Exercise walk-through

Representing Motion ▪ 1.3

eXercise

You must be able to

- read **position-time**, **velocity-time**, and **acceleration-time** graphs
- use the **slope 斜率**: slope of an x-t graph $=$ velocity; slope of a v-t graph $=$ acceleration
- use the **area 面积**: area under a v-t graph $=$ displacement; area under an a-t graph $=$ change in velocity
- apply the **kinematic equations 运动学方程** for constant acceleration
- analyse **free fall 自由落体** with $g = 9.8$ m s^{-2}

Method — The kinematic equations (constant a)

$$v = v_0 + at, \qquad \Delta x = v_0 t + \tfrac{1}{2} a t^2,$$

$$v^2 = v_0^2 + 2a\,\Delta x, \qquad \Delta x = \tfrac{1}{2}(v_0 + v)\,t.$$

Choose the one that is **missing the quantity you don't know**.

Method — Slopes and areas

On a *v*-*t* graph the **slope** is the acceleration and the **area** under the line is the displacement. A line rising from 0 to 12 m s^{-1} over 4.0 s: slope $= 3.0$ m s^{-2}; area $= \frac{1}{2}(4.0)(12) = 24$ m.

Method — Free fall

Take down as positive, so $a = g = 9.8$ m s^{-2}. A ball dropped from rest for 2.0 s: $\Delta x = \tfrac{1}{2}(9.8)(2.0)^2 = 19.6$ m and $v = 9.8 \times 2.0 = 19.6$ m s^{-1}.

Practice 2.1 ▪ 1 mark

A car accelerates from rest at 2.0 m s^{-2} for 6.0 s. Find its final velocity.

Solution 2.1

Method: Free fall

Worked steps

$v = 0 + 2.0(6.0) = 12$ m s^{-1} **B1**.

Practice 2.2 ▪ 2 marks

For the same car, find the distance it travels in that time.

Solution 2.2

Worked steps

$\Delta x = \frac{1}{2}(2.0)(6.0)^2 = 36$ m M1 A1.

Practice 2.3 ▪ 2 marks

On a velocity-time graph, state what (a) the slope and (b) the area under the line represent.

Solution 2.3

Method: Slopes and areas

Worked steps

(a) acceleration B1; (b) displacement B1.

Practice 2.4 ▪ 1 mark

A stone is dropped from rest. Find its speed after 3.0 s (take $g = 9.8$ m s^{-2}).

Solution 2.4

Method: Free fall

Worked steps

$v = 9.8(3.0) = 29.4$ m s^{-1} B1.

Exam-style 3.1 ▪ 1 mark

The area under a velocity-time graph gives the

A acceleration

B displacement

C speed

D jerk

Solution 3.1

Method: Slopes and areas

A acceleration

B displacement ✓

C speed

D jerk

Worked steps

B.

Exam-style 3.2 ▪ 1 mark

A ball is thrown straight up. At its highest point, its

A velocity and acceleration are both zero

B velocity is zero and acceleration is 9.8 m s^{-2} downward

C velocity is maximum and acceleration is zero

D velocity and acceleration both point up

Solution 3.2

A velocity and acceleration are both zero

B velocity is zero and acceleration is 9.8 m s^{-2} downward ✓

C velocity is maximum and acceleration is zero

D velocity and acceleration both point up

Worked steps

B — the speed is zero at the top but gravity still acts downward.

Exam-style 3.3 ▪ 2 marks

A car travelling at 25 m s^{-1} brakes to rest in a distance of 50 m.
(a) Find its acceleration.
(b) Find the time it takes to stop.

Solution 3.3

Worked steps

(a) $v^2 = v_0^2 + 2a\Delta x \Rightarrow 0 = 25^2 + 2a(50)$, so $a = -6.25$ m s^{-2} M1 A1. (b) $t = \dfrac{0 - 25}{-6.25} = 4.0$ s A1.

Exam-style 3.4 ▪ 1 mark

A ball is thrown vertically upward at 20 m s^{-1} (take $g = 10$ m s^{-2}).
(a) Find the time to reach the top.
(b) Find the maximum height reached.

Solution 3.4

Method: Free fall

Worked steps

(a) $t = \dfrac{20}{10} = 2.0$ s A1. (b) $h = \dfrac{v_0^2}{2g} = \dfrac{20^2}{20} = 20$ m M1 A1.