EDEXCEL INTERNATIONAL A LEVEL · M1 MECHANICS 1

M1 Kinematics: exam questions

10 questions · 36 marks · full mark schemes

Name _____ Date _____ Score / 36

- Constant-acceleration (suvat) formulae; vertical motion under gravity; displacement-time and velocity-time graphs (variable acceleration and projectiles are M2).
- Try every question before you look at the mark schemes. They start after the questions: M marks for method, A marks for accuracy, B marks for a correct result on its own.
- Online, with more practice: alevelmathrevision.com/alevel-frontend/units/m1/kinematics-questions

1. **2 marks · warm-up**

A stone is dropped from the top of a cliff and hits the ground below 3 seconds later. Assuming air resistance is negligible, find the height of the cliff. (Take $g = 9.8\ \text{m s}^{-2}$).

2. **3 marks · warm-up**

A ball is thrown vertically upwards from the ground with a speed of $19.6\ \text{m s}^{-1}$. Find the maximum height reached by the ball.

3. **3 marks · standard**

A train accelerates uniformly from $5\ \text{m s}^{-1}$ to $V\ \text{m s}^{-1}$ over a period of 10 seconds. The total distance travelled during this acceleration is $150\ \text{m}$. Find the value of V.

4. 3 marks · standard

A stone is thrown vertically downwards from a $20\ \text{m}$ high bridge with an initial speed of $5\ \text{m s}^{-1}$. Find the time it takes to hit the water below.

5. 4 marks · standard

A car travels at a constant speed of $20\ \text{m s}^{-1}$ for T seconds, and then decelerates uniformly to rest in 5 seconds. If the total distance travelled is $400\ \text{m}$, find the value of T.

6. 4 marks · standard

Particle A passes a fixed point O travelling at a constant velocity of $15\ \text{m s}^{-1}$. At the exact same instant, Particle B starts from rest at O and accelerates uniformly at $2\ \text{m s}^{-2}$ along the same path. Find the time it takes for Particle B to catch Particle A.

7. 4 marks · harder

A motorcycle starts from rest, accelerates uniformly to $30\ \text{m s}^{-1}$ in 20 seconds, maintains this speed for t seconds, and then decelerates uniformly to rest in 15 seconds. The total distance covered is $1500\ \text{m}$. Find the total time for the journey.

8. 4 marks · harder

A sprinter's velocity-time graph for a $400\ \text{m}$ race is modelled as an isosceles triangle. He accelerates uniformly from rest for the first 20 seconds, reaching a maximum speed of V, and then immediately decelerates uniformly to rest over the next 20 seconds. Find the magnitude of his deceleration.

9. 4 marks · harder

A particle is projected vertically upwards and reaches a maximum height of $25\ \text{m}$. It passes a certain height h on the way up, and passes it again exactly 2 seconds later on the way down. Find the value of h.

10. 5 marks · harder

A hot air balloon is ascending vertically at a constant speed of $5\ \text{m s}^{-1}$. When the balloon is at a height of $100\ \text{m}$ above the ground, a sandbag is released. Determine the time taken for the sandbag to hit the ground.

Answers and worked solutions

Question 1 — 2 marks

1. M1 for using $s = ut + \frac{1}{2}at^2$ with $u = 0$, $t = 3$, $a = 9.8$.
2. A1 for calculating $s = 0 + 0.5(9.8)(3^2) = 44.1\ \text{m}$.

Question 2 — 3 marks

1. M1 for identifying that at max height, $v = 0$.
2. M1 for using $v^2 = u^2 + 2as$ with $u = 19.6$ and $a = -9.8$: $0 = 19.6^2 + 2(-9.8)s$.
3. A1 for solving $19.6s = 384.16 \implies s = 19.6\ \text{m}$.

Question 3 — 3 marks

1. M1 for applying the formula $s = \frac{1}{2}(u + v)t$.
2. M1 for substituting: $150 = \frac{1}{2}(5 + V) \times 10$.
3. A1 for simplifying to $30 = 5 + V \implies V = 25\ \text{m s}^{-1}$.

Question 4 — 3 marks

1. M1 for taking downwards as positive and using $s = ut + \frac{1}{2}at^2$: $20 = 5t + 4.9t^2$.
2. M1 for formulating the quadratic $4.9t^2 + 5t - 20 = 0$ and applying the quadratic formula.
3. A1 for selecting the positive root: $t = \frac{-5 + \sqrt{25 - 4(4.9)(-20)}}{9.8} = 1.57\ \text{s}$ (3 s.f.).

Question 5 — 4 marks

1. M1 for drawing a velocity-time graph or setting up the total distance as the sum of a rectangle and a triangle.
2. M1 for forming the equation: $20T + \frac{1}{2} \times 5 \times 20 = 400$.
3. M1 for simplifying to $20T + 50 = 400 \implies 20T = 350$.
4. A1 for finding $T = 17.5\ \text{s}$.

Question 6 — 4 marks

1. M1 for setting up the distance expression for A: $s_A = 15t$.
2. M1 for setting up the distance expression for B: $s_B = \frac{1}{2}(2)t^2 = t^2$.
3. M1 for equating the distances since they meet: $t^2 = 15t$.
4. A1 for solving to get $t^2 - 15t = 0 \implies t = 15\ \text{s}$ (rejecting $t = 0$).

Question 7 — 4 marks

1. M1 for expressing the total distance as the area of a trapezium or sum of shapes: $\frac{1}{2} \times 20 \times 30 + 30t + \frac{1}{2} \times 15 \times 30 = 1500$.
2. M1 for simplifying the equation to $300 + 30t + 225 = 1500$.
3. M1 for solving for the constant velocity time t: $30t = 975 \implies t = 32.5$.
4. A1 for calculating the total time: $20 + 32.5 + 15 = 67.5\ \text{s}$.

Question 8 — 4 marks

1. M1 for writing the equation for the area of the triangle: $\frac{1}{2} \times 40 \times V = 400$.
2. M1 for solving to find the maximum velocity: $20V = 400 \implies V = 20\ \text{m s}^{-1}$.
3. M1 for setting up the deceleration calculation: $a = \frac{\Delta v}{\Delta t} = \frac{0 - 20}{20}$.
4. A1 for stating the magnitude of deceleration is $1\ \text{m s}^{-2}$.

Question 9 — 4 marks

1. M1 for using symmetry: if the time gap is 2 seconds, it takes 1 second to go from height h to the max height.
2. M1 for calculating the distance fallen from max height in 1 second: $s = 0.5(9.8)(1^2) = 4.9\ \text{m}$.
3. M1 for setting up the equation for h: $h = \text{Max Height} - \text{fall distance}$.
4. A1 for calculating $h = 25 - 4.9 = 20.1\ \text{m}$.

Question 10 — 5 marks

1. M1 for recognising the initial velocity of the sandbag is $5\ \text{m s}^{-1}$ upwards.
2. M1 for setting up the equation $s = ut + \frac{1}{2}at^2$ with $s = -100$, $u = 5$, and $a = -9.8$.
3. M1 for arranging into a quadratic equation: $-100 = 5t - 4.9t^2 \implies 4.9t^2 - 5t - 100 = 0$.
4. M1 for using the quadratic formula: $t = \frac{5 \pm \sqrt{25 - 4(4.9)(-100)}}{2(4.9)} = \frac{5 \pm \sqrt{1985}}{9.8}$.
5. A1 for selecting the positive root: $t = 5.06\ \text{s}$ (3 s.f.).

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