Kinematics of motion in a straight line 1 MS

Q1.

7	**(i)**			
	$\int_0^{15} v_1 dt = 225$ ➔	M1		For integrating v_1 to find s_1
	$A[(15^2/2 - 0.05 \times 15^3/3) - (0 - 0)] = 225$	A1		
	$A = 4$	A1		
	$[4(15 - 0.05 \times 15^2) = B/15^2]$	M1		For using $v_1(15) = v_2(15)$
	$B = 3375$	A1		AG
			[5]	
	(ii) $s_2(t) = Bt^{-1}/(-1)$ (+ C)	B1		
	$[-3375/15 + C = 225]$	M1		For using $s_2(15) = 225$ to find C
	Distance travelled is $[450 - 3375/t]$ m (for $t \geqslant 15$)	A1		
			[3]	
	(iii) $[450 - 3375/t = 315]$	M1		For attempting to solve $s_2(t) = 315$
	$[v = 3375/25^2]$	M1		For substituting into $v = 3375/t^2$
	Speed is $5.4\,ms^{-1}$	A1		
			[3]	

Alternative for **7(ii)**		
$s = \int_{15}^{t} 3375t^{-2} dt = -3375(\frac{1}{t} - \frac{1}{15})$	B1	
$= 225 - 3375/t$		
Distance travelled $= 225 + (225 - 3375/t)$	M1	
Distance travelled is $[450 - 3375/t]$ m (for $t \geqslant 15$)	A1	

Q2.

1	**(i)**	M1		For using $-g = (0 - V)/(2 - 0)$ or $0 = V - gt$
	$V = 20$	A1	[2]	
	(ii) Speed is $40\,ms^{-1}$	B1	[1]	
	(iii)	M1		For using $h = ½\,4 \times 40$ or $h = ½g \times 4^2$ or $40^2 = 2gh$
	Height is 80 m	A1	[2]	
2	$[F - R = ma]$	M1		For using Newton's second law (3 terms)
	$F_A - 800 = 600a_A$	A1		
	$F_A = 40000/25$ (1600)	B1		
	$40000/v_B - 800 = 600$ (400/600)	A1		
	Speed is $33.3\,ms^{-1}$	A1	[5]	

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Q3.

2	$[1.2 - 0.24t = 0.6]$	M1		For using a = dv/dt and attempting to solve a = 0.6
	$t = 2.5$	A1		
	$[s = 0.6t^2 - 0.04t^3]$	M1		For using $s = \int v dt$
	$s = (0.6 \times 2.5^2 - 0.04 \times 2.5^3) - (0 - 0)$	DM1		For using limits 0 to 2.5 or equivalent (dependent on integration)
	Displacement is 3.125 m	A1		Accept 3.12 or 3.13
			[5]	

Q4.

5	**(i)** $[15 = 20t - 5t^2 \rightarrow 5(t^2 - 4t + 3) = 0]$	M1		For use of $h = ut - \frac{1}{2}gt^2$
	$t = 1, 3$	A1		
	Duration is 2 s (accept $1 < t < 3$)	B1ft	**[3]**	ft $t_2 - t_1$
	(ii)	M1		For using $h_P = h_Q$ at time t after P's (or Q's) projection
	$20t - 5t^2 = 25(t - 0.4) - 5(t - 0.4)^2$ (or $20(t + 0.4) - 5(t + 4)^2 = 25t - 5t^2$ or $(20 \times 0.4 - 5 \times 0.4^2) + 16t - 5t^2 = 25t - 5t^2$)	A1		
	$t = 1.2$ (or $t = 0.8$)	A1		
	$[v_P = 20 - 10x1.2; v_Q = 25 - 10x(1.2 - 0.4)$ (or $v_P = 20 - 10x(0.8 + 0.4); v_Q = 25 - 10x0.8)]$	M1		For using $v = u - gt$ for both v_P and v_Q
	Velocities are $8\,ms^{-1}$ and $17\,ms^{-1}$	A1	**[5]**	

Q5.

6	**(i)** $[\frac{1}{2}\, 2.5(speed_{max}) = 4]$	M1		For using area property for distance
	Greatest speed is $3.2\,ms^{-1}$	A1	**[2]**	
	SR (max. 1/2) for candidates who (implicitly) make the unjustifiable assumption that $speed_{max}$ occurs when t = 1.25			
	Greatest speed is 3.2 ms^{-1} from $2 \times \frac{1}{2}\, 1.25(speed_{max})v = 4$	B1		
	(ii) $[V = 3x2]$	M1		For using $a = (V - 0)/(4.5 - 2.5)$ or $V = 0 + at$
	$V = 6$	A1	**[2]**	

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(iii)		M1		For using area property for distance from t = 2.5 to t = 14.5
	½ 6(12 + T) = 48 or ½ 6x2 + 6T + ½ 6(10 – T) = 48 or ½ 6x2 + 6(10 – τ) + ½ 6τ = 48	A1ft		
	t = 8.5	A1	**[3]**	from 4.5 + T or 14.5 – τ
(iv)		M1		For using a = (0 – V)/(14.5 – 8.5) or 0 = V + a(14.5 – 8.5)
	Deceleration is 1 ms^{-2}	A1ft	**[2]**	

Q6.

4	**(i)** v(4) = 0.75x4	B1		
	v(54) = v(4) and v(60) = v(54) – 0.5(60 – 54)	B1		
	Velocity is 3 ms^{-1} when t = 4 and 0 when t = 60	B1		
		M1		Graph consists of 3 straight line segments with 1st and 3rd having +ve and –ve slopes respectively; v is single valued and continuous throughout, and v(0) = 0.
	2nd segment has zero slope; end points of segments are seen to be correct {(0,0), (4,3), (54,3), (60,0)}	A1ft	**[5]**	ft incorrect value(s) for v(4) and v(60)
(ii)	[XY = ½ (60 + 50)x3 or XY = ½ x0.75x4^2 + 3x50 – ½ x0.5x6^2]	M1		For using area property for distance or $s_1 = ½ a_1t_1^2$, $s_2 = u_2t_2$, $s_3 = ½ a_3t_3^2$ and XY= $s_1 + s_2 – s_3$
	Distance is 165 m	A1	**[2]**	

Q7.

3	**(i)** [½ 5 × 50 + ½ 7(8 + 50) + 90 × 8]	M1		For using the area property for distance or s = ½ (u + v)t
	Distance is 1048 m	A1	**[2]**	AG
(ii)		M1		For use of the gradient property for acceleration (deceleration)
	a = (8 – 50)/(12 – 5) or d = (50 – 8)/(12 – 5)	A1		
		M1		For using Newton's second law (3 terms)
	850 – F = 85a (or –85d)	A1		
	Upward force is 1360 N	A1	**[5]**	

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Q8.

7	(i)	[$1.3 = 0.9 + 0.004T$, $1.3^2 = 0.9^2 + 2 \times 0.004S$]	M1		For using $v = u + at$ or $v^2 = u^2 + 2as$
		Time is 100 s (or distance is 110 m)	A1		
		Distance is 110 m (or time is 100 s)	B1	[3]	
	(ii)	$\int kt^3\,dt = \frac{1}{4}kt^4$	B1		
		[$k(\frac{1}{4} 100^4 - 0) = 110$]	M1		For using limits 0 to T and equating definite integral to S
		$k = 4.4 \times 10^{-6}$	A1		
		[$v_W = 0.9 + 0.004 \times 64.05$, $v_C = 4.4 \times 10^{-6} \times 64.05^3$]	M1		For attempting to find the speed of the walker and of the cyclist.
		Both are equal to 1.16 ms^{-1} correct to 3 sf.	A1	[5]	
	(iii)	Acceleration = $3kt^2$	B1		
		Acceleration at B is 0.132 ms^{-2}	B1	[2]	

Q9.

4	(i)	For correct shading composite figure consisting of 2 rectangles: 1st has boundaries t = 0 & t = 20, v = 0 and v = 2.5; 2nd has boundaries t = 20 & t = T, v = 0 and v = 4	B1	[1]	
	(ii)	[50 + 4(T – 20) = 70 or 4T – 30 = 70]	M1		For attempt to find equation in T
		T = 25	A1	[2]	
	(iii)	[Distance = 70 + (4 – 2.5)20 or 50 + 4[(T – 20) + 20] – 50]	M1		For identifying and using area representing required distance
		Distance between P and Q is 100 m	A1ft	[2]	ft 4T
	(iv)	For 2 straight line segments representing P, 1st with +ve slope and 2nd with steeper slope, t = 20 indicated appropriately	B1		
		For Q, 1st & 2nd segments parallel to P's and displaced to the right, t = 25 and t = 45 indicated appropriately	B1ft	[2]	ft T and T + 20