Test answers - Kinematics

Year: Year 12 · Duration: 60 minutes · /20

Answer to Question 1 (4 marks)

a. List the quantities: $u = 8$, $v = 20$, $s = 140$. The time is unknown, so use $v^2 = u^2 + 2as$. $400 = 64 + 2a \times 140$ so $a = \dfrac{336}{280} = 1.2$ m/s^2 (2) The car accelerates at 1.2 m/s^2.

b. Use $v = u + at$ rearranged for t. $t = \dfrac{20 - 8}{1.2} = 10$ s (2) Check with $s = \frac{1}{2}(u + v)t = \frac{1}{2} \times 28 \times 10 = 140$ ✓.

Mark scheme for (a): 1 for choosing $v^2 = u^2 + 2as$ with correct values, 1 for 1.2. In (b), $s = \frac{1}{2}(u + v)t$ gives $140 = 14t$, so $t = 10$ s directly, a useful alternative that avoids relying on the acceleration found in (a).

Answer to Question 2 (4 marks)

a. Take upwards as positive; at the top $v = 0$, so use $v^2 = u^2 + 2as$ with $a = -9.8$, then add the 2 m starting height. $h = \dfrac{441}{19.6} = 22.5$ m above the start, so 24.5 m above the ground (2) The stone reaches 24.5 m above the ground.

b. The ground is 2 m below the starting point, so the displacement is -2 m; use $s = ut + \frac{1}{2}at^2$ and keep the positive root. $-2 = 21t - 4.9t^2$, $4.9t^2 - 21t - 2 = 0$, $t = \dfrac{21 + \sqrt{441 + 39.2}}{9.8} = 4.38$ s (2) The stone hits the ground after about 4.38 s.

Answer to Question 3 (4 marks)

a. The distance is the area under the velocity-time graph: a triangle, a rectangle and another triangle.
$\frac{1}{2} \times 60 \times 30 + 30 \times 120 + \frac{1}{2} \times 40 \times 30 = 900 + 3600 + 600 = 5100$ m (3) The train travels 5 100 m, which is 5.1 km.

b. Divide the total distance by the total time $60 + 120 + 40 = 220$ s. $\dfrac{5100}{220} = 23.2$ m/s (1) The average speed is about 23.2 m/s.

Sketch the graph: a rising line from $(0, 0)$ to $(60, 30)$, a horizontal line to $(180, 30)$, then a falling line to $(220, 0)$. The trapezium formula gives $\frac{1}{2}(120 + 220) \times 30 = 5100$ ✓.

Answer to Question 4 (4 marks)

a. The particle is at rest when $v = 0$; take out the factor 3 and factorise. $3(t-1)(t-3) = 0$, $t = 1$ and 3 (2) So it is at rest after 1 s and after 3 s.
b. Integrate the velocity and use $s = 4$ at $t = 0$ to find the constant. $s = t^3 - 6t^2 + 9t + 4$ (1), $s(4) = 64 - 96 + 36 + 4 = 8$ m (1) At $t = 4$ the particle is 8 m from the origin.

Between $t = 1$ and $t = 3$ the velocity is negative, so the particle moves backwards.

Answer to Question 5 (4 marks)

a. The police car's distance is $\frac{1}{2} \times 2t^2 = t^2$ and the van's distance is $20t$; they meet when these are equal. $t^2 = 20t$ so $t = 20$ (2) The root $t = 0$ is the start, so the police car catches the van after 20 s.
b. Use $v = u + at$ with $u = 0$. $v = 2 \times 20 = 40$ m/s (1) The police car is moving at 40 m/s, twice the van's speed.
c. Use the van's distance $20t$, or the police car's t^2. $20 \times 20 = 400$ m (1) Both give 400 m from the junction.