Question	Answer	Marks	Guidance
1(i)	$\tan\theta = 12/20$	**M1**	θ is the angle of projection
	$\theta\ (= 30.96) = 31(.0)°$	**A1**	
	$V\cos 30.96 = \dfrac{20}{0.9}$	**M1**	Use horizontal motion. Allow their θ for the M mark.
	$V = 25.9\ \text{m}\,s^{-1}$	**A1**	
	Total:	**4**	
1(ii)	$H = 25.9\sin 31 \times 0.9 - g \times \dfrac{0.9^2}{2}\ (= 7.948)$	**M1**	Use $s = ut + \frac{1}{2}at^2$ vertically. H is the height above the ground. Allow their V and θ for the M mark.
	AB (= 12 – 7.95) = 4.05 m	**A1**	Allow AB = 4.06
	Total:	**2**	
2	EPE = $24(x-0.6)^2/(2\times 0.6)$	**B1**	Correct EPE term. Note x = OP
	$0.4 \times 1.5^2/2 = 0.4gx - 24(x-0.6)^2/(2\times 0.6)$ $[20x^2 - 28x + 7.65 = 0$ or equivalent]	**M1**	Attempt to find a 3 term energy equation
		M1	Attempt to solve the 3 term quadratic equation
	OP = 1.0279 m, 0.372 m (reject)	**A1**	Correct answer chosen
	$0.4 \times 1.5^2/2 = 0.4gx$	**M1**	Note the particle is moving upwards and the string is slack
	OP = 0.1125 m	**A1**	
	Total:	**6**	

Question	Answer	Marks	Guidance
2	**Alternative method**		
	EPE = $24x^2/(2 \times 0.6)$	**B1**	x is the extension
	$0.4 \times 1.5^2/2 = 0.4g(x + 0.6) - 24x^2/(2 \times 0.6)$ $[20x^2 - 4x - 1.95 = 0$ or equivalent]	**M1**	Attempt to find a 3 term energy equation
		M1	Attempt to solve the 3 term quadratic equation
	[$x = 0.42787, -0.22787$ .reject] OP = 0.6 + 0.42787 = 1.0279	**A1**	
	$0.4 \times 1.5^2/2 = 0.4g(x + 0.6)$ [$x = -0.4875$]	**M1**	Note the particle is moving upwards and the string is slack
	OP = 0.6 – 0.4875 = 0.1125	**A1**	
	Total:	**6**	
3(i)	d = $x\sin\theta/2 - a\cos\theta$ or equivalent	**B1**	Note d is the distance of the C of M of BC from the vertical through A
	$a(a\cos\theta)/2 = x(x\sin\theta/2 - a\cos\theta)$	**M1**	Take moments about A
	$x^2\tan\theta - 2ax - a^2 = 0$ **AG**	**A1**	
	Total:	**3**	
3(ii)	$1.25x^2 - 2ax - a^2 = 0$ [$x = 2a$ and $x = -2a/5$]	**M1**	Attempts to solve the equation
	Length (= 2a + a) = 3a	**A1**	
	Total:	**2**	

Question	Answer	Marks	Guidance
4(i)	$x = (20\cos30)t$ or $10\sqrt{3}\,t$	B1	Use horizontal motion
	$y = (20\sin30)t - \frac{1}{2}g t^2$ or $10t - 5t^2$	B1	Use vertical motion
	$y = (20\sin30)[x/(20\cos30)] - 5[x/(20\cos30)]^2$	M1	Attempt to eliminate t
	$y = x/\sqrt{3} - x^2/60$ or $0.577x - 0.0167x^2$	A1	
	Total:	4	
4(ii)	$x/\sqrt{3} - x^2/60 = (x+15)/\sqrt{3} - (x+15)^2/60$	M1	Simplifies to $0 = 15/\sqrt{3} - (30x+225)/60$
	$x = 9.821$	A1	
	$y = 4.06(25)$ m	A1	
	Total:	3	
	Alternative method		
	$0.577x - 0.0167x^2 = 0.577(x+15) - 0.0167(x+15)^2$	M1	
	$x = 9.775$	A1	
	$y = 4.044$	A1	
	Total:	3	

Question	Answer	Marks	Guidance
5(i)	$\tan\theta = (0.6 - 0.5)/0.4$ (= 1/4)	B1	θ is the angle made by the base and the vertical
	$\tan\theta = \bar{x}/0.6$	M1	
	$\bar{x} = 0.15$ m **AG**	A1	
	Total:	3	
5(ii)	$(\pi 0.6^2 \times 0.8/3) \times (0.8/4) - [\pi(0.5^2 - x^2) \times 0.4] \times (0.4/2)$ $= [\pi 0.6^2 \times 0.8/3 + \pi(0.5^2 - x^2) \times 0.4]\bar{x}$	M1 A1	Attempts to take moments about the base of the cone using their $\bar{x}$ Note $\bar{x}$ =0.15 Correct equation for the A mark.
		M1	Attempts to solve the equation
	$x = 0.464$	A1	Note $x^2 = 0.216$
	Total:	4	
6(i)	$\cos\theta = 0.5$ and $\sin\theta = \sqrt{3}/2$	B1	θ is the angle that AP makes with the horizontal. Note $\tan\theta = \sqrt{3}$
	$T\sin\theta = 0.2\,g$	M1	Resolve vertically for P. Note tension in BP is zero
	$T\cos\theta = 0.2\,\omega^2 \times 0.3$	M1	Use Newton's Second Law horizontally
	$\omega = 4.39$ rad s^{-1}	A1	
	Total:	4	

Question	Answer	Marks	Guidance
6(ii)	$T_A \sin\theta = 0.2\,g + T_B \sin\theta$	**M1**	Resolve vertically for P
	$T_A \sin\theta = 0.2\,g + 5\sin\theta$	**M1**	Use $T_B = 5$
	$T_A = 7.309$	**A1**	
	$5\cos\theta + 7.309\cos\theta = 0.2\,v^2/0.3$	**M1**	Use Newton's Second Law horizontally
	$v = 3.04\ \text{m}\,s^{-1}$	**A1**	
	Total:	**5**	

Question	Answer	Marks	Guidance
7(i)	$0.2\,dv/dt = 0.2\,g + 0.6t - k\,e^{-t}$	**M1**	Use Newton's Second Law downwards
	$dv/dt = 10 + 3t - 5\,ke^{-t}$ **AG**	**A1**	
	Total:	**2**	
7(ii)	$dv/dt = 10 - 5k\,e^{0} = 0$	**M1**	Recognise that dv/dt = 0 when t = 0
		M1	Attempts to solve the equation
7(ii)	$k = 2$	**A1**	
	Total:	**3**	

Question	Answer	Marks	Guidance
7(iii)	$\int dv = \int(10 + 3t - 5k\,e^{-t})dt$	**M1**	Attempts to integrate the equation from part i with k not replaced
	[$v = 10t + 3t^2/2 + 5e^{-t} + c$, $v = 0$, $t = 0$ so $c = -5$] $v = 10t + 3t^2/2 + 5e^{-t} - 5$	**A1**	
	$\int dx = \int(10t + 3t^2/2 + 5e^{-t} - 5)dt$ $x = 5t^2 + t^3/2 - 5e^{-t} - 5t + c$	**M1**	Attempts to integrate again. Allow their k or just k not replaced
	$x = 0$, $t = 0$, so $c = 5$ and substitutes $t = 2$ $x = 5 \times 2^2 + 2^3/2 - 5e^{-2} - 5 \times 2 + 5$	**M1**	
	Height = 18.3 m	**A1**	
	Total:	**5**	