Motion in One Dimension - Important Formulae for NEET & JEE

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Topic / Formula Name	Formula(e)	Conditions / Notes
1. Average Velocity & Speed	$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i}$	Valid for any type of motion (uniform or non-uniform). Δx is displacement.
	$\text{Speed}_{avg} = \frac{\text{Total Path Length}}{\text{Total Time}}$	
Special Case: Equal Distances	$v_{avg} = \frac{2v_1 v_2}{v_1 + v_2}$	When a body covers equal distances with different speeds v_1 and v_2. (Harmonic Mean)
Special Case: Equal Time Intervals	$v_{avg} = \frac{v_1 + v_2}{2}$	When a body travels for equal time intervals with different speeds v_1 and v_2. (Arithmetic Mean)
2. Instantaneous Velocity & Speed	$\vec{v}_{inst} = \lim_{\Delta t \to 0} \frac{\Delta \vec{x}}{\Delta t} = \frac{d\vec{x}}{dt}$	\vec{v}_{inst}
	$$\text{Speed}_{inst} =	
3. Instantaneous Acceleration	$a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$	Used for variable acceleration. The form $v(dv/dx)$ is crucial when v is a function of x.
	$a = v\frac{dv}{dx}$	

4. Equations of Kinematics (Scalar Form)

1.

$$v = u + at$$

STRICTLY for Constant Acceleration ($a = \text{const}$).

u: initial velocity, v: final velocity, a: acceleration, s: displacement, t: time.

2.

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

3.

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

4.

$$s = \left(\frac{u+v}{2}\right)t$$

5. Displacement in n^{th} Second

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

Displacement covered strictly during the n^{th} second of motion. Only for constant acceleration.

6. Motion Under Gravity (Free Fall)

1.

$$v = u - gt$$

Sign Convention (Upward +ve):

$a = -g$, Displacement h is +ve if up, -ve if down.

2.

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

For dropped object: $u = 0$.

3.

$$v^2 = u^2 - 2gh$$

7. Max Height & Time of Flight

$$H_{max} = \frac{u^2}{2g}$$

For a particle thrown vertically upward with speed u returning to the same level.

$$T_{flight} = \frac{2u}{g}$$

8. Stopping Distance	$d_{stop} = \frac{u^2}{2a}$	Distance traveled before coming to rest ($v = 0$) with retardation a.
9. Relative Velocity in 1D	$v_{AB} = v_A - v_B$ $a_{AB} = a_A - a_B$	Velocity/Acceleration of A with respect to B. Signs are crucial (+ve for one direction, -ve for opposite).
10. Graphical Interpretations	1. Slope of $x - t$ graph = Velocity (v) 2. Slope of $v - t$ graph = Acceleration (a) 3. Area under $v - t$ graph = Displacement (Δx) 4. Area under Speed-time graph = Distance 5. Area under $a - t$ graph = Change in velocity (Δv)	Valid for all types of motion.
11. Variable Acceleration (Integration)	$v = \int a\, dt$ $x = \int v\, dt$	Use definite integrals with limits when acceleration is a function of time ($a = f(t)$).

Key Tips for Solving Problems:

- **Sign Convention:** Always choose a positive direction (usually right or up). Any vector (displacement, velocity, acceleration) opposite to this is negative.

- **Vector Form:** For complex problems, use $\vec{v} = \vec{u} + \vec{a}t$.
- **Differentiation vs Integration:**
  - $x \xrightarrow{\text{diff}} v \xrightarrow{\text{diff}} a$
  - $a \xrightarrow{\text{int}} v \xrightarrow{\text{int}} x$