# FORMULA SHEET

## MOTION IN A STRAIGHT LINE

1. **Speed** The rate of change of position of an object.

Speed = $\frac{\text{Distance}}{\text{time}}$

$$v = \frac{s}{t}$$

2. **Average speed** Total distance divided by total time.

Average speed

$$v = \frac{\text{Total distance travelled}}{\text{Total time taken}}$$

3. **Instantaneous speed** Speed of an object at a perticular istant of time. $v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$

4. **Velocity** Rate of change of displacement with direction.

$$v = \frac{\text{displacement}}{\text{time}}$$

5. **Average velocity** Total displacement divided by total time.

$$v_{av} = \frac{\text{Net displacement}}{\text{Total time taken}}$$

$$v_{av} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{\Delta x}{\Delta t}$$

6. **Instantaneous velocity** Velocity of an object at a specific instant of time. $\vec{v} = \lim_{\Delta t \to 0} \frac{\Delta \vec{x}}{\Delta t} = \frac{d\vec{x}}{dt}$

7. **Acceleration** Rate of change of velocity with time.

$$a = \frac{\text{Change in velocity}}{\text{Time taken}}$$

8. **Average acceleration** Change in velocity by total time.

$$a_{av} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{\Delta v}{\Delta t}$$

9. **Instantaneous acceleration** Accⁿ at a perticular instant of time.

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

10. **Equation of motion for constant acceleration**

(I) $v = u + at$

(II) $S = ut + \frac{1}{2}at^2$

(III) $v^2 = u^2 + 2aS$

(IV) $S_{nth} = u + \frac{a}{2}(2n-1)$

$u \rightarrow$ initial velocity at $t=0$

$v \rightarrow$ final velocity after time 't'

$s \rightarrow$ distance travelled in time 't'

$S_{nth} \rightarrow$ distance travelled in nth second.

**In Cartesian form**

(I) $v = v_0 + at$

(II) $x = x_0 + v_0 t + \frac{1}{2}at^2$ or $S = v_0 t + \frac{1}{2}at^2$

(III) $v^2 = v_0^2 + 2a(x - x_0)$ or $v^2 = v_0^2 + 2aS$

(IV) $S_{nth} = v_0 + \frac{a}{2}(2n-1)$

here $x_0$ and $x$ be its position coordinates and $v_0$ and $v$ be its velocities at times $t=0$ and $t$ respectively

**Motion under gravity** (For a freely falling body)

(I) $v = u + gt$ — $v = -9.8t$

(II) $S = ut + \frac{1}{2}gt^2$ — $S = -4.9t^2$

(III) $v^2 = u^2 + 2gh$ — $v^2 = 19.6h$

[ $u = 0$, $g = -9.8 \, m/s^2$ ]

* Sign of 'g' (Acceleration due to gravity)

→ 'g' is always directed downward toward the centre of the earth.

→ However its sign depends on the coordinate system (which direction you choose as positive.)

| Situation | Velocity | Direction of 'g' | Sign (assume upward +ve) |
|---|---|---|---|
| Free fall | Increasing (downward) | Downward (towards Earth) | −ve, $g = -9.8\,m/s^2$ speeds up in downward |
| Object thrown upward | Decreasing (upward) | Downward Opp. to velocity | −ve, $v$ is upward but $g$ is downward $g = -9.8\,m/s^2$ |

* If we assume downward as '+ve' direction, then
- In downward motion, $g$ is taken '+ve' (as $g$ and motion are in same dirⁿ) and for upward motion $g$ is taken '−ve' as motion is opposite to $g$. ($g = -9.8\,m/s^2$)

For a body thrown vertically upward with initial velocity $u$

(I) Maximum height, $h = \frac{u^2}{2g}$

(II) Time of ascent = Time of descent = $\frac{u}{g}$

(III) Total time of flight = $\frac{2u}{g}$

(IV) Velocity of fall $= u$

(V) Velocity attained by a body dropped from height '$h$'
$v = \sqrt{2gh}$

not in new syllabus

*Relative velocity

$$\vec{v}_{AB} = \vec{v}_A - \vec{v}_B$$
$$\vec{v}_{BA} = \vec{v}_B - \vec{v}_A$$

$v_{AB}$ → Relative velocity of A, w.r.to B

$v_{BA}$ → Relative velocit of B, w.r.to A