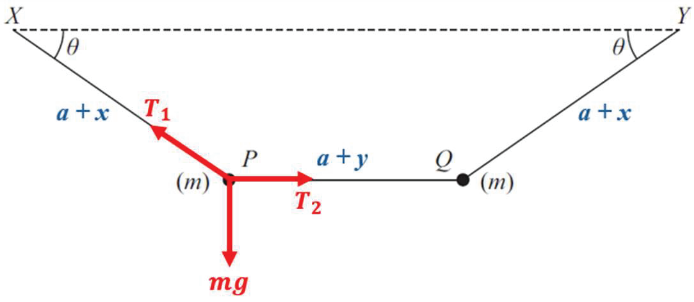
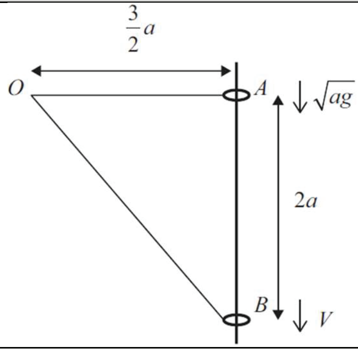
WME03 2501
Mark Scheme

Question Number	Scheme		Marks
1(a)	Differentiate the second expression with respect to t		M1
	Correct derivative $(a=)\frac{1}{4}t+\frac{8}{t^2}$		A1
	$t=8$, $(a=)\ \frac{17}{8}=2\frac{1}{8}$ oe		A1
			(3)
1(b)	Equate velocity expressions, substitute $t=4$ and solve for k $\frac{1}{8}(4)^2=\frac{1}{8}(4)^2-\frac{8}{(4)}+k \quad\Rightarrow\quad k=\ldots$		M1
	$k=2$		A1
	Integrate $v\left(0\leqslant t<4\right)$ wrt t $\int\frac{1}{8}t^2\mathrm{d}t=\frac{1}{24}t^3\quad(+C)$		M1
	Integrate $v\left(t\geqslant 4\right)$ wrt t $\int\frac{1}{8}t^2-\frac{8}{t}+\text{"2"}\mathrm{d}t=\frac{1}{24}t^3-8\ln t+\text{"2"}t\quad(+C)$		M1
	Either • a correct **definite** integral • **and** the correct limits, 4 and 8. $\left[\frac{1}{24}t^3-8\ln t+\text{"2"}t\right]_4^8$	**Or** • a correct **indefinite** integral $\frac{1}{24}t^3-8\ln t+\text{"2"}t+C$ • **and** use $t=4$ to equate distances to find an expression for the constant of integration $\frac{4^3}{24}=\frac{4}{24}^3-8\ln 4+4(\text{"2"})+C$	A1 ft
	$(x=)\ \frac{88}{3}-8\ln 2$		A1
			(6)
			(9)
	Notes for question 1		
Note: There is a calculator warning so candidates must show their differentiation and integration.			
(a)			
M1	Differentiate the second expression wrt t, with both powers decreasing by 1. M0 if numerical answer appears without sight of the derivative.		
A1	Correct derivative, accept $\frac{2t}{8}+8t^{-2}$, $\frac{1}{4}t+\frac{8}{t^2}$ o.e.		
A1	Correct answer, accept 2.125, 2.13, 2.1		

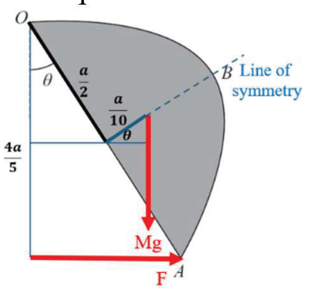
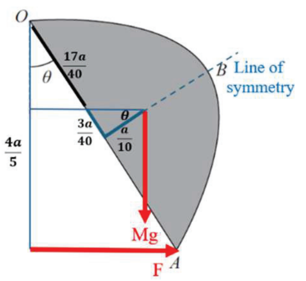
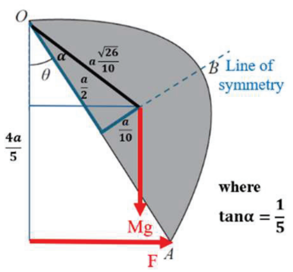
Question Number	Scheme	Marks
(b)		
M1	Equate the given expressions for v, substitute $t = 4$ and solve for k. If k is found in part (a) it must be used in (b) to earn the marks.	
A1	Correct answer for k	
M1	Attempt to integrate $v\left(0 \leqslant t < 4\right)$ wrt t, with power of t increasing by 1. M0 if numerical answer appears without sight of the integral. $\left(\text{no need to evaluate to } \frac{8}{3} \text{ at this stage}\right)$	
M1	Attempt to integrate $v\left(t \geqslant 4\right)$ wrt t, with a power of t increasing by 1 and a ln$t$. Condone working with k or their numerical k. M0 if numerical answer appears without sight of the integral.	
A1ft	Integrate $v\left(t \geqslant 4\right)$ wrt t. Condone working in terms of k or ft on their numerical k. $\left(\frac{80}{3} - 8\ln 2 \text{ oe may be seen but is not necessary for this mark}\right)$ $\left(C = 8\ln 4 - 8 \text{ oe may be seen but is not necessary for this mark}\right)$	
A1	Correct answer, $\frac{88}{3} - 8\ln 2$, $\frac{88}{3} + 8\ln\frac{1}{2}$, $\frac{88}{3} + 8\ln 0.5$ Accept equivalent exact form but must have fractions combined and ln terms combined	

Question Number	Scheme	Marks
2		
	First relevant force equation	M1
	Correct unsimplified equation Relevant force equations: • Horiz $T_1 \cos\theta = T_2$ Vert $T_1 \sin\theta = mg$ or $2T_1 \sin\theta = 2mg$ • // $T_1 = T_2 \cos\theta + mg\sin\theta$ Perp $T_2 \sin\theta = mg\cos\theta$ (accept $T_2 \tan\theta = mg$) • Lami $\frac{T_2}{\sin(90+\theta)} = \frac{mg}{\sin(180-\theta)} = \frac{T_1}{\sin 90}$ $\frac{T_2}{\cos\theta} = \frac{mg}{\sin\theta} = \frac{T_1}{\sin 90}$ It may be useful to note the simplified expressions for tensions are $T_1 = \frac{5mg}{3}$, $T_2 = \frac{4mg}{3}$ but need not be seen explicitly.	A1
	Second relevant force equation	M1
	Correct unsimplified equation	A1
	Hooke's Law for either tension $T_1 = \frac{\frac{20mg}{7}x}{a}$ or $T_2 = \frac{\frac{20mg}{7}y}{a}$	B1
	Solve their relevant force equation(s) and HL to find x or y	M1
	$x = \frac{7a}{12}$, $y = \frac{7a}{15}$	A1 A1
	$(XY =)\ 2(a+x)\cos\theta + (a+y)$	DM1
	$= 4a$	A1
		(10)
	Notes for question 2	
M1	First relevant force equation. All required forces present with no extras, condone sign errors and sin/cos confusion. M0 if $T_{XP} = T_{PQ}$ or $T_{PQ} = T_{QY}$. Condone W instead of mg.	
A1	Correct unsimplified equation. Condone W instead of mg.	

Question Number	Scheme	Marks
M1	Second relevant force equation.To be relevant, it must be possible to combine with the first force equation to find both T_1 and T_2. All required forces present with no extras, condone sign errors and sin/cos confusion. Condone W instead of mg. M0 if $T_{XP} = T_{PQ}$ or $T_{PQ} = T_{QY}$.	
A1	Correct unsimplified equation. Condone W instead of mg.	
B1	Correct use of Hooke's Law. Accept with extension in terms of the lengths PX and QY. Eg $T_1 = \frac{\frac{20mg}{7}(PX - a)}{a}$ $\quad T_2 = \frac{\frac{20mg}{7}(QY - a)}{a}$	
M1	Solve their relevant force equation and HL to find the unknown extension (x or y) or length PX or QY in terms of a. HL must be of the form $\frac{\lambda x}{ka}$ where k is a constant. If using W, it must be replaced with mg here.	
A1	One correct (x or y) or (PX or QY) $PX = \frac{19a}{12}$ $\quad QY = \frac{22a}{15}$	
A1	Both correct (x and y) or (PX and QY)	
DM1	Dependent on the first two method marks. Complete expression for XY with calculated x and y, condone sin/cos confusion.	
A1	cao	

Question Number	Scheme	Marks
3		
	Attempt to find final extension: $\sqrt{\left(\left(\frac{3a}{2}\right)^2+(2a)^2\right)}-a$	M1
	Method to find at least one expression for EPE	M1
	Two correct expressions for EPE (final and initial) $\frac{mg}{2a}\left(\frac{3a}{2}\right)^2$, $\frac{mg}{2a}\left(\frac{a}{2}\right)^2$	A1
	GPE Loss = $mg\times 2a$	B1
	Use of conservation of mechanical energy	M1
	$mg\times 2a+\frac{1}{2}mag+\frac{mg}{2a}\left(\frac{a}{2}\right)^2=\frac{1}{2}mV^2+\frac{mg}{2a}\left(\frac{3a}{2}\right)^2$ $\left(2mga+\frac{1}{2}mag+\frac{mga}{8}=\frac{1}{2}mV^2+\frac{9mga}{8}\right)$	A1
	$(V=)\ \sqrt{3ag}$	A1
		(7)
	Notes for question 3	
M1	Complete method to find the final extension (their $OB-a$). May see use of the 3,4,5 triangle or Pythagoras to find OB. May be implied by a correct final extension.	
M1	Method using EPE formula at least once. EPE must have the form $\frac{\lambda x^2}{k a}$ where λ is modulus of elasticity, x is their extension and k is a constant (condone $k=1$).	
A1	Two correct expressions for EPE	
B1	GPE term seen or implied	
M1	Use of the principle of conservation of mechanical energy. All required terms present and of the correct structure with no extras (2 EPE, 2KE, GPE). Condone sign errors. Note there are different rearrangements. For example, Initial = Final $\quad mg\times 2a+\frac{1}{2}mag+\frac{mg}{2a}\left(\frac{a}{2}\right)^2=\frac{1}{2}mV^2+\frac{mg}{2a}\left(\frac{3a}{2}\right)^2$	

Question Number	Scheme	Marks
	Gain = Loss $\frac{1}{2}mV^2 - \frac{1}{2}mag + \frac{mg}{2a}\left(\frac{3a}{2}\right)^2 - \frac{mg}{2a}\left(\frac{a}{2}\right)^2 = mg \times 2a$	
A1	Correct unsimplified equation	
A1	Correct answer in terms of a and g, accept $1.3\sqrt{ag}$ or better	

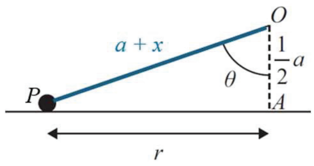
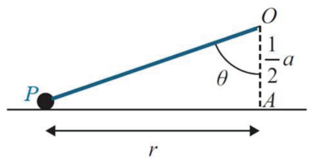
Question Number	Scheme	Marks
4(a)	Use of $\frac{1}{2}\int y^2\,\mathrm{d}x$ with $y=\frac{1}{a}(ax-x^2)$ to integrate the expression $\left(\frac{1}{2}\right)\left(\frac{1}{a}(ax-x^2)\right)^2$ oe	M1
	Correct integration $\left(\frac{1}{2}\right)\frac{1}{a^2}\left[\frac{a^2x^3}{3}-\frac{2ax^4}{4}+\frac{x^5}{5}\right]$	A1
	Use of $\int y\,\mathrm{d}x$ with $y=\frac{1}{a}(ax-x^2)$ to integrate the expression $\frac{1}{a}(ax-x^2)$ oe	M1
	Correct integration $\frac{1}{a}\left[\frac{ax^2}{2}-\frac{x^3}{3}\right]$	A1
	Correct use of centre of mass formula for $\bar{y}$ with $y=\frac{1}{a}(ax-x^2)$ $\bar{y}=\dfrac{\frac{1}{2}\int_0^a \frac{1}{a^2}(ax-x^2)^2\,\mathrm{d}x}{\int_0^a \frac{1}{a}(ax-x^2)\,\mathrm{d}x}\quad\left(=\dfrac{\frac{a^3}{60}}{\frac{a^2}{6}}\right)$	M1
	$(\bar{y}=)\ \frac{1}{10}a$	A1
		(6)
4(b)	$\bar{x}=\frac{1}{2}a$	B1
	Horizontal distance of G from the vertical at O Examples of valid methods  $\frac{a}{2}\sin\theta+\frac{a}{10}\cos\theta$ $\frac{17a}{40}\sin\theta+\frac{a}{8}$ $\frac{a\sqrt{26}}{10}\sin(\theta+\alpha)$	M1
	Correct horizontal distance $\frac{19a}{50}$	A1

Question Number	Scheme	Marks
	Moments equation about O to form an equation in F, M, θ (and g)	DM1
	$Fa\cos\theta = Mg\times d$	A1
	$F = \frac{19Mg}{40}$ oe	A1
		(6)
		(12)
	Notes for question 4	
4(a)		
M1	Attempt to integrate $\frac{1}{2}y^2$ with $y = \frac{1}{a}(ax - x^2)$. Must see at least two powers of x increasing by 1. Ignore any limits and condone missing $\frac{1}{2}$. The correct expansion to integrate is $\left(\frac{1}{2}\right)\frac{1}{a^2}(a^2x^2 - 2ax^3 + x^4)$ oe. Condone a slip when expanding the brackets before integration.	
A1	Correct integrated expression (ignore limits, condone missing $\frac{1}{2}$)	
M1	Attempt to integrate y with $y = \frac{1}{a}(ax - x^2)$. Must see both powers of x increase by 1. Ignore any limits.	
A1	Correct integrated expression (ignore limits)	
M1	Complete method to find $\bar{y}$. Use of the correct formula (up the right way). If ρ appears it must appear in both numerator and denominator. Limits must be correct and $\frac{1}{2}$ must be present. $\bar{y} = \dfrac{\frac{1}{2}\int_0^a \frac{1}{a^2}(ax - x^2)^2\,\mathrm{d}x}{\int_0^a \frac{1}{a}(ax - x^2)\mathrm{d}x}$	
A1	Correct answer, $\frac{1}{10}a$ or $0.1a$ oe	
4(b)		
B1	$\bar{x} = \frac{1}{2}a$ seen or implied. May be seen on diagram, embedded in a length eg $\frac{1}{2}a\sin\theta$ or found from first principles using $\bar{x}\int_0^a y\,\mathrm{d}x = \int_0^a xy\,\mathrm{d}x$	
M1	A complete method to obtain the required horizontal distance from G to the vertical at O. For example, method to find the lengths of two right-angled triangles that sum to the required distance. Condone sin/cos confusion.	
A1	Correct horizontal distance	

Question Number	Scheme	Marks
DM1	Dependent on first method mark. Moments about O, using the horizontal distance, to obtain an equation in F, M and θ (and a). Dimensionally correct with all required terms of the correct structure and no extras. Condone sin/cos confusion. Missing g is an accuracy error.	
A1	Correct unsimplified equation.	
A1	Accept $0.48Mg$ or $0.475Mg$ (must be in terms of M and g)	

Question Number	Scheme	Marks
5(a)	$\frac{1}{2}mU^2 - \frac{1}{2}mV^2 = mg\left(a + \frac{a}{4}\sin\theta\right)$	M1A1A1
	$V^2 = U^2 - \frac{ag}{2}(4 + \sin\theta)$ *	A1*
		(4)
5(b)	Equation of motion towards the peg	M1
	$T + mg\sin\theta = m\frac{V^2}{\left(\frac{a}{4}\right)}$	A1
	Eliminate V^2 $T + mg\sin\theta = \frac{4m}{a}(U^2 - \frac{ag}{2}(4 + \sin\theta))$	DM1
	$T = \frac{4mU^2}{a} - 8mg - 3mg\sin\theta$	A1
		(4)
5(c)	Substitute $U = \sqrt{\frac{19ag}{8}}$ and $T = 0$ in their equation of motion and solve for $\sin\theta$ $\frac{4m}{a}\left(\sqrt{\frac{19ag}{8}}\right)^2 - mg(8 + 3\sin\theta) = 0 \quad \Rightarrow \quad \sin\theta = ...$	M1
	$\sin\theta = \frac{1}{2} \quad \Rightarrow \text{height} = \frac{1}{8}a$	A1
		(2)
		(10)
	Notes for question 5	
5(a)		
M1	Energy equation with the correct number of terms (2KE, GPE). All terms dimensionally correct and with the correct structure. Condone sign errors and sin/cos confusion. Must include m in each term.	
A1	Correct unsimplified equation with at most one error	
A1	Correct unsimplified equation	
A1*	Answer obtained from complete and correct working. There must be at least one line of working or simplification between the initial equation and the given answer. Accept $V^2 = U^2 - \frac{ag}{2}(\sin\theta + 4)$, $V^2 = U^2 - \frac{1}{2}ag(4 + \sin\theta)$, $V^2 = U^2 - \frac{1}{2}ag(\sin\theta + 4)$	
5(b)		
M1	Equation of motion towards the peg. Must have all required terms and no extras. Condone sin/cos confusion and sign errors. Accept any form of acceleration, condone 'a' for acceleration for the method mark only.	

Question Number	Scheme	Marks
A1	Correct equation using the form $\frac{v^2}{r}$ for acceleration where $r = \frac{a}{4}$	
DM1	Dependent on the first M. Use the given answer from (a) to eliminate V^2 from their equation of motion and form an equation in T, m, g, u, a and θ. Condone a slip when transferring the expression for V^2 as long as the intention to use the expression given in (a) is clear.	
A1	A correct expression for T with $\sin\theta$ terms collected. ISW once the correct expression is seen with collected terms.	
5(c)		
M1	Substitute $U^2 = \frac{19ag}{8}$ and $T = 0$ in their equation of motion to find a value for $\sin\theta$. M0 for using $V = 0$	
A1	Correct answer, accept $0.13a$ and $0.125a$	

<table>
<tr><th>Question Number</th><th colspan="2">Scheme</th><th>Marks</th></tr>
<tr><td rowspan="9">6(a)</td><td colspan="2">Horizontal equation of motion</td><td>M1</td></tr>
<tr><td colspan="2">$T\sin\theta=\frac{mrg}{a}$</td><td>A1</td></tr>
<tr><td>Use triangle AOP to form an equation in θ, r, a and x

</td><td>Use triangle AOP to form an equation in θ, r and OP

</td><td>M1</td></tr>
<tr><td>Eg
• $\sin\theta=\frac{r}{a+x}$</td><td>Eg
• $\sin\theta=\frac{r}{OP}$
• $r=OP\sin\theta$</td><td>A1</td></tr>
<tr><td>Use of HL with x
$T=\frac{3mgx}{a}$</td><td>Use of HL with OP
$T=\frac{3mg\left(OP-a\right)}{a}$</td><td>M1</td></tr>
<tr><td>Eliminate θ and T</td><td>Eliminate θ and T</td><td>DM1</td></tr>
<tr><td>Eg
• $\frac{3mgx}{a}\left(\frac{r}{a+x}\right)=\frac{mgr}{a}$</td><td>Eg
• $\frac{3mg\left(OP-a\right)}{a}\left(\frac{r}{OP}\right)=\frac{mgr}{a}$</td><td>A1</td></tr>
<tr><td colspan="2">$(OP=)\ \frac{3}{2}a$ *</td><td>A1*</td></tr>
<tr><td colspan="2"></td><td>(8)</td></tr>
<tr><td rowspan="5">6(b)</td><td colspan="2">Vertical equilibrium</td><td>M1</td></tr>
<tr><td colspan="2">$"R"+T\cos\theta=mg$</td><td>A1</td></tr>
<tr><td colspan="2">Use $T=\frac{3mg}{2}$ and $\cos\theta=\frac{1}{3}$ to find an expression for $"R"$ in terms of m and g only</td><td>DM1</td></tr>
<tr><td colspan="2">$(R=)\ \frac{1}{2}mg$</td><td>A1</td></tr>
<tr><td colspan="2"></td><td>(4)</td></tr>
<tr><td rowspan="2">6(c)</td><td colspan="2">$\text{EPE}=\frac{3mg}{2a}\left(\frac{1}{2}a\right)^2\quad\left(=\frac{3mga}{8}\right)$</td><td>B1</td></tr>
<tr><td colspan="2">Expression for sum of EPE and KE
KE of the form $\frac{1}{2}m\left(r\omega\right)^2$ with $\omega=\sqrt{\frac{g}{a}}$ and $r=\sqrt{\left(\frac{3a}{2}\right)^2-\left(\frac{a}{2}\right)^2}$
$\left(r\omega=\sqrt{2ag}\right)$</td><td>M1</td></tr>
</table>

Question Number	Scheme	Marks
	$=\frac{1}{2}m\left(a\sqrt{2}\sqrt{\frac{g}{a}}\right)^2+\frac{3mg}{2a}\left(\frac{1}{2}a\right)^2$	A1
	$=\frac{11mga}{8}$	A1
		(4)
		(16)
	Notes for question 6	
6(a)		
M1	Horizontal equation of motion. All required terms and no extras. Condone sin/cos confusion. Acceleration does not need to be replaced. Accept any form of acceleration, $r\omega^2$ or $\frac{v^2}{r}$. Condone a for acceleration for this M mark only.	
A1	Correct equation with acceleration correctly replaced and correct radius. A0 if OP is the radius.	
M1	Use triangle OPA to form an equation in θ, r and **either** OP **or** a and x. Condone sin/cos confusion. (Pythagoras alone is M0)	
A1	Correct equation	
M1	Use of Hooke's Law in terms of x or OP	
DM1	Dependent on all 3 previous M marks. Eliminate T and θ to produce an equation in m, g, a, r and either OP or x (r's may have been cancelled)	
A1	Correct equation	
A1*	Given answer obtained from complete and correct working. Condone missing OP. Accept $\frac{3}{2}a$, $\frac{3a}{2}$.	
6(b)		
M1	Method using vertical equilibrium. All required terms present and no extras. Condone sign errors and sin/cos confusion. If seen in part (a), it must be used in (b) to earn the marks. Note that R is not defined in the question, may use another letter or even the wording from the question.	
A1	Correct unsimpified equation.	
DM1	Dependent on previous M. Substitute for T and $\cos\theta$ to obtain an expression for "R" in terms of m and g only.	
A1	Correct answer in terms of m and g	
6(c)		
B1	Correct expression for EPE	
M1	Method to find total, KE + EPE. Must have terms added together and not just listed. Required terms only. Dimensionally correct expression with energy terms of the correct structure. KE term, must use $v=r\omega$ with $\omega=\sqrt{\frac{g}{a}}$ and $r=\sqrt{\left(\frac{3a}{2}\right)^2-\left(\frac{a}{2}\right)^2}$	
A1	Correct unsimplified expression.	
A1	Correct answer. Must be simplified to one term in m, g and a. Accept $1.375mga$, $1.38\,mga$, $1.4\,mga$.	

<table>
<tr><th>Question Number</th><th colspan="2">Scheme</th><th>Marks</th></tr>
<tr><td>7(a)</td><td>General equation of motion for particle, measuring up from E.
$T-\frac{3mg}{2}=\frac{3m\ddot{x}}{2}$</td><td>General equation of motion for particle, measuring down from E.
$\frac{3mg}{2}-T=\frac{3m\ddot{x}}{2}$</td><td>M1</td></tr>
<tr><td></td><td>Use HL in equation of motion with extension $\left(\frac{3L}{8}\pm x\right)$</td><td>Use HL in equation of motion with extension $\left(\frac{3L}{8}\pm x\right)$</td><td>DM1</td></tr>
<tr><td></td><td>Correct equation
$\frac{4mg}{L}\left(\frac{3L}{8}-x\right)-\frac{3mg}{2}=\frac{3m\ddot{x}}{2}$</td><td>Correct equation
$\frac{3mg}{2}-\frac{4mg}{L}\left(\frac{3L}{8}+x\right)=\frac{3m\ddot{x}}{2}$</td><td>A1</td></tr>
<tr><td></td><td colspan="2">Complete conclusion
$-\frac{8g}{3L}x=\ddot{x} \quad \therefore \quad SHM \quad *$</td><td>A1*</td></tr>
<tr><td></td><td colspan="2">Identify ω from SHM method and use to find the Period</td><td>DM1</td></tr>
<tr><td></td><td colspan="2">$\omega^2=\frac{8g}{3L}$ or $\omega=\sqrt{\frac{8g}{3L}}$
Period $=\frac{2\pi}{\omega}=2\pi\sqrt{\frac{3L}{8g}}=\pi\sqrt{\frac{3L}{2g}}$ *</td><td>A1*</td></tr>
<tr><td></td><td colspan="2"></td><td>(6)</td></tr>
<tr><td>7(b)</td><td colspan="2">Correct amplitude, $a=\frac{1}{2}L$</td><td>B1</td></tr>
<tr><td></td><td colspan="2">Use of SHM displacement equation with amplitude substituted. No need to substitute for ω.
[1] $x=-a\cos\omega t$
[2] $x=a\cos\omega t$
[3] $x=a\sin\omega t$
[4] $x=-a\sin\omega t$</td><td>M1</td></tr>
<tr><td></td><td colspan="2">Complete method to find an equation for a relevant time. No need to substitute for ω.

Either
Use $\ddot{x}=-\omega^2 x$ with $-\frac{2g}{3}$ to find displacement $\left(x=\pm\frac{L}{4}\right)$ and use to form an equation in t (and ω).
i.e. combine $\pm\frac{L}{4}$ with one of [1], [2], [3] or [4] above.</td><td>M1</td></tr>
</table>

Question Number	Scheme	Marks
	(if starting again with N2L and HL, it reduces to $\pm\frac{4mgx}{L}=-mg$ $\Rightarrow \quad x=\pm\frac{L}{4}$) **Or** Substitute $-\frac{2g}{3}$ and their a in the corresponding acceleration equation to form an equation in t (and ω) [1] $\ddot{x}=a\omega^2\cos(\omega t)$ [2] $\ddot{x}=-a\omega^2\cos(\omega t)$ [3] $\ddot{x}=-a\omega^2\sin(\omega t)$ [4] $\ddot{x}=a\omega^2\sin(\omega t)$	
	Dependent on both previous M marks. Complete method to find the required time. Where appropriate, must use the correct proportion of the given period to find an expression for the required time. Must use the correct ω. [1] $t=\frac{1}{\omega}\times\cos^{-1}\left(-\frac{1}{2}\right)$ [2] $t=\frac{1}{\omega}\cos^{-1}\left(\frac{1}{2}\right)-\frac{\text{period}}{2}=\frac{5\pi}{3\omega}-\frac{\text{period}}{2}$ [3] $t=\frac{1}{\omega}\sin^{-1}\left(\frac{1}{2}\right)+\frac{\text{period}}{4}=\frac{\text{period}}{4}+\frac{\pi}{6\omega}$ [4] $t=\frac{1}{\omega}\sin^{-1}\left(-\frac{1}{2}\right)-\frac{\text{period}}{4}=\frac{7\pi}{6\omega}-\frac{\text{period}}{4}$	DM1
	$t=\frac{2\pi}{3}\sqrt{\frac{3L}{8g}}$ o.e.	A1
		(5)
		(11)
	Notes for question 7	
7(a)		
M1	Equation of motion in a *general* position ie T does not take a particular value. Allow a for acceleration here. Required terms present with no extras. Condone sign errors but must have a difference between T and weight. Condone missing $\frac{3}{2}$ in 'ma' term for this mark.	
DM1	Dependent on previous M. Use of Hooke's Law in a *general* equation of motion with general position measured from E. Extension in HL must be of the appropriate form: $\left(\frac{3L}{8}-x\right)$ or $\left(\frac{3L}{8}+x\right)$. Allow a for	

Question Number	Scheme	Marks
	acceleration, condone sign errors. Must use the correct mass, $\frac{3m}{2}$ in 'ma' term.	
A1	For a fully correct unsimplified equation. Must use $\ddot{x}$ for acceleration.	
A1*	Correct SHM equation and conclusion. Equation must have required form, $\ddot{x} = -\omega^2 x$ with $\ddot{x}$ for acceleration. Conclusion must include 'SHM'	
DM1	Dependent on both previous M's. Use of $\frac{2\pi}{\omega}$ where ω has come from an attempt at using N2L at a general point.	
A1*	Obtain the given answer for the period. Must follow from complete and correct working. At least one line of working must be seen between $\ddot{x} = -\frac{8g}{3L}x$ and reaching the given Period. Eg • period $= \frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{\frac{8g}{3L}}} = \pi\sqrt{\frac{3L}{2g}}$ • $\omega = \sqrt{\frac{8g}{3L}}$, period $= \frac{2\pi}{\omega} = \pi\sqrt{\frac{3L}{2g}}$ Note The score of M1 DM1 A1 A0* DM1 A1* is possible if there is no conclusion of 'SHM' The score of M1 DM1 A0 A0* DM1 A1* is possible if $\ddot{x}$ is not used for acceleration.	
7(b)		
B1	Correct amplitude, $\frac{L}{2}$.	
M1	Use of suitable SHM equation with their amplitude substituted. May be implied if starting with a corresponding velocity or acceleration equation. No need to replace ω.	
M1	All necessary steps completed to find an equation for a relevant time. No need to replace ω.	
DM1	Complete method to find an expression for the **required** time. Must use the correct ω.	
A1	Correct value for required time in **exact** form, in terms of L and g e.g. $\frac{2\pi}{3}\sqrt{\frac{3L}{8g}}$, $\frac{\pi}{3}\sqrt{\frac{3L}{2g}}$, $\pi\sqrt{\frac{L}{6g}}$, $\frac{\pi}{6}\sqrt{\frac{6L}{g}}$	