Question	Answer	Marks	Guidance
1	$-5 = 24t - 5t^2$	**M1**	Use $s = ut + \frac{1}{2}at^2$
	$5t^2 - 24t - 5 = 0$	**M1**	Solve relevant 3 term quadratic
	$t = 5$	**A1**	
		3	
	Alternative scheme for Question 1		
	$0 = 24 - 10t_1 \rightarrow t_1 = 2.4$	**M1**	Attempt to find the time taken to reach the highest point
	$0 = 24^2 + 2 \times (-10) \times h \rightarrow h = 28.8$ And $33.8 = \frac{1}{2}gt_2^2 \rightarrow t_2 = 2.6$	**M1**	Find total height h reached and attempt to find time taken from highest point to ground level
	$t = t_1 + t_2 = 5$	**A1**	

Question	Answer	Marks	Guidance
2	[10 cos α = 8 or 10 cos β = 6]	**M1**	Introduce α or β, an angle between the 10N force and the vertical or horizontal and attempt to resolve forces
	$\alpha = 36.9$ or $\beta = 53.1$	**A1**	
	Angle between 6N and 10N is 126.9	**B1**	
	Angle between 8N and 10N is 143.1	**B1**	
		4	
	Alternative scheme for Question 2		
	$\frac{10}{\sin 90} = \frac{6}{\sin \gamma} = \frac{8}{\sin \delta}$	**M1**	Attempt to use Lami's theorem γ (8 and 10), δ (6 and 10)
	All correct	**A1**	
	Angle between 8N and 10N is γ =143.1	**B1**	
	Angle between 6N and 10N is δ =126.9	**B1**	

Question	Answer	Marks	Guidance
3(i)		**M1**	Attempt to resolve forces along the plane (2 terms)
	$100 \cos \theta = 8g \sin 30 \quad \rightarrow \quad \theta = 66.4$	**A1**	
	$[R = 8g \cos 30 + 100 \sin \theta]$	**M1**	Resolve forces perpendicular to the plane (3 terms)
	$R = 161$	**A1**	
		4	
3(ii)	$100 \cos 30 - 8g \sin 30 = 8a$	**M1**	Apply Newton's 2nd law parallel to the plane (3 terms)
	$a = 5.83$	**A1**	
		2	

Question	Answer	Marks	Guidance
4(i)		**M1**	Attempt differentiation
	$v = 3t^2 - 8t + 4$	**A1**	
		2	
4(ii)	$3t^2 - 8t + 4 = 0$	**M1**	Set $v = 0$ and attempt to solve a relevant 3 term quadratic
	$t = \frac{2}{3}$ and $t = 2$	**A1**	
		2	

Question	Answer	Marks	Guidance
4(iii)	$[6t - 8 = 0]$	M1	Differentiate v and equate to 0
	$[t = \frac{4}{3},\ v = 3(\frac{4}{3})^2 - 8(\frac{4}{3}) + 4]$	M1	Solve for t and attempt v
	$v = -\frac{4}{3}$	A1	
		3	
	Alternative scheme for Question 4(iii)		
	$[v = 3(t^2 - \frac{8}{3}t) + 4 = 3(t - \frac{4}{3})^2 + ...]$	M1	Attempt to complete the square for v
	$[t = \frac{4}{3},\ v = 3(t - \frac{4}{3})^2 - \frac{4}{3}]$	M1	Find value of t for minimum v and attempt to find v
	$v = -\frac{4}{3}$	A1	

Question	Answer	Marks	Guidance
5(i)	$[s_1 = \frac{1}{2}(0 + 12) \times 6]$	M1	Use constant acceleration equations or find area in (t,v) graph to find the distance s_1 travelled in the first 6 seconds
	$[s_2 = 10 \times 12]$	M1	Use constant acceleration equations or find area in (t,v) graph to find s_2 the distance travelled between 6s and 16s
	Distance for first 16 s is $36 + 10 \times 12 = 156$	A1	
	Curve concave up for $0 < t < 6$ starting at (0 , 0) ending at (6 , 36)	B1	Co-ordinates refer to (t,s) in a displacement-time graph
	Line, positive gradient, $6 < t < 16$ starts at (6 , 36) ends at (16 , 156)	B1	
	Curve concave down, $16 < t < 20$ from (16 , 156) to (20 , 200)	B1	
		6	
5(ii)	$[44 = \frac{1}{2}(12 + V) \times 4]$	M1	Use relevant constant acceleration equations or the area property of a v–t graph
	$V = 10$	A1	
		2	

Question	Answer	Marks	Guidance
6(i)	[P = DF × v = 850 × 36]	**M1**	Apply P = DF × v with DF = Resistance force
	Power = rate of working = 30.6 kW	**A1**	
		2	
6(ii)	[DF = 1250 g × 0.1 + 850]	**M1**	Driving force comprising of resistance plus a weight component
	DF = $\frac{63000}{v}$	**M1**	DF = $\frac{P}{v}$
	v = 30 so speed of car is 30 ms^{-1}	**A1**	
		3	
6(iii)	Gain in KE = $\frac{1}{2}$ × 1250 × (24^2 – 20^2)	**B1**	[= 110 000]
	Loss in PE = 1250 g × 176 × 0.1	**B1**	[= 220 000]
	WD by car's engine = 20 000 × 8	**B1**	[= 160 000]
	[160 000 + 220 000 = WD against resistance + 110 000]	**M1**	4 term work energy equation
	WD = 270 000 J = 270 kJ	**A1**	
		5	

Question	Answer	Marks	Guidance
7(i)	*A* $T - 0.8g \sin 45 = 0.8a$ *B* $1.2g \sin 30 - T = 1.2a$ System $1.2g \sin 30 - 0.8g \sin 45 = 2a$	**M1**	Apply Newton 2nd law to either *A* or to *B* or to the system
		A1	One correct equation
		A1	A second correct equation
	$a = 0.171$	**M1**	Solve for *a*
	$v^2 = 2 \times a \times 0.4$	**M1**	Use $v^2 = u^2 + 2as$ with $u = 0$
	$v = 0.370$ so speed of *A* is 0.370 ms^{-1}	**A1**	
		6	
	Alternative scheme for Question 7(i)		
		M1	Attempt KE gain or PE loss
	KE gain = $\frac{1}{2} \times 0.8 \times v^2 + \frac{1}{2} \times 1.2 \times v^2$	**A1**	*v* is the required speed of *A*
	PE loss = $1.2g \times 0.4 \sin 30 - 0.8g \times 0.4 \sin 45$	**A1**	
	$\frac{1}{2} \times 0.8 \times v^2 + \frac{1}{2} \times 1.2 \times v^2 =$ $1.2g \times 0.4 \sin 30 - 0.8g \times 0.4 \sin 45$	**M1**	4 term energy equation
		M1	Solving for *v*
	$v = 0.370$ so speed of *A* is 0.370 ms^{-1}	**A1**	

Question	Answer	Marks	Guidance
7(ii)	$R_A = 0.8g\cos 45 = 4\sqrt{2}$ $R_B = 1.2g\cos 30 = 6\sqrt{3}$	**B1**	For either R_A or R_B
	$F_A = 4\sqrt{2}\ \mu$ and $F_B = 6\sqrt{3}\ \mu$	**M1**	Either F_A or F_B used
	A $0.8\,g\sin 45 + F_A = T$ B $1.2\,g\sin 30 - F_B = T$ or system equation: $12\sin 30 - 8\sin 45 = F_A + F_B$	**M1**	Resolve parallel to the plane either for both particles A and B **or** for the system equation
	Correct equation(s)	**A1**	
		M1	Eliminate T and solve for μ
	$\mu = \dfrac{(6 - 4\sqrt{2})}{(6\sqrt{3} + 4\sqrt{2})}$ $= 0.0214$	**A1**	
		6	