A-LEVEL MATHEMATICS • EXERCISE SHEET

4.2 Kinematics of motion in a straight line

Name: _____ Class: _____ Date: _____ **Total: 16 marks**

Objective

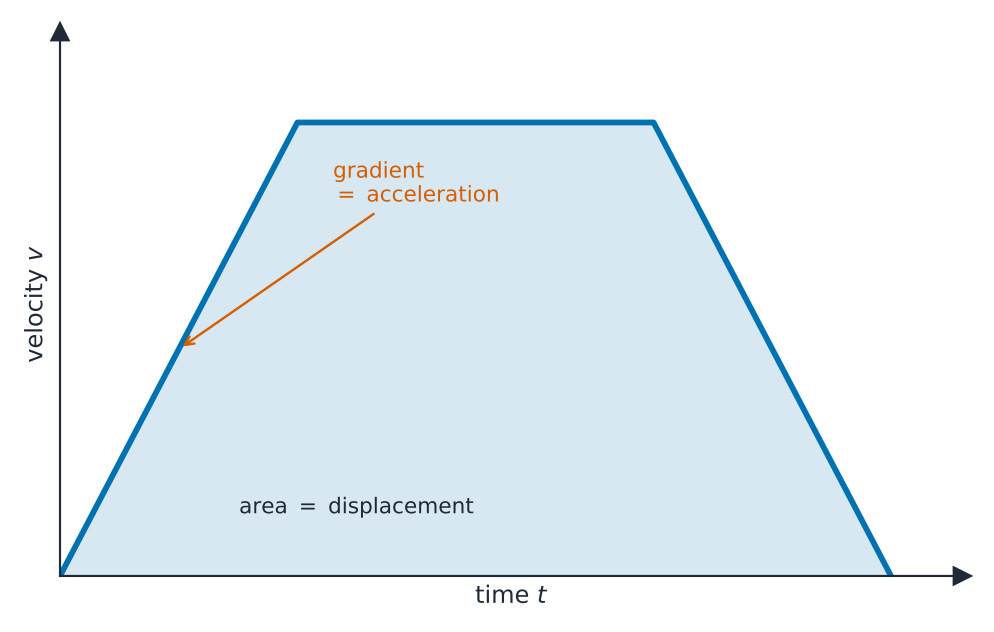
Build the skills to answer exam questions on **kinematics** 运动学—the **velocity–time graph** 速度时间图, the **suvat** equations for constant acceleration, and using calculus for variable acceleration. Take $g = 10\ \text{m s}^{-2}$.

You must be able to:

- read displacement (area) and acceleration (gradient) from a v–t graph
- use $v = u + at$, $s = ut + \frac{1}{2}at^2$, $v^2 = u^2 + 2as$
- differentiate/integrate between s, v, a for variable acceleration

1 Worked examples

Graph & suvat



Area under a v–t graph = displacement; gradient = acceleration

Car from rest, $a = 2.5\ \text{m s}^{-2}$ for 4 s: $v = 2.5 \times 4 = 10\ \text{m s}^{-1}$; $s = \frac{1}{2}(2.5)(16) = 20$ m.

Variable: if $s = t^3 - 3t^2$ then $v = \dfrac{ds}{dt} = 3t^2 - 6t$, $a = \dfrac{dv}{dt} = 6t - 6$.

2 Practice

2.1 A particle accelerates from 4 m s^{-1} at 3 m s^{-2} for 5 s. Find its final velocity. [2]

2.2 A v–t graph is a straight line from $(0, 2)$ to $(6, 14)$. Find the acceleration. [2]

3 Exam-style questions

3.1 A stone is dropped from rest. After 3 s its speed is ($g = 10$): [1]

- **A** 10 m s^{-1}
- **B** 20 m s^{-1}
- **C** 30 m s^{-1}
- **D** 45 m s^{-1}

3.2 A car travelling at 30 m s^{-1} brakes with constant deceleration and stops in 75 m.

(a) Find the deceleration. [3]

(b) Find the time taken to stop. [2]

3.3 A particle moves so that its velocity is $v = 12t - 3t^2$ m s^{-1} at time t s.

(a) Find the time when the particle is instantaneously at rest (other than $t = 0$). [2]

(b) Find the distance travelled in the first 4 seconds. [4]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **4.2 Kinematics of motion in a straight line** past-paper sheet in the Library, or try these in **Practice mode**:

- 9709/41 N25 —Q7 (kinematics)
- 9709/42 N25 —Q1 (suvat)
- 9709/42 N25 —Q3 (variable acceleration)

Solutions

2.1 $v = u + at = 4 + 3(5) = 19$ m s^{-1}.

2.2 gradient $= \dfrac{14 - 2}{6 - 0} = 2$ m s^{-2}.

3.1 C. $v = u + gt = 0 + 10(3) = 30$ m s^{-1}.

3.2 (a) $v^2 = u^2 + 2as$: $0 = 30^2 + 2a(75)$; $a = -\dfrac{900}{150} = -6$, so deceleration 6 m s^{-2}.
(b) $v = u + at$: $0 = 30 - 6t \Rightarrow t = 5$ s.

3.3 (a) $v = 0$: $12t - 3t^2 = 0 \Rightarrow 3t(4 - t) = 0 \Rightarrow t = 4$ s.
(b) $v \geqslant 0$ for $0 \leqslant t \leqslant 4$, so distance $= \displaystyle\int_0^4 (12t - 3t^2)\, dt = [6t^2 - t^3]_0^4; = 96 - 64 = 32$ m.