Question Number	Scheme	Marks
1(a)	$T_{AP} = 6mg$	M1
	$\frac{6mgx}{8a} = 6mg$	M1
	$AP = 16a$	A1
		(3)
1(b)	$2mg = \frac{6mgy}{3a}$	M1
	$y = a$	A1
	$PQ = 4a$	A1 (3)
		(6)
	Notes for question 1	
1(a)	M1 for resolving vertically for the system	
	M1 Use of Hooke's Law to set up an equation using their tension M0 if $11a$ is used for natural length	
	A1 cao	
1(b)	M1 M0 if $11a$ is used for natural length	
	A1 cao	
	A1 cao	

Question Number	Scheme	Marks
2.	$T\cos\theta(+R) = mg$	M1A1
	$T\sin\theta = ma\sin\theta\dfrac{2g}{a} \quad (T = 2mg)$	M1A1
	$\cos\theta < \dfrac{1}{2}$ or $\cos\theta \le \dfrac{1}{2}$ or $\cos\theta = \dfrac{1}{2}$	M1
	$\theta > 60$ or $\theta \ge 60$	A1
	$90 > \theta > 60$ or $90 > \theta \ge 60$	A1
		(7)
	Notes for question 2	
	M1 for resolving vertically, correct no. of terms, T resolved	
	A1 for a correct equation	
	M1 for equation of motion horizontally	
	A1 for a correct unsimplified equation	
	M1 for producing an appropriate inequality in $\cos\theta$ Allow an equation	
	A1 Must come from an inequality.	
	A1 cao	
3(a)	$a = v\dfrac{\mathrm{d}v}{\mathrm{d}x} = -\dfrac{2}{(2x+1)^3}$ separate and integrate	M1
	$\dfrac{1}{2}v^2 = \dfrac{1}{2(2x+1)^2} + (C)$	A1
	$x = 0,\ v = 1 \Rightarrow C = 0$	M1
	$v = \dfrac{1}{(2x+1)}$	A1
		(4)
3(b)	$\dfrac{\mathrm{d}x}{\mathrm{d}t} = \dfrac{1}{(2x+1)}$ separate and integrate	M1
	$x^2 + x + (D) = t$	A1
	Complete the square: $(x+\frac{1}{2})^2 - \frac{1}{4} = t$ or use quadratic formula: $x = \dfrac{-1 \pm \sqrt{1+4t}}{2}$	M1
	$x = \dfrac{1}{2}(\sqrt{(4t+1)} - 1)$ *	A1* (4)
		(8)
	Notes for question 3	
3(a)	M1 allow omission of - sign, powers increasing by 1	
	A1 correct equation, but allow omission of C	
	M1 use of initial conditions to find C	
	A1 cso	
3(b)	M1 powers increasing by 1	
	A1 correct equation, but allow omission of D	

1

Question Number	Scheme	Marks
	M1 complete the square	
	A1* given answer correctly obtained, with at least one line of working and justification of positive root e.g. $x > 0$	
4(a)	$\bar{x} = \dfrac{\pi\int_0^r x\left(r^2 - x^2\right)\mathrm{d}x}{\frac{2\pi r^3}{3}}$	M1A1
	$= \dfrac{\left[r^2\frac{x^2}{2} - \frac{x^4}{4}\right]_0^r}{\frac{2r^3}{3}}$	A1
	$= \dfrac{3r}{8}$ *	A1*
		(4)
4(b)	Mass ratios: $\dfrac{2\pi r^3}{3}$ $\quad \pi r^2 h \quad$ $\left(\dfrac{2\pi r^3}{3} + \pi r^2 h\right)$	B1
	Distances: $\dfrac{5r}{8}$ $\quad \left(r + \dfrac{1}{2}h\right) \quad$ $\bar{y}$	B1
	$\left(\dfrac{2\pi r^3}{3} \times \dfrac{5r}{8}\right) + \pi r^2 h\left(r + \dfrac{1}{2}h\right) = \left(\dfrac{2\pi r^3}{3} + \pi r^2 h\right)\bar{y}$	M1A1
	$\bar{y} = \dfrac{5r^2 + 12rh + 6h^2}{8r + 12h}$ *	A1*
		(5)
4(c)	$r = \dfrac{5r^2 + 12rh + 6h^2}{8r + 12h}$	M1
	$r = \sqrt{2}h$	A1
		(2)
		(11)
	Notes for question 4	

Question Number	Scheme	Marks
4(a)	M1 for use of $\bar{x} = \dfrac{\pi\int_0^r xy^2\,dx}{\frac{2\pi r^3}{3}}$	
	A1 for $\bar{x} = \dfrac{\pi\int_0^r x\left(r^2 - x^2\right)dx}{\frac{2\pi r^3}{3}}$	
	M1 for integrating with powers increasing by 1	
	A1* for given answer correctly obtained	
4(b)	B1 correct mass ratios	
	B1 correct distances (for their parallel axis)	
	M1 for use of a moments equation with correct terms (Allow about a parallel axis)	
	A1 for correct unsimplified equation (for their parallel axis)	
	A1* for given answer correctly obtained	
4(c)	M1 for equating given answer to r oe	
	A1 cao	

Question Number	Scheme	Marks
5(a)	$\frac{1}{2}mu^2 - \frac{1}{2}mv^2 = mga(1+\cos\theta)$	M1A2,1,0
	$mg\cos\theta = \frac{mv^2}{a}$	M1A1
	Eliminate θ	M1
	$3v^2 = u^2 - 2ag$ *	A1*
		(7)
5(b)	Vertical motion: $-\frac{a\sqrt{3}}{2} = (v\sin 30^o)T - \frac{1}{2}gT^2$	M1A1
	Solve for T: $T = \frac{v \pm \sqrt{v^2 + 4ag\sqrt{3}}}{2g}$	M1
	Use $v^2 = ag\frac{\sqrt{3}}{2}$ and $T > 0$ to show the given answer: $T = \frac{2v}{g}$	A1*
		(4)
5(c)	Horizontal motion: $x = v\cos 30^o \times \frac{2v}{g}$	M1
	$= \frac{3a}{2}$ and hence taut $(= a + a\sin30^o)$*	A1*
		(2)
		(13)
	Notes for question 5	
5(a)	M1 for an energy equation with the correct terms	
	A2 for a correct equation, A1 for an equation with at most one error	
	M1 for an equation of motion towards O with correct terms, condone sign errors and sin/cos confusion (R may appear)	
	A1 for a correct equation ($R = 0$ must be used at some point)	
	M1 for eliminating θ	
	A1* for given answer correctly obtained	
5(b)	M1 for equation for vertical motion ,with correct terms, condone sign errors and sin/cos confusion	
	A1 for a correct equation	
	M1 for solving for T	
	A1* for correctly obtaining the given answer	
5(c)	M1 for equation for horizontal motion ,with correct terms, condone sign errors and sin/cos confusion	
	A1* for given answer correctly justified	

Question Number	Scheme	Marks
6(a)	$mg = \frac{\lambda \times 4l}{2l} \Rightarrow \lambda = \frac{1}{2}mg$	M1 A1
	$mg - \frac{\frac{1}{2}mg(x+4l)}{2l} = m\ddot{x}$ (or x replaced by $-x$ on both sides)	M1 A2,1,0
	$-\frac{g}{4l}x = \ddot{x}$, hence SHM (with $\omega = \sqrt{\frac{g}{4l}}$)	A1
	$T = \frac{2\pi}{\omega}$	M1
	$2\pi\sqrt{\frac{4l}{g}} = 4\pi\sqrt{\frac{l}{g}}$ *	A1*
		(8)
6(b)	Their $\omega \times 2l$	M1
	$\sqrt{gl}$	A1
	$\frac{1}{2}mgl$	A1
		(3)
6(c)	$-l = 2l\cos\omega t$	M1A1
	$t = \frac{2\pi}{3\omega}$	M1
	$\frac{1}{3}T$	A1
		(4)
		(15)
	Notes for question 6	
6(a)	M1 Resolving vertically and using Hooke's Law	
	A1 cao	
	M1 equation of motion in a general position with correct no. of terms, allow use of accln instead of derivative	
	A2 for a correct equation, A1 for an equation with at most one error	
	A1 for correct equation in correct form	
	M1 Use of correct formula	
	A1* Given answer correctly obtained	
6(b)	M1 for use of correct formula	
	A1 for correct speed	
	A1 cao	
6(c)	M1 for complete method to find t	
	A1 for correct equation(s) (ω does not need to be substituted for this mark)	
	M1 for solving for t	
	A1 cso	

Question Number	Scheme	Marks
7(a)	EPE Gain = $\dfrac{2mgx^2}{2a}$	B1
	PE loss = $mgx\sin\alpha$	B1
	WD against friction = $\mu mg\cos\alpha \times x$	B1
	$\mu mg\cos\alpha \times x = mgx\sin\alpha - \dfrac{2mgx^2}{2a}$	M1
	$x = AB = a(\sin\alpha - \mu\cos\alpha)$ *	A1*
		(5)
7(b)	$\mu mg\cos\alpha \times y = mgy\sin\alpha - \dfrac{1}{2}mv^2 - \dfrac{2mgy^2}{2a}$	M1A2,1,0
	At max speed, $\mu mg\cos\alpha = mg\sin\alpha - \dfrac{2mgy}{a}$	M1
	$y = \dfrac{1}{10}a$	A1
	Use their y value to find the max speed	M1
	$v = \sqrt{\dfrac{ag}{50}}$ oe	A1
		(7)
7(b)	$\mu mg\cos\alpha \times y = mgy\sin\alpha - \dfrac{1}{2}mv^2 - \dfrac{2mgy^2}{2a}$	M1A2,1,0
7(c)	At B, nett force down plane = $\dfrac{3}{5}mg - \dfrac{2mgx}{a} = \dfrac{1}{5}mg$	M1
	Max friction available = $\dfrac{1}{2} \times mg \times \dfrac{4}{5} = \dfrac{2}{5}mg$	B1
	Hence, friction = $\dfrac{1}{5}mg$ up and P remains at B.	A1
		(3)
		(15)
	Notes for question 7	
7(a)	B1 correct expression	
	B1 correct expression	
	B1 correct expression	
	M1 for energy equation dim correct with correct terms, condone sign errors	
	A1* for given answer correctly obtained	
7(b)	M1 for energy equation, dim correct with correct terms, condone sign errors	
	A2 for a correct unsimplified equation, A1 for for a correct unsimplified equation with at most one error	
	M1 for finding the resultant force parallel to the plane and equating to 0 or differentiating energy equation wrt y and equating $\dfrac{dv}{dy}$ to 0	

1

Question Number	Scheme	Marks
	A1 for correct value of y	
	M1 for using their y value to find the max speed	
	A1 cao	
7(b)	M1 for energy equation, dim correct with correct terms, condone sign errors	
7(c)	M1 for finding nett force up or down plane, correct terms, condone sign errors	
	B1 for max friction	
	A1 correct conclusion and justification	