

Kinematics

A-Level Physics 9702 · Topic 2 revision notes · AS

Motion described: displacement, velocity and acceleration, the graphs that link them, the SUVAT equations, free fall and projectiles.

8 definitions to learn word for word, 10 equations in their own column, 4 diagrams and graphs. Read it, cover it, test yourself.

1. 2.1a Describing motion and motion graphs
2. 2.1b The equations of uniformly accelerated motion (SUVAT)
3. 2.1c Free fall and projectiles

Definitions (mark-scheme wording) Equations Exam traps

2.1a Describing motion and motion graphs

Definitions

Distance: the total length of path travelled (scalar).

Displacement: the distance in a straight line from a fixed point in a specified direction (vector).

Speed: the rate of change of distance (distance travelled per unit time).

Velocity: the rate of change of displacement.

Acceleration: the rate of change of velocity.

Equations

$$v = \Delta s / \Delta t$$

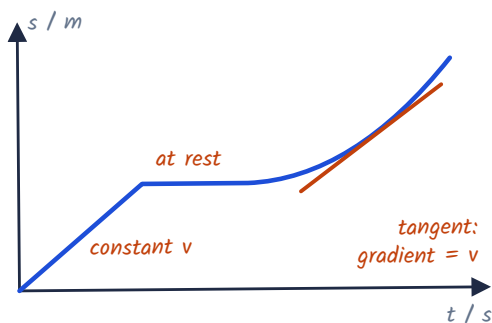
velocity = change in displacement / time
 m s^{-1}

$$a = \Delta v / \Delta t$$

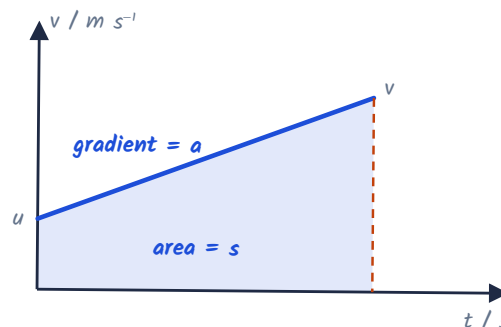
acceleration = change in velocity / time
 m s^{-2}

Key points

- ✓ Displacement, velocity and acceleration are **vectors**: choose a positive direction and keep it.
- ✓ s-t graph: **gradient = velocity**. A curve means changing velocity; take the gradient of the tangent.
- ✓ v-t graph: **gradient = acceleration, area under the line = displacement**.
- ✓ Area below the time axis on a v-t graph is displacement in the **negative** direction.
- ✓ a-t graph: **area = change in velocity**.
- ✓ Average velocity = total displacement / total time; instantaneous velocity = gradient at that instant.



s-t graph: steeper = faster; flat = at rest; the tangent gradient gives the instantaneous velocity.



v-t graph: gradient = acceleration, shaded area = displacement.

Watch out!

- ! The **gradient** of a v-t graph is acceleration, but the **area** is displacement. Do not mix them up.
- ! For a curved graph, the gradient at a point needs a **tangent**, not the line from the origin.

2.1b The equations of uniformly accelerated motion (SUVAT)

Definitions

Uniform acceleration: acceleration that is constant in magnitude and direction.

Key points

- ✓ Use SUVAT **only when acceleration is constant**.
- ✓ Five quantities: s, u, v, a, t. Each equation leaves out one; pick the one without the quantity you neither know nor want.
- ✓ List the three knowns and the one unknown before choosing an equation.
- ✓ Decelerating object: a is negative (if forward is positive).
- ✓ Derivation: $a = (v - u)/t$ gives $v = u + at$; area under the v-t graph gives $s = \frac{1}{2}(u + v)t$; combine for the other two.

Equations

$$v = u + at$$

no s
m s⁻¹

$$s = \frac{1}{2}(u + v)t$$

no a
m

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

no v
m

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

no t
m² s⁻²

Watch out!

- ! Mixing sign conventions mid-question. Thrown up at $u = +20 \text{ m s}^{-1}$ means $a = -9.81 \text{ m s}^{-2}$ for the whole flight.
- ! At the top of a vertical throw $v = 0$ but $a = g$ (not zero).

2.1c Free fall and projectiles

Definitions

Free fall: motion under gravity alone, with no air resistance; acceleration = $g = 9.81 \text{ m s}^{-2}$ downwards.

Acceleration of free fall (g): the acceleration of a body falling freely in a uniform gravitational field.

Key points

- ✓ Measuring g : drop a ball through heights s , time with light gates; plot s against t^2 ; gradient = $g/2$.
- ✓ Projectile: horizontal and vertical motions are **independent**; only the time is shared.
- ✓ Horizontal: no force (air resistance ignored), so $v_x = u \cos \theta$ stays constant.
- ✓ Vertical: uniform acceleration g downwards, starting from $u_y = u \sin \theta$.
- ✓ At maximum height $v_y = 0$; speed there = v_x .
- ✓ Maximum range on level ground at $\theta = 45^\circ$ (no air resistance).
- ✓ With air resistance: lower height, shorter range, path no longer symmetrical.

Equations

$$v_x = u \cos \theta$$

horizontal velocity (constant)
 m s^{-1}

$$u_y = u \sin \theta$$

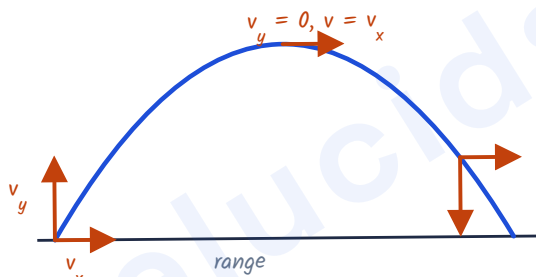
initial vertical velocity
 m s^{-1}

$$x = v_x t$$

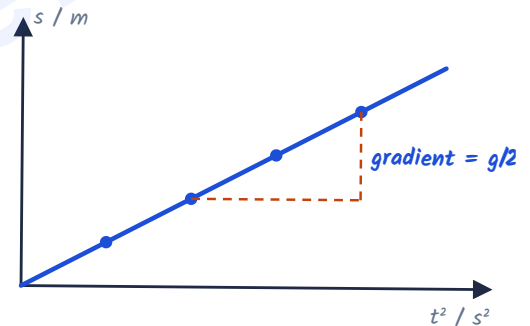
horizontal distance
 m

$$s = \frac{1}{2}gt^2$$

fall from rest: gradient of $s-t^2 = g/2$
 m



Projectile: v_x is the same at every point; v_y falls to zero at the top, then grows downwards.



Measuring g : s against t^2 is a straight line through the origin with gradient $g/2$.

Watch out!

- ! Never use the launch speed u in the horizontal and vertical equations at once. Resolve it first.
- ! Gradient of s against t^2 is $g/2$, not g . Double it.