Kinematics

1. *(a)* ratio is $\dfrac{\frac{3}{4}d}{3} : \dfrac{\frac{1}{4}d}{2}$ M1 A1

$= \dfrac{1}{4} : \dfrac{1}{8} = 2 : 1$ M1 A1

(b) 80 kmh^{-1} for 5 hrs = 400 km M1

$\frac{3}{4}$ of 400 = 300 km M1

av. speed on first part of journey = $\frac{300}{3} = 100 \text{ kmh}^{-1}$ M1 A1 **(8)**

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2. *(a)* use of $s = ut + \frac{1}{2}at^2$ for OL (54m, $t = 1$) and OM (144m, $t = 4$) M2

to give $54 = u + \frac{1}{2}a$ and $144 = 4u + 8a$ A1

solve simult. to give $a = {}^{-}12\text{ms}^{-2}$ M1 A1

(b) for ON, $u = 60$, $a = {}^{-}12$, $v = 0$ M1

$v^2 = u^2 + 2as$, so $0 = 3600 - 24s$ M1

$s = 150$m, so $MN = 150 - 144 = 6$m. M1 A1 **(9)**

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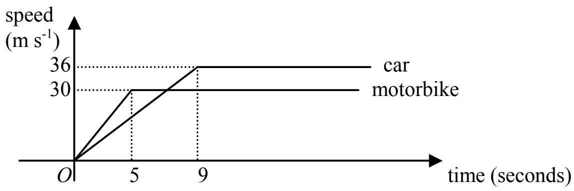
3. *(a)* $\text{acc}^n = \frac{36-0}{9} = 4 \text{ ms}^{-2}$ M1 A1

(b)



B4

(c) after t seconds $s_M = \frac{1}{2}(5)(30) + 30(t - 5)$ (for $t > 5$) M1 A1

after t seconds $s_C = \frac{1}{2}(9)(36) + 36(t - 9)$ (for $t > 9$) M1 A1

car level with bike when $s_M = s_C$ i.e. $75 + 30t - 150 = 162 + 36t - 324$ M2

$t = 14.5$ seconds A1 **(13)**

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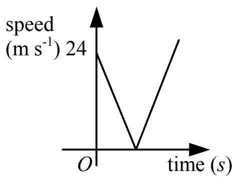
4. *(a)*



B3

(b) at max. height, $v = 0$; use $v^2 = u^2 + 2as$ with $a = {}^{-}9.8$, $u = 24$ M1

$0 = 576 - 19.6s \quad \therefore s = 29.387\ldots$ M1 A1

start value 2.5 m, so max. height = 31.89 m. (nearest cm) A1

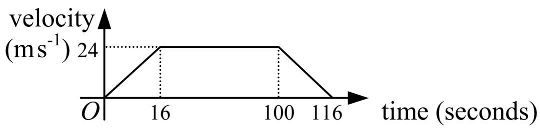
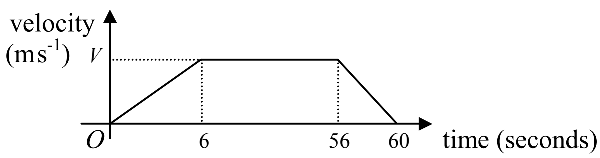
(c) use $v^2 = u^2 + 2as$ with $a = {}^{-}9.8$, $u = 24$ and $s = {}^{-}2.5$ (up is +ve) M1

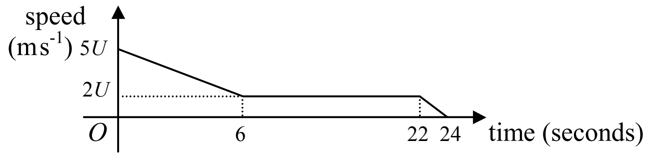
$v^2 = 576 + 49 = 625$ M1 A1

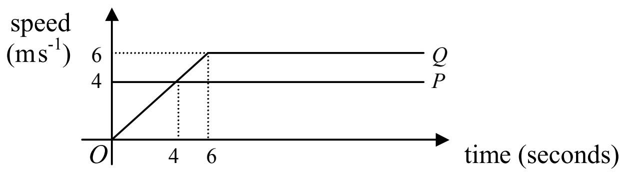
so $v = \pm 25$ i.e. speed = 25 ms^{-1} downwards A1

(d) use $v = u + at$ with $v = 25$, $u = {}^{-}24$ $a = 9.8$ (down is +ve) M1

$25 = {}^{-}24 + 9.8\,t \quad \therefore\ t = 5$ M1 A1 **(14)**

5.	*(a)*	$s = 122.5$, $u = 0$, $a = \text{g}$ use $s = ut + \frac{1}{2}at^2$	M1	
		$122.5 = 4.9t^2 \Rightarrow t = 5$	M1 A1	
	(b)	$v^2 = u^2 + 2as = 0 + 2g(122.5)$	M1	
		$v = 49 \text{ m s}^{-1}$	A1	
	(c)	$s = u(t-2) + \frac{1}{2}a(t-2)^2$	M1	
		Jim must hit before $t = 5$ i.e. $122.5 = 3u + 4.9(3)^2$	M2 A1	
		$3u = 78.4 \Rightarrow u = 26.1 \text{ m s}^{-1}$	A1	
	(d)	e.g. u larger as tennis ball would have experienced more air resistance due to greater speed / large surface area for mass	B2	**(12)**
6.	*(a)*	$t = \frac{116-84}{2} = 16$ seconds	M1 A1	
	(b)		B2	
	(c)	dist. = area under graph = $\frac{1}{2}(116 + 84)(24) = 2400$ m	M2 A1	**(7)**
7.	*(a)*	$u = 21$, $v = 0$ (at max. ht.), $a = {}^{-}g$ use $v^2 = u^2 + 2as$	M1	
		$0 = 21^2 - 2gs \therefore s = 22.5$ m	M1 A1	
		ball starts from 1.9 m, so it reaches 24.4 m above ground level	A1	
	(b)	$s = 7.5 - 1.9 = 5.6$, $u = 21$, $a = {}^{-}g$, use $s = ut + \frac{1}{2}at^2$	M1	
		$5.6 = 21t - 4.9t^2$ i.e. $7t^2 - 30t + 8 = 0$	M1 A1	
		$(7t-2)(t-4) = 0$ giving $t = \frac{2}{7}$, $t = 4$	M1 A1	
		$\therefore$ Barbara waits for $3\frac{5}{7}$ (≈ 3.71) seconds	A1	**(10)**
8.	*(a)*	$u = 10.5$, $v = 0$, $a = {}^{-}\text{g}$ use $v^2 = u^2 + 2as$	M1	
		$0 = 110.25 - 19.6s \Rightarrow s = 5.625$	M1 A1	
		ball starts from 0.6 m, so it reaches 6.225 m above ground level	A1	
	(b)	$s = 2 - 0.6 = 1.4$, $u = 10.5$, $a = {}^{-}\text{g}$, use $s = ut + \frac{1}{2}at^2$	M1	
		$10.5t - 4.9t^2 > 1.4$ i.e. $7t^2 - 15t + 2 < 0$	M1 A1	
		$(7t-1)(t-2) < 0$ leading to $\frac{1}{7} < t < 2$	M1 A1	
		ball is above ground for $\frac{13}{7}$ (≈ 1.86) seconds	A1	**(10)**
9.	*(a)*	e.g. since acc^n and decel^n are uniform, time for decel^n = $\frac{1}{1.5}$ time for acc^n	M1	
		$\therefore$ decel^n = 4 seconds, so total time = 6 + 50 + 4 = 60 seconds	M1 A1	
	(b)		B3	
	(c)	area under graph = $\frac{1}{2}(6)(V) + 50V + \frac{1}{2}(4)(V) = 1320$	M1	
		$55V = 1320$ so $V = 24 \text{ m s}^{-1}$	M1 A1	
	(d)	car accelerates more quickly at first, but acceleration decreases throughout the six seconds	B2	**(11)**

10.	*(a)*	$u = 0$, $s = 2200 - 240 = 1960$, $a = 9.8$ use $v^2 = u^2 + 2as$	M2	
		$v^2 = 0 + 2(9.8)(1960)$ so $v = 196\text{ ms}^{-1}$	M1 A1	
	(b)	$s = ut + \frac{1}{2}at^2$	M1	
		$1960 = 0 + 4.9t^2 \Rightarrow t = 20$ seconds	M1 A1	
	(c)	$140 - 20 = 120$ seconds to travel 240 m	M1	
		speed $= 2\text{ ms}^{-1}$	A1	
	(d)	e.g. no air resistance; velocity on opening parachute will not immediately reduce	B2	
		e.g. if air resistance included, value in *(a)* would be much lower and consequently value in *(b)* much higher	B2	**(13)**
11.	*(a)*		B2	
	(b)	using $v = u + at$ with $v = 2U$, $u = 5U$, $t = 6$ gives 1st decel. $= \frac{1}{2}U\text{ ms}^{-2}$	M1 A1	
		using $v = u + at$ with $v = 0$, $u = 2U$, $t = 2$ gives 2nd decel. $= U\text{ ms}^{-2}$	M1 A1	
	(c)	area under graph = dist. travelled = 220 m	M1	
		$\frac{1}{2}(6)(3U) + 22(2U) + \frac{1}{2}(2)(2U) = 220$	M1 A2	
		$55U = 220 \therefore U = 4\text{ ms}^{-1}$	M1 A1	**(12)**
12	*(a)*	use of $s = (\frac{u+v}{2})t$ with $u = 5$, $v = 20$ and $t = 30$	M1	
		$s = \frac{25}{2} \times 30 = 375$ m	M1 A1	
	(b)	$a = \frac{\Delta v}{t} = \frac{20-5}{30} = 0.5$, $s = 187.5$, $u = 5$ use $s = ut + \frac{1}{2}at^2$	M1 A1	
		$187.5 = 5t + 0.25t^2 \therefore t^2 + 20t - 750 = 0$	M1	
		use quadratic formula to give $t = {}^{-}10 \pm 5\sqrt{34}$	M1 A1	
		take +ve root $\therefore t = 19.15$ seconds (2dp)	A1	**(9)**

13.	*(a)*	For Q: $a = \frac{\Delta v}{t} = \frac{6-0}{6} = 1$	M1	
		$u = 0$, $v = 4$, use $v = u + at$: $4 = 0 + 1t$ i.e. $t = 4$ seconds	M1 A1	
	(b)		B3	
	(c)	Q will catch P when area under Q graph = area under P graph		
		$\therefore \frac{1}{2}(6)(6) + 6(t - 6) = 4t$	M1	
		i.e. $18 + 6t - 36 = 4t \therefore 2t = 18 \therefore t = 9$	M1 A1	
		after 9 seconds, P has travelled $4 \times 9 = 36$ cm,		
		$\therefore Q$ reaches top first if $x > 36$	M1 A1	**(11)**