2 Kinematics – Part 1

Name: ______________ Class: __________ Date: ____________

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	中文	Write it 3 times (English)		
Speed	速率			
distance	距离			
velocity	速度			
scalar	标量			
vector	矢量			
displacement	位移			
uniform acceleration	匀加速			
acceleration	加速度			
free fall	自由落体			
gradient	斜率			

Recall

You measured motion at IGCSE. Bring this with you:

- **Speed** 速率 tells you how fast something moves: speed = distance ÷ time.
- A **distance** 距离 is how far you travel; **velocity** 速度 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** 标量 has size only (distance, speed, time). A **vector** 矢量 has size **and** direction. A **displacement** 位移 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.

■ 2 The equations of motion

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

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

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

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

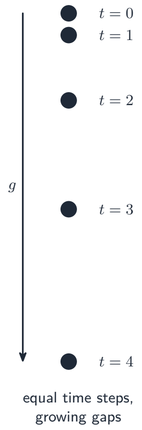
Worked example. A car speeds up from $u = 8$ m s^{-1} at $a = 2$ m s^{-2} for $t = 5$ s. Find v: use $v = u + at = 8 + (2)(5) = 18$ m s^{-1}. Find s: use $s = ut + \frac{1}{2}at^2 = (8)(5) + \frac{1}{2}(2)(5^2) = 40 + 25 = 65$ m.

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

■ 3 Free fall

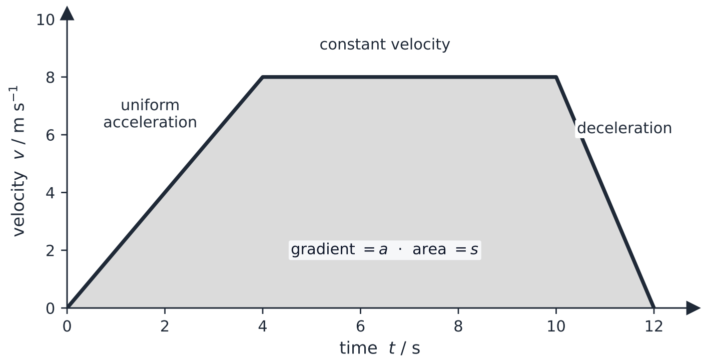
An object falling freely has acceleration $g = 9.81$ m s^{-2} downward (often rounded to 9.8). This is **free fall** 自由落体. Use the same four equations with $a = g$.

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



4 Velocity–time graphs

On a velocity–time graph the **gradient** 斜率 (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 $u = 4$ m s^{-1} and accelerates at $a = 1.5$ m s^{-2} for $t = 6$ 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 $g = 9.8$ 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 area $= \frac{1}{2} \times$ base $\times$ 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]