Free Fall Reference Sheet

AP Physics 1 · Unit 1 · g = 9.8 m/s² · up is positive · air resistance neglected

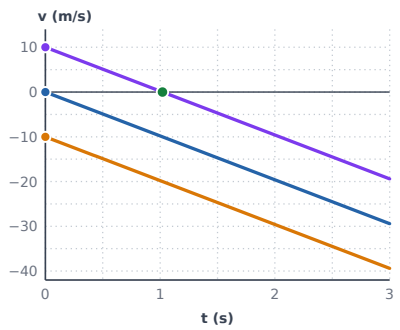
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SETUP

- Take up as positive and measure height y from the ground.
- In free fall a = −g = −9.8 m/s², from release until just before landing, including the highest point.
- Air resistance is neglected. Mass does not appear in any equation.

Equation	Leaves out
$v = v_0 - gt$	height
$y = y_0 + v_0t - \frac{1}{2}gt^2$	final velocity
$v^2 = v_0^2 - 2g(y - y_0)$	time

ONE SLOPE, THREE STARTS



THREE PROBLEM TYPES

Type	v_0 (up positive)	Useful results	Watch for
Dropped	0	$t = \sqrt{(2h/g)}$; impact speed = $\sqrt{(2gh)}$	Both shortcuts assume $v_0 = 0$
Tossed down	negative	impact speed = $\sqrt{(v_0^2 + 2gh)}$; then t from $v = v_0 - gt$	Write v_0 with a minus sign
Thrown up	positive	$t_{top} = v_0/g$; rise = $v_0^2/2g$; back at launch height after $2v_0/g$	Add y_0 for height above the ground

THROWN UP: SYMMETRY

- Time up equals time down when the ball lands at its launch height.
- At a given height, the speed is the same on the way up and on the way down.
- At the top: v = 0 and a = −9.8 m/s².
- The ball reaches a height H above launch only if $v_0^2 \geq 2gH$.

THREE-BALL RACE

From the same height h, a ball thrown down at speed v and a ball thrown up at speed v land with the same speed, $\sqrt{(v^2 + 2gh)}$. A dropped ball lands slower. Landing order: thrown down, dropped, thrown up.

HANDY NUMBERS FOR AN OBJECT DROPPED FROM REST

t (s)	0.5	1.0	1.5	2.0	2.5	3.0
Fallen (m)	1.2	4.9	11.0	19.6	30.6	44.1
Speed (m/s)	4.9	9.8	14.7	19.6	24.5	29.4

FIVE CHECKS BEFORE YOU HAND IT IN

1. Does the sign of v_0 match the direction of the throw?
2. Does my shortcut assume $v_0 = 0$, or equal launch and landing heights?
3. Is the height measured from the ground or from the launch point?
4. Did I keep the positive time root, and a negative velocity for a falling object?
5. Is the size sensible? A drop of about 20 m takes about 2 s.