Discussion on the Topic

CHAPTER 8-**MOTION**

Class-IX

CONTENTS

- *Rest and Motion*
- *Important terms related with motion*
- *Establishment of equations of uniformly accelerated motion theoretically*
- *Graphical representation for different types of motion*
- *Establishment of equations of uniformly accelerated motion graphically*
- *Basic concept of uniform circular motion*

REST AND MOTION

Rest- A body is said to at rest if it does not change its position with respect to its immediate surrounding

Ex.*- book kept on a table is said to be at rest with respect to any other stationary objects.*

Motion- A body is said to be in motion if it changes its position with respect to its immediate surroundings.

with respect to a stationary object taken as reference point.

Ex*.- When the position of a moving car changes continuously with respect to a*

stationary objects like houses and trees, ect., we say that the car is in motion.

But, Rest and Motion all are relative.

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DISTANCE AND DISPLACEMENT

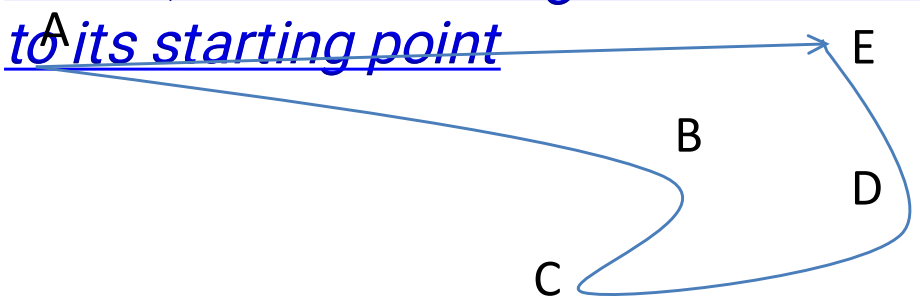
Distance- The distance travelled by a body is the actual length of the path covered by a moving body irrespective of the direction in which the body travels.

- *Its S.I. unit metre (m) and C.G.S. unit is centimeter(cm)*
- *It is a scalar quantity*

Displacement-. The shortest distance from initial to final position of the body is the magnitude of he displacement and its direction is from initial to final position.

- *Its S.I. unit metre (m) and C.G.S. unit centimetre (cm)*
- *It is vector quantity*

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 finally comes back to its starting point



Here distance is length of the path ABCDE
But Displacement is the length of the straight line AE , Directed along A to E

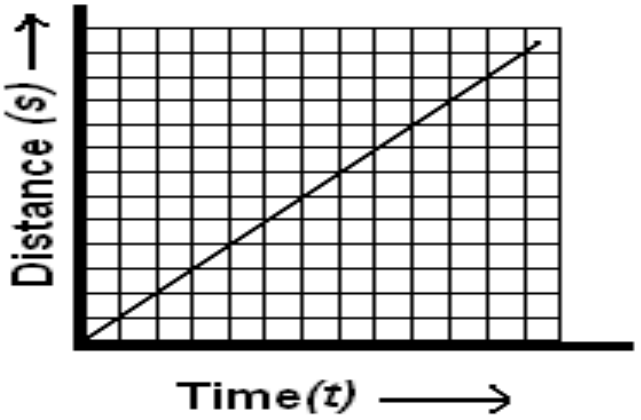
UNIFORM AND NON-UNIFORM MOTION

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.

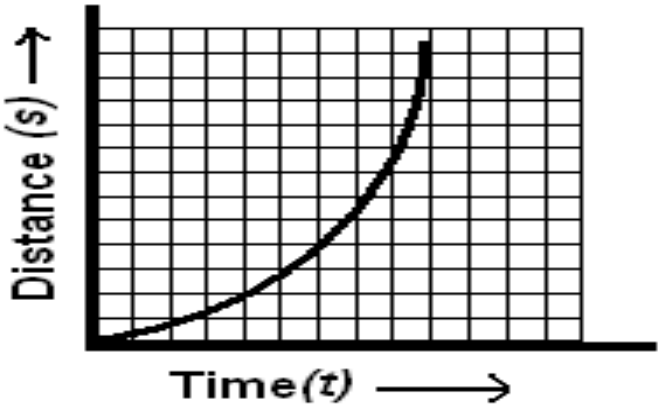
The distance-time graph for uniform motion is a straight line.

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 non-uniform motion is a curved line.



Distance-time graph of an object moving with uniform speed



Distance-time graph for a car moving with non-uniform speed

SPEED

Speed- Speed of a body is the rate change of distance with time.

- *S.I. unit is m/s and C.G.S unit cm/s*
- *Speed of a body is = distance travelled / time taken.*

$$i.e.\ v = d/t$$

Where v = speed ; d = distance travelled ; t = time taken

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

- *Average speed = total distance travelled / total time taken.*

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.

VELOCITY

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

- We know that the 'distance travelled in a given direction' is known as 'Displacement'.
- *Velocity = displacement / time taken*

i.e. V = s / t

Where V = velocity of the body ; S = displacement of the body ; t = time taken

- The SI unit of velocity is the same as that, (m/s). 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 the direction .

Average Velocity- **It is define as the ratio of displacement to the time taken in entire journey is called average velocity.**

Average velocity = Displacement / Total time taken

- **Also it is measured as**

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

  u is the initial velocity and v is the final velocity .

Speed And Velocity Are Not Always Equal In Magnitude

** 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 .

ACCELERATION

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

OR

Acceleration = (final velocity – initial velocity) / time taken

i.e. $a = (v-u) / t$

- *Where a = acceleration of the body ; v = final velocity of the body ; u= initial velocity of the body ; t = time taken for the change in velocity*
- ***The SI unit of acceleration is meters/second square .***
- ***When a body is moving with uniform velocity, its acceleration will be zero.***

Retardation (or Deceleration or Negative Acceleration)- **If the velocity of the body decreases, the acceleration is negative called retardation.**

Retardation is measured in the same way as acceleration. Retardation is actually acceleration with the negative sign .

Uniform Acceleration- **A body has a uniform acceleration if it travels in a straight line and its velocity increases by equal amounts in equal intervals of time.**

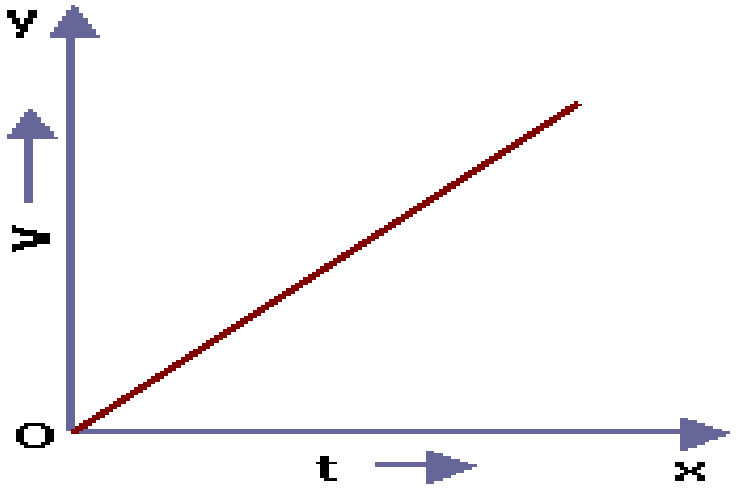
The velocity -time graph of a body having uniformly accelerated motion is a straight line.

EX.- Motion of a body under gravity

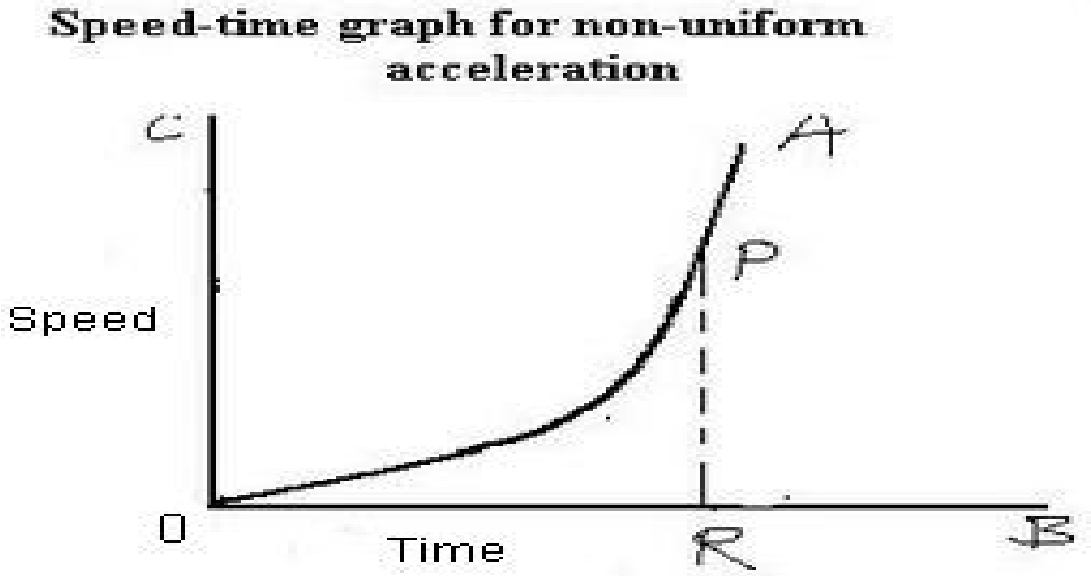
Non- Uniform Acceleration- **A body has a non-uniform acceleration if its velocity increase by unequal amounts in equal intervals of time.**

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

Ex.-Motion of a car on a crowded road



Uniform acceleration



Equations Of Uniformly Accelerated Motion

- There are three equations for the motion of those bodies which travel with a uniform acceleration .

1- First Equation Of Motion

-The first equation of motion is : $v = u + at$. It gives the velocity acquired by a body in time t .

Acceleration = change in velocity / time taken .

Or $a = v - u / t$

And $at = v - u$

And, $v = u + at$

The equaction $v = u + at$ is known as the first equation of motion and it is used to find out the velocity ' v ' acquired by a body in time, the body having an initial velocity 'u' and a uniform acceleration 'a'. In this equation has four values in it, if three values are known, the fourth value can be calculated .

2- Second Equation Of Motion

The second equation of motion is : $s = ut + \frac{1}{2} at^2$. It gives the distance travelled by the a body in time ′t′. Let the distance travelled by the body in time be′s′. The distance travelled by a moving body in time ′t′ can be found out by considering its average velocity .

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

Also, Distance travelled = average velocity × t

- From the first equation of motion we have, $v = u + at$. Putting this value of v in equation (1), we get :

$$s = (u + u + at) \times t / 2$$

$$s = (2u + at) \times t / 2$$

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

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

This is the second equation of motion and it is used to calculate the distance travelled by a body in time .

3- Third Equation Of Motion

- The third equation of motion is : $v^2 = u^2 + 2as$. It gives the velocity acquired by a body in travelling a distance s .

-The third equation of motion can be obtained by eliminating t between the first two equations of motion .

From the second equation of motion we have : $s = ut + \frac{1}{2}at^2$

And from the first equation of motion we have : $v = u + at$

This can be rearranged and written as : $at = v - u$

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

Putting this value of t in equation (1), we get :

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

$$\text{Or } s = uv - u^2 / a + a (v^2 + u^2 - 2uv) / 2a^2$$

$$\text{Or } s = uv - u^2 / a + v^2 + v^2 + u^2 - 2uv / 2a$$

$$\text{Or } s = 2uv - 2u^2 + v^2 + u^2 - 2uv /2a$$

$$\text{Or } 2as = v^2 - u^2$$

$$\text{Or } v^2 = u^2 + 2as$$

This equation gives us the velocity acquired by a body in travelling a distances .

To solve the problems on motion we should remember that :

1) if a body starts form rest, its initial velocity, $u = 0$.

2) if a body comes to rest (it stops), its final velocity, $v = 0$.

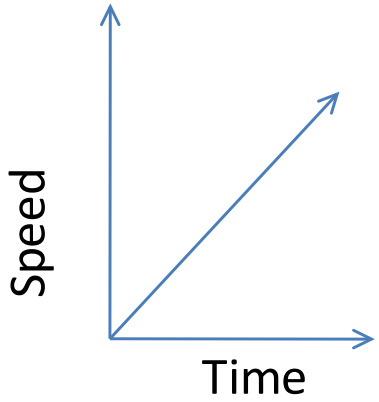
3) if a body moves with uniform velocity, its acceleration, $a = 0$.

Graphical Representation Of Motion

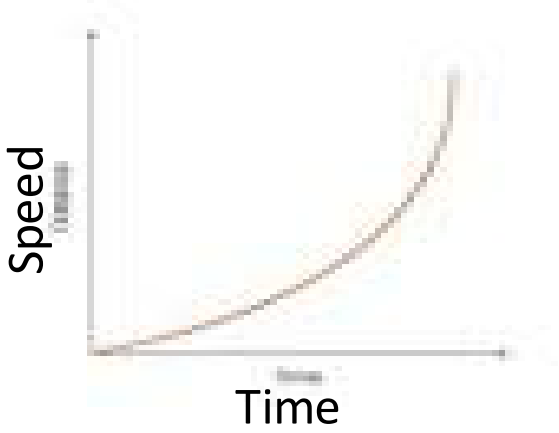
1- Distance – Time Graphs

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

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



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



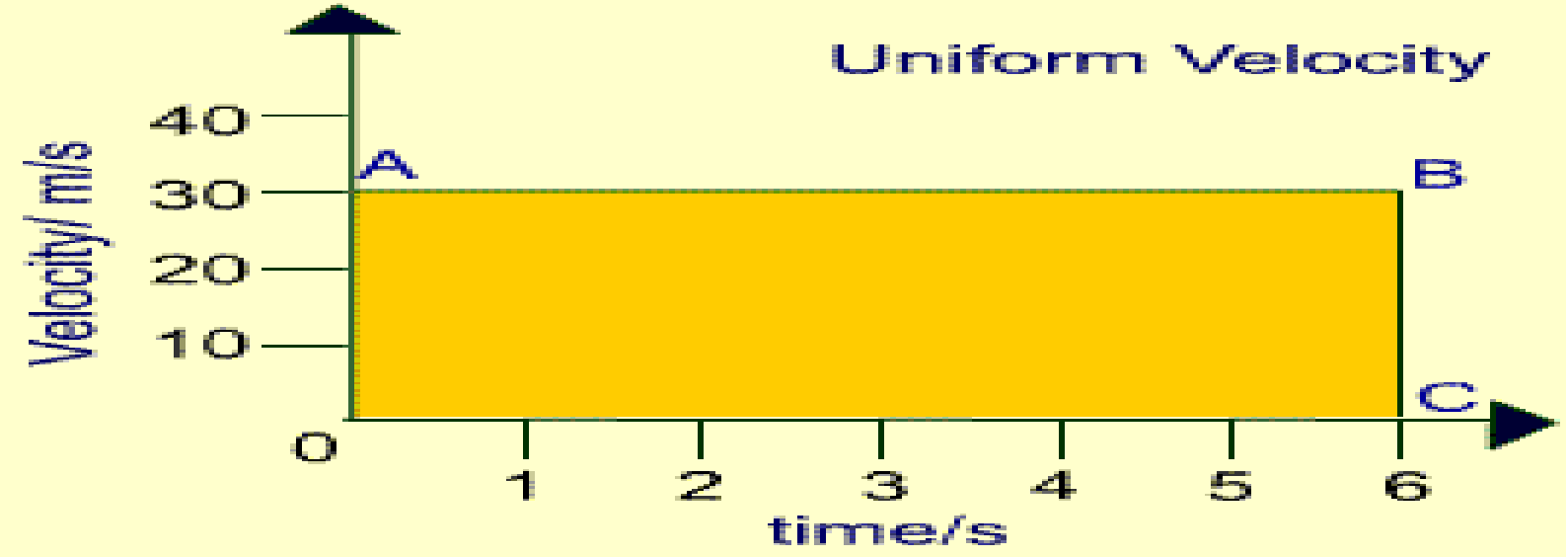
2- Speed – Time Graphs (Or Velocity – Time Graphs)

We can have three types of speed – time graphs for a moving body :

❑ 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 .
= Area of rectangle OABC



❑ 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 .

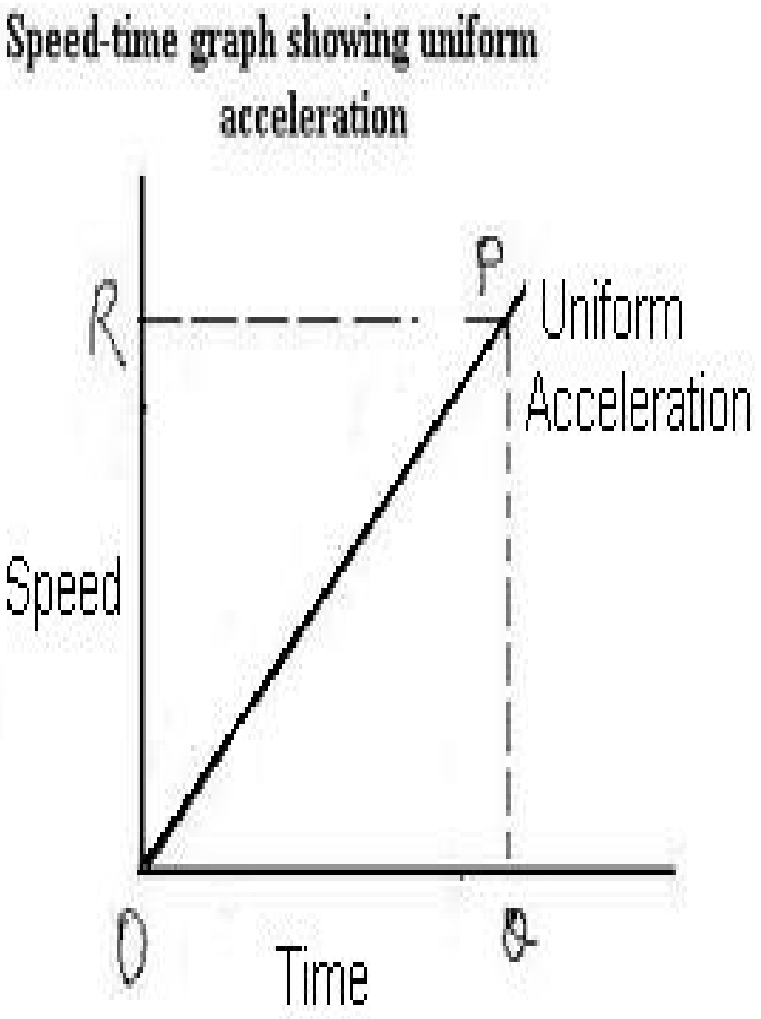
- The slope of a speed-time graph of a moving body gives its acceleration .

- In a speed-time graph of a body, 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 by finding its SLOPE. So, *Acceleration = PQ / OQ .*

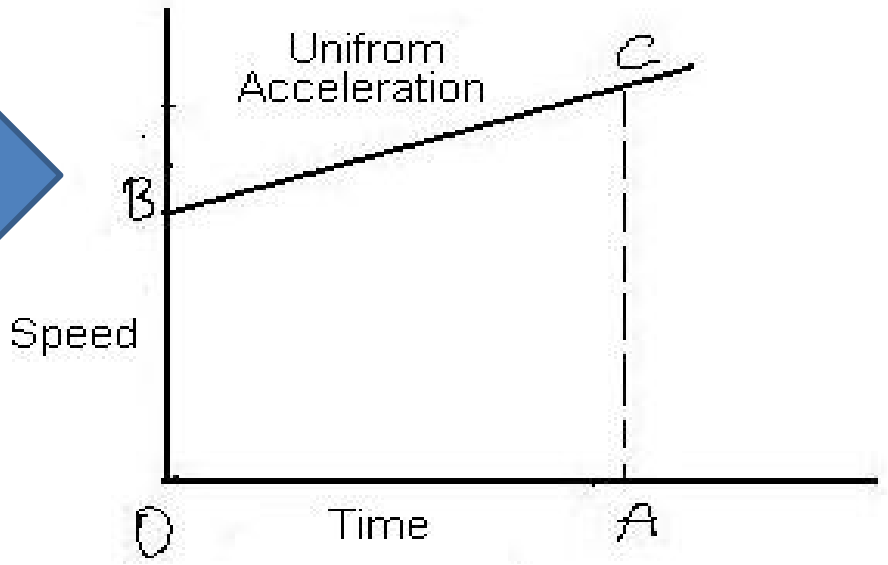
- The distance travelled by the body in the time corresponding to point Q will be equal to the area of the triangle OPQ, which is equal to half the area of the rectangle ORPQ .

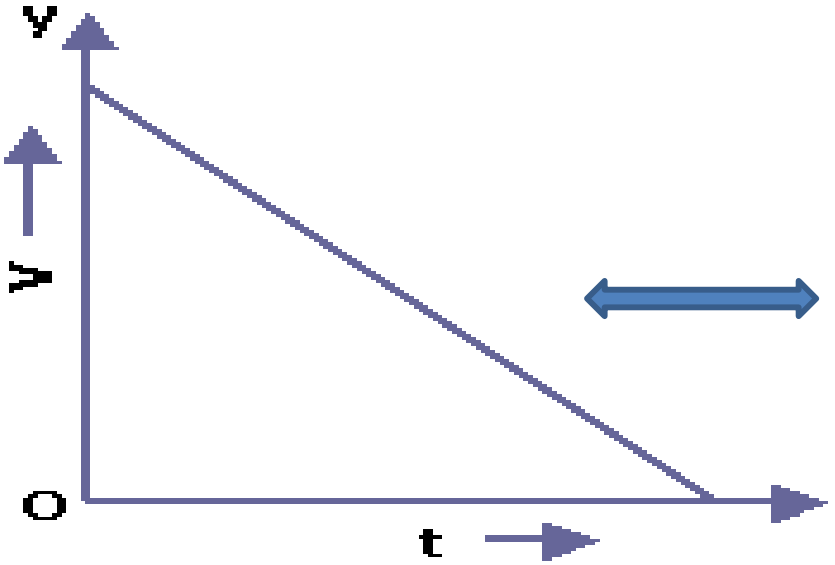
Distance travelled = Area of triangle OPQ



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

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





Uniform retardation

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

To Derive The Equations Of Unifomly Accelerated Motion By Graphical Method

❑ To derive v = u + at by graphical method

Now, Initial velocity of the body, u = OA

And, 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

Now, from equation (1), OA = u

So, v = DB + u

Or BD= v-u.

We know that the slope of a velocity-time graph is equal to

Acceleration, a = slope of line AD

Or a = DB/ AB

But AB = OC = t,

so, putting t in place of AB in the above relation,

we get :

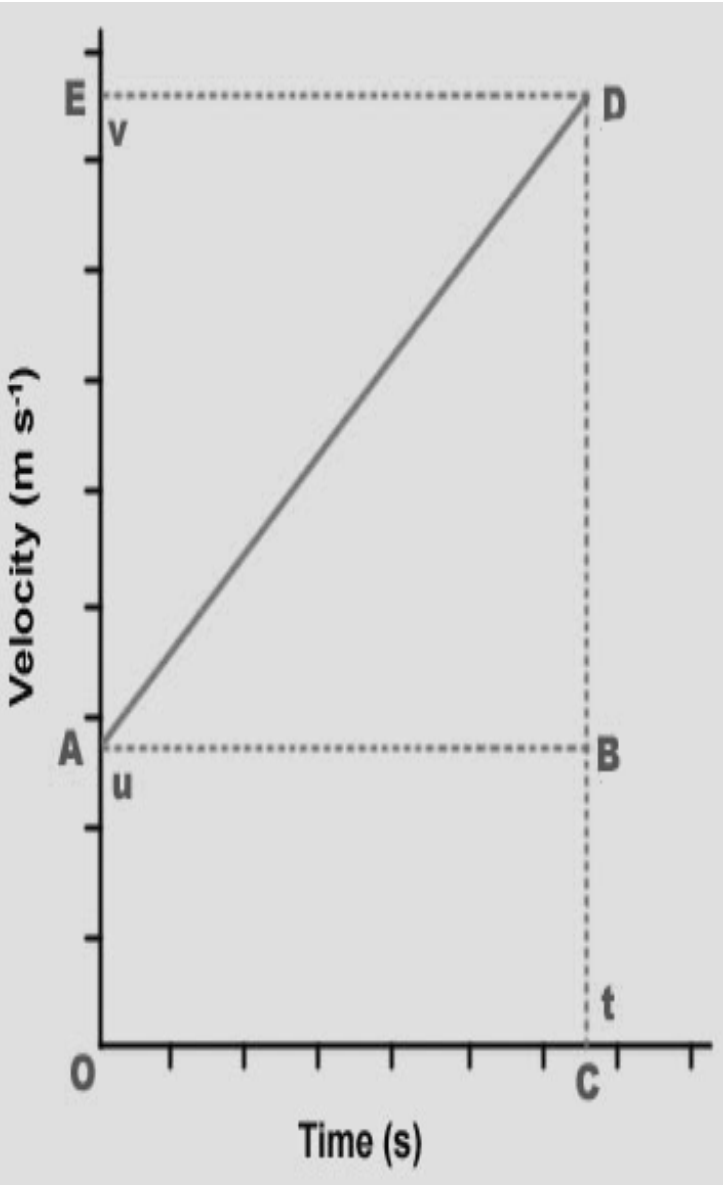
so, a= DB / t

Or DB = at

Now, putting this value of DB in equation (4) we get :

v= at + u

This equation can be rearranged to give : **v = u + at** .



❑ To Derive $s = ut + \frac{1}{2}at^2$ by graphical method

Distance travelled S= Area of fig. OADC

= Area of rectangle OABC + Area of triangle ADB

•I- Area of rectangle OABC = OA × OC

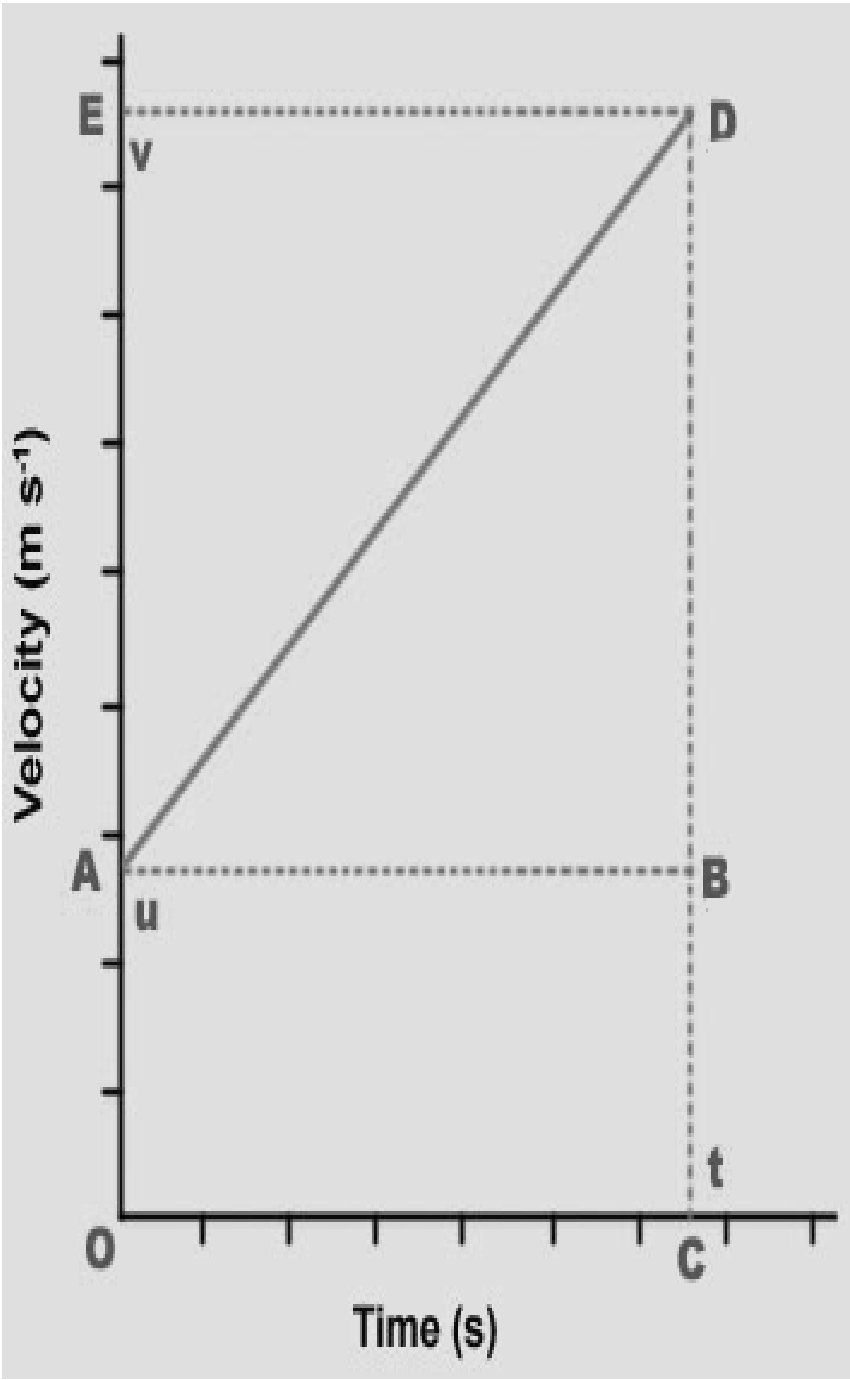
= u × t = ut

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

= ½ × t × at

= $\frac{1}{2}at^2$

So, distance travelled, $s = ut + \frac{1}{2}at^2$.



❑3- To Derive $v^2 = u^2 + 2as$ by graphical method

The distance travelled is given by the area of the fig. OADC which is a trapezium .

i.e. Distance travelled , s = Area of trapezium OADC

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

Or s = (OA + CD) × OC / 2

Now, OA + CD = u + v and OC = t

So, S = (u + v) × t / 2

We know that t = (v – u) / a

Putting this value of t in equation, we get :

S = (u + v) × (v – u) / 2a

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

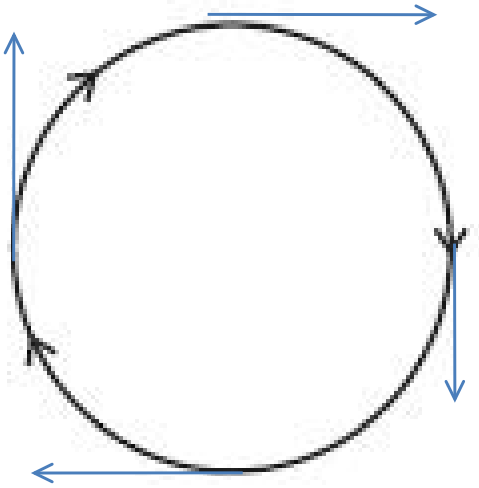
Or $v^2 = u^2 + 2as$.

UNIFORM CIRCULAR MOTION

- **When a body moves in a circle, it is called *circular motion* .**
- **When a body moves in a circular path with uniform speed, its motion is called *uniform circular motion* .**
- **When a body moves along a circular path, then its direction of motion keeps changing continuously . So *uniform circular motion is an accelerated motion.***

- *We know that the circumference of a circle of radius r is given by 2πr . If the athlete takes t seconds to go once around the circular path of radius r, the speed is given by*
- *v = 2πr / t . But velocity is zero as displacement in one complete rotation is zero.*

Circular Motion



HOME WORK

1. A car is moving in a straight line with speed 18km/hr. It is stopped in 5 s by applying brakes. Find

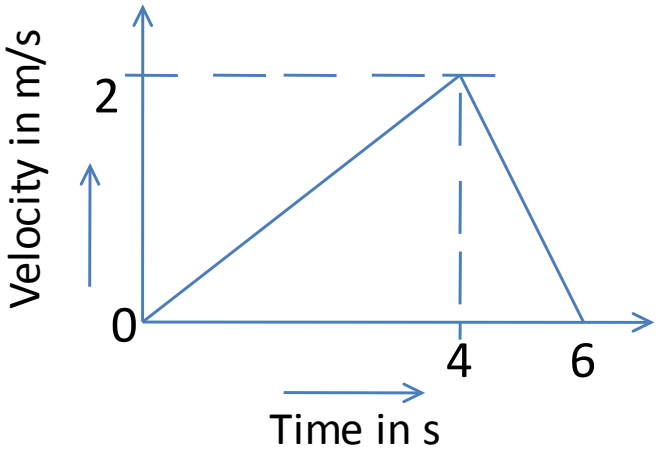
i) The initial speed of he car in m/s

ii) the retardation

iii) the speed of the car after 2 s of applying the brakes

2. A bicycle initially moving with a velocity 5 m/s accelerates for 5 s at a rate of 2 ms^{-2}. What will be its final velocity?

3. Motion of a body is represented by following v-t graph



i) Find out the displacement at t=6 s

ii) Find the acceleration from 0 to 4 s and retardation from 4 s to 6 s

iii) Compare the distance ravelled by the body from 0 to 4 s and from 4 s to 6 s

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