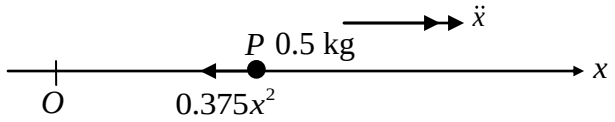
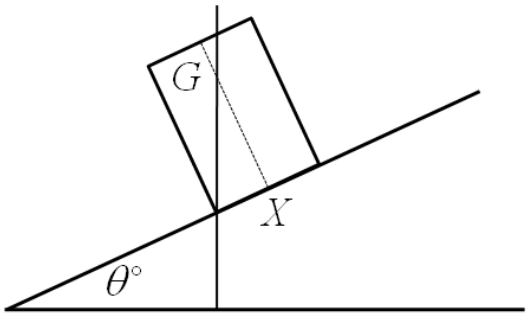
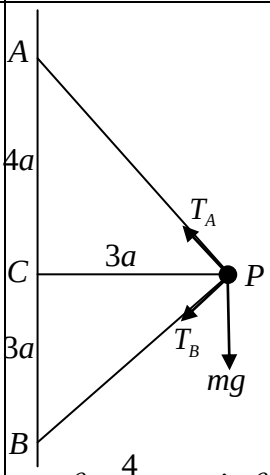
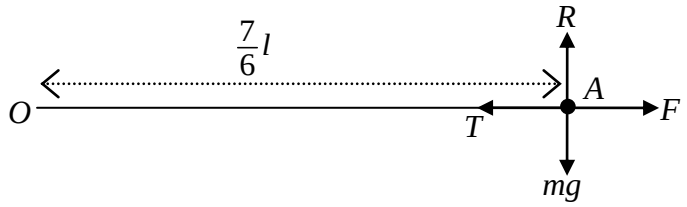
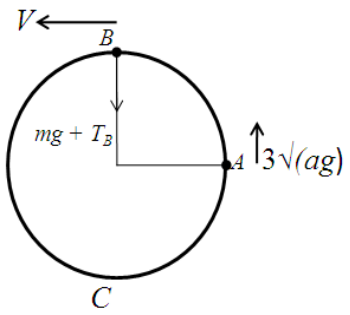
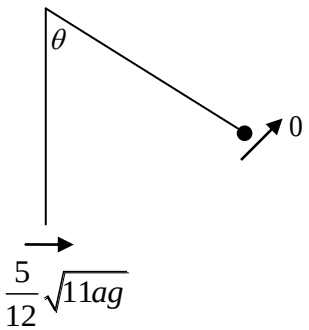
Question Number	Scheme	Marks
1. **(a)**	 $0.5v\dfrac{\mathrm{d}v}{\mathrm{d}x} = -0.375x^2$ $\dfrac{1}{2}v^2 = -0.25x^3 + c$ $t = 0, v = 2, x = 8$ $\dfrac{1}{2}\times 2^2 = -0.25\times 8^3 + c$ $c = 130$ $\therefore v^2 = -\dfrac{1}{2}x^3 + 260$ *	M1 M1 A1 A1 (4)
(b)	$v = 5 \quad x^3 = 520 - 50$ $x = 7.77$	M1 A1 (2) **6**
2.	$V = \pi\int_0^3 \left(9 - x^2\right)^2 \mathrm{d}x = \pi\int_0^3 \left(81 - 18x^2 + x^4\right)\mathrm{d}x$ $= \pi\left[81x - 6x^3 + \dfrac{x^5}{5}\right]_0^3 = \dfrac{648}{5}\pi$ OR: $\int_0^3 \pi\left(9 - x^2\right)^2 x\,\mathrm{d}x$ $\pi\int_0^3 \left(81x - 18x^3 + x^5\right)\mathrm{d}x$ $= \dfrac{\pi}{6}\left[-\left(9 - x^2\right)^3\right]_0^3$ $= \pi\left[\dfrac{81}{2}x^2 - \dfrac{9}{2}x^4 + \dfrac{1}{6}x^6\right]_0^3$ $= \dfrac{\pi}{6}\left[0 + (9)^3\right]$ $= \pi\left[\dfrac{81}{2}\times 3^2 - \dfrac{9}{2}\times 3^4 + \dfrac{1}{6}\times 3^6\right]$ $= \dfrac{243}{2}\pi$ $= \dfrac{243}{2}\pi$	M1 M1 A1 M1 A1 M1 A1
	$\bar{x} = \dfrac{\frac{243}{2}}{\frac{648}{5}} = \dfrac{15}{16}$ (accept 0.94)	M1 A1 (9) **9**

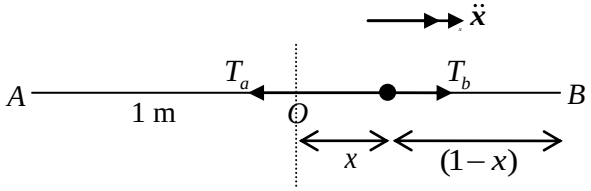
Question Number	Scheme	Marks
3.		
(a)	Mass ratio $\pi(3l)^2\times 5l\rho$: $\frac{2}{3}\pi(3l)^3\times 2\rho$ :: $81\pi l^3\rho$	
	5 : 4 :: 9	B1
	Dist. from O $\frac{5}{2}l$: $-\frac{3}{8}\times 3l$ :: $\bar{x}$	B1
	Moments equation:	
	$5\times\frac{5}{2}l-4\times\frac{9}{8}l=9\bar{x}$	M1 A1 ft
	$\bar{x}=\frac{8}{9}l$	A1 (5)
(b)		
	$GX=5l-\frac{8}{9}l=\frac{37}{9}l$	B1ft
	$\tan\theta^\circ=\frac{3l}{\frac{37}{9}l}=\frac{27}{37}$	M1 A1 ft
	$\theta^\circ=36.1^\circ$ accept 36°, 0.63 or 0.630 rad or better	A1 (4)
		9

Question Number	Scheme	Marks
4. **(a)**		
	$\cos\theta = \frac{4}{5}$ or $\sin\theta = \frac{3}{5}$	B1
	R(vert) $T_B\cos 45 + mg = T_A\cos\theta$	M1 A1
	$\frac{1}{\sqrt{2}}T_B + mg = \frac{4}{5}T_A$	
	R(horiz) $T_A\sin\theta + T_B\cos 45 = m\times 3a\omega^2$	M1 A1=A1
	$\frac{3}{5}T_A + \frac{1}{\sqrt{2}}T_B = 3ma\omega^2$	
	$\frac{3}{5}T_A - mg = 3ma\omega^2 - \frac{4}{5}T_a$	M1
	$\frac{7}{5}T_A = 3ma\omega^2 + mg$	
	$T_A = \frac{5}{7}m\left(3a\omega^2 + g\right)$ *	A1 (8)
(b)	$T_b = \sqrt{2}\left(\frac{4}{5}T_a - mg\right)$	M1
	$= \sqrt{2}\left(\frac{4}{7}m\left(3a\omega^2 + g\right) - mg\right)$	
	$= \frac{3\sqrt{2}}{7}m\left(4a\omega^2 - g\right)$ oe	A1 (2)
(c)	$T_b \geqslant 0 \Rightarrow 4a\omega^2 \geqslant g$	M1
	$\omega^2 \geqslant \frac{g}{4a}$	
	$\omega \geqslant \frac{1}{2}\sqrt{\frac{g}{a}}$ *	A1
	(Allow strict inequalities in (c).)	(2)
		12

Question Number	Scheme	Marks
5. **(a)**		
	$T = \frac{3mg}{l}\left(\frac{1}{6}l\right) = \frac{1}{2}mg$	B1
	$\text{R}(\uparrow)\ \ R = mg \qquad \text{R}(\rightarrow)\ \ F = T = \frac{1}{2}mg$	M1
	$F \leqslant \mu R$	
	$\frac{1}{2}mg \leqslant \mu mg$	M1
	$\mu \geqslant \frac{1}{2}$ *	A1
		(4)
(b)	E.P.E. lost $= \frac{1}{2} \times \frac{3mg}{l}\left(\frac{1}{2}l\right)^2 = \frac{3mgl}{8}$	B1
	Work done by friction $= \frac{1}{2}mg\left(\frac{l}{2}\right)$	B1
	$\frac{3mgl}{8} = \frac{1}{2}mv^2 + \frac{1}{2}mg\left(\frac{l}{2}\right)$	M1 A1ft
	$v^2 = \frac{gl}{4}$	
	$v = \frac{1}{2}\sqrt{gl}$	A1
		(5)
(c)	$\frac{3mgl}{8} = \frac{1}{2}mgx$	M1 A1 ft
	$x = \frac{3l}{4}$	A1
		(3)
		12

Question Number	Scheme	Marks
6.		
(a)		
	Energy to B:	
	$\frac{1}{2}m\left(3\sqrt{ag}\right)^2-\frac{1}{2}\times mV^2=mag$	M1 A1
	$9ag-V^2=2ag$	
	$V^2=7ag$	
	NL2 along radius at B:	
	$T_B+mg=m\frac{V^2}{a}$	M1 A1
	$T_B+mg=7mg$	M1
	$T_B=6mg$	
	$T_B>0\Rightarrow$ particle reaches B	A1 (6)
(b)	Energy to C:	
	$\frac{1}{2}\times mU^2-\frac{1}{2}m\left(3\sqrt{ag}\right)^2=mag$	M1
	$U^2=2ag+9ag$	
	$U=\sqrt{11ga}$	A1 (2)
(c)	Energy from C to rest:	
	$\frac{1}{2}\times m\times\left(\frac{5}{12}\sqrt{11ag}\right)^2=mga\left(1-\cos\theta\right)$	M1 A1
	$\frac{25}{144}\times 11ag=2ga\left(1-\cos\theta\right)$	
	$\cos\theta=\frac{1}{2}\left(2-\frac{25\times 11}{144}\right)$	M1
	$\theta=87.4...$	
	$\theta=87°$ (or 1.5 rad) or better	A1
		(4)
		12



Question Number	Scheme	Marks
7.		
(a)	Total extn. = 0.6 $T_b = \dfrac{\lambda \times \text{ext}}{l} = \dfrac{2(0.3-x)}{0.7} = \dfrac{2}{7}(3-10x)$ *	M1 A1 (2)
(b)	$T_a = \dfrac{2(x+0.3)}{0.7} \quad \left(= \dfrac{2}{7}(10x+3)\right)$	B1 (1)
(c)	$T_b - T_a = 0.5\ddot{x}$ $\dfrac{2}{7}(3-10x) - \dfrac{2}{7}(10x+3) = 0.5\ddot{x}$ $2 \times \left(-\dfrac{20x}{7}\right) = 0.5\ddot{x}$ $\ddot{x} = -\dfrac{40}{7 \times 0.5}x$ $(\therefore$ S.H.M.$)$ Period $= \dfrac{2\pi}{\omega} = 2\pi\sqrt{\dfrac{7 \times 0.5}{40}} = 2\pi\sqrt{\dfrac{7}{80}}$ *	M1 A1 ft M1 A1 M1 A1 (6)
(d)	$v_{\max} = a\omega = 0.2\sqrt{\dfrac{80}{7}}$ o.e. or a.w.r.t. 0.68 m s^{-1}	M1 A1 (2)
(e)	$x = a\cos\omega t = 0.2\cos\left(\sqrt{\dfrac{80}{7}}t\right)$ $x = -0.1 \quad -\dfrac{0.1}{0.2} = \cos\left(\sqrt{\dfrac{80}{7}}t\right)$ $t = \sqrt{\dfrac{7}{80}}\cos^{-1}(-0.5)$ $t = \sqrt{\dfrac{7}{80}} \times \dfrac{2\pi}{3} = \dfrac{\pi}{3}\sqrt{\dfrac{7}{20}}$ o.e. (accept a.w.r.t. 0.62) s	M1 A1 M1 A1 (4) **15**