Question 5 (Answer: **D**)

- The goods train covers $10t$; the express covers $\frac{1}{2}(0.5)t^2 = 0.25t^2$.
- Overtaking means equal distances: $0.25t^2 = 10t$, so $t = 40$ s.
- C is only when the express matches the goods train's *speed*, which is not yet level with it.

Question 6 (Answer: **D**)

- P is the moment of release, where the ball is momentarily at rest – its velocity there is zero.
- The greatest upward velocity comes immediately after the first bounce, not at P.
- A, B and C are all correct: the area under PQ is the drop height, the bounces get lower, and a free-flight gradient is g.

Question 7 (Answer: **B**)

- The horizontal velocity never changes, so the distance depends only on the time of flight.
- From $y = \frac{1}{2}gt^2$, $t \propto \sqrt{y}$, so four times the drop doubles the time.
- Twice the time at the same horizontal speed gives $2x$.

Question 5 (Answer: **B**)

- Start from $v^2 = u^2 + 2ad$ and make u the subject.
- $u^2 = v^2 - 2ad$, so $u = \sqrt{v^2 - 2ad}$.
- A and C treat the relation as if it were linear in v, which it is not.

Question 6 (Answer: **B**)

- From $v^2 = u^2 + 2as$: $a = (6^2 - 8^2)/(2 \times 7) = -2$ m s^{-2}.
- Stopping from 6 m s^{-1} needs $s = 6^2/(2 \times 2) = 9$ m.
- The bicycle is slower now but still decelerating at the same rate, so it takes more than the first 7 m, not less.

1(a)	rate of change of velocity
1(b)(i)	acceleration = 320 / 20 = 16 m s^{-2}
1(b)(ii)	$s = \frac{1}{2}((u) + v)t$ **or** distance = area under graph
	(height) = $\frac{1}{2} \times 20 \times 320$ = 3200 m **or** 3.2 km
1(c)(i)	(ΔE_P) = $mg\Delta h$
	= $2.9 \times 10^6 \times 9.81 \times 3200$ = 9.1×10^{10} J
1(c)(ii)	(ΔE_K) = $\frac{1}{2}m\Delta(v^2)$
	= $\frac{1}{2} \times 2.9 \times 10^6 \times 320^2$ = 1.5×10^{11} J
1(c)(iii)	(power =) work done / time
	power = $((1.5 + 0.91) \times 10^{11})$ / 20 = 1.2×10^{10} W

1(a)(i)	$v_H = 28 \times \cos 34°$ = 23 m s^{-1}
	$v_V = 28 \times \sin 34°$ = 16 m s^{-1}
1(a)(ii)	time = 16 / 9.81 = 1.6 s
1(a)(iii)	horizontal straight line at v = 23 m s^{-1} from t = 0 to t = 3.2 s
1(a)(iv)	straight diagonal line starting at a positive velocity from t = 0 to t = 3.2 s, crossing the time axis
	line starting at v = 16 m s^{-1} and ending at v = –16 m s^{-1}
	line passing through v = 0 at t = 1.6 s
1(b)(i)	product of mass and velocity
1(b)(ii)	$F = \Delta p / t$
	= 13 / 3.2 = 4.1 N

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1(b)(iii)	$m = \Delta p / v$ $= 13 / (2 \times 16)$ $= 0.41$ kg **or** $m = F / g$ $= 4.06 / 9.81$ $= 0.41$ kg

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Question 7 (Answer: **C**)

- The gradient of a velocity–time graph is the acceleration: $a = (v - u)/t$.
- Rearranging that single statement gives $v = u + at$.
- A and B need the area under the graph, and D needs the area and the gradient together.

Question 8 (Answer: **A**)

- With no air resistance nothing acts horizontally, so the horizontal velocity is constant – graph Q.
- Vertically the object starts at rest and gains speed at a steady g, so $v = gt$ – the straight line P.
- R has the horizontal speed decreasing (that needs drag) and S has the acceleration increasing.

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1(a)	rate of change of velocity
1(b)(i)	$s = ut + ½at^2$ **and** $u = 0$ or $s = ½at^2$ $t = \sqrt{(2 \times 14 / 9.81)}$
	$t = 1.7$ s
	OR $v = \sqrt{(0^2 + 2 \times 9.81 \times 14)}$ $v = 17$ (m s^{-1}) $17 = (0 + 9.81) \times t$ **or** $17 = 9.81 \times t$ or $14 = ½ \times (0 + 17) \times t$ **or** $14 = ½ \times 17 \times t$
	$t = 1.7$ s
1(b)(ii)	$s = ut + ½at^2$ $u = (3.6 – ½ \times 9.81 \times 1.7^2) / 1.7$
	$u = (–)\ 6.2$ m s^{-1}
	OR $v = (3.6 + ½ \times 9.81 \times 1.7^2) / 1.7$ $v = 10$ (m s^{-1}) $10 = u + 9.81 \times 1.7$ or $10^2 = u^2 + (2 \times 9.81 \times 3.6)$ or $3.6 = ½ \times (u + 10) \times 1.7$
	$u = (–)\ 6.2$ m s^{-1}

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1(c)(i)	Less time (as it reaches a lower height)
	(because) the initial vertical (component of the) velocity is smaller (than in part **(b)**)
1(c)(ii)	The (total) initial energy is the same (as in part **(b)**)
	change in gravitational potential energy is same, so speed is the same

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Question 4 (Answer: **A**)

- Convert first: 85 km h^{-1} = $85000/3600 = 23.6$ m s^{-1}, and 1.20 km = 1200 m.
- From rest, $v^2 = 2as$, so $a = v^2/2s = 23.6^2/2400 = 0.23$ m s^{-2}.
- B drops the factor of 2; C and D come from leaving the speed in km h^{-1}.

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3(a)(i)	$a = (v^2 – u^2) / 2s$ $= (22^2 – 13^2) / (2 \times 180)$
	$= 0.88$ m s^{-2}
	OR [$t = (180 \times 2) / (22 + 13) = 10.3$] $180 = 13 \times 10.3 + ½\ a \times 10.3^2$ or $180 = 22 \times 10.3 – ½\ a \times 10.3^2$ or $22 = 13 + a \times 10.3$
	$a = 0.88$ m s^{-2}
3(a)(ii)	$(\Delta)E = ½m(\Delta)v^2$
	gain in KE $= ½m(v^2 – u^2)$ $= ½ \times 9400 \times (22^2 – 13^2)$
	$= 1.5 \times 10^6$ J
	OR $W = Fs$ $= ma \times d$
	gain in KE $= 9400 \times 0.88 \times 180$
	$= 1.5 \times 10^6$ J
3(b)(i)	rate of change of momentum
3(b)(ii)	(Force =) $(2.5 \times 10^4 – 21 \times 10^4) / 15 = – 1.2 \times 10^4$ (N)
3(b)(iii)	The change of momentum (for S and R to come to rest) is the same
	(Average) force on R (to come to rest) is ($–21 \times 10^4 / 23$ =) 0.91×10^4 N **or** (Average) force on R (to come to rest) is less than the force on S / less than F
	(S will come to rest in) less time (than R).
	OR The change of momentum (for S and R to come to rest) is the same
	Time for S to come to rest is ($–21 \times 10^4 / 1.2 \times 10^4$ =) 17.5 s (and time for R to come to rest is 23 s)
	(S comes to rest in) less time (than R).