

2 Kinematics – Part 1

Name: _____ Class: _____ Date: _____

Vocabulary

Write each word three times.

English	Write it 3 times (English)		
Speed	_____	_____	_____
distance	_____	_____	_____
velocity	_____	_____	_____
scalar	_____	_____	_____
vector	_____	_____	_____
displacement	_____	_____	_____
uniform acceleration	_____	_____	_____
acceleration	_____	_____	_____
free fall	_____	_____	_____
gradient	_____	_____	_____

Recall

You measured motion at IGCSE. Bring this with you:

- **Speed** tells you how fast something moves: $\text{speed} = \text{distance} \div \text{time}$.
- A **distance** is how far you travel; **velocity** is speed in a stated direction.
- You read simple distance–time and speed–time graphs.

At AS we sharpen these ideas and add four equations that solve almost any straight-line motion problem.

New ideas

Read these first, then do the Practice.

■ 1 Scalars and vectors

A **scalar** has size only (distance, speed, time). A **vector** has size **and** direction. A **displacement** is the straight-line distance in a direction – the vector version of distance.

So if you walk 3 km east then 3 km back, your distance is 6 km but your displacement is 0.

scalar (size only)

$$\text{speed} = 5 \text{ m s}^{-1}$$

vector (size + direction)

$$\xrightarrow{5 \text{ m s}^{-1}} \text{east}$$

■ 2 The equations of motion

For motion with **uniform acceleration** (a steady **acceleration** a), five quantities link up: displacement s , start velocity u , end velocity v , acceleration a , time t . Four equations connect them:

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

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

The general method: write down the quantities you **know** and the one you **want**; choose the equation that uses only those letters; substitute.

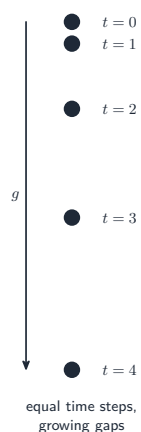
Worked example. A car speeds up from $u = 8 \text{ m s}^{-1}$ at $a = 2 \text{ m s}^{-2}$ for $t = 5 \text{ s}$. Find v : use $v = u + at = 8 + (2)(5) = 18 \text{ m s}^{-1}$. Find s : use $s = ut + \frac{1}{2}at^2 = (8)(5) + \frac{1}{2}(2)(5^2) = 40 + 25 = 65 \text{ m}$.

Watch out: these four equations only work for *uniform* (constant) acceleration – do not use them when the acceleration changes.

■ 3 Free fall

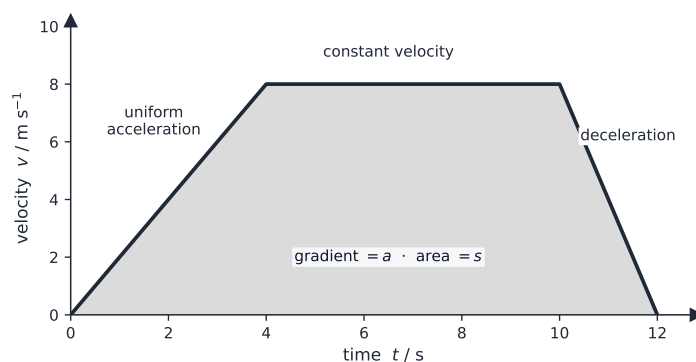
An object falling freely has acceleration $g = 9.81 \text{ m s}^{-2}$ downward (often rounded to 9.8). This is **free fall**. Use the same four equations with $a = g$.

Worked example. A stone is dropped ($u = 0$). After $t = 2.0 \text{ s}$: $v = u + at = 0 + (9.81)(2.0) = 19.6 \text{ m s}^{-1}$.



■ 4 Velocity–time graphs

On a velocity–time graph the **gradient** (steepness) is the acceleration, and the **area** under the line is the displacement.



Practice

2.1 A runner jogs 100 m north, then 100 m back south. State (a) the total distance, (b) the final displacement. [2]

2.2 State whether each is a scalar or a vector: (a) time, (b) velocity, (c) speed, (d) displacement. [2]

2.3 A cyclist starts at $u = 4 \text{ m s}^{-1}$ and accelerates at $a = 1.5 \text{ m s}^{-2}$ for $t = 6 \text{ s}$. Find the final velocity v . [2]

2.4 Using the same cyclist, find the distance s travelled in those 6 s. [2]

2.5 A ball is dropped from rest. Taking $g = 9.8 \text{ m s}^{-2}$, find its speed after 1.5 s. [2]

2.6 A car speeds up uniformly from 0 to 20 m s^{-1} in 8.0 s. (a) Find its acceleration. (b) On its velocity–time graph the area under the line is a triangle; find the distance from $\text{area} = \frac{1}{2} \times \text{base} \times \text{height}$. [3]

2.7 Challenge. A ball is thrown straight up. At its highest point it is momentarily still. State its acceleration there, and explain your answer. [2]