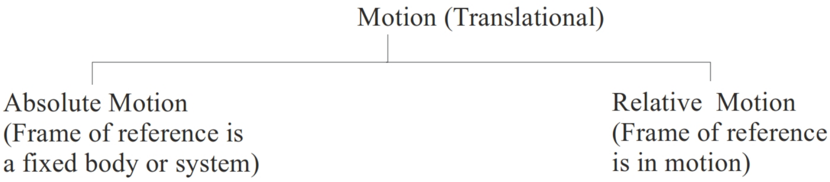
KINEMATICS-1D

- Kinematics in which we deal with the motion i.e. change in position with respect to a either fixed system or a moving system (frame of reference) without taking into account of its cause or force.

- For analysing motion of a particle, there are some physical quantities as its parameters
  (i) Position or position vector - which is the location of the particle with respect to system of co-ordinate axes.
  (ii) Displacement - the change in position vector.
  (iii) Velocity - The time rate of change of displacement
  (iv) Acceleration - The time rate of change of velocity.



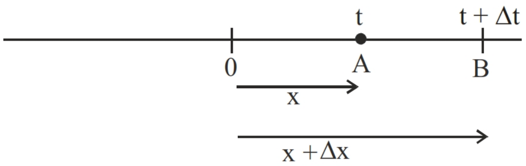


figure (i)

In figure (i) motion is along positive x-direction $\overrightarrow{AB}$ = displacement in time Δt = $= \Delta\vec{x}$

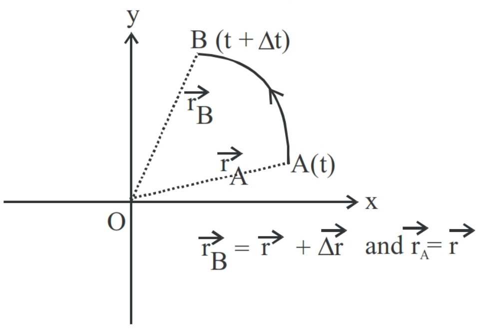


figure (ii)

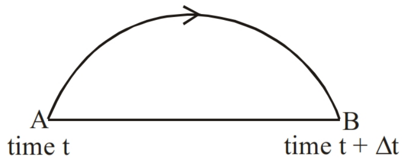
In fig (ii) displacement in time Δt , $\overrightarrow{AB} = \overrightarrow{OB} - \overrightarrow{OA} = \Delta\vec{r}$ = change in position vector.

In any kind of motion, the magnitude of displacement is less than or equal to distance (actual path traversed).

- $AB = \Delta S$ = Distance covered in time Δt .
  $\overrightarrow{AB}$ = Displacement is time $\Delta t = \overrightarrow{\Delta r}$ or path length

  $\frac{\Delta S}{\Delta t}$ = Average speed in time Δt = $\frac{\text{Distance covered}}{\text{Time elapsed}}$

  $\frac{\overrightarrow{\Delta r}}{\Delta t}$ = Average velocity in time Δt = $\frac{\text{Displacement}}{\text{Time elapsed}}$



If for different interval the particle has same average velocity then motion is said to be in uniform motion or otherwise motion is said to be in non-uniform motion and if particle is in non-uniform motion then velocity at a point is defined as $\lim_{\Delta t \to 0} \frac{\Delta \vec{r}}{\Delta t} = \frac{d\vec{r}}{dt} = \vec{v}$ called instantaneous velocity, for one dimension $\vec{v} = \frac{d\vec{x}}{dt}$. The instantaneous velocity at any print is equal to average velocity in any interval for uniform motion i.e., $\vec{v} =$ constant.

As $\Delta S \geq |\Delta \vec{r}|$

$$\frac{\Delta S}{\Delta t} \geq \left|\frac{\Delta \vec{r}}{\Delta t}\right| \text{ i.e. Av. speed} \geq |\text{Av. velocity}|.$$

Equality sign holds when motion is in one-dimensional and unidirectional.

But for $\Delta t \to 0$, $\frac{\Delta s}{\Delta t} = \frac{|\Delta \vec{r}|}{\Delta t} \Rightarrow \frac{ds}{dt} = \frac{|dr|}{dt}$ i.e. magnitude of instantaneous velocity is the speed at a point.

- If force is in the direction of motion then motion is accelerated and if force is opposite to direction of motion then it is deaccelerated or retared. Rate of change of velocity w.r. to time is same for any interval and it is equal to instantaneous acceleration. Motion is said to be uniformly accelerated otherwise non-uniformly accelerated.

$\vec{a}_{av} = \frac{\Delta \vec{v}}{\Delta t} =$ Average acceleration in time interval Δt.

$\lim_{\Delta t \to 0} \frac{\Delta \vec{v}}{\Delta t} = \frac{d\vec{v}}{dt} =$ acceleration at a point = constant for uniformally accelerated

$\frac{d\vec{v}}{dt} = f(t)$ or $f(s)$ of $f(v)$ then motion is said to be non-uniformly accelerated.

- Translational kinematical equation of motion for uniformly accelerated motion.

$$\vec{s} = \vec{u}t + \frac{1}{2}\vec{a}.t^2 = \frac{1}{2}(\vec{u} + \vec{v})t$$

$$v^2 = u^2 + 2\vec{a}.\vec{s}$$

$$\vec{v} = \vec{u} + \vec{a}.t$$

$$\vec{S}_n = \vec{u} + \frac{1}{2}\vec{a}(2n-1)$$ ($S_n =$ Displacement is in last one second.)

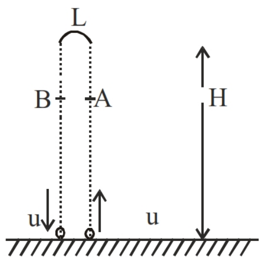
- Equation for non uniformly accelerated motion.

$$\frac{d\vec{x}}{dt} = \vec{v} \qquad \frac{d\vec{v}}{dt} = f(t) \text{ or } f(s) \text{ or } f(v) \text{ and } \frac{d\vec{v}}{d\vec{s}}.\vec{v} = f(s)$$

- Direction of velocity is in direction of change of displacement while direction of acceleration is in direction of change in velocity.

- Vertical motion under gravity - Motion of a particle under the effect of gravity - This is motion in one dimension with constant acceleration a = g = 9.8 ms^{-2} = 32 ft sec^2.

If a particle is projected veritcally up with velocity u then time of ascent = $\frac{u}{g}$ and during which height attained $H = \frac{u^2}{2g}$. Time of descent = $\frac{u}{g}$ $\qquad |\vec{v}_A|(\uparrow) = |\vec{v}_B|(\downarrow)$



$t_{AL} = t_{LB}$ where L is the point up to which particle ascends. where A and B are at same height from surface of earth.

- Effect of air resistance on motion of a particle in vertical motion under gravity - Air resistance is a force that acts on the body opposite to direction of motion and its value depends on the speed.

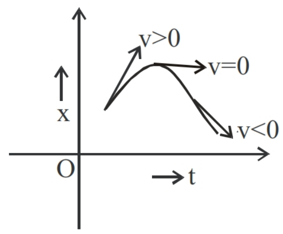
KINEMATICAL GRAPH -

Displacement time graph

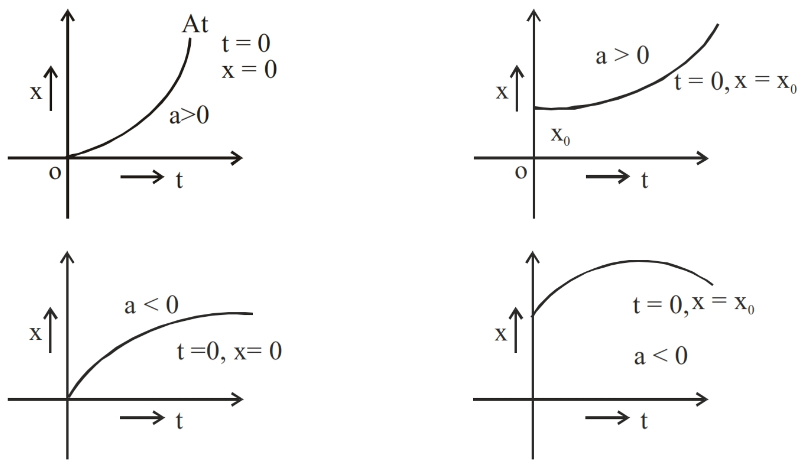
From displacement time graph we find

(i) slope at a point gives the instantaneous velocity

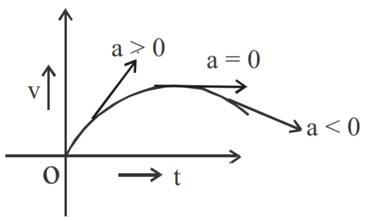
(ii) slope of the chord gives the average velocity in the given interval



x-t curve for constant acceleration.



VELOCITY TIME CURVE -



From velocity time graph we have

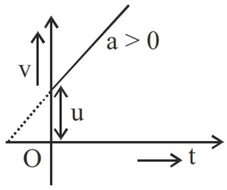
(i) slope of the tangent at a point gives the acceleration at a point.

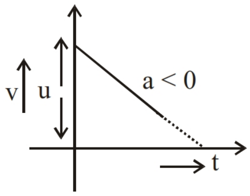
(ii) slope of the chord gives the average acceleration in a given interval.

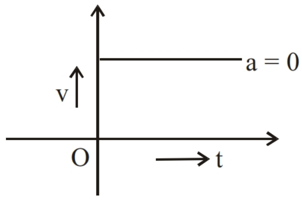
(iii) Area under the v-t curve gives displacement, taking area positive for upper of time axis and area negative for lower of time axis.

(iv) Area under the v-t curve gives distance when all the areas either above or below t-axis taken to be positive.

Velocity time curve for uniformly accelerated motions.







Acceleration time curve -

It is of very physical significance in which area under the curve in the given interval is the change in velocity in that interval.