InkPhysics

ANSWER BOOK

Motion graphs and the SUVAT equations

Mechanics · Year 12

AQA 3.4.1.3 · CIE 2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5, 2.1.6, 2.1.7
OCR A 3.1.1(a), 3.1.1(b), 3.1.1(c), 3.1.1(d), 3.1.2(a)(i), 3.1.2(b)(i), 3.1.2(c)

19 questions · 62 marks

NAVY EDITION

SECTION A · Warm-up

A1 Average velocity is total displacement divided by total time (1). Instantaneous velocity is the rate of change of displacement at one instant, that is the gradient of the displacement–time graph at that point (1). [2]

A2 $v = u + at = 0 + 2.0 \times 6.0$ (1) [2]
$v = 12\ \text{m s}^{-1}$ (1)

A3 The gradient represents acceleration (1); the area between the line and the time axis represents displacement (1). [2]

SECTION B · Standard

B1 (a) $v = u + at = 8.0 + 1.5 \times 4.0$ (1) [4]
$v = 14\ \text{m s}^{-1}$ (1)
(b) $s = ut + ½at^2 = 8.0 \times 4.0 + ½ \times 1.5 \times 4.0^2$ (1)
$s = 44$ m (1)

B2 (a) $v^2 = u^2 + 2as$ gives $a = -(20^2)/(2 \times 40)$ (1) [4]
$a = -5.0\ \text{m s}^{-2}$, a deceleration of $5.0\ \text{m s}^{-2}$ (1)
(b) $t = v/|a| = 20/5$ (1)
$t = 4.0$ s (1)

B3 Distance = ½ × 5.0 × 15 (area of the triangle) (1) [3]
+ 15 × 10 (area of the rectangle) (1)
Distance = 187.5 m (1)

B4 $v = gt = 9.81 \times 2.0 = 19.62\ \text{m s}^{-1}$ (1) [3]
$s = ½gt^2 = ½ \times 9.81 \times 2.0^2$ (1)
$s = 19.62$ m (1)

SECTION C · Stretch

C1 (a) $v = u + at = 0 + 0.50 \times 20 = 10\ \text{m s}^{-1}$ (1) [5]
(b) $v^2 = u^2 + 2as$ gives $a = -10^2/(2 \times 100)$ (1)
$a = -0.50\ \text{m s}^{-2}$, a deceleration of $0.50\ \text{m s}^{-2}$ (1)
(c) Accelerating: $s = ½at^2 = ½ \times 0.50 \times 20^2 = 100$ m (1)
Total = 100 + 100 = 200 m (1)

C2 (a) At the top $v = 0$, so $h = u^2/2g = 15^2/(2 \times 9.81)$ (1) [4]
$h = 11.47$ m (1)
(b) $t = u/g = 15/9.81$ (1)
$t = 1.53$ s (1)

C3 The acceleration is the gradient of the line, change in velocity divided by change in time (1). The displacement is the area of the trapezium between the line and the time axis (1), which equals $\frac{1}{2}(u + v)t$ (1). [3]

SECTION A · Warm-up

A4 $a = \Delta v/\Delta t = (3.0 - 12.0)/6.0$ (1) $= -1.5$ m s^{-2}, a deceleration of 1.5 m s^{-2} (1). [2]

A5 (a) The instantaneous velocity at that point (1). (b) The object is stationary; its displacement is not changing (1). [2]

A6 The acceleration must be constant (uniform) throughout the motion (1). [1]

SECTION B · Standard

B5 From rest, $s = \frac{1}{2}gt^2$, so $t = \sqrt{(2s/g)}$ (1). $t = \sqrt{(2 \times 0.28/9.81)}$ (28 cm converted to 0.28 m) (1) $= 0.239$ s ≈ 0.24 s (1). [3]

B6 $v^2 = u^2 + 2as$ (1) $= 1.2^2 + 2 \times 2.5 \times 4.2 = 22.4$ (1), so $v = 4.7$ m s^{-1} (1). [3]

B7 $u = 90$ km h^{-1} $= 90\,000/3600 = 25$ m s^{-1} (1). With $v = 0$: $v^2 = u^2 + 2as$ (1), so $s = 25^2/(2 \times 0.75)$ (1) $= 417$ m ≈ 420 m (1). [4]

SECTION C · Stretch

C4 (a) Equal displacements when the courier draws level: $16t = \frac{1}{2} \times 2.0 \times t^2$ (1), so $t = 16$ s (1). (b) $s = 16 \times 16 = 256$ m (1). $v = u + at = 2.0 \times 16$ (1) $= 32$ m s^{-1} (1). [5]

C5 Thinking distance $= 20 \times 0.60 = 12$ m (1). Braking distance $= v^2/2a = 20^2/(2 \times 5.0) = 40$ m (1). Stopping distance $= 12 + 40 = 52$ m (1). 52 m is greater than 42 m, so the car cannot stop before the line (1). [4]

C6 During every flight the graph is a straight line of gradient +g (9.81 m s^{-2}), because gravity is the only force acting (1). Every up and every down section has this same gradient (1). From release the velocity rises from zero to its largest positive value just before the first impact (1). At each bounce the line is almost vertical: the velocity reverses from positive (downwards) to negative (upwards) in a very short contact time (1). Each rebound speed is smaller than the impact speed before it, because energy is lost in the bounce, so the peaks of the graph shrink (1). The velocity passes through zero at the top of each bounce, and the graph ends at v = 0 when the ball comes to rest (1). [6]