Question	Answer	Marks	Guidance
1	$0.2\mathrm{d}v/\mathrm{d}t = t\,\mathrm{e}^{-v}$	**M1**	Uses Newton's Second Law to set up a differential equation. Allow a for $\mathrm{d}v/\mathrm{d}t$.
	$\int \mathrm{e}^{v}\,\mathrm{d}v = 5\int t\,\mathrm{d}t$ leading to $\mathrm{e}^{v} = 5t^2/2\ (+c)$	**M1**	Separates the variables and integrates.
	$\mathrm{e}^{v} - 1 = 2.5t^2$	**A1**	Substitutes $t = 0$, $v = 0$.
	$v(2) = \ln 11 = 2.4$	**A1**	
		4	

Question	Answer	Marks	Guidance
2	$0.15W + 0.3(60 - W) = 0.25 \times 60$	**M1A1**	Attempts to take moments about the base of the cone. W = weight of the cone.
	$W = 20$ N	**A1**	
		3	

Question	Answer	Marks	Guidance
3(i)	$0.4v\mathrm{d}v/\mathrm{d}x = 0.4g\sin 30 - 0.2v^2$	**M1**	Uses Newton's Second Law down the plane. Allow a for $v\mathrm{d}v/\mathrm{d}x$.
	$v\mathrm{d}v/\mathrm{d}x = 5 - 0.5v^2$	**A1**	AG
		2	
3(ii)	$\int v/(5 - 0.5v^2)\mathrm{d}v = \int x\,\mathrm{d}x$	**M1**	Separates the variables and attempts to integrate.
	$-\ln(5 - 0.5v^2) = x\ (+c)$	**A1**	
	$c = -\ln 5$ [$5 - 0.5v^2 = 5\,\mathrm{e}^{-x}$]	**M1**	Puts $x = 0$, $v = 0$ to find c and attempts to solve for v.
	$v = \sqrt{(10 - 10\mathrm{e}^{-x})}$	**A1**	
		4	

Question	Answer	Marks	Guidance
4(i)	$e = \sqrt{(0.5^2 + 1.2^2)} - 1 = 0.3$	**B1**	
	$T = 39 \times 0.3/1$	**M1**	Uses $T = \lambda x/L$.
	$mg = 2 \times (39 \times 0.3/1) \times 0.5/1.3$	**M1**	Resolves vertically.
	$m = 0.9$	**A1**	AG
		4	
4(ii)	$E = \sqrt{(1.6^2 + 1.2^2)} - 1 = 1$ m	**B1**	E = extension when the particle comes to instantaneous rest.
	$EE = 39 \times 1^2/(2 \times 1)$ or $39 \times 0.3^2/(2 \times 1)$	**B1**	
	$0.9v^2/2 + 0.9g(1.6 - 0.5)$ $= 2[39 \times 1^2/(2 \times 1) - 39 \times 0.3^2/(2 \times 1)]$	**M1A1**	Set up a 4 term energy equation involving EE, KE and PE.
	$v = 7.54$ m s^{-1}	**A1**	
		5	

Question	Answer	Marks	Guidance
5(i)	$OG = 2 \times 0.8\sin(\pi/4)/(3\pi/4)$ (0.48016…m)	**B1**	
	$AG^2 = (0.8\sin45)^2 + (0.8\cos45 - OG)^2$ OR $AG^2 = 0.8^2 + OG^2 - 2 \times 0.8 \times OG\cos45$	**M1**	Uses Pythagoras's Theorem OR the cosine formula.
	$AG = 0.572(11...)$ m	**A1**	
		3	
5(ii)	$\tan BAG = (0.8\cos45 - OG)/(0.8\sin45)$	**M1**	Uses trigonometry to find angle BAG.
	$BAG = 8.5965° = 8.6(0)°$	**A1**	
	$W \times AG = 12 \times 2 \times 0.8\sin45 \times \sin BAG$	**M1**	Takes moments about A.
	$0.572W = 12 \times 2 \times 0.8\sin45 \times \sin8.6$	**A1FT**	
	$W = 3.55$ N	**A1**	
		5	

Question	Answer	Marks	Guidance
6(i)	$T = 0.2 \times 2.5^2/(0.4 + e)$	**B1**	Uses Newton's Second Law towards the centre of the circle.
	$T = 8e/0.4$	**B1**	Uses $T = \lambda x/L$.
	$1.25/(0.4 + e) = 20e \rightarrow 20e^2 + 8e - 1.25 = 0$	**M1**	Eliminates T to find e.
	$e = 0.12(0)$ m	**A1**	
		4	
6(ii)	$0.2v^2/2 = 2[8x^2/(2 \times 0.4)]$	**B1**	Uses $KE = 2EE$.
	$0.2v^2/(0.4 + x) = 8x/0.4$	**B1**	Uses $T = \lambda x/L$ and $T = mv^2/r$.
		M1	Attempts to solve the 2 equations to find v or x.
	$x = 0.4$ and $v = 5.66$ or $4\sqrt{2}$	**A1A1**	
		5	

Question	Answer	Marks	Guidance
7(i)	$U_H = 18\cos 30$ and $U_V = 18\sin 30 + 2g(=29)$	**B1**	
	$U = \sqrt{[(18\cos 30)^2 + 29^2]}$ or $\tan\theta = 29/(18\cos 30)$	**M1**	Uses Pythagoras's Theorem and trigonometry.
	$U = 32.9(24..)$ m s^{-1}	**A1**	
	$\theta = 61.7°$	**A1**	
		4	
7(ii)	$v^2 = 38^2 - (18\cos 30)^2 = (+/-29)^2 + 2gh$	**M1**	Uses 2 ways to find v, the vertical velocity at the ground and equates.
	$h = 18$	**A1**	
	OR $mgh + m \times 32.924^2/2 = m \times 38^2/2$	**M1**	
	$h = 18$	**A1**	
		2	

Question	Answer	Marks	Guidance
7(iii)	$-\sqrt{[(38^2 - (18\cos 30)^2]} = 29 - gt$	**M1**	Uses $v = u + at$ for first part of flight.
	$t = 6.36(6)$	**A1**	
	$v = \sqrt{[20^2 - (18\cos 30)^2]} = 12.5(3)$ $-12.5(3) = 12.5(3) - gt'$	**M1**	Uses $v = u + at$ for second part of flight.
	$t' = 2.50(6)$	**A1**	
	$T\ (= 6.366 + 2.506) = 8.87$	**A1**	
		5	