Question	Answer	Marks
1	A	1
2	D	1
3	B	1
4	(Marking points assume upwards is positive, but the opposite is acceptable) Starts with positive velocity. Velocity drops linearly to a negative value. Labels start e.g. 'leaves board', zero velocity e.g. 'highest point' and end 'enters water'.	 1 1 1
5	Axes with appropriate scales, correctly labelled quantity/units Points correctly plotted Smooth best-fit curve through all points Tangents drawn at two different times (not 0 s or 2.5 s) Correct calculation of velocities = gradients using $\Delta t > 0.4$ s g found from $v = u + g\Delta t$	1 1 1 1 1 1
6	Correct tip-to-tail diagram (accept parallelogram) Displacement magnitude = 9.9 km (scale drawing or Pythagoras theorem: if scale drawing used, allow value in the range 9.8 – 10.0 km) Angle by direct measurement or tan θ = 5.2 km ÷ 8.4 km $\Rightarrow \theta$ = 32° (can use any trigonometric function here): if direct measurement, allow 31°-33°. Correct description of direction, e.g. N 31°W, or bearing of 328°.	1 1 1 1
7	For the fall, s = 50 m, u = 0, v = ?, a = 9.8 m s^{-2}, t = ? $s = ut + ½at^2 \Rightarrow$ 50 m = 0 + 4.9 m $s^{-2} \times t^2 \Rightarrow t^2$ = 50 m ÷ 4.9 m s^{-2} = 10.2 s^2 $t = \sqrt{(10.2\ s^2)}$ = 3.19 s horizontally, $s = ut$ = 15 m s^{-1} × 3.19 s = 48 m (2 s.f.)	 1 1 1
8 a	3.0 m s^{-2}	1
8 b	0.57 s	1
9 a	Any three from: Accelerates, then constant velocity, then decelerates to rest. Constant velocity is 29 m s^{-1}. Mean acceleration is greater than mean deceleration. Acceleration/deceleration (either) greatest in centre of velocity change.	 1 mark for each correct point (3 max)
9 b	Suggestion, e.g. need to stop at exact point on station. Explanation, e.g. if braked too rapidly, might have some coaches not on platform.	1 1
9 c	Tangent drawn at 215 s Gradient triangle with base at least 25 s used Gradient correctly calculated and answer expressed to 2 s.f. with units m s^{-2} (expect value = 0.35 m s^{-2})	1 1 1
9 d	Distance = area under graph Method: counting squares, or approximating curves to straight lines with same area below, or dividing curved parts into approximately straight-line sections Answer in range 5100 m – 5300 m	1 1 1
10 a	v_N = 20 m s^{-1} cos(40°) = 183.9 m s^{-1} = 180 m s^{-1} (2 s.f.) v_W = 20 m s^{-1} sin(40°) = 154.3 m s^{-1} = 150 m s^{-1} (2 s.f.)	1 1
10 b	Tip-to-tail scale drawing of addition of wind velocity due E to plane velocity relative to the air to give resultant velocity. Resultant velocity is in direction N 40° W (bearing 320°). Correct ratio of wind speed to magnitude of plane velocity relative to the air of 15:240.	 1 1 1

	Resultant velocity has magnitude (230 ± 5) m s^{-1}. Direction of plane velocity relative to the air is of magnitude 240 m s^{-1} giving resultant velocity in direction N (43 ± 2)° W (bearing (317 ± 2)°)	 1 1
10 c	On a still day, $s = ut \Rightarrow t = \frac{s}{u} = \frac{510 \times 10^3 \text{ m}}{240 \text{ m s}^{-1}}$ = 2125 s On this day, $t = \frac{s}{u} = \frac{510 \times 10^3 \text{ m}}{230 \text{ m s}^{-1}}$ = 2217 s so extra time = 2217 – 2125 s = 92 s	1 1
11 a	0.37 s (2 s.f.) ± 0.02 s (1 s.f.)	1 1
11 b	(table below)	All correct (2) At most 1 error (1)
11 c	$s = ut + ½at^2 \Rightarrow s = ½gt^2$ so fits $y = mx + c$ with $c = 0$ and gradient $m = ½g$	1 1 1
11 d	All values plotted correctly Method of estimating $\Delta(t^2)$ (e.g. by $t_{max}^2 - t_{mean}^2$, or by percentage uncertainty in t^2 is 2× percentage uncertainty in t). Value of uncertainty in t is in the range 0.01 to 0.04 s^2. Best fit line well plotted (i.e. through uncertainty bars, points straddle line). Gradient measured correctly and g = 2 × gradient.	2 (1 mark if 1 or 2 incorrect) 1 1 1 1
11 e	Systematic error in measuring s as intercept > 0. Suggested improvement (e.g. greater range of heights, larger values of s) explanation (e.g. more data points give a better line, larger s minimises effect of systematic error and percentage uncertainty in t)	1 1 1

Table for 11 b:

s /m	t /s	Δt /s	t^2 /s^2
0.65	0.37	0.02	0.14
0.70	0.38	0.03	0.14
0.75	0.40	0.03	0.16
0.80	0.42	0.03	0.18
0.85	0.43	0.02	0.18
0.90	0.44	0.03	0.19