Q · Kinematics · supported focus

AQA · A-Level · Mathematics

Scope and prerequisites

AQA A-level Mathematics 7357, section Q (Kinematics), version 1.3 (first assessment 2018). Original teaching notes; objective-level mapping lives in content/teaching/aqa_a_level_mathematics/objective-review.yaml.

Prerequisites: gradients and areas from GCSE graphs, and the quantities and units of section P. Each lesson develops its own method before independent transfer.

These are original teaching examples, not official AQA material.

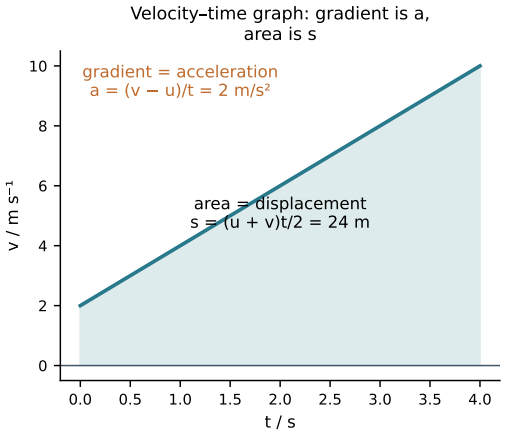
Kinematics

■ What would explain this observation?

- Two cars cover the same 24 metres in the same 4 seconds, yet their speed–time graphs look completely different – one is a sloping line, one is flat. How can both trips be 24 m?
- Start with a prediction. State what the gradient and the area of a velocity–time graph each measure, and why a flat graph and a sloping graph can enclose the same area.

■ Build the model

- **Kinematics** describes motion without asking what causes it. **Displacement** s is position change in metres; velocity v is the rate of change of displacement; **acceleration** a is the rate of change of velocity, in m/s^2.
- On a velocity–time graph the gradient is the acceleration and the area under the graph is the displacement. When acceleration is constant, five quantities s, u, v, a, t are linked by the suvat equations, each omitting one quantity: $v = u + at$, $s = ut + at^2/2$, $s = (u + v)t/2$, $v^2 = u^2 + 2as$, $s = vt - at^2/2$.
- kinematics: The description of motion through displacement, velocity, acceleration and time, without reference to causes; displacement: Position change in a stated direction, in metres; acceleration: Rate of change of velocity, in m/s^2.



suvat: each equation omits one quantity — choose by what is missing

$v = u + at$	lacks no s
$s = ut + at^2/2$	lacks no v
$v^2 = u^2 + 2as$	lacks no t

valid only for constant acceleration

Choose evidence that can test it

- Choose the suvat equation by what is MISSING, not by what is given: list the four quantities involved in the question, find which of the five is absent, and pick the equation that omits it.
- Vertical motion under gravity is the same model with $a = -g \approx -9.8$ m/s^2 when up is positive: a ball thrown up keeps the same downward acceleration on the way up, at the top, and on the way down.

Work from known quantities

- State the known values and their units. Choose the relation because its assumptions fit this case, then rearrange before substitution.
- Known: a cyclist starts at $u = 2$ m/s and accelerates at $a = 2$ m/s^2 for $t = 4$ s. Final velocity $v = u + at = 2 + 2 \times 4 = 10$ m/s. Displacement $s = (u + v)t/2 = (2 + 10) \times 4/2 = 24$ m – the trapezium area under the graph, matching the flat-graph car at 6 m/s for 4 s.

Example:

A stone is dropped from rest and falls for 3 s. Using $g = 9.8$ m/s^2, find its speed and the distance fallen, using the same sequence: known $\rightarrow v = u + at \rightarrow s = ut + at^2/2$. (Answer: $v = 0 + 9.8 \times 3 = 29.4$ m/s; $s = 0 + 9.8 \times 9/2 = 44.1$ m.)

Check the conclusion and its limits

- Check the answer against the graph: the numerical displacement must equal the area, and the sign of the acceleration must match the slope. A negative displacement means the object finished behind its start, not that it "moved backwards in time."

- Return to the original observation. Explain what the result supports, which conditions it assumes, and one way to test a competing explanation.

Warn:

The suvat equations apply to any motion. This claim is false: they assume CONSTANT acceleration. On a curved velocity–time graph the gradient and area still give acceleration and displacement, but $v = u + at$ and its siblings do not apply – and real falling objects eventually reach terminal velocity, where acceleration is zero.

Key:

Kinematics: on a velocity–time graph gradient is acceleration and area is displacement; for constant acceleration pick the suvat equation that omits the missing quantity; vertical motion is the same model with $a = -g$.