

Total 41 marks. Each marking point ends with ✓ and is worth one mark. Words in « » are not needed for the mark. A correct numerical answer with no working is awarded full marks unless the Notes say otherwise. ECF = error carried forward: award the mark if the candidate used their own wrong earlier answer correctly. Do not penalize errors in units or significant figures unless the Notes say so.

Question 1: A car on a test track

Part	Answers	Notes	Total
1(a)	$a = 24/8.0 = 3.0 \text{ «m s}^{-2}\text{»}$ ✓		1
1(b)	area under the graph used, e.g. $\frac{1}{2} \times 8.0 \times 24 + 12 \times 24 + \frac{1}{2} \times 6.0 \times 24$ ✓ 456 «m» / 460 «m» ✓	Award [1 max] for one region missed. Allow trapezium: $\frac{1}{2}(12 + 26) \times 24$.	2
1(c)	$456/26 = 17.5 \text{ «m s}^{-1}\text{»}$ ✓	Allow ECF from (b).	1
1(d)	the acceleration is not constant / the acceleration changes «at 8 s and 20 s» ✓		1
1(e)	curve with increasing gradient for 0–8 s, then a straight line for 8–20 s ✓ curve with decreasing gradient for 20–26 s, ending with zero gradient «horizontal» at 26 s ✓	Do not award the second mark if the graph decreases.	2
1(f)	deceleration = $24/6.0 = 4.0 \text{ «m s}^{-2}\text{»}$ ✓ $s = 30^2 / (2 \times 4.0) = 112.5 \text{ «m»} \approx 110 \text{ m}$ ✓	Answer must be given to at least 3 s.f. or a clear substitution shown.	2

Question 2: A ball thrown from a roof

Part	Answers	Notes	Total
2(a)	height above roof = $18^2 / (2 \times 9.8) = 16.5 \text{ «m»}$ ✓ $16.5 + 20 = 36.5 \text{ «m»}$ ✓	Award [1 max] for 16.5 m.	2
2(b)	$-20 = 18t - 4.9t^2$ «or equivalent with down positive» ✓ $t = \langle (18 + \sqrt{18^2 + 4 \times 4.9 \times 20}) / 9.8 \rangle = 4.57 \text{ «s»}$ ✓	Award [1 max] for a method that adds the time up (1.84 s) to the time down from 36.5 m (2.73 s) with one error.	2

2(c)	$v = \sqrt{18^2 + 2 \times 9.8 \times 20} = 26.8 \text{ «m s}^{-1}\text{»}$ ✓	Allow ECF from (b): $18 - 9.8 \times 4.57 = -26.8$.	1
2(d)	(i) the maximum height is smaller ✓ because drag acts downwards on the way up / energy is transferred to the air ✓ (ii) on the way up both the weight and the drag act downwards ✓ so the resultant force is greater than mg «and $a > g$ » ✓		4
2(e)	drag increases as the speed increases ✓ the resultant force « $mg - \text{drag}$ » decreases, so the acceleration decreases ✓ when drag = weight «buoyancy in air is negligible» the resultant force is zero, so the speed is constant ✓		3

Question 3: A ball thrown at a wall

Part	Answers	Notes	Total
3(a)	horizontal: $12 \cos 50^\circ = 7.7 \text{ «m s}^{-1}\text{»}$ ✓ vertical: $12 \sin 50^\circ = 9.2 \text{ «m s}^{-1}\text{»}$ ✓		2
3(b)	$t = 9.0 / 7.71 = 1.17 \text{ «s»}$ ✓	Allow ECF from (a).	1
3(c)	$y = 9.19 \times 1.17 - \frac{1}{2} \times 9.8 \times 1.17^2 = 4.06 \text{ «m»}$ above the launch point ✓ height = $4.06 + 2.0 = 6.1 \text{ «m»}$ ✓	Award [1 max] for 4.1 m.	2
3(d)	$v_y = 9.19 - 9.8 \times 1.17 = -2.2 \text{ «m s}^{-1}\text{»}$ OR time to the top = $9.19/9.8 = 0.94 \text{ s}$ ✓ v_y is negative / $1.17 \text{ s} > 0.94 \text{ s}$, so the ball is falling ✓	Do not award the second mark without a calculation.	2
3(e)	$v = \sqrt{7.71^2 + 2.24^2}$ ✓ $8.0 \text{ «m s}^{-1}\text{»}$ ✓	Allow ECF from (d).	2
3(f)	at the top: $t = u \sin 50^\circ / g$ ✓ horizontal distance: $9.0 = u \cos 50^\circ \times u \sin 50^\circ / g$ ✓ $u = \sqrt{9.0 \times 9.8 / (\sin 50^\circ \cos 50^\circ)} = 13.4 \text{ «m s}^{-1}\text{»}$ ✓		3

Question 4: A sprinter's start

Part	Answers	Notes	Total
4(a)	the gradient «of the v - t graph» changes / decreases «the graph is curved» ✓		1

4(b)	gradient of the tangent, e.g. $(8.3 - 1.4) \div (2.0 - 0)$ ✓	Allow answers in the range 3.0–3.8 m s ⁻² .	2
	3.4 «m s ⁻² » ✓		
4(c)	area under the graph from 0 to 4.0 s used, e.g. by counting squares (each small square is 0.5 m) ✓	Allow answers in the range 24–28 m.	2
	26 «m» ✓		
4(d)	the equation assumes constant acceleration «a straight line from 0 to 9.3 m s ⁻¹ », but the acceleration decreases ✓		2
	the curve lies above the straight line, so the area under the curve «the real distance» is larger «than $\frac{1}{2} \times 9.3 \times 4.0 = 19$ m» ✓		
4(e)	$9.3 \div 4.0 = 2.3$ «m s ⁻² » ✓		1

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