CLASS 11 PHYSICS — FORMULA SHEET

Chapter 2 : Motion in a Straight Line (NCERT)

2.1 Basic Terms — Distance, Displacement, Speed, Velocity

Quantity	Definition / Formula
Distance (path length)	Total length of path travelled; scalar; always ≥ 0
Displacement (Δx)	$\Delta x = x_2 - x_1$; shortest straight-line change in position; vector
Average speed	= Total distance ÷ Total time (scalar, always ≥ 0)
Average velocity	$v_{avg} = \Delta x \div \Delta t = (x_2 - x_1) \div (t_2 - t_1)$ (vector)
Instantaneous velocity	v = dx/dt (slope of x–t graph at a point)
Instantaneous speed	Magnitude of instantaneous velocity
|Displacement| ≤ Distance	Equal only when motion is along a straight line without reversing

2.2 Acceleration

Quantity	Formula
Average acceleration	$a_{avg} = \Delta v \div \Delta t = (v_2 - v_1) \div (t_2 - t_1)$
Instantaneous acceleration	$a = dv/dt = d^2x/dt^2$
a in terms of position	a = v (dv/dx)
Uniform motion	a = 0, velocity constant (x–t graph is a straight line)
Uniformly accelerated motion	a = constant (v–t graph is a straight line)
Retardation	Negative acceleration (a opposite to v)

2.3 Equations of Motion (Uniform Acceleration)

Equation	Use / Note
$v = u + at$	Velocity after time t (no displacement needed)
$s = ut + \frac{1}{2}at^2$	Displacement in time t
$v^2 = u^2 + 2as$	Relates velocity & displacement (no time)
$s = \frac{1}{2}(u + v)t$	Displacement from average velocity
$s_{nth} = u + (a/2)(2n - 1)$	Displacement in the n-th second only
Sign convention	Take one direction +ve; u, v, a, s carry signs accordingly

2.4 Motion Under Gravity (Free Fall, a = g)

Situation	Equation (taking g = 9.8 m/s², downward +ve)
Dropped from rest (u = 0)	$v = gt$; $h = \frac{1}{2}gt^2$; $v^2 = 2gh$
Thrown down (initial speed u)	$v = u + gt$; $h = ut + \frac{1}{2}gt^2$
Thrown up (u, taking up +ve, a = −g)	$v = u - gt$; $h = ut - \frac{1}{2}gt^2$

Situation	Equation (taking g = 9.8 m/s², downward +ve)
Max height (thrown up)	$H = u^2 \div (2g)$
Time of ascent = time of descent	t = u ÷ g (each); total time of flight = 2u ÷ g
Velocity on return to start	Equal in magnitude to u (opposite direction)

2.5 Graphs in Motion

Graph	What its Slope / Area Gives
Position–time (x–t)	Slope = velocity ; straight line = uniform velocity
Velocity–time (v–t): slope	Slope = acceleration
Velocity–time (v–t): area	Area under curve = displacement
Acceleration–time (a–t): area	Area under curve = change in velocity
x–t for uniform acceleration	Parabola (curved)
v–t for uniform acceleration	Straight inclined line

2.6 Relative Velocity (1-D)

Concept	Formula
Velocity of A relative to B	$v_{AB} = v_A - v_B$
Velocity of B relative to A	$v_{BA} = v_B - v_A = -v_{AB}$
Same direction	Relative speed = $\lvert v_A - v_B \rvert$
Opposite directions	Relative speed = $\lvert v_A + v_B \rvert$
Time to meet (separation d)	$t = d \div v_{relative}$

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3 main equations	'v = u + at, s = ut + ½at², v² = u² + 2as' — memorise these three first.
When to use which	No s → use v = u + at ; no t → use v² = u² + 2as ; need s → s = ut + ½at².
s in n-th second	$s_n = u + (a/2)(2n - 1)$ — note it's a DISTANCE in 1 s, not total displacement.
Up-throw symmetry	Time up = time down ; speed at launch = speed on return.
Max height	H = u²/2g ; total flight time = 2u/g (thrown straight up).
Graph slopes	x–t slope = velocity ; v–t slope = acceleration ; v–t area = displacement.
Sign convention	Fix +ve direction FIRST, then give u, v, a, s their correct signs.
Relative velocity	Same way → subtract speeds ; opposite ways → add speeds.