Question	Answer	Marks	Guidance
1	$x' = 24\cos 30$ ($= 12\sqrt{3}$)	B1	Use horizontal motion
	$y' = 24\sin 30 - 4g$ ($= -28$)	B1	Use vertical motion
	$V^2 = (24\cos 30)^2 + (24\sin 30 - 4g)^2 = (12\sqrt{3})^2 + (-28)^2$ OR $\tan\alpha = (24\sin 30 - 4g)/(24\cos 30) = -28/(12\sqrt{3})^2$	M1	Where V is the required speed and α is the angle below the horizontal
	$V = 34.9$ m s^{-1}	A1	
	$\alpha = 53.4°$ below the horizontal	A1	
		5	

Question	Answer	Marks	Guidance
2(i)	Total volume (= 27 + 8 + 1) = 36	B1	
	$36x = 27\times 1.5 + 8\times 4 + 1\times 5.5$	M1	Take moments about base of largest cube
	x (= 13/6) = 2.17 m	A1	
		3	
2(ii)	Mass of new cube = 35 + m	B1	Where m is the mass of the new cube
	$(35 + m) \times 3 = 27\times 1.5 + 8\times 4 + 5.5m$ (leads to m = 13)	M1	Take moments about base of largest cube
	13:1 or 1:13	A1	Accept 13
		3	

Question	Answer	Marks	Guidance
3(i)	$x = 4t$ and $y = 6t - 5t^2$	M1	Use horizontal and vertical motion and attempt to eliminate t
	y [= $6x/4 - 5(x/4)^2$] = $1.5x - 5x^2/16$ or $1.5x - 0.3125x^2$	A1	
		2	
3(ii)	$\tan\theta = 1.5$	M1	Use the trajectory equation from the formula sheet
	$\theta = 56.3°$	A1	
	$V^2 \cos^2 56.3 = 16$	M1	Again use the trajectory equation
	V = 7.21 m s^{-1}	A1	
	OR		
	$V\cos\theta = 4$ and $V\sin\theta = 6$	M1	Initial horizontal and vertical velocities
	$V^2\cos^2\theta + V^2\sin^2\theta = 4^2 + 6^2$ OR $\tan\theta = 6/4$	M1	Use Pythagoras's theorem or trigonometry of a right angled triangle
	V = 7.21 m s^{-1}	A1	
	$\theta = 56.3°$	A1	
		4	

Question	Answer	Marks	Guidance
4	$T\cos 60 = 0.3g$	M1	Resolve vertically
	$T = 6$ N	A1	
	$T = 16e/0.8$ ($= 6$) leads to $e = 0.3$	M1	Use $T = \lambda x/L$
	$r = (0.8 + 0.3)\sin 60$ ($= 1.1\sin 60$)	A1	
	$T\sin 60 = 0.3 v^2/(1.1\sin 60)$	M1	Use N2L horizontally
	$v = 4.06$ m s^{-1}	A1	
		6	

Question	Answer	Marks	Guidance
5(i)	$0.3g = 24e/0.6$	M1	Note greatest speed occurs at the equilibrium position. Use $T=\lambda x/L$
	$e = 0.075$ m	A1	Fall = 0.275 m
	PE Change = $0.3g \times 0.275$	B1	
	$0.3 v^2/2 = 0.3g \times 0.275 - 24 \times 0.075^2/(2 \times 0.6)$	M1	Set up a 3 term energy equation
	$v = 2.18$ m s^{-1}	A1	
		5	

Question	Answer	Marks	Guidance
5(ii)	$0.3g(0.2 + E) = 24E^2/(2 \times 0.6)$	M1	Set up an energy equation. Note v = 0 at the greatest distance
	$20E^2 - 3E - 0.6 = 0$	M1	Attempt to solve a 3 term quadratic equation
	E = 0.264 and so greatest distance is 0.864 m	A1	
		3	

Question	Answer	Marks	Guidance
6(i)	Area of hole = πr^2 and Area of original circle = $25\pi r^2$	M1	
	Area of cross-section = $24\pi r^2$	A1	
	$\pi r^2(2r) = 24\pi r^2(d)$	M1	Take moments about the centre of the cylinder
	d = r/12 (= 0.083333....r)	A1	
		4	
6(ii)	P(2 × 5r) = W(r/12)cos60	M1	Take moments about the point of contact with the plane
	P = Wcos60/120 = W/240 = 0.00417W (= F)	A1	
	μ = (Wcos60/120)/W	M1	Use F = μR Note R = W by resolving vertically
	μ = 1/240 = 0.00417	A1	
		4	

Question	Answer	Marks	Guidance
7(i)	$0.2mg = 0.06 \times 8$	**M1**	Resolve along the plane
	$m = 0.24$ kg **AG**	**A1**	
		2	
7(ii)	$m\frac{dv}{dt} = 0.06t - 0.2mg$ or $0.24\frac{dv}{dt} = 0.06t - 0.2 \times 0.24g$	**M1**	Use N2L along the plane
	$\frac{dv}{dt} = 0.25t - 2$ **AG**	**A1**	
	$\int dv = \int (0.25t - 2)dt$	**M1**	Attempt to integrate
	$v = 0.25t^2/2 - 2t + c$, Put v = 0 and t = 4 (leads to c = 6)	**M1**	Attempt to find c
	Initial velocity = 6 m s^{-1}	**A1**	
		5	
7(iii)	$x = \int (0.25t^2/2 - 2t + 6)dt$	**M1**	Attempt to integrate
	$x = 0.25t^3/6 - t^2 + 6t\ (+ k)$	**A1ft**	ft candidates c from part **(ii)**
	Finds or assumes k = 0 and substitutes t = 4 OR uses limits of 0 and 4	**M1**	
	$OP = 32/3 = 10\frac{2}{3} = 10.7$ m	**A1**	
		4	