Marwari College Darbhanga

Subject - Science (Physics)
Class - I.Sc. first year (XIth)
Topic - Types of Motion
Lecture Series — 03

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Motion in a straight line

Uniform motion ⟹ The motion of an object is said to be uniform if it covers equal displacements in equal intervals of time.

Velocity in uniform motion $v = \frac{\text{displacement}}{\text{time interval}}$

Non-Uniform motion ⟹ The motion of an object is said to be non-uniform if it covers equal distances in unequal intervals of time or unequal distances in equal intervals of time or if the direction of motion is reversed.

Average velocity (औसत वेग) → The ratio of displacement to the time interval in which displacement occurs.

$$\bar{v} = \Delta x / \Delta t$$

Average Speed → The ratio of distance (Path length) travelled to the corresponding time interval.

Instantaneous Velocity (तत्कालिक वेग) → Instantaneous velocity is equal to the instantaneous rate of change of position with respect to time and is the limit of average velocity ($\Delta x/\Delta t$) as the time interval (Δt) approaches zero.

$$v = \lim_{\Delta t \to 0} \bar{v} = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$

Instantaneous Speed → The absolute magnitude of instantaneous velocity without reference to its direction is called the instantaneous speed.

i.e. Instantaneous speed = magnitude of instantaneous velocity $= |v|$

Relative Velocity ⟹ The relative velocity of a body 'A' w.r.t. another body 'B' (i.e. V_{AB}) is the rate at which body 'A' changes its position w.r.t. body 'B'.

Uniformly Accelerated Motion

Acceleration → The rate of change of velocity is called acceleration. or

A body is said to possess uniformly accelerated motion if its velocity changes by equal amounts in equal intervals of time.

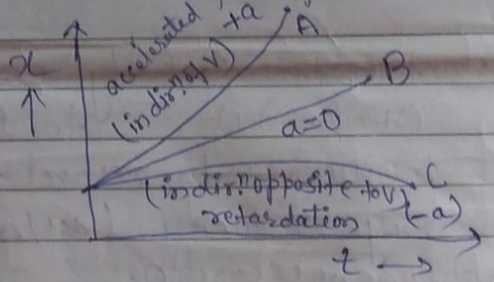
It is vector quantity. S.I unit is m/s^2

Its dimension is LT^{-2}.

Let v ~~and~~ is velocity and t is time.

Then $a = \frac{v}{t}$ or $a = \frac{dv}{dt}$

* The acceleration can be positive as well as negative.
* The negative acceleration is said to be retardation or deceleration.
* A body possessing zero acceleration is one whose velocity remains constant. i.e, It is the case of uniform motion.



Average Acceleration ($\bar{a}$) ⟹ It is defined as the ration of the change in velocity to the time interval in which this change occurs.

Let a particle moving with variable acc^n

If v_1 and v_2 the velocities at the instants t_1 and t_2 respectively

Then,

change of velocity $= \vec{v_2} - \vec{v_1} = \Delta v$

time interval during this change occurs $= t_2 - t_1 = \Delta t$

$\therefore$ Average acc^n $\bar{a} = \frac{\Delta v}{\Delta t} = \frac{\vec{v_2} - \vec{v_1}}{t_2 - t_1}$

Instantaneous accleration (a) → The instantaneous rate of change of velocity with respect to time and is the limit of average acc^n as the time interval approaches zero.

Thus $a = \lim_{\Delta t \to 0} \bar{a} = \lim_{\Delta t \to 0} \frac{\Delta \vec{v}}{\Delta t} = \frac{d\vec{v}}{dt} = \frac{d^2x}{dt^2}$

Instantaneous accl.ⁿ is simply called acceleration.

Motion with Constant Acceleration

Suppose that acceleration of a particle is a and remains constant. Let the velocity at time 0 be u and the velocity at time t be v.

Thus $\frac{dv}{dt} = a \Rightarrow dv = a dt$

or $\int_u^v dv = \int_0^t a\,dt \Rightarrow [v]_u^v = a[t]_0^t$

$\Rightarrow v - u = at \Rightarrow \boxed{v = u + at}$ —— ①

this is written as

$\frac{dx}{dt} = u + at \Rightarrow dx = (u+at)\,dt$

$\int_0^x dx = \int_0^t (u+at)\,dt \Rightarrow [x]_0^x = \int_0^t u\,dt + \int_0^t at\,dt$

$\Rightarrow x = u\int_0^t dt + a\int_0^t t\,dt = u[t]_0^t + a\left[\frac{t^2}{2}\right]_0^t = ut + \frac{at^2}{2}$

$\Rightarrow \boxed{x = ut + \frac{1}{2}at^2}$ —— ②

from eqn ① squaring both side,

$v^2 = (u+at)^2 = u^2 + 2uat + a^2t^2$

$v^2 = u^2 + 2a\left(ut + \frac{1}{2}at^2\right) = u^2 + 2ax$

$\Rightarrow \boxed{v^2 = u^2 + 2ax}$ —— ③

Freely Falling Bodies (Motion under gravity)

The motion of a body under gravity is an important case of one dimensional motion with constant acceleration.

(i) The accl.ⁿ due to gravity, i.e, $g = \text{const} = 9.8\ m/s^2 = 32\ ft/s^2$. It is directed vertically downwards.

(ii) The frictional force due to air is absent i.e, motion takes place in vacuum.

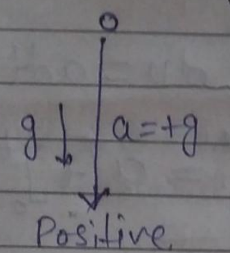
Radius of the earth = 6400 km

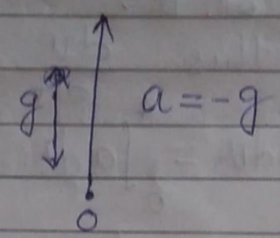
Sign Conventions

(i) The initial position of the body is taken to be the origin O.

(ii) For a freely falling body, the vertically downward direction is taken as positive.
As 'g' also vertically downwards, $a = +g$

(iii) For a body projected vertically upwards, the vertically upwards direction is taken as positive.
As 'g' acts vertically downwards, $a = -g$





$v = u + gt$	$v = u - gt$
$h = ut + \frac{1}{2}gt^2$	$h = ut - \frac{1}{2}gt^2$
$v^2 = u^2 + 2gh$	$v^2 = u^2 - 2gh$

Projectile Motion

An important eg. of motion in a plane with constant acceleration is the projectile motion.
When a particle is thrown obliquely (तिरछे) (diagonally) near the earth's surface, it move along a curved path. Such a particle is called a projectile and its motion is called projectile motion.