Worksheet - Kinematics

Year: Year 12 · 20

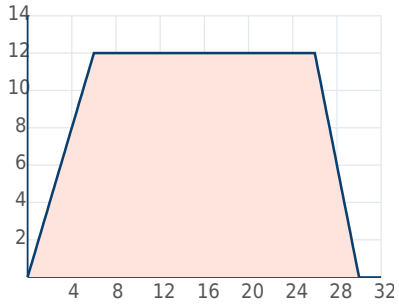
Show your working.

Question 1

Question 1 – Reading a velocity-time graph *(Section A · Skills practice)*

A lift travels between floors. It accelerates uniformly from rest to 12 m/s in 6 s, travels at 12 m/s for 20 s, then decelerates uniformly to rest in 4 s.

a. Find the acceleration in the first stage and the deceleration in the last stage. [2 marks]
b. Find the distance travelled in each stage. [3 marks]
c. Find the total distance and the average speed for the whole journey. [3 marks]



Question 2

Question 2 – The constant acceleration equations *(Section A · Skills practice)*

Use the equations of constant acceleration ("suvat").

a. A particle has $u = 3$ m/s and $a = 2$ m/s^2. Find v and s after 5 s. [3 marks]
b. A particle has $u = 5$ m/s, $v = 17$ m/s and $s = 66$ m. Find t and a. [4 marks]
c. A particle travels 48 m in 4 s with acceleration 1.5 m/s^2. Find the initial speed. [3 marks]

Question 3

Question 3 – Stopping a car *(Section A · Skills practice)*

A car travelling at 20 m/s brakes with a constant deceleration of 4 m/s^2.

a. Find the braking distance. [3 marks]
b. Find the time taken to stop. [2 marks]
c. Find the speed after it has travelled 30 m while braking. [3 marks]

Question 4

Question 4 – Motion under gravity *(Section A · Skills practice)*

A ball is thrown vertically upwards from the ground at 14 m/s. Take $g = 9.8$ m/s^2.

a. Find the maximum height. [3 marks]
b. Find the time to reach the maximum height and the total time in the air. [3 marks]
c. Find the velocity and height after 2 s. [4 marks]

Question 5

Question 5 – Differentiating displacement *(Section A · Skills practice)*

A particle moves in a line with displacement $s = 2t^3 - 9t^2 + 12t$ metres at time t seconds.

a. Find expressions for the velocity and the acceleration. [3 marks]
b. Show that the particle is at rest at $t = 1$ and $t = 2$. [2 marks]
c. Find the displacement at each of these times and the acceleration at $t = 1$. [4 marks]

Question 6

Question 6 – Integrating acceleration *(Section A · Skills practice)*

A particle has acceleration $a = 6t - 4$ m/s^2. When $t = 0$ its velocity is 3 m/s and its displacement is 0.

a. Find the velocity at time t. [3 marks]
b. Find the displacement at time t. [3 marks]
c. Find the velocity and displacement when $t = 2$. [2 marks]

Question 7

Question 7 – A train between stations *(Section B · Real-life practice)*

A train leaves a station, accelerates uniformly at 0.5 m/s^2 until it reaches 25 m/s, travels at this speed for 4 minutes, then decelerates uniformly at 1 m/s^2 to stop at the next station.

a. Find the time for each of the three stages. [3 marks]
b. Find the distance between the stations. [4 marks]
c. Find the average speed for the whole journey in m/s and km/h. [3 marks]
d. Sketch the velocity-time graph. [2 marks]

Question 8

Question 8 – Reaction time and braking *(Section B · Real-life practice)*

A driver travelling at 15 m/s sees a hazard 30 m ahead. Her reaction time is 0.7 s, during which the car keeps moving at 15 m/s. She then brakes with a constant deceleration of 5 m/s^2.

a. Find the thinking distance. [1 mark]
b. Find the braking distance needed to stop. [3 marks]
c. Show that she cannot stop before reaching the hazard. [2 marks]
d. Find the speed at which she hits the hazard. [3 marks]

Question 9

Question 9 – Dropping a stone from a bridge *(Section B · Real-life practice)*

A stone is released from rest at the top of a bridge 45 m above the water. Take $g = 9.8$ m/s^2.

a. Find the time to reach the water and the speed on impact. [4 marks]
b. A second stone is thrown downwards at 5 m/s from the same point. Show that it reaches the water when $4.9t^2 + 5t - 45 = 0$. [2 marks]
c. Find the time and impact speed for the second stone. [4 marks]

Question 10

Question 10 – A lift journey *(Section B · Real-life practice)*

A lift accelerates uniformly from rest for 3 s at 1.2 m/s^2, then travels at constant speed for 10 s, then decelerates uniformly to rest in 4 s.

a. Find the maximum speed. [1 mark]
b. Find the deceleration. [2 marks]
c. Find the total height climbed. [4 marks]
d. Find the average speed. [2 marks]

Question 11

Question 11 – Catching up *(Section B · Real-life practice)*

Runner A runs at a constant 7 m/s. Runner B starts 12 m behind A at the same instant from rest with a constant acceleration of 1.5 m/s^2.

a. Write A\'s distance from B\'s starting point after t s. [1 mark]
b. Write B\'s distance after t s. [1 mark]
c. Show that B catches A when $0.75t^2 - 7t - 12 = 0$ and find t. [4 marks]
d. How far has B run when she catches A, and what is her speed then? [3 marks]

Question 12

Question 12 – A lorry with variable acceleration *(Section B · Real-life practice)*

A lorry\'s acceleration is $a = 0.6 - 0.04t$ m/s^2 for $0 \le t \le 15$, where t is in seconds. Its initial speed is 2 m/s.

a. Show that $v = 2 + 0.6t - 0.02t^2$. [2 marks]
b. Find the speed when $t = 15$ and explain why the acceleration is zero then. [3 marks]
c. Find the distance travelled in the 15 seconds. [4 marks]
d. Find the average speed over the 15 s. [1 mark]

Question 13

Question 13 – Fireworks *(Section B · Real-life practice)*

A firework rocket is fired vertically upwards from the ground at 40 m/s and explodes at its highest point. Take $g = 9.8$ m/s^2.

a. Find the height and time of the explosion. [4 marks]
b. Find the height after 3 s. [2 marks]
c. Suppose the rocket did not explode. For how long would it be above 70 m? [5 marks]

Question 14

Question 14 – Accelerating on a straight road *(Section B · Real-life practice)*

A car is travelling at 20 m/s on a straight road and accelerates uniformly at 0.8 m/s^2 for a distance of 300 m.

a. Show that the time taken satisfies $t^2 + 50t - 750 = 0$. [3 marks]
b. Find the time. [2 marks]
c. Find the final speed. [2 marks]
d. Check the final speed using $v^2 = u^2 + 2as$. [2 marks]

Question 15

Question 15 – A cyclist's four stages *(Section C · Problem solving)*

A cyclist rides along a straight road in four stages.

Stage	Description	Time
1	accelerates uniformly from rest to 6 m/s	8 s
2	constant speed 6 m/s	40 s
3	decelerates uniformly to 2 m/s	10 s

Stage	Description	Time
4	constant speed 2 m/s	30 s

a. Find the acceleration in stage 1 and the deceleration in stage 3. [3 marks]
b. Find the distance covered in each stage. [4 marks]
c. Find the total distance and the average speed. [3 marks]
d. The cyclist claims her average speed was 4 m/s for the whole ride. Is she right? [2 marks]

Question 16

Question 16 – Motion with a changing direction *(Section C · Problem solving)*

The velocity of a particle on a line is $v = t^2 - 8t + 12$ m/s for $0 \le t \le 8$. At $t = 0$ the particle is at the origin.

t (s)	0	2	4	6	8
v (m/s)	12	0	-4	0	12

a. Show that $s = \dfrac{t^3}{3} - 4t^2 + 12t$. [2 marks]
b. Find the displacement at $t = 2$, 6 and 8. [4 marks]
c. Find the total distance travelled in 8 seconds. [3 marks]
d. Find the acceleration at $t = 4$ and explain its sign in the table. [2 marks]

Question 17

Question 17 – Two stages of constant acceleration *(Section C · Problem solving)*

A car passes point A with speed u and accelerates uniformly at a. It reaches point B after 4 s having travelled 60 m. It reaches point C 10 s after passing A, having travelled 210 m from A.

a. Write two equations in u and a. [3 marks]
b. Solve them. [3 marks]
c. Find the speeds at B and C. [2 marks]
d. Find the distance from B to C and the average speed between B and C. [2 marks]

Question 18

Question 18 – A ball thrown from a cliff *(Section C · Problem solving)*

A ball is thrown vertically upwards at 12 m/s from the top of a cliff 25 m above the sea. It eventually falls into the sea. Take $g = 9.8$ m/s^2 and upwards as positive.

a. Find the greatest height of the ball above the cliff top. [3 marks]

b. Show that the time to reach the sea satisfies $4.9t^2 - 12t - 25 = 0$ and solve it. [4 marks]
c. Find the speed when it hits the sea. [2 marks]
d. Find the total distance travelled by the ball. [3 marks]

Question 19

Question 19 – A train timetable problem *(Section C · Problem solving)*

A train travels 8 km between two stations in 300 s. It accelerates uniformly from rest for 40 s, then travels at constant speed V m/s, then decelerates uniformly at 0.5 m/s^2 to rest.

a. Show that the time spent decelerating is $2V$ seconds. [1 mark]
b. Show that the total distance is $280V - V^2$ metres. [5 marks]
c. Find V to 1 decimal place. [3 marks]
d. Find the acceleration in the first stage and the time at constant speed. [3 marks]

Question 20

Question 20 – Challenge: two objects meeting *(Section D · Challenge)*

Particle A is dropped from rest from a height of 80 m at the same moment as particle B is projected vertically upwards from the ground, directly below A, with speed u m/s. Take $g = 9.8$.

a. Show that the particles meet after $t = \dfrac{80}{u}$ seconds, whatever g is. [4 marks]
b. For $u = 40$ find the time of meeting and the height at which they meet. [3 marks]
c. Find u if they meet at a height of 20 m. [4 marks]