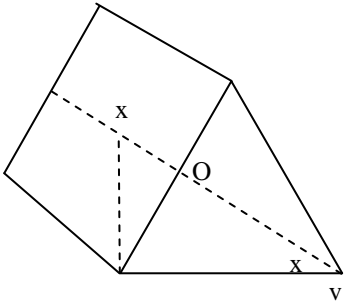


Question Number	Scheme	Marks
1.	$1000 \text{ r.p.m} = \frac{1000 \times 2\pi}{60} \text{ rad/s}$ $v = 0.035 \times \frac{1000 \times 2\pi}{60} = 3.67 \text{ ms}^{-1} \text{ (3 SF)}$	B1 M1 their $r \times$ their ω M1 A1 (3 marks)
2.	$\text{Extn at bottom} = \frac{a}{\cos \alpha} - a = \frac{2a}{3} \text{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

(ft = follow through mark)

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

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

Question Number	Scheme			Marks
5. (a)	<p>Cylinder ($36\pi r^3$)</p> <p>mass ratio 3</p> <p>dist. From O $2r$</p>	<p>Cone ($12\pi r^3$)</p> <p>1</p> <p>($-$)r</p>	<p>Toy ($48\pi r^3$)</p> <p>4</p> <p>\bar{x}</p> <p>$(3 \times 2r) - r = 4\bar{x}$</p> <p>$\frac{5r}{4} = \bar{x}$</p> <p>M1 for clear attempt at $\Sigma mx = \bar{x} \Sigma m$ – correct no. of terms. If distances not measured from O, B1B1M1A1 available.</p>	<p>B1</p> <p>B1</p> <p>M1 A1</p> <p>A1 (5)</p>
(b)	<p>AG vertical, seen or implied</p>			M1
(c)		<p>$\tan \theta = \frac{3r}{4r - x}$</p> <p>$\theta = 47.5^\circ$ (1 d.p.)</p> <p>Sim Δ's: $\frac{OX}{3r} = \frac{3r}{4r}$ ($= \tan \alpha$)</p> <p>$\Rightarrow OX = \frac{9r}{4}$</p> <p>$\bar{x} < OX$</p> <p>$\Rightarrow$ won't topple</p>	<p>second M1 for use of tan</p> <p>A1 (4)</p> <p>M1</p> <p>A1</p> <p>M1</p> <p>A1 c.s.o (4)</p>	<p>A1 A1</p> <p>A1 (4)</p> <p>M1</p> <p>A1</p> <p>M1</p> <p>A1 c.s.o (4)</p>
<p>Note that second M1 is independent, for the general idea.</p>				<p>(13 marks)</p>

(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 B to C: $\frac{1}{2}mv^2 - \frac{1}{2}m20^2 = mg \times 50(1 - \sin 30^\circ)$ $v = 30 \text{ ms}^{-1} (29.8)$	M1 A1 A1 (3)
	(↑) at C, $R - mg = m \frac{890}{50}$ $R = 1900 \text{ N} (1930 \text{ N})$	M1 A1 ft A1 (3)
	C to D: $\frac{1}{2}m890 - \frac{1}{2}mw^2 = mg \times 50(1 - \cos 30^\circ)$ $w = 28 \text{ ms}^{-1} (27.5)$	M1 A1 ft A1 (3)
	Before: $R = mg \cos \theta$ After: $R = mg \cos \theta + m \frac{20^2}{50}$ Change = $70 \times \frac{20^2}{50} = 560 \text{ N}$	B1 M1 A1 A1 c.s.o (4)
	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
	$\text{S.H.M., period} = \frac{2\pi}{\sqrt{36}} = \frac{\pi}{3} *$	A1 c.s.o. (4)
(b)	$\text{At A: } v = aw = 1.5 \times 6 = 9 \text{ ms}^{-1}$	M1 A1 (2)
(c)	$x = a \cos \omega t$	
	$0.75 = 1.5 \cos 6t$	M1
	$\frac{\pi}{3} = 6t \Rightarrow t = \frac{\pi}{18} \text{ (no decimals)}$	M1 A1 (3)
(d)	$(-) \frac{21.6x}{2} = 0.5\ddot{x}$	M1 A1
	$-21.6x = \ddot{x} \Rightarrow \text{S.H.M., } \omega = \sqrt{21.6}$	A1
	$\text{At collision: CLM: } 0.3 \times 9 = 0.5v \Rightarrow v = 5.4$	M1 A1 ft
	$a \times \sqrt{21.6} = 5.4$	M1
	$a = 1.16 \text{ m (3SF)}$	A1 (7)
		(16 marks)

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