Kinematics

International Baccalaureate · IB Diploma · Physics · HL

Scope and prerequisites

This handout covers selected HL topics for the course first assessed in 2025; it is not the whole syllabus.

Prerequisites: read the stated quantities and units, and use arithmetic and the model conditions below.

The examples are original and fictional: they are not real measurements or real student investigations.

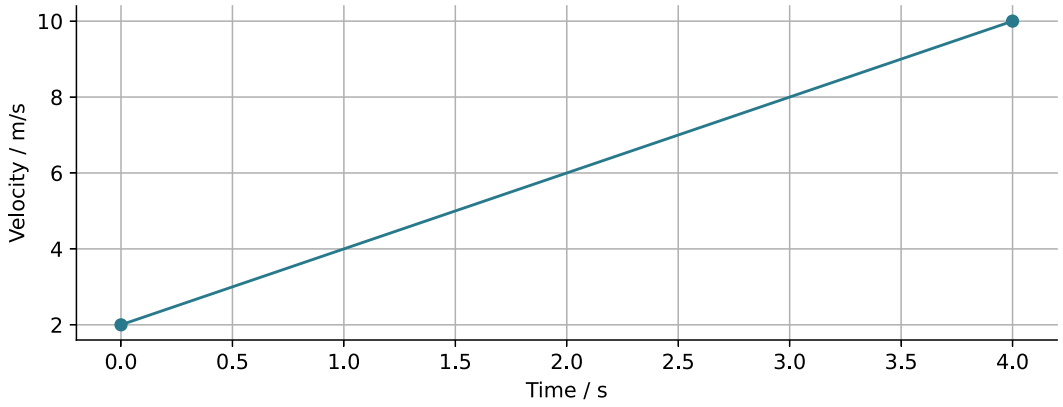
Motion graphs and acceleration

What would explain this observation?

- A speedometer gives a reading at one moment. A journey average can hide stops and rapid changes in speed.

Build the model

- Displacement includes direction; distance counts total path length.
- **Velocity** is change in displacement per time.
- **Acceleration** is change in velocity per time.
- velocity: Rate of change of displacement.
- acceleration: Rate of change of velocity.



A straight v–t line means constant acceleration: $a = (10 - 2) \div 4 = 2.0\ m/s^2$

Choose evidence that can test it

- The gradient of a displacement-time graph is velocity.
- The area under a velocity-time graph gives displacement.
- A constant-acceleration formula is valid only when its assumption is justified.

In the lab: Choose a positive direction and state it. Use a light gate or video with a known scale and frame interval for repeatable motion measurements. Avoid assuming hand timing is exact over very short intervals.

Work from known quantities

- Known: velocity rises uniformly from 2 to 10 metres per second in 4 s. a = (v-u)/t. a = (10-2)/4 = 2 metres per second squared.
- Displacement is trapezium area: s = (u+v)t/2 = (2+10)×4/2 = 24 m.

Your turn: Velocity changes from 3 to 15 metres per second in 6 s. Find acceleration.

Check the conclusion and its limits

- Negative velocity indicates direction under the chosen sign convention; it does not necessarily mean slowing down.

Not true: A negative velocity always means the object is slowing down. Negative velocity means motion opposite to the chosen positive direction. The object slows down only when the acceleration opposes the velocity; a negative velocity with negative acceleration is speeding up.

Key:

- Displacement includes direction; distance counts total path length.
- The gradient of a displacement-time graph is velocity.
- Watch for: negative velocity indicates direction under the chosen sign convention; it does not necessarily mean slowing down.

Write from an acceleration of 6 metres per second squared

- Velocity changes from 4 to 22 metres per second in 3 s.
- Find the acceleration and the displacement. A negative velocity is a direction.

Write from a gradient of minus 2

- A velocity-time line falls from 6 to 0 metres per second between t = 0 and t = 3 s.
- The gradient is $(0 - 6) \div 3 = -2$ metres per second squared – uniform deceleration, the sign only naming the chosen positive direction.

Write from a displacement of 100 metres

- An object moves at a steady 20 metres per second for 5 s.
- Displacement $= 20 \times 5 = 100$ m, and its displacement-time graph is a straight line of gradient 20.

Write from a negative final velocity

- An object at $+8$ m s^{-1} decelerates at 2 m s^{-2} for 6 s.
- $v = 8 - 12 = -4$ m s^{-1}: it stopped at $t = 4$ s and reversed – the formula tracks direction honestly.