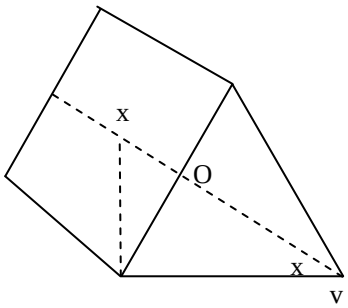
Question Number	Scheme	Marks
1.	1000 r.p.m = $\frac{1000\times 2\pi}{60}$ rad/s $v = 0.035 \times \frac{1000\times 2\pi}{60} = 3.67$ ms^{-1} (3 SF) M1 their $r \times$ their ω	B1 M1 A1 **(3 marks)**
2.	Extn at bottom = $\frac{a}{\cos\alpha} - a = \frac{2a}{3}$ ($0.67a$ or better) Energy: $mga\tan\alpha = \frac{2\lambda\left(\frac{2a}{3}\right)^2}{2a}$ $3mg = \lambda$ Second M0 if treated as equilibrium Third M1 for solving for λ	M1 A1 M1 A1 A1 ft M1 A1 **(7 marks)**
3. (a)	$mg\sin 30° - mx^2 = ma$ $\frac{g}{2} - x^2 = v\frac{dv}{dx}$ or $\frac{d\left(\frac{1}{2}v^2\right)}{dx}$ $\frac{gx}{2} - \frac{x^3}{3}(+C) = \frac{v^2}{2}$ $x = 2 : g - \frac{8}{3} = \frac{v^2}{2}$ $v = 3.8$ms^{-1} (3.78) Third M1 for attempting to integrate	M1 A1 M1 M1 A1 M1 A1 (7)
(b)	$v = 0$: $\frac{gx}{2} - \frac{x^3}{3} = 0$ $x^2 = \frac{3g}{2} \Rightarrow x = 3.8, (3.83), \sqrt{\frac{3g}{2}}$ must have integrated for first M1	M1 M1 A1 c.s.o (3) **(10 marks)**

(ft = follow through mark)

Question Number	Scheme	Marks
4. (*a*)	$(\uparrow), R = mg$	B1
	$m\frac{4a}{3}\omega^2$ (seen and used)	B1
	$m\frac{4a}{3}\omega^2 \leq \frac{3}{5}$ mg	M1
	$\omega^2 \leq \frac{9g}{20a}$ *	A1 c.s.o (4)
(b)	$T = \frac{2mg}{a}\frac{a}{3} = \frac{2mg}{3}$	B1
	$(\rightarrow), \quad \frac{3}{5}mg + \frac{2mg}{3} \geq = m\frac{4a}{3}\omega_{\max}^2$	M1 A1 f.t
	$\frac{19g}{20a} = \omega_{\max}^2$	A1
	$(\rightarrow), \quad -\frac{3}{5}mg + \frac{2mg}{3} \leq = m\frac{4a}{3}\omega_{\min}^2$	M1 A1 f.t
	$\frac{g}{20a} = \omega_{\min}^2$	A1 (7)
	If only one answer, must be clear whether max or min for final A1	**(11 marks)**

(ft = follow through mark; (*) indicates final line is given on the paper)

Question Number	Scheme				Marks
5. (*a*)		Cylinder ($36\pi r^3$)	Cone ($12\pi r^3$)	Toy ($48\pi r^3$)	
	mass ratio	3	1	4	B1
	dist. From *O*	$2r$	$(-)r$	$\bar{x}$	B1
		$(3 \times 2r) - r = 4\bar{x}$			M1 A1
		$\frac{5r}{4} = \bar{x}$			A1 (5)
		M1 for clear attempt at $\Sigma mx = \bar{x}\,\Sigma m$ – correct no. of terms.			
		If distances not measured from O, B1B1M1A1 available.			
(b)		*AG* vertical, seen or implied			M1
		$\tan\theta = \frac{3r}{4r - \bar{x}}$			M1 A1
		$\theta = 47\ 5°$ (1 d.p.) second M1 for use of tan			A1 (4)
(c)		Sim Δ's: $\frac{OX}{3r} = \frac{3r}{4r}$ (= tan α)			M1
		$\Rightarrow OX = \frac{9r}{4}$			A1
		$\bar{x} < OX$			M1
		$\Rightarrow$ won't topple			A1 c.s.o (4)
		Note that second M1 is independent, for the general idea.			**(13 marks)**

(ft = follow through mark; (*) indicates final line is given on the paper)

Question Number		Scheme	Marks
6.		All M marks require correct number of terms with appropriate terms resolved	
	(*a*)	B to C: $\frac{1}{2}mv^2 - \frac{1}{2}m20^2 = mg \times 50(1 - \sin 30°)$	M1 A1
		$v = 30$ ms^{-1} (29.8)	A1 (3)
	(*b*)	($\uparrow$) at C, $R - mg = m\frac{890}{50}$	M1 A1 ft
		$R = 1900$ N (1930 N)	A1 (3)
	(*c*)	C to D: $\frac{1}{2}\ m\ 890 - \frac{1}{2}mw^2 = mg \times 50\ (1 - \cos 30°)$	M1 A1 ft
		$w = 28$ ms^{-1} (27.5)	A1 (3)
	(*d*)	Before: $R = mg \cos \theta$	B1
		After: $R = mg \cos \theta + m\ \frac{20^2}{50}$	M1 A1
		Change = $70 \times \frac{20^2}{50} = 560$ N	A1 c.s.o (4)
	(*e*)	Lower speed at $C \Rightarrow$ R reduced	M1 A1 (2)
			(15 marks)

(ft = follow through mark)

Question Number	Scheme	Marks
7. (*a*)	$(-)\ \frac{21.6x}{2} = 0.3\ddot{x}$	M1 A1
	$-36x = \ddot{x}$	M1
	S.H.M., period $= \frac{2\pi}{\sqrt{36}} = \frac{\pi}{3}$ *	A1 c.s.o. (4)
(*b*)	At *A*: $v = aw = 1.5 \times 6 = 9\ \text{ms}^{-1}$	M1 A1 (2)
(*c*)	$x = a\cos \omega t$	
	$0.75 = 1.5\cos 6t$	M1
	$\frac{\pi}{3} = 6t \Rightarrow t = \frac{\pi}{18}$ (no decimals)	M1 A1 (3)
(*d*)	$(-)\ \frac{21.6x}{2} = 0.5\ddot{x}$	M1 A1
	$-21.6x = \ddot{x} \Rightarrow$ S.H.M., $\omega = \sqrt{21.6}$	A1
	At collision: CLM: $0.3 \times 9 = 0.5v \Rightarrow v = 5.4$	M1 A1 ft
	$a \times \sqrt{21.6} = 5.4$	M1
	$a = 1.16$ m (3SF)	A1 (7)
		(16 marks)

(ft = follow through mark; (*) indicates final line is given on the paper)