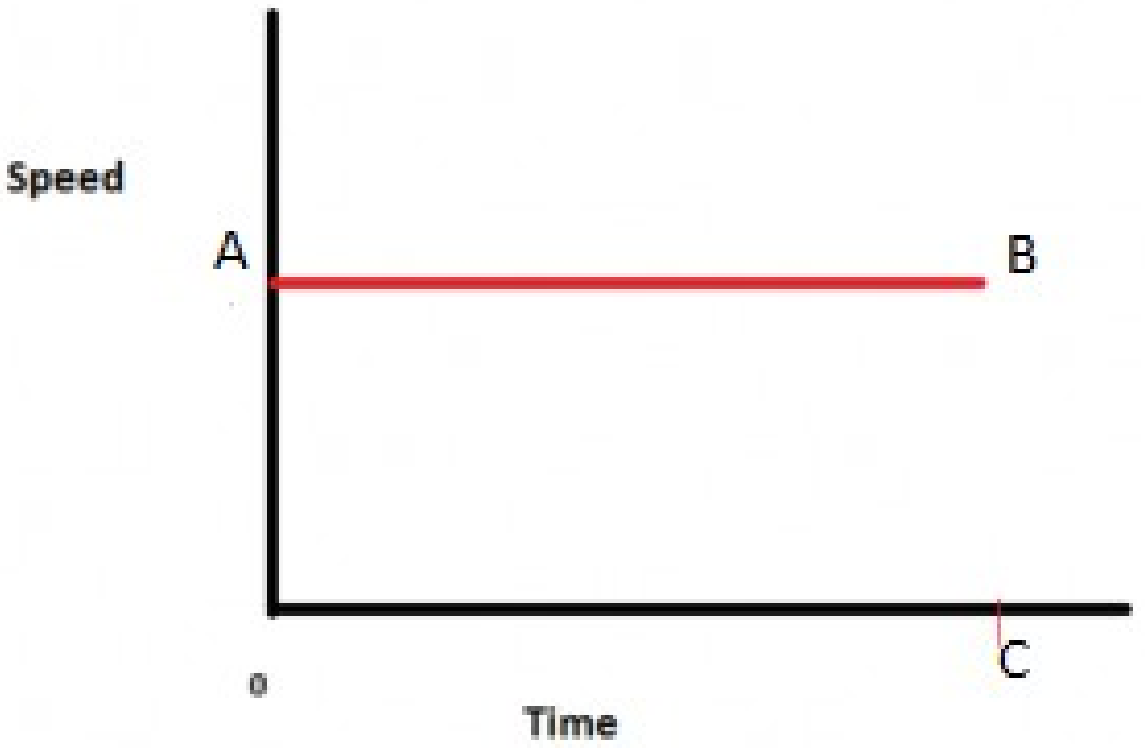
i)Speed – Time Graphs When the Speed Remains Constant

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

In a speed-time graph, the area enclosed by the speed-time curve and the time axis gives us the distance travelled by the body .

The distance travelled by the body in a given time for such a speed-time graph is,

Distance travelled = speed × time .



II) Speed-Time Graph when Speed Changes at a Uniform Rate

The speed-time graph for a uniformly changing speed (or uniform acceleration) will be a straight line .The slope of a speed-time graph of a moving body gives its acceleration .

a straight line sloping upwards shows uniform acceleration

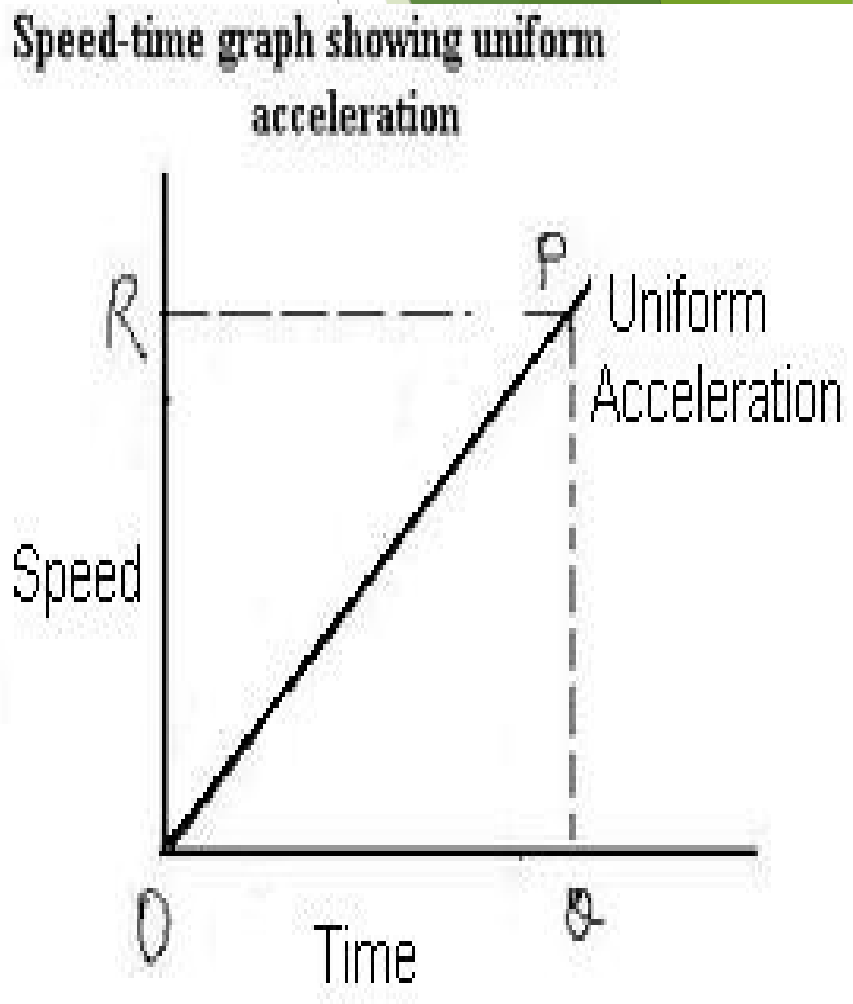
We can find out the value of acceleration from the speed-time graph of a moving body. To calculate the acceleration at a time corresponding to point Q. Draw a perpendicular QP from point Q which touches the straight line graph at point P .

Acceleration = changes on speed / time taken

The change in speed is represented by PQ whereas time taken is equal to OQ .

Acceleration = PQ / OQ .

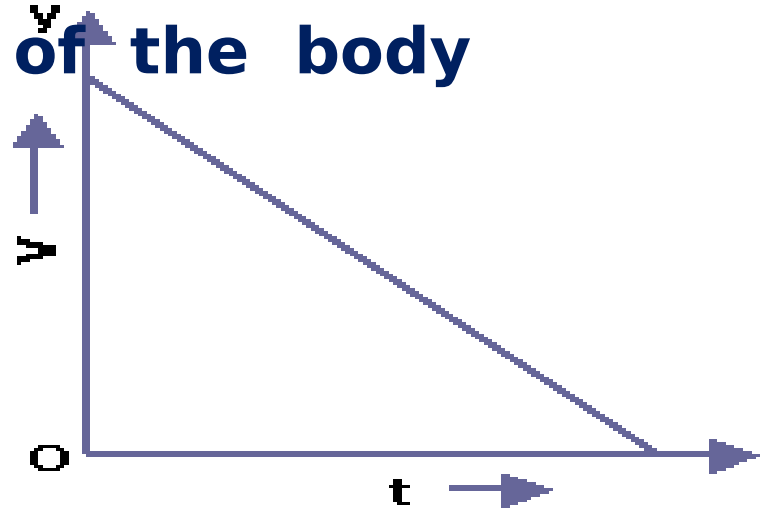
The distance travelled by the body in the time corresponding to point Q will be equal to the area of the triangle OPQ, which is equal to half the area of the rectangle ORPQ



Calculating distance

iii)Speed-time Graph when the Initial Speed of the body is not zero

In a speed-time graph of a body, a straight line sloping downwards indicates uniform retardation .



Uniform retardation

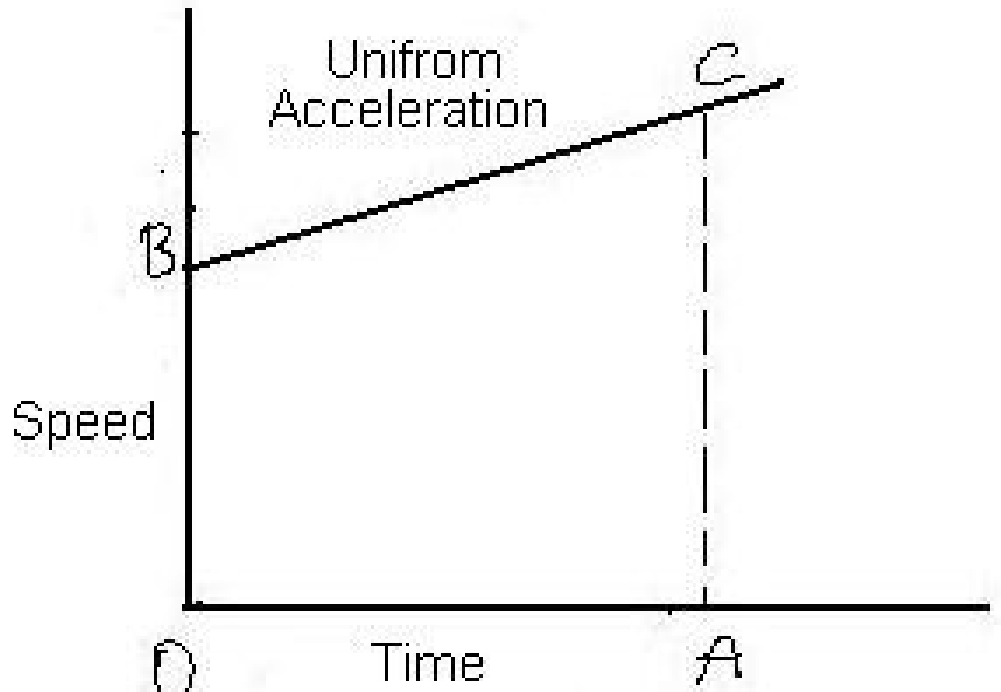
Speed-time graph of a body when its initial speed is not zero

The distance travelled by the body in this case is equal to the area of trapezium . Now,

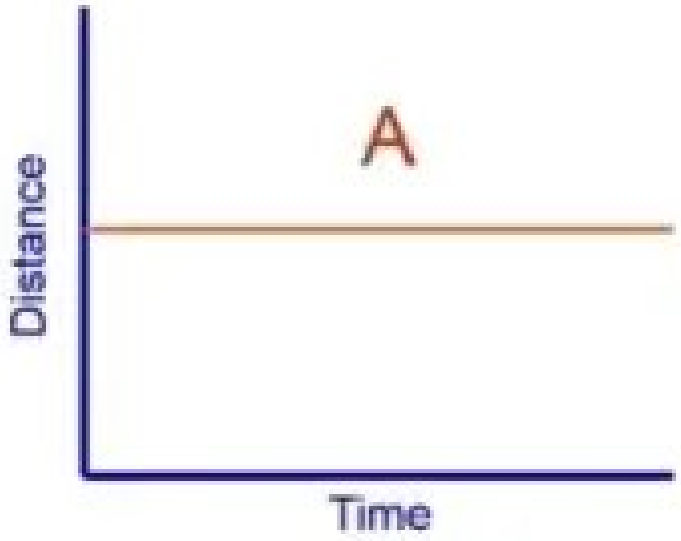
Area of trapezium = sum of two parallel sides × height / 2

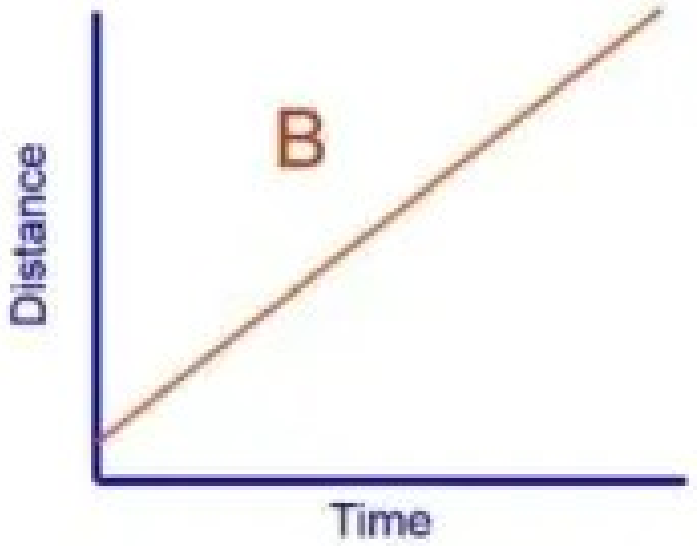
Here, sum of parallel sides is OB + AC and height is OA .

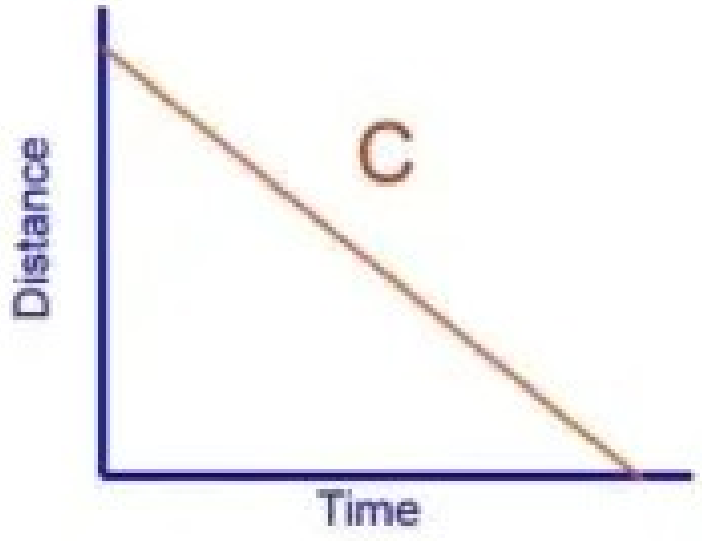
So, distance travelled = (OB + AC) × OA / 2

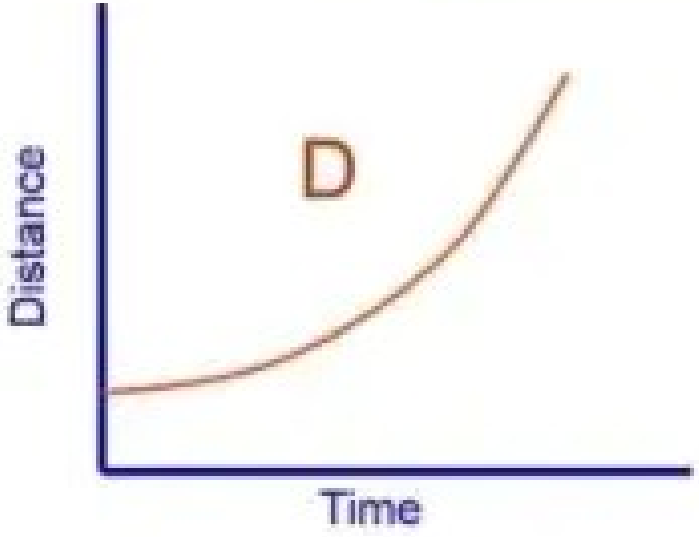


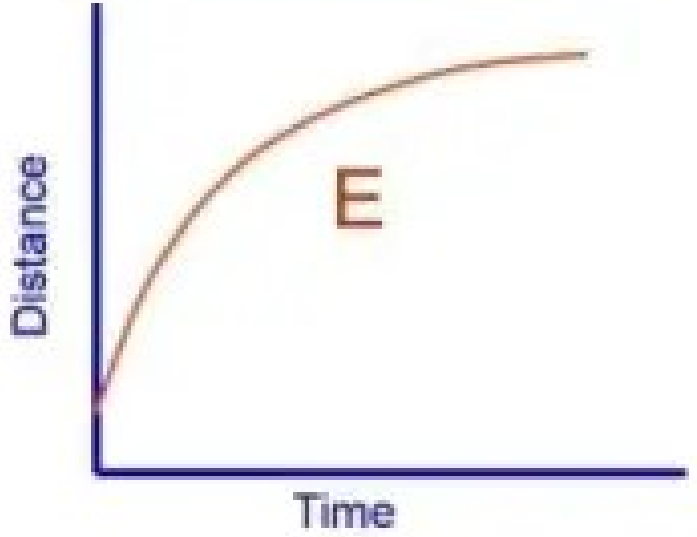
Now try these graphs

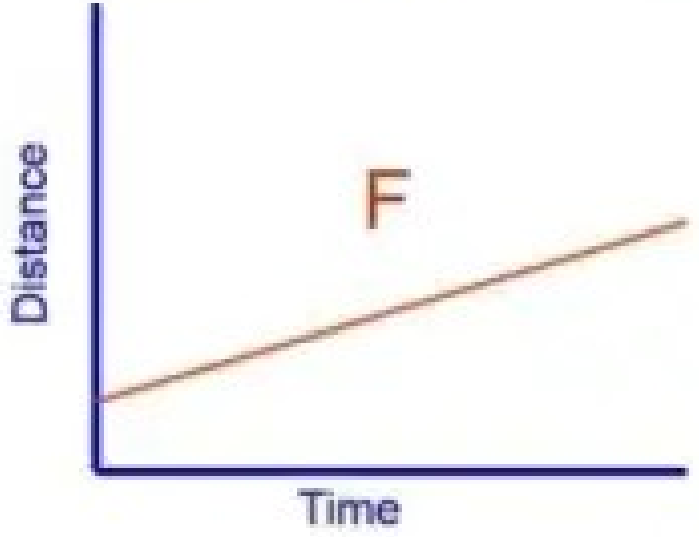












Questions

1. A bus decreases its speed from 80 km h^{-1} to 60 km h^{-1} in 5 s. Find the acceleration of the bus.

Initial speed of the bus, u= 80 km/h $= 80 \times \frac{5}{18} = 22.22$ m/s

Final speed of the bus, v= 60 km/h $= 60 \times \frac{5}{18} = 16.66$ m/s

Time take to decrease the speed, t= 5 s

Acceleration, $a = \frac{v-u}{t}$ $= \frac{16.66-22.22}{5} = -1.112\ m/s^2$

2. A train is travelling at a speed of 90 km h^{-1}. Brakes are applied so as to produce a uniform acceleration of 0.5 m s^{-2}. Find how far the train will go before it is brought to rest.

Initial speed of the train, u= 90 km/h = 25 m/s

(Final speed of the train, v = 0 (finally the train comes to rest and its velocity becomes 0)

Acceleration = - 0.5 m s^{-2}

According to third equation of motion:

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

$(0)^2 = (25)^2 + 2(-0.5)s$

Where, s is the distance covered by the train

$$s = \frac{25^2}{2(0.5)} = 625\ m$$

To Derive The Equations of Motion (Graphical Method)

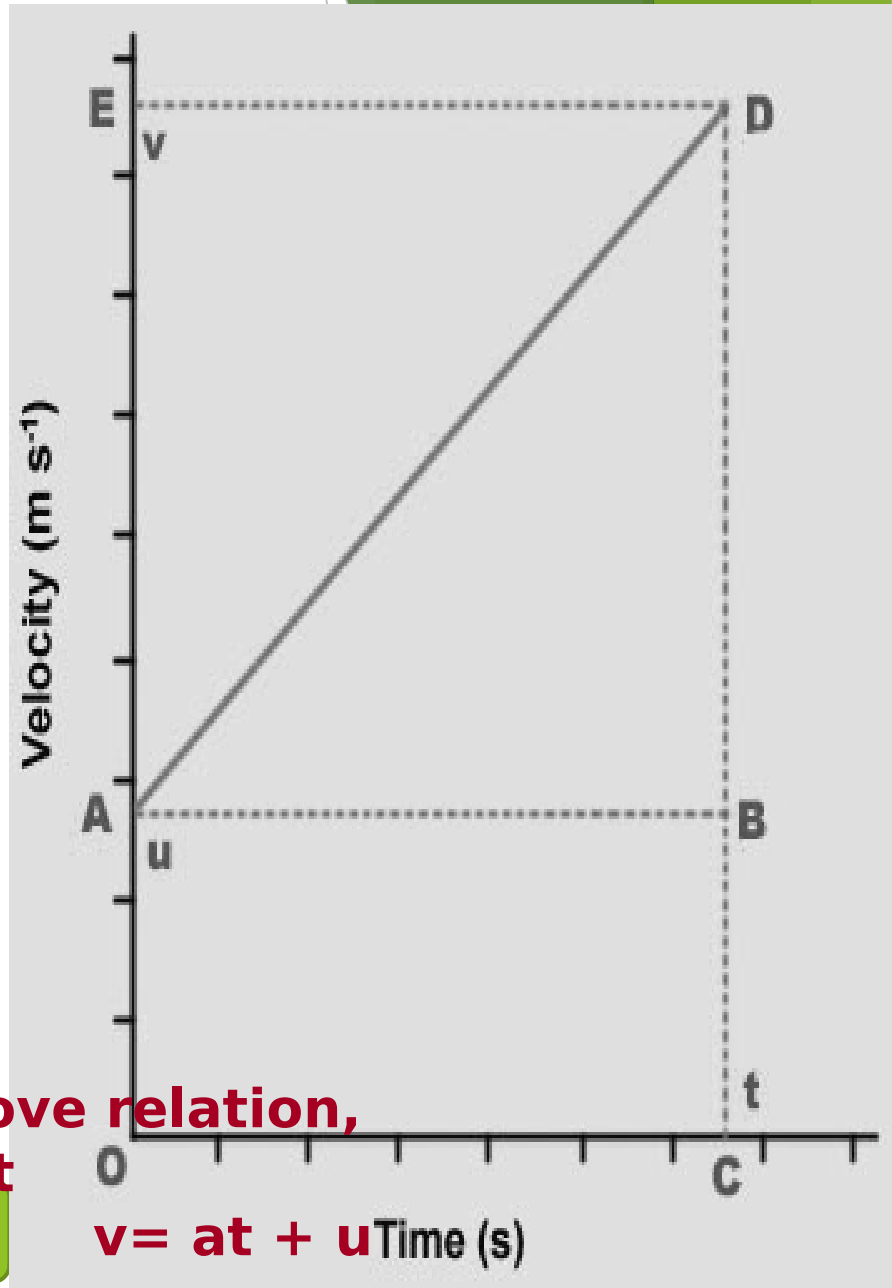
v = u + at

Initial velocity of the body, u = OA
Final velocity of the body, v = DC
But from the graph DC = DB + BC
Therefore, **v = DB + BC**

Again BC = OA So, v = DB + OA
But, OA = u So, v = DB + u .....(1)

We should find out the value of DB now .
We know that the slope of a velocity-time graph is equal to Acceleration, a = slope of line AD

Or a = DB/ AB .....(2)
But AB = OC = t, so, putting t in place of AB in the above relation,
we get : a = DB / t Or DB = at
Now, putting this value of DB in equation (1) we get v = u + at v= at + u



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

Distance travelled = Area of fig. OADC

= Area of rectangle OABC

+ Area of triangle ADB

We will now find out area of the rectangle OABC and the area of triangle ADB **.**

I- Area of rectangle OABC = OA × OC

= u × t = ut

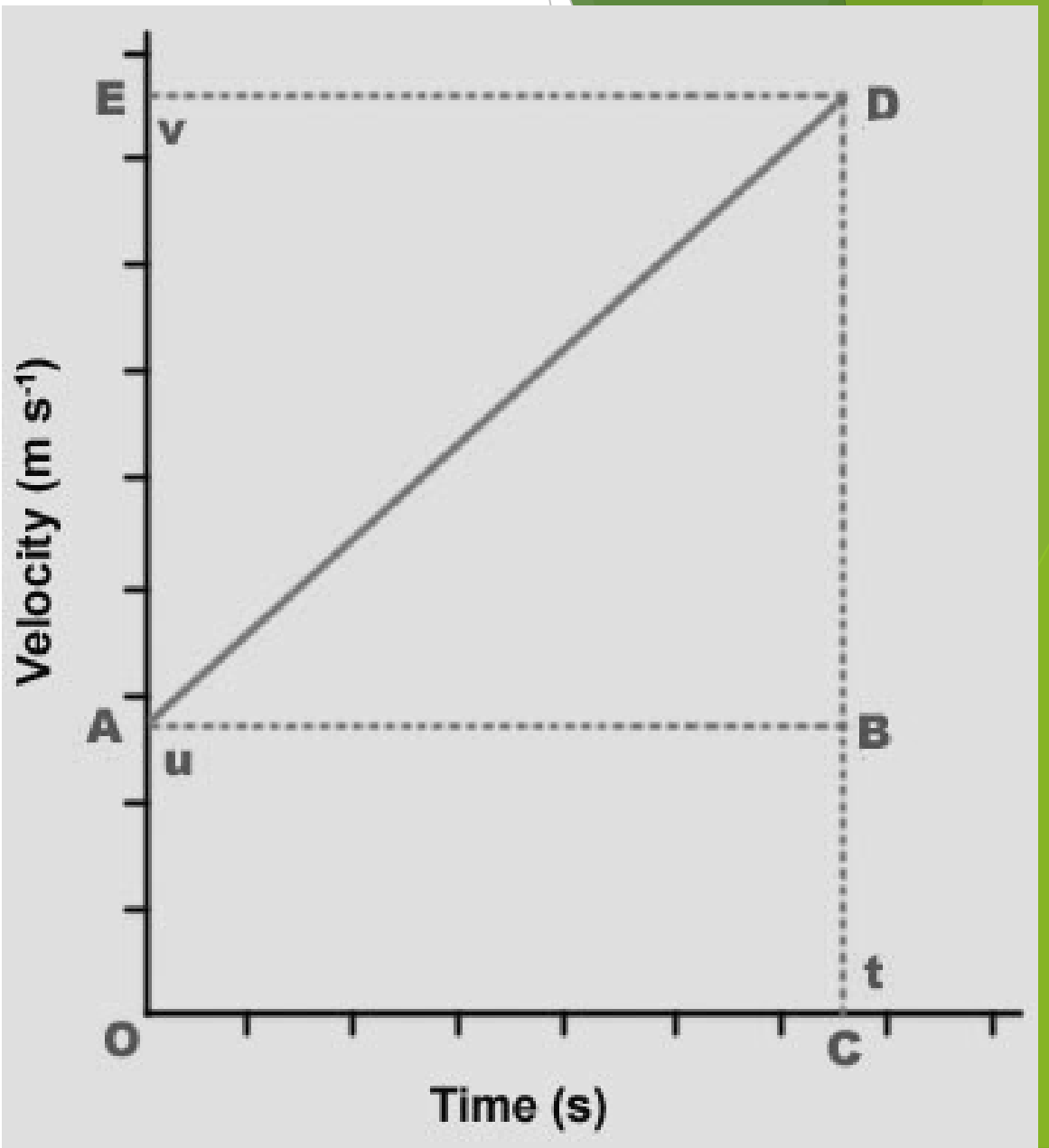
II- Area of triangle ADB = ½ × AB × DB

= ½ × t × at

= ½at²

So, distance travelled

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



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

The distance travelled s by a body in time t is given by the area of the fig. OADC which is a trapezium .

Distance travelled , s = Area of trapezium OADC

The s = (Sum of parallel sides) × Height / 2

Or $s = (OA + CD) \times OC / 2$

Now, $OA + CD = u + v$

And $OC = t$.

Putting these values in the above relation, we get :

$$S = (u + v) \times t / 2$$

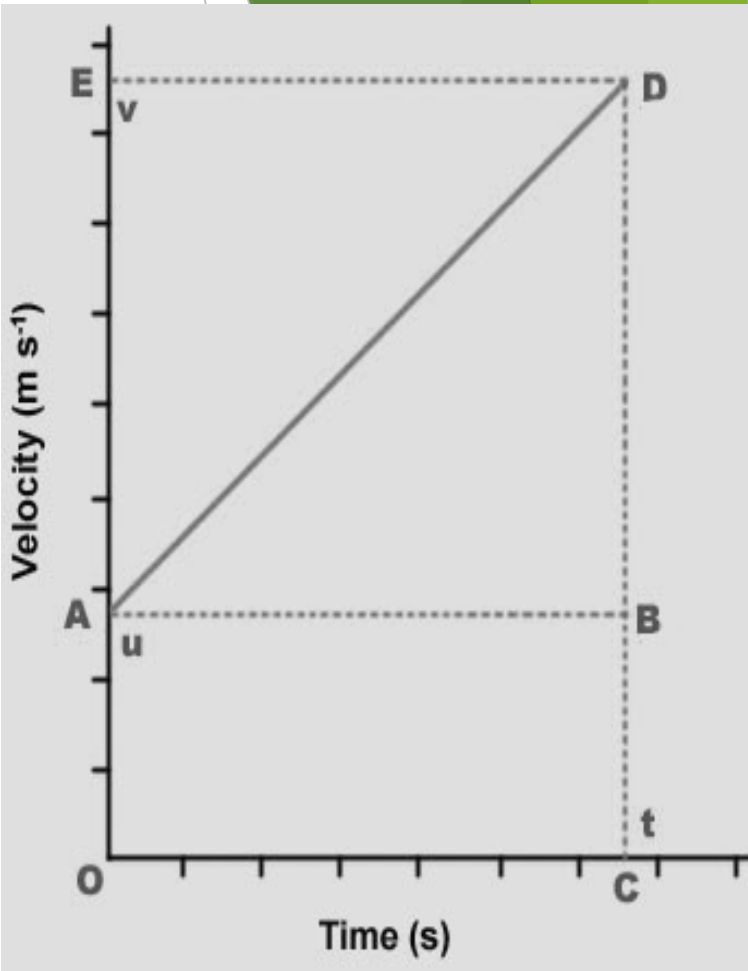
We know that $t = (v - u) / a$

Putting this value of t in equation, we get :

$$S = (u + v) \times (v - u) / 2a$$

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

Or. $v^2 = u^2 + 2as$



Summary

Motion- *A body is said to be in motion when its position changes continuously with respect to a stationary object*

Distance: path length (scalar), Displacement: shortest path (Vector)

Uniform motion- A body has a uniform motion if it travels equal distances in equal intervals of time

Non-Uniform motion:A body has a non-uniform motion if it travels unequal distance in equal intervals of time.

Speed =Distance / time , unit m/s

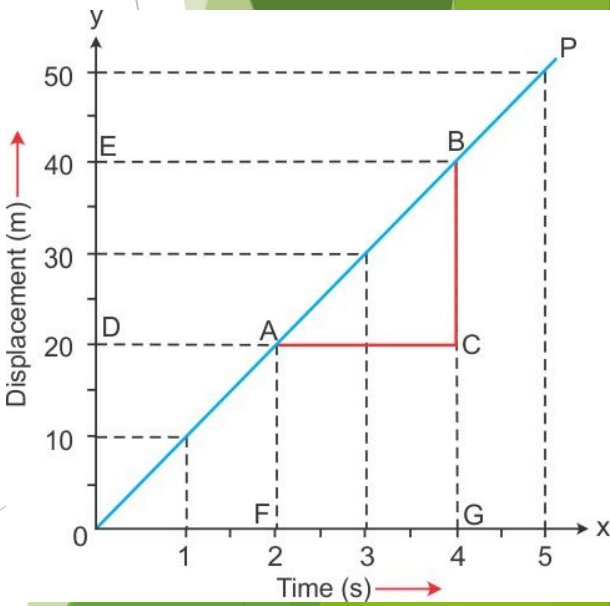
Uniform speed = equal distances in equal intervals of time

Average speed= total distance / total time

Velocity : Velocity of a body is the distance travelled by it per unit time in a given direction.

Velocity = displacement / time taken, V = s / t , unit is m/s

Uniform Velocity : A body has a uniform velocity if it travels in a specified direction in a straight line and moves over equal distances in equal intervals of time, no matter how small these time intervals may be



Summary

- Speed And Velocity Are Not Always Equal In Magnitude
- Acceleration of a body is defined as the rate of change of its velocity with time
- a = (v-u) / t , *The SI unit of acceleration is meters per second square*
- Uniform Acceleration: velocity increases by equal amounts in equal intervals of time.
- Non- Uniform Acceleration : velocity increase by unequal amounts in equal intervals of time.
- If the velocity of a body increases, the acceleration is positive, and if the velocity of the body decreases, the acceleration is negative
- Area under the speed-time graph gives the distance travelled by the body
- The three equations of motion are
  - $v = u + at$
  - $s = ut + \frac{1}{2}at^2$
  - $v^2 = u^2 + 2as$

My sincere thanks to NVS for providing me this opportunity

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