Question	Answer	Mark	Guidance
1	(X =) 78 □ 5/13 – 50 × 3/5 = 78 cos 67.4 – 50 cos 53.1 (Y =) 78 □ 12/13 □ 50 × 4/5 – 112 = 78 sin 67.4 □ 50 sin 53.1 – 112	**M1**	Attempt to resolve forces either horizontally (2 terms) or vertically (3 terms)
	[X = 30 – 30 = 0 Y = 72 + 40 – 112 = 0]	**A1**	Correct expressions horizontally and vertically
	X = 0 and Y = 0	**A1**	From convincing exact calculations
	Alternative method for question 1		
	$\frac{112}{\sin 59.5}$ □ $\frac{50}{\sin 157.4}$ □ $\frac{78}{\sin 143.1}$	**M1**	Attempt to use Lami, one pair of terms
		A1	All terms correct
	$\frac{112}{56/65}$ □ $\frac{50}{5/13}$ □ $\frac{78}{3/5}$ □130	**A1**	Exact values seen and used and shown to be = 130 cos [180 – (θ + α)] = 33/65 and sin [180 – (θ + α)] = 56/65
		3	

Question	Answer	Mark	Guidance
2(i)	[0 = 25 – 10t]	**M1**	Use of $v = u$ □ at with u = 25, v = 0 and a = –g or other complete method for finding t to highest point
	t = 2.5	**A1**	
		3	

Question	Answer	Mark	Guidance
2(ii)	[$20 = 25t – ½ gt^2$]	**M1**	Applying $s = ut + ½at^2$ with $s = 20$, $u = 25$
	[$t = 1$ and $t = 4$]	**M1**	Solve a 3-term quadratic for t, factorising or formula
	Required time = 4 – 1 = 3 seconds	**A1**	
	Alternative method for question 2(ii)		
	[$v^2 = 25^2$ □ 2 □ (-10) □ 20 → v = □ 15]	**M1**	Using $v^2 = u^2 + 2as$ with $u = 25$, $s = 20$ and $a = –g$
	[$-15 = 15 – 10T$] or equivalent	**M1**	Use v at $s = 20$ to find the time, T, taken to reach the maximum height and to return to $s = 20$
	Required time = 1.5 □ 1.5 = 3 seconds	**A1**	
		3	
2(iii)	Max height reached at 2.5 s, hence reaches h after 2 s $h – 3 = 25$ □ $2 – 5$ □ 2^2	**M1**	Using their t from 2(i) – 0.5 in $s = ut + ½at^2$ Allow finding h without taking note of the additional 3 m
	$h = 33$ m	**A1**	
	Alternative method for question 2(iii)		
	Maximum height = ½ □ (25 + 0) □ 2.5 [= 31.25] o.e. In 0.5 s it falls distance ½ □ 10×0.5^2 [= 1.25]	**M1**	For attempting to find both the maximum height and the distance fallen in 0.5 seconds
	$h = 31.25 – 1.25$ □ $3 = 33$ m	**A1**	
		2	

Question	Answer	Mark	Guidance
3(i)	DF = 1500 □ 12 000 □ g □ 0.08 [DF = 11100]	**M1**	Using DF = Resistance □ weight component (3 terms)
	Power = DF □ 5	**M1**	Using $P = Fv$ (their 2 term DF □ 5)
	Power = 11 100 □ 5 = 55.5 kW	**A1**	**AG**
		3	
3(ii)	k □ 5^2 = 1500, k = 60	**B1**	**AG**
		1	
3(iii)	DF = $60v^2$	**B1**	Using DF = resistance = $60v^2$
	55500 = DF □ v = $60v^2$ □ v = $60v^3$	**M1**	$P = Fv$ used and attempt to solve a 2-term cubic equation for v
	v = 9.74 ms^{-1}	**A1**	
		3	

Question	Answer	Mark	Guidance
4(i)	R = 13 cos 67.4 = 13 (5/13) [R = 5]	**B1**	Resolve forces perpendicular to plane. Allow 67.4 used
	F □ 13 sin 67.4 = F + 13(12/13) = 20 [F = 8]	**B1**	Resolve forces parallel to plane. Allow 67.4 used
		M1	Use $F = \mu R$
	μ = 8/5 = 1.6	**A1**	**AG** Must be from exact working here
		4	

Question	Answer	Mark	Guidance
4(ii)	13 sin 67.4 – F = 1.3a F = μR = 8 → [4 = 1.3a]	M1	For applying Newton's second law along the plane and also using F = μR (3 terms)
	a = 3.08 ms^{-2}	A1	Allow a = 40/13
		2	
4(iii)	s = 0 □ 0.5 □ (40/13) □ 2^2 [= 80/13 = 6.15]	M1	Use s = ut □ ½at^2 with u = 0 and their $a \neq \pm g$ to find the distance moved in the first 2 seconds
	WD = 8 □ 6.15	M1	WD = F □ d
	WD = 49.2 J	A1	Allow WD = 640/13 J
	Alternative method for question 4(iii)		
	s = 0 □ 0.5 □ (40/13) □ 2^2 [= 80/13 = 6.15]	M1	
	[v = (40/13) × 2] and [WD = 1.3g(80/13)(12/13) – ½ □ 1.3 □ (80/13)^2]	M1	Finding v after 2 seconds and using WD = PE loss – KE gain
	WD = 49.2 J	A1	Allow WD = 640/13 J
		3	

Question	Answer	Mark	Guidance
5(i)	$a = 2t - 8$	**M1**	Differentiate to find a
	$a = 0 \rightarrow t = 4$	**M1**	Set $a = 0$ and solve for t
	Minimum $v = -4$ ms^{-1}	**A1**	Full marks available for correct use of a v-t graph or correct use of "$t = -b/2a$"
	Alternative method for question 5(i)		
	$v = (t-4)^2 - 4$	**M1**	Attempt to complete the square for v
	[$t = 4$]	**M1**	Choose the t value which gives minimum v
	Minimum $v = -4$ ms^{-1}	**A1**	
		3	
5(ii)	$v = 0$ when $(t-2)(t-6) = 0$	**M1**	Find values of t when $v = 0$, factorise or formula
	$t = 2$ or $t = 6$	**A1**	
	[$s = ⅓\,t^3 - 4t^2 + 12t$ (+c)]	**M1**	Integrate v to find s
		A1	Correct integration
	$0 \le t \le 2$ $s_1 = 8/3 - 16 + 24 = 32/3$ $2 \le t \le 6$ $s_2 = (216/3 - 144$ □ $72) - (8/3 - 16$ □ $24) = -32/3$ $6 \le t \le 8$ $s_3 = (512/3 - 4$ □ 8^2 □ 12 □ $8) - (216/3 - 144$ □ $72) = 32/3$	**M1**	Attempt to find s_1, s_2 and s_3 Look for consideration of the need for 3 intervals Allow use of symmetry when finding s_1, and s_3
		A1	2 correct values of displacement
	Total distance = 32 m	**A1**	All correct
		7	

Question	Answer	Mark	Guidance
6(i)	Particle A: $T = 4 \sin \theta$ Particle B: $T = 2$	M1	Resolve forces for A and for B
		M1	Eliminate T and solve for θ
	$\theta = 30$	A1	
		3	
6(ii)(a)	A: $T - 4 \sin 20 = 0.4a$ B: $2 - T = 0.2a$ System: $2 - 4 \sin 20 = (0.4$ □ $0.2)a$	M1	Apply Newton's second law to A or to B or to the system
		A1	Two correct equations
		M1	Solve for a or T
	$T = 1.79$ and $a = 1.05$	A1	Both correct
		4	
6(ii)(b)	$v^2 = 2$ □ 1.053 □ $0.5 = 1.053$	M1	Attempt to find v using their $a \neq \pm g$
	$v = 1.03 \text{ ms}^{-1}$	A1	
		2	

Question	Answer	Mark	Guidance
6(ii)(c)	Loss in KE = ½ × 0.4 × 1.053 = 0.2106 Gain in PE = 0.4 × 10 × *d* sin 20	**M1**	Attempt KE loss or PE gain for particle *A* only after particle *B* hits the ground.
		A1ft	Both correct, *d* is distance moved up the plane after *B* hits ground
	½ × 0.4 × 1.053 = 0.4 × 10 × *d* sin 20	**M1**	Apply KE loss = PE gain
		A1	**FT** Correct energy equation
	Total dist *A* moves up plane = 0.5 + *d* = 0.654 m	**A1**	
		5	