The Simple AP® Physics 1 Unit 1 Cheat Sheet

1.1 Scalars & Vectors in 1D

Scalar vs. Vector

Scalar: magnitude only. **Vector**: magnitude + direction; an arrow w/ length ∝ magnitude.

Quantity	Type	Units
Distance	Scalar	m
Speed	Scalar	m/s
Position x	Vector	m
Displacement Δx	Vector	m
Velocity v	Vector	m/s
Acceleration a	Vector	m/s²

Signs = Direction (1D)

Choose + first (right/up usually) and state it. In 1D the sign of a component fully gives its direction; no arrow needed. Mark + on the sketch.

1D vector sum: add signed values. 5 m right + 8 m left = (+5) + (−8) = −3 m → 3 m left.

Negative ≠ slowing: a sign only gives direction. Slowing ↔ v and a have opposite signs.

Distance vs. Displacement

Distance: total path length (always +).
Displacement: $\Delta x = x_f - x_i$ (can be −, 0).

Round trip: back to the start → Δx = 0 but distance > 0 → avg velocity = 0, avg speed > 0.

⚠ Switching sign convention mid-problem is the #1 kinematics error. Pick + once & use it for every vector (x, v, a), start to finish, always.

✓ Mark + on a number line before any equation.

1.2 Displacement, Velocity & Acceleration

Average vs. Instantaneous

Average velocity: $v_{avg} = \Delta x/\Delta t$ (uses displacement, NOT total distance).
Avg acceleration: $a_{avg} = \Delta v/\Delta t$. Only the initial and final velocities matter, not the path.
Instantaneous: average over a tiny Δt ≈ the value at that instant (slope of the tangent).
Units: x in m; v in m/s; a in m/s²; t in s.

Speeding Up or Slowing Down?

Accelerating ↔ speed OR direction of v changes. Constant speed on a curve still accelerates.

v sign	a sign	Motion
+	+	speeding up, +
+	−	slowing, moving +
−	−	speeding up, −
−	+	slowing, moving −
0	≠ 0	turning around

v = 0 ≠ a = 0: top of a toss: v = 0, a = −g.

Worked Examples

Car: +20 → +8 m/s in 3 s: a = (8 − 20)/3 = −4 m/s² → slowing down (v +, a −); a points backward.
Bounce: +10 → −10 m/s off a wall in 0.1 s: Δv = −20 m/s, a = −200 m/s². Same speed, Δv ≠ 0.

⚠ $\Delta v = v_f - v_i$ WITH signs. A bounce doubles Δv; never subtract the magnitudes.

✓ Sign check: v and a same sign → speeding up; opposite signs → slowing down.

1.3 Kinematic Equations (Constant a)

The 3 Sheet Equations

$v_x = v_{x0} + a_x t$: no Δx (displacement).

$x = x_0 + v_{x0}t + \frac{1}{2}a_x t^2$: no final v.

$v_x^2 = v_{x0}^2 + 2a_x(x - x_0)$: no time t.

Valid ONLY for constant a. If a changes, split into stages; end of stage 1 = start of stage 2.

Pick the Equation

Missing / unwanted	Use
Δx	$v = v_o + at$
final v	$\Delta x = v_o t + \frac{1}{2}at^2$
t	$v^2 = v_o^2 + 2a\Delta x$
a	$\Delta x = \frac{1}{2}(v_o + v)t$

Steps: sketch → pick + → list Δx, v_0, v, a, t → find 3 knowns → use the eqn that skips the unwanted one. Solve, then check units & sign.

Symbolic Derivations (MR/QQT)

Derive: start from a sheet equation, substitute, solve for the target. Answer only in given symbols + physical constants; plug numbers last.
Stopping distance: $0 = v_0^2 - 2ad \rightarrow d = v_0^2/(2a)$.

2× v_0 → 4× the stopping distance d.

Scaling: from rest, Δx ∝ t² → 2× time = 4× distance; v ∝ t → 2× time = 2× v.

⚠ Hidden knowns: "from rest" or "dropped" → v_o = 0; "comes to a stop" → v = 0.

✓ "What if v_o doubles?" Write the eqn, hold the rest fixed, then scale the answer.

1.3 Motion Graphs: Slope & Area

Slope & Area Rules

Graph	Slope =	Area =
x vs. t	velocity	—
v vs. t	acceleration	displacement
a vs. t	—	Δv

Instant v = slope of the tangent on x–t. **Avg v** = slope of the secant between 2 points.
Area below the t-axis counts negative for displacement; add |areas| for distance.

Read the Shape

Shape	On x–t	On v–t
Horizontal	at rest	const v (a = 0)
Straight slope	const v	const a
Curves up	a > 0	a increasing
Curves down	a < 0	a decreasing
Crosses t-axis	passes x = 0	turns around

Turnaround: v–t crosses zero; x–t has a peak or valley (slope 0) at that same instant.

Sketching (TBR FRQ)

Translate: x–t → v–t: plot each segment's slope. v–t → a–t: plot slope; const a = flat line.
Sketch rules: label axes w/ quantity + units, mark key times (v = 0), keep x and v continuous (no jumps); only a can jump suddenly.

⚠ v–t height ≠ position. Highest point on v–t = max velocity, not farthest away.

✓ FRQ: slope of x–t = v; slope of v–t = a.

1.3 Free Fall & Motion Diagrams

Free Fall

Near Earth: a = g, downward, constant. Use g = 10 m/s² (9.8 also accepted). Ignore air unless told.
Up = +: $a_y = -10$ m/s² the WHOLE flight: while rising, at the peak & while falling back down.
Peak: v = 0, a = −g. Time up = time down (same launch & landing height, no air drag).
Symmetry: returns to launch height w/ the same speed, in the opposite direction (down).
Mass doesn't matter: heavy and light objects fall w/ the same a (no air resistance).
Thrown down at v_0: a is still −g; it just starts w/ v_0 < 0 (up = +), so its speed keeps growing.

Toss up at 20 m/s	Result
Time to peak	v_o/g = 2 s
Max height	$v_o^2/(2g)$ = 20 m
Total air time	4 s
Speed on return	20 m/s, downward

Motion Diagrams

Dot diagram: dots at equal Δt. Equal spacing → constant v; growing spacing → speeding up; shrinking spacing → slowing down.
Velocity arrows: 1 per dot, length ∝ speed. **a arrow**: direction of Δv ($v_i \rightarrow v_f$).

⚠ At the peak a ≠ 0. Gravity never switches off; only v is 0, & just for an instant.

✓ Use symmetry: solve the way up first, then double that time for the full flight.

1.4 Reference Frames & Relative Motion

Reference Frames

Reference frame: an observer's viewpoint + axes. The frame sets the measured direction AND magnitude of x and v (but not a).
Inertial frame: not accelerating. Assume every frame is inertial unless told otherwise.

Relative Velocity (1D only)

Rule: observed v = object's v in the frame + frame's v. Subscripts: $v_{AG} = v_{AB} + v_{BG}$ (inner letters cancel out; A rel. to ground).
Reverse it: $v_{BA} = -v_{AB}$ (flip the sign).

Situation	Observed v
Walk +1 on train +20	+21 m/s (ground)
Walk −1 on train +20	+19 m/s (ground)
Cars +25, +30 m/s	5 m/s apart
Cars +25, −30 m/s	55 m/s closing

Moving walkway: time = length/($v_{walk} \pm v_{belt}$); use + w/ the belt, − when walking against it.
Gap closing: time = gap ÷ relative speed (100 m gap, 5 m/s closing speed → 20 s to catch up).

Acceleration Is Frame-Free

Same a in all inertial frames: a ball dropped on a steady train has a = g for rider and ground.
Different paths: rider sees a straight drop; ground sees a parabola (adds the train's v). Both are right.

⚠ AP1 keeps relative-velocity math to 1D. Expect add/subtract along a line, not 2D river-crossing or airplane-in-the-wind triangles.

1.5 Vectors & Components in 2D

Components

Resolve: $A_x = A\cos\theta$, $A_y = A\sin\theta$ (θ from the +x axis). Trig + Pythagorean are on the sheet.

Rebuild: $A = \sqrt{(A_x^2 + A_y^2)}$; $\theta = \tan^{-1}(A_y/A_x)$.

Signs by direction: pointing left → $A_x < 0$; down → $A_y < 0$. Draw it; don't trust the calculator's angle.

θ	cos θ	sin θ
0°	1	0
30°	0.87	0.50
45°	0.71	0.71
60°	0.50	0.87
90°	0	1

Adding Vectors

Tip-to-tail: resultant runs from the 1st tail to the last tip. **Components**: add x's, add y's, rebuild.
2D displacement: 3 m E then 4 m N → 5 m at $\tan^{-1}(4/3) \approx 53°$ N of E; distance = 7 m.

Independence of x & y

Key idea: perpendicular components don't affect each other → 2D motion = two separate 1D problems sharing the same time t.
2D speed: $v = \sqrt{(v_x^2 + v_y^2)}$ (Pythagorean).

⚠ Calculator in DEGREE mode. A sin/cos mix-up flips which component is bigger.

✓ Check: at 30° the x-component is bigger; at 60° the y-component is bigger. 45° → equal.

1.5 Projectile Motion

The Model

Projectile: only gravity acts → $a_x = 0$, $a_y = -g$. x: constant velocity; y: free fall (same t).
Launch: $v_{x0} = v_0\cos\theta$, $v_{y0} = v_0\sin\theta$ (θ above horizontal). The same time t links x and y.

	x	y
Accel.	0	−g
Velocity	constant	changes
Equation	$x = v_x t$	sheet eqns
At peak	v_x same	$v_y = 0$

Horizontal launch: $v_{y0} = 0$ → fall time $t = \sqrt{(2h/g)}$; range = $v_x t$ (horizontal speed × time).

Drop vs. throw: dropped and horizontally launched balls from the same height land at the SAME time.
Speed anywhere = $\sqrt{(v_x^2 + v_y^2)}$; min at peak = v_x.

Max height: $H = v_{y0}^2/(2g)$; depends only on v_{y0}.

Best angle: max range at 45° on level ground.

FRQ Moves

Justify: name the principle + tie it to the scenario: "only gravity acts → v_x stays constant → equal horizontal spacing between the dots."

⚠ Fall time depends only on vertical motion (h, v_{y0}), never on horizontal speed.

✓ Solve the vertical motion first to get t, then use that same t for the horizontal motion.