Question	Answer	Marks	Guidance
1(i)	$F = 0.2g \sin 20 = 0.684$ N	**B1**	AG
		1	
1(ii)	$R = 0.2g \cos 20$	**B1**	
	$F = \mu R$ [$= 0.6 \times 0.2g \cos 20$]	**M1**	Using $F = \mu R$ $F = 1.1276\ldots$
	[$0.9 + 0.2g \sin 20 - F = 0.2a$]	**M1**	Use of Newton's 2nd law along the plane (4 relevant terms)
	$a = 2.28$ ms^{-2}	**A1**	
		4	

Question	Answer	Marks	Guidance
2	*EITHER:*	**(M1**	Attempt to resolve (either direction with correct number of terms and dimensionally correct)
	$T \sin\theta + 120 \sin 45 = 15g$	**A1**	Resolving vertically
	$T \cos\theta = 120 \cos 45$	**A1**	Resolving horizontally
	[$\tan\theta = \dfrac{(15g - 120\sin 45)}{(120\cos 45)}$ or $T = \sqrt{65.15^2 + 84.85^2}$]	**M1**	For using division to find θ or for using Pythagoras to find T
	$\theta = 37.5$	**A1**	
	$T = 107$	**A1)**	
	OR1: $\dfrac{120}{\sin(90+\theta)} = \dfrac{T}{\sin 135} = \dfrac{15g}{\sin(135-\theta)}$	**(A1**	One correct equation
		A1	A second correct equation
		M1	Attempt to solve for θ or T
	$\theta = 37.5$	**A1**	
	$T = 107$	**A1**	
		M1)	Attempt to use triangle of forces

Question	Answer	Marks	Guidance
	OR2: $\frac{T}{\sin 45} = \frac{15g}{\sin(45+\theta)} = \frac{120}{\sin(90-\theta)}$	**(A1**	One correct equation
		A1	A second correct equation
		M1	Attempt to solve for θ or T
	$\theta = 37.5$	**A1**	
	$T = 107$	**A1)**	
	OR3: $[T^2 = 150^2 + 120^2 - 2(150)(120)\cos 45]$	**(M1**	Use cosine rule in a triangle with sides 120, 150 and T and with corresponding angles $90 - \theta$, $45 + \theta$, 45
		A1	Correct equation
	$T = 107$	**A1**	
		M1	Use sin rule or cosine rule in an attempt to find θ
	$120/\sin(90 - \theta) = 106.97/\sin 45$	**A1**	A correct equation in θ such as this
	$\theta = 37.5$	**A1)**	
		6	

Question	Answer	Marks	Guidance
3(i)	$s_{AB} = 14 \times 5 + \frac{1}{2}a \times 5^2$	**B1**	or $s_{AB} = \frac{1}{2}(14 + 14 + 5a) \times 5$ OE
	$s_{AC} = 14 \times 8 + \frac{1}{2}a \times 8^2$	**B1**	or $s_{AC} = \frac{1}{2}(14 + 14 + 8a) \times 8$ OE
	$[112 + 32a = 2(70 + 12.5a)]$	**M1**	Using $AC = 2AB$ and solving for a or for substituting $a = 4$ and finding AB and AC
	$a = 4$ m s^{-2}	**A1**	AG, If substituting $a = 4$ must show $AB = 120$ and $AC = 240$ OE
		4	
3(ii)	$[v = 14 + 4 \times 8]$	**M1**	Use of $v = u + at$ or any complete method to find v
	Velocity = 46 m s^{-1}	**A1**	
		2	

Question	Answer	Marks	Guidance
4(i)	$[12t - \frac{1}{2}gt^2 = 0]$ or $[0 = 12 - gT]$ with $t = 2T$ used	**M1**	Using $s = ut + \frac{1}{2}at^2$ or equivalent such as finding time T to highest point and doubling.
	$t = 2.4$ s	**A1**	
		2	
4(ii)	Critical point at $t = 1.2$	**B1**	Seen in **4(ii)**
	Critical point at $t = 2$	**B1**	Seen in **4(ii)**
	Both moving in same direction $1 < t < 1.2$	**B1**	
	Both moving in same direction $2 < t < 2.4$	**B1**	
		4	

Question	Answer	Marks	Guidance
5(i)	*EITHER:* Resistance force = $\frac{600}{25}$ = 24 N	**(B1**	
	Weight component = 80 g (0.04) = 32 N	**B1**	For correct unsimplified numerical form of the weight component
	[Power = 56 × 4]	**M1**	For use of $P = Fv$ where F is from two relevant force terms
	Power = 224 W	**A1)**	
		4	
	OR: PE gain = 80g × 25 (0.04) = 800	**(B1**	For a correct unsimplified numerical expression for PE
	Time taken = $\frac{25}{4}$ = 6.25	**B1**	
	[WD by cyclist = P × 6.25 = 800 + 600]	**M1**	For using WD = $P \times t$ where WD is from two relevant terms
	Power = 224 W	**A1)**	
		4	

Question	Answer	Marks	Guidance
5(ii)	Work done by cyclist = 224 × 10 (= 2240J)	**B1 FT**	For stating WD = power × time FT on P value found in **5(i)**
	Initial KE = ½ × 80 × 4^2 [= 640 J]	**B1**	
	[½ × 80v^2 = 640 + P×10 –1200]	**M1**	For using Work/Energy equation
	Speed = 6.48 m s^{-1}	**A1**	Allow speed = √42
		4	

Question	Answer	Marks	Guidance
6(i)	$R = mg\cos\alpha$ ($R = 9.6m$)	**B1**	Allow use of α = 16.3º throughout
	[$T = mg$ $F = mg\sin\alpha + T$]	**M1**	For resolving forces on P and Q and eliminating T **or** for considering the equilibrium of the system
	$F = mg\sin\alpha + mg$	**A1**	($F = 12.8m$)
		M1	For use of $F = \mu R$
	Coefficient of friction = 1⅓ = $\frac{4}{3}$	**A1**	**AG** so must be from exact working
		5	

Question	Answer	Marks	Guidance
6(ii)	*EITHER:* *P* equation is $10 - mg \sin \alpha - F - T = 2.5\, m$ *Q* equation is $T - mg = 2.5m$	**(*M1**	For applying Newton's 2nd law to *P* (5 terms) **or** *Q* (3 terms)
		***M1**	For applying Newton's 2nd law to the other particle and eliminate *T*
	$10 - mg \sin \alpha - \mu mg \cos \alpha$ $- mg = 2m\ (2.5)$	**A1**	If evaluated then this is $10 - 2.8m - 12.8m - 10m = 5m$
		DM1	For solving this equation for *m* as far as *m* = Dependent on one or other of the previous M marks having been scored
	$m = 0.327$	**A1)**	Allow $m = \frac{50}{153}$
	OR: $[10 - mg \sin \alpha - F - mg = m(2.5 + 2.5)]$	**(*M1**	For applying Newton's 2nd law to the system. Allow with 5 terms
		***M1**	System equation with all 6 terms
	$10 - mg \sin \alpha - \mu mg \cos \alpha$ $- mg = 2m\ (2.5)$	**A1**	
		DM1	For solving this equation for *m* as far as *m* = Dependent on one or other of the previous M marks having been scored
	$m = 0.327$	**A1)**	Allow $m = \frac{50}{153}$
		5	

Question	Answer	Marks	Guidance
7(i)	$-0.01t(t^2 - 22t + 40) = 0$ $-0.01t(t - 20)(t - 2) = 0$	**M1**	Attempting to solve $v = 0$ for t for a solvable quadratic using factors or quadratic formula and obtaining two non-zero solutions
	$t = 2$ or $t = 20$	**A1**	
		2	
7(ii)	$a = -0.03t^2 + 0.44t - 0.4$	**M1**	For differentiation
	a is greatest (maximum) when $0.44 - 0.06t = 0$	**M1**	For differentiation **or** finding values of $t = t_1$ and $t = t_2$ where $a = 0$ and using $t = \frac{1}{2}(t_1 + t_2)$ **or** completing the square **or** other method to find maximum value
	Max acceleration when $t = 7.33$	**A1**	Allow $t = \frac{22}{3}$
		3	
7(iii)	$\int\left(-0.01t^3 + 0.22t^2 - 0.4t\right)\mathrm{d}t$	***M1**	For using integration.
	$s(t) = -\frac{0.01}{4}t^4 + \frac{0.22}{3}t^3 - 0.2t^2$	**A1**	Correct Integration Allow + C included
	$s(20) - s(2)$	**DM1**	Limits 2 and 20 used correctly Dependent on previous M1 having been scored
	Distance = 107 m	**A1**	Distance = $\frac{2673}{25} = 106.92$
		4	