CHAPTER-2: MOTION IN A STRAIGHT LINE

1. Important Definitions

Motion
Changing the position of an object with time is called Motion.

Rest
When the position of an object does not change with time, is said to be in rest.

Reference Frame
To measure the relative position of an object with respect to a point or coordinate is called Reference Frame.

Position
The stae of an object with respect to reference point is called position.

$$\boxed{x}$$

SI Unit: $\boxed{metre\ (m)}$

2. Distance and Displacement

Distance
It is the actualpath length covered by an object.
Formula:

$$\boxed{Distance = Total\ Path\ Length}$$

Nature:

- Scalar quantity
- Always positive

SI Unit: $\boxed{m\ (metre)}$

Displacement
The shortest distance covered between initial position and final position with direction is called displacement.
Formula:

$$\boxed{\Delta x = x_f - x_i}$$

Nature:

- Vector quantity
- Positive, negative or zero

SI Unit: $\boxed{m\ (metre)}$

3. Speed

Definition

Distance travelled per unit time is called speed.

Formula:

$$\boxed{Speed = \frac{distance}{time}}$$

SI Unit: $\boxed{m/s}$

Average Speed

$$\boxed{\boldsymbol{Average\ Speed = \frac{Total\ Distance}{Total\ Time}}}$$

Instantaneous Speed

The speed of a particle at particular instant of time is called instantanous speed.

4. Velocity

Definition

Displacement per unit time is called velocity.

Formula:

$$\boxed{velocity = \frac{displacement}{time}}$$

SI Unit: $\boxed{m/s}$

Average Velocity

$$\boxed{\boldsymbol{Average\ velocity = \frac{Total\ displacement}{Total\ time}}}$$

Instantaneous Velocity

$$\boxed{\boldsymbol{v = \frac{dx}{dt}\,OR\,\frac{dy}{dt}\,OR\,\frac{ds}{dt}\,OR\,\frac{dr}{dt}}}$$

5. Acceleration

Definition

Rate of change in velocity is called acceleration.
Formula:

$$\boxed{a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i} = \frac{v - u}{t}}$$

where:

- u = Initial velocity
- v = Final velocity

SI Unit: $\boxed{ms^{-2}}$

Dimensions: $\boxed{[a] = [LT^{-2}]}$

Instantaneous Acceleration

$$\boxed{a = \frac{dv}{dt}}$$

6. Equations of Motion (SUVAT Equations)

Condition:

Uniform acceleration

First Equation

$$\boxed{\boldsymbol{v = u + at}}$$

Second Equation

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

Third Equation

$$\boxed{\boldsymbol{v^2 = u^2 + 2as}}$$

7. Motion under Gravity

Acceleration due to gravity: $\boxed{9.8\ ms^{-2}}$

Falling Body

$$\boxed{\boldsymbol{v = u + gt}}$$

$$\boxed{\boldsymbol{h = ut + \frac{1}{2}gt^2}}$$

$$\boxed{\boldsymbol{v^2 = u^2 + 2gh}}$$

Body Thrown Upward

$$\boxed{\boldsymbol{v = u - gt}}$$

$$\boxed{\boldsymbol{h = ut - \frac{1}{2}gt^2}}$$

$$\boxed{\boldsymbol{v^2 = u^2 - 2gh}}$$

8. Maximum Height

$$\boxed{\boldsymbol{h = \frac{u^2}{2g}}}$$

9. Time of Ascent

$$\boxed{t = \frac{u}{g}}$$

10. Total Time of Flight

$$\boxed{\boldsymbol{T = \frac{2u}{g}}}$$

11. Relative Motion

Relative velocity of A with respect to B:

$$\boxed{v_{AB} = V_A - v_B}$$

Relative acceleration:

$$\boxed{\boldsymbol{a_{AB} = a_A - a_V}}$$

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12. Graph Formulae

Position–Time Graph

Slope gives velocity:

$$\boxed{Slope = v = \frac{\Delta x}{\Delta t}}$$

Velocity–Time Graph

Slope gives acceleration:

$$\boxed{Slope = Acceleration = \frac{\Delta v}{\Delta t}}$$

Area gives displacement:

$$\boxed{Area = displacement}$$

Acceleration–Time Graph

Area gives change in velocity:

$$\boxed{Area = Change\ in\ velocity\ (\Delta V)}$$

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13. SI Units Summary Table

Physical Quantity	Symbol	SI Unit
Position	x	metre (m)
Distance	d	metre (m)
Displacement	Δx or s	metre (m)
Time	t	second (s)
Speed	v	m s^{-1}
Velocity	v	m s^{-1}
Acceleration	a	m s^{-2}
Gravity	g	m s^{-2}

14. Dimensional Formula Summary

Quantity	Dimension
Distance	[L]
Velocity	$[LT^{-1}]$
Acceleration	$[LT^{-2}]$

15. Calculus:

From calculus, we find rate of change or slope by Differentiation and to find area, we use Integration.

Some important Differential formulae

$$\boxed{\frac{d(t^n)}{dt} = nt^{n-1}}$$

Hence, $\frac{d(any\ constant)}{dt} = 0, \frac{d(t)}{dt} = 1, \frac{d(t^2)}{dt} = 2t, - - -$

We read $\frac{d(t^n)}{dt}$ as differentiating t^n with respect to t.

$$\boxed{\frac{d(\sin t)}{dt} = \cos t, and\ \frac{d(\cos t)}{dt} = -\sin t}$$

Some Important Integral Formula:

$$\boxed{\int t^n dt = \frac{t^{n+1}}{n+1}}$$

Note: In Physics, we use mostly the definite integration, so no need to put a constant plus in the above integration formula.

$$\boxed{\int_1^2 t^2 dt = \left(\frac{t^3}{3}\right)_1^2 = \left(\frac{8}{3} - \frac{1}{3}\right) = \frac{7}{3}}$$

16. When we use differentiation and Integration in order to get displacement, velocity or acceleration?

(1) From displacement-time equation ($x - t\ equation, or, y - t\ equation\ or, s - t\ equation, or\ r - t\ equation$) to velocity-time equation (v-t) , (differentiation), use,

$$v = \frac{dx}{dt}$$

(2) From velocity-time equation (v-t) to acceleration time equation (a-t) , (differentiation), use,

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

(3) From acceleration-time (a-t) to velocity-time equation (v-t), (Integration), use,

$$\boxed{\int_{v_i}^{v_f} dv = \int_{t_i}^{t_f} adt}$$

(4) From velocity-tine equation (v-t equation) to displacement-time (s-t) equation, (Integration), use,

$$\boxed{\int_{s_i}^{s_f} ds = \int_{t_i}^{t_f} vdt}$$