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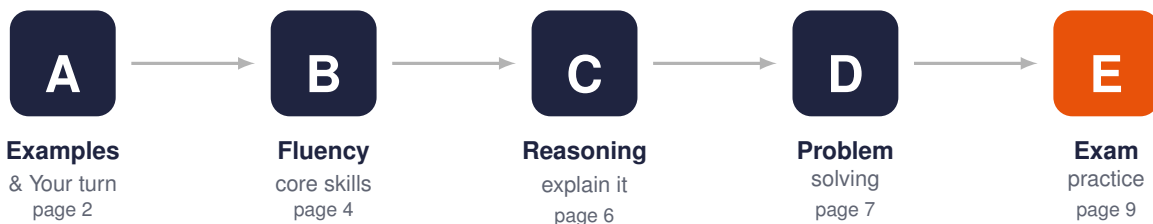
A-LEVEL MATHEMATICS • MECHANICS 1

Constant Acceleration

Worksheet

Pearson Edexcel International A Level (WME01) & A Level (9MA0) • Calculator and statistical tables allowed: take $g = 9.8 \text{ m s}^{-2}$ and give answers to 2 or 3 s.f.

Free Constant Acceleration worksheet for A-Level and International A-Level Maths, with full worked solutions



Tap a section to jump straight to it

By the end of this worksheet you can: use the suvat formulae • read and draw speed-time and displacement-time graphs • solve vertical motion under gravity • *Stretch:* multi-stage journeys, two objects that meet, and quadratics with a root to reject.

Which questions are for me?

CORE The methods every A-level student must secure. Start here.

STRETCH Signs, graphs, roots to reject, and journeys that change from one stage to the next.

Every section has both, clearly labelled. Questions get harder as you go, and every skill in Sections A to D is needed in Section E.

Track your progress

Section	B	C	D	E
Core marks	23	10	13	21
Stretch marks	16	14	17	13
My score				

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Name

Class

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A

Worked examples & Your turn

Read each example carefully. Cover it up, then answer the question beside it using the same method.

CORE

Secure the method

Worked example A1: two suvat formulae

A particle has $u = 4 \text{ ms}^{-1}$ and $a = 2.5 \text{ ms}^{-2}$. Find v and s after 6 s.

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

$$v = 4 + 15; \quad s = 24 + 45$$

$$v = 19 \text{ ms}^{-1}, \quad s = 69 \text{ m}$$

Your turn A1

A particle has $u = 12 \text{ ms}^{-1}$ and $a = -1.5 \text{ ms}^{-2}$. Find v and s after 4 s.

Worked example A2: no time given

A car starts from rest with $a = 3 \text{ ms}^{-2}$. Find its speed after 24 m.

$$v^2 = u^2 + 2as$$

$$v^2 = 0 + 2(3)(24) = 144$$

$$v = 12 \text{ ms}^{-1}$$

Your turn A2

A car at 20 ms^{-1} decelerates at 2.5 ms^{-2} until it stops. Find the distance.

Worked example A3: a speed-time graph

A tram accelerates from rest to 15 ms^{-1} in 6 s, travels at 15 ms^{-1} for 20 s, then stops in 4 s. Find the total distance and the deceleration.

Distance is the area; acceleration is the gradient.

$$45 + 300 + 30; \quad \frac{15}{4}$$

$$375 \text{ m}, \quad 3.75 \text{ ms}^{-2}$$

Your turn A3

A tram accelerates from rest to 10 ms^{-1} in 5 s, travels at 10 ms^{-1} for 30 s, then stops in 8 s. Find the total distance and the deceleration.



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STRETCH

Worked example A4: projected upwards

A ball is projected vertically upwards at 14.7 ms^{-1} . Find its greatest height and the time to reach it.

Up is positive, so $a = -9.8$; at the top $v = 0$

$$0 = 14.7^2 - 19.6s; \quad 0 = 14.7 - 9.8t$$

11 m, 1.5 s

Your turn A4

A ball is projected vertically upwards at 19.6 ms^{-1} . Find its greatest height and the time to reach it.

Worked example A5: from a height

A stone is thrown upwards at 4.9 ms^{-1} from the top of a 14.7 m tower. Find the time until it hits the ground.

The ground is -14.7 m from the start: $s = ut + \frac{1}{2}at^2$

$$-14.7 = 4.9t - 4.9t^2, \text{ so } t^2 - t - 3 = 0$$

$t = 2.30\text{ s}$ (reject the negative root)

Your turn A5

A stone is thrown upwards at 9.8 ms^{-1} from the top of a 29.4 m tower. Find the time until it hits the ground.

Worked example A6: two stages

A car starts from rest, accelerates at 2 ms^{-2} for 5 s , then decelerates at 0.5 ms^{-2} to rest. Find the total distance.

The end speed of stage 1 is the start speed of stage 2

$$\text{Stage 1: } v = 10, s = 25; \text{ stage 2: } s = \frac{10^2}{2(0.5)} = 100$$

125 m

Your turn A6

A car starts from rest, accelerates at 1.5 ms^{-2} for 8 s , then decelerates at 2 ms^{-2} to rest. Find the total distance.

Worked example A7: two objects meet

Car A starts from rest at O with $a = 2\text{ ms}^{-2}$. At the same instant car B passes O at a constant 12 ms^{-1} . When and where does A catch B?

Equal displacements from O

$$t^2 = 12t, \text{ so } t = 12$$

12 s, 144 m from O

Your turn A7

Car A starts from rest at O with $a = 3\text{ ms}^{-2}$. At the same instant car B passes O at a constant 9 ms^{-1} . When and where does A catch B?



B**Fluency**

Each question is a designed sequence. From one part to the next, ask yourself: what changed, and what did it do to the answer?

CORE*Secure the method*

B1 A car passes a point at 8 ms^{-1} and accelerates at 0.5 ms^{-2}

(a) Find its speed after 12 s

(b) Find the distance in 12 s

(c) Find the time to reach 20 ms^{-1}

(d) Find the distance while its speed goes from 8 to 20 ms^{-1}

[4 marks]

B2 A train at 30 ms^{-1} brakes with a deceleration of 1.2 ms^{-2}

(a) Find the time to stop

(b) Find the stopping distance

(c) Find the speed after 250 m

(d) Find the time to travel 250 m

[4 marks]

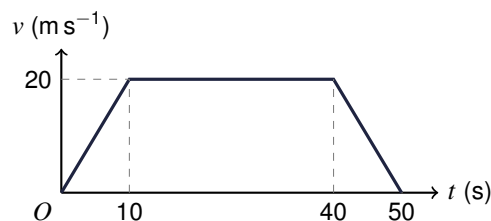
B3 The speed-time graph of a tram is shown.

(a) Find the acceleration.

(b) Find the deceleration.

(c) Find the total distance.

(d) Find the average speed.



[4 marks]

B4 A ball is projected vertically upwards from the ground at 21 ms^{-1}

(a) Find the greatest height

(b) Find the time to the top

(c) Find the total time in the air

(d) Find its speed when 15 m up

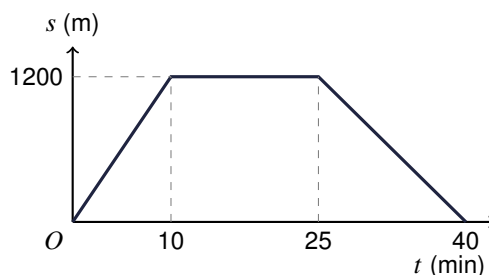
[4 marks]



CORE *continued: displacement and units*

B5 The displacement-time graph of a walker is shown.

- (a) Find her velocity, in m s^{-1} , for the first 10 minutes.
(b) State how long she is at rest.
(c) Find her velocity, in m s^{-1} , for the last stage.



[3 marks]

B6 A car travelling at 54 km h^{-1} brakes uniformly and stops in 45 m.

- (a) Convert 54 km h^{-1} to m s^{-1}
(b) Find the deceleration
(c) Find the time to stop
(d) Find the distance in the last second

[4 marks]

STRETCH

B7 A stone is thrown vertically upwards at 7 m s^{-1} from the top of a cliff 40 m above the sea.

- (a) Find its greatest height above the cliff
(b) Find the time until it hits the sea
(c) Find its speed as it hits the sea
(d) Find the time it is above the cliff top

[4 marks]

B8 A cyclist starts from rest, accelerates uniformly to $V \text{ m s}^{-1}$ in 8 s, then decelerates uniformly to rest in 12 s. The total distance is 150 m.

- (a) Find V
(b) Find the acceleration
(c) Find the deceleration
(d) Find the average speed

[4 marks]

B9 At $t = 0$, car A starts from rest at O with acceleration 2 m s^{-2} , and car B passes O at 15 m s^{-1} with deceleration 1 m s^{-2}

- (a) Write each displacement in terms of t
(b) Find when they meet
(c) Find where they meet
(d) Find each speed when they meet

[4 marks]

B10 A ball is projected vertically upwards from the ground at 19.6 m s^{-1}

- (a) Find the times when it is 14.7 m up
(b) Find how long it is at least 14.7 m up
(c) Find its greatest height
(d) Find its speed when 14.7 m up

[4 marks]



C**Reasoning**

Show your working and explain your thinking. A correct answer without a reason does not score full marks.

CORE*Secure the method*

- C1** A ball is projected upwards at 9.8 m s^{-1} . Ama writes $s = 9.8t + 4.9t^2$
Explain her error, and write the correct equation. [2 marks]
- C2** A car at 72 km h^{-1} stops in 8 s. Ben writes the deceleration as $\frac{72}{8} = 9 \text{ m s}^{-2}$
Explain his error, and find the deceleration. [2 marks]
- C3** A motorbike passes A at 5 m s^{-1} , accelerates to $V \text{ m s}^{-1}$, then decelerates to rest. Cal draws its speed-time graph starting at the origin.
Explain why this is wrong, and describe the correct shape. [3 marks]
- C4** Dee solves $7V^2 - 99V - 340 = 0$ for the top speed of a motorbike, gets $V = 17$ or $V = -\frac{20}{7}$, and gives both.
Explain her error. [3 marks]

STRETCH

- C5** A ball is projected upwards and lands 4 s later. Eli draws the speed-time graph with a solid vertical line at the instant the ball is at the top.
Explain his error, and describe the correct graph. [3 marks]
- C6** A rocket rises at 5 m s^{-1} when a part falls off. Faye finds the time for the part to reach the ground using $u = 0$
Explain her error. [3 marks]
- C7** A ball is thrown up 6 m and caught at the same point. Gus says it travels 0 m.
Explain what is wrong, and give the distance and the displacement. [3 marks]
- C8** A particle has initial speed u , constant acceleration a and speed v after time t
(a) Use the area under a speed-time graph to show that $s = \frac{1}{2}(u + v)t$ (2)
(b) Hence, using $v = u + at$, show that $v^2 = u^2 + 2as$ (3)
[5 marks]



D**Problem solving**

You decide the method. Read the whole question first, and show every step.

CORE

Secure the method

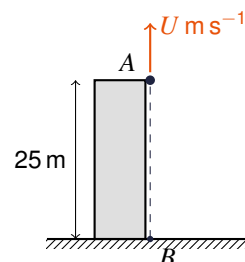
- D1** A ball is projected vertically upwards with speed $U \text{ ms}^{-1}$ from a point A at the edge of the flat top of a tower. The point A is 25 m vertically above the point B on horizontal ground, as shown in the figure. The ball moves freely under gravity and hits the ground 3 seconds after it is projected.

(a) Find the value of U

(2)

(b) Find the speed of the ball as it hits the ground.

(1)



[3 marks]

- D2** A car passes a point A at 4 ms^{-1} and accelerates uniformly to a point B , 100 m from A , reaching a speed of $V \text{ ms}^{-1}$. It then decelerates uniformly from B and comes to rest at a point C , 120 m from B . The journey from A to C takes 25 seconds.

(a) Show that $5V^2 - 68V - 192 = 0$, and hence find the value of V

(3)

(b) Find the deceleration of the car.

(1)

[4 marks]

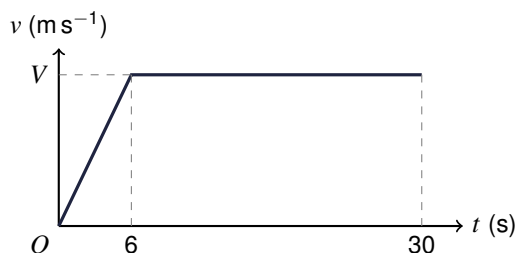
- D3** A runner starts from rest and accelerates uniformly for 6 seconds until her speed is $V \text{ ms}^{-1}$. She then runs at constant speed $V \text{ ms}^{-1}$, as shown in the speed-time graph. In the first 30 seconds she runs 216 m.

(a) Show that $V = 8$

(2)

(b) Find her acceleration in the first 6 seconds.

(1)



[3 marks]

- D4** A ball A is projected vertically upwards from a point on horizontal ground with speed 12.6 ms^{-1} . One second later, a ball B is projected vertically upwards from another point on the same ground with speed 9.8 ms^{-1} . The balls move freely under gravity.

Find the time after A is projected when the two balls are at the same height, and find that height.

[3 marks]



STRETCH

- D5** A parachutist falls from rest from a height of 500 m. She falls freely under gravity for 4 seconds, then her parachute opens and she decelerates uniformly at 3.5 m s^{-2} until her speed is 5 m s^{-1} . She then falls at a constant 5 m s^{-1} until she reaches the ground.

(a) Find her speed when the parachute opens, and the distance she has fallen by then.

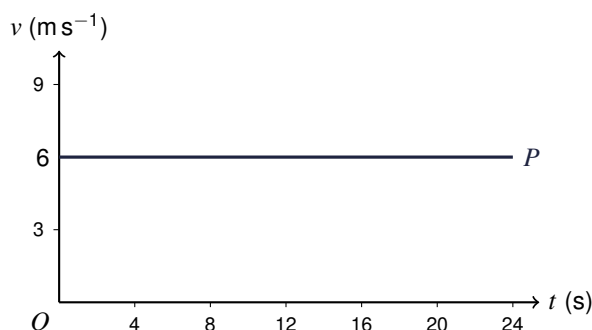
(2)

(b) Find the total time from leaving the aircraft until she reaches the ground.

(2)

[4 marks]

- D6** Cyclist P rides along a straight road at a constant speed of 6 m s^{-1} , and passes a point O at time $t = 0$. At $t = 4$, cyclist Q starts from rest at O and rides in the same direction, accelerating at 1.5 m s^{-2} until her speed is 9 m s^{-1} , then continuing at 9 m s^{-1} . The speed-time graph of P is shown.



Add Q 's graph to the figure, and find the time at which Q catches up with P , and the distance from O

[4 marks]

- D7** A balloon is rising vertically at a constant speed of 4.9 m s^{-1} . When it is 58.8 m above the ground, a sandbag is released from the balloon. The sandbag moves freely under gravity.

(a) Find the time the sandbag takes to reach the ground.

(2)

(b) Find the speed of the sandbag as it reaches the ground.

(1)

(c) Find the height of the balloon at that instant.

(1)

[4 marks]

- D8** A train moves along a straight track with constant acceleration. It passes a post P , and then covers the next 120 m in 8 seconds and the following 120 m in 6 seconds.

(a) Find the acceleration of the train and its speed at P

(4)

(b) Find its speed at the end of the 240 m.

(1)

[5 marks]



E**Exam practice**

Full-size exam questions in the style of WME01. Write your answers in the spaces, and show every step.

CORE

Exam questions for everyone

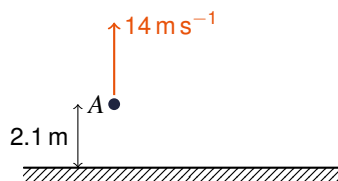
E1 A train travels along a straight horizontal track from station A to station B . The train is modelled as a particle. It starts from rest at A and accelerates uniformly for 40 seconds until its speed is $V \text{ m s}^{-1}$. It then travels at constant speed $V \text{ m s}^{-1}$ for T seconds and then decelerates uniformly for 60 seconds, coming to rest at B . The distance from A to B is 6 km and the whole journey takes 300 seconds.

- (a) Sketch a speed-time graph for the journey of the train from A to B (2)
- (b) Write down the value of T (1)
- (c) Find the value of V (3)
- (d) Find the acceleration of the train in the first 40 seconds. (1)
- (e) Find the time, in seconds after the train leaves A , at which the train is exactly halfway between station A and station B (2)
- (f) Find the average speed of the train for its whole journey from A to B (1)

(Total for Question E1 is 10 marks)



- E2** A ball is projected vertically upwards with speed 14 m s^{-1} from a point A , which is 2.1 m above horizontal ground. The ball is modelled as a particle moving freely under gravity, and it moves until it hits the ground for the first time.



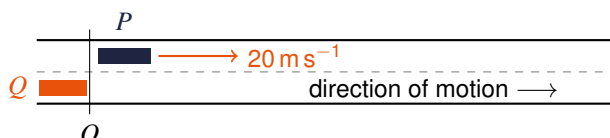
- (a) Find the greatest height of the ball above the ground. (2)
- (b) Show that the ball hits the ground 3 seconds after it is projected. (3)
- (c) Find the speed of the ball as it hits the ground. (2)
- (d) Sketch a velocity-time graph for the motion of the ball from A to the ground, taking upwards as positive. (2)
- (e) Find the length of time, in seconds, for which the ball is at least 9.8 m above the ground during its motion. (2)

(Total for Question E2 is 11 marks)



STRETCH

- E3** Two cars, P and Q , move along the same straight road in the same direction. At time $t = 0$, car P passes a point O with speed 20 m s^{-1} and then decelerates uniformly at 0.8 m s^{-2} until it comes to rest. At time $t = 5$, car Q starts from rest at O and accelerates uniformly at 1.2 m s^{-2} until its speed is 18 m s^{-1} . It then moves at a constant 18 m s^{-1} . The positions of the cars at $t = 0$ are shown in the figure. The cars are modelled as particles.



- (a) Find the time at which P comes to rest, and its distance from O then. (2)
- (b) Find the time at which Q reaches 18 m s^{-1} , and its distance from O then. (2)
- (c) Show that car Q has not caught up with car P by the time car Q reaches its constant speed of 18 m s^{-1} . (2)
- (d) Find the time at which car Q catches up with car P . You must show your working clearly, including how you know whether P is still moving at that time. (4)
- (e) Sketch, on the same axes, the speed-time graphs of P and Q for $0 \leq t \leq 30$. (3)

(Total for Question E3 is 13 marks)

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