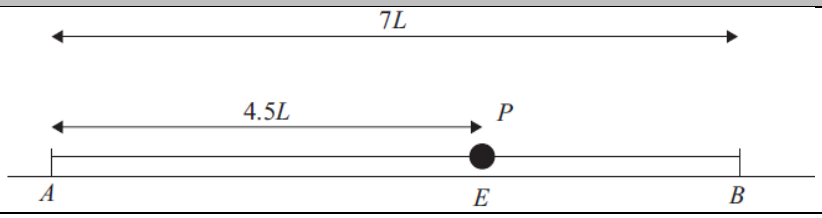
Question Number	Scheme	Marks
7(a)		
	Equation of motion for P at a general position $T_{PB} - T_{PA} = m\ddot{x}$	M1
	Use HL in the equation of motion	M1
	$\frac{2mg}{2L}(0.5L - x) - \frac{mg}{3L}(1.5L + x) = m\ddot{x}$	A1 A1
	Obtain SHM equation of the correct form and conclude $-\frac{4g}{3L}x = \ddot{x}$ **and** SHM	A1*
	Use of $\omega^2 = \frac{4g}{3L}$ with the formula period $= \frac{2\pi}{\omega}$	dM1
	Must include working that leads to the given answer for the period. For example • Clearly identify ω within the period formula to reach the answer period $= \frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{\frac{4g}{3L}}} = \pi\sqrt{\frac{3L}{g}}$ • Clearly identify ω and state the period formula to reach the answer $\omega = \sqrt{\frac{4g}{3L}}$, period $= \frac{2\pi}{\omega} = \pi\sqrt{\frac{3L}{g}}$ $\Rightarrow$ (period =) $\pi\sqrt{\frac{3L}{g}}$	A1*
		(7)
7(b)	amplitude $= 0.5L$	B1
	$v_{MAX} = a \times \sqrt{\frac{4g}{3L}}$	M1
	$= \sqrt{\frac{gL}{3}}$	A1
		(3)
7(c)	Method for use of SHM equation for displacement with their amplitude. [1] $x = a\cos\omega t$ [2] $x = a\sin\omega t$ [3] $x = -a\cos\omega t$ [4] $x = -a\sin\omega t$ [5] Any of the above with their x found after use of $v^2 = \omega^2(a^2 - x^2)$	M1

	Form SHM equation with $v=\sqrt{\frac{gL}{12}}$ [1] $v=-a\omega\sin\omega t$ [2] $v=a\omega\cos\omega t$ [3] $v=a\omega\sin\omega t$ [4] $v=-a\omega\cos\omega t$ [5] $v^2=\omega^2(a^2-x^2)$	M1
	Correct equation in g, L , t (and ω). [1] $\sqrt{\frac{gL}{12}}=-\sqrt{\frac{gL}{3}}\sin\omega t$ [2] $\sqrt{\frac{gL}{12}}=\sqrt{\frac{gL}{3}}\cos\omega t$ [3] $\sqrt{\frac{gL}{12}}=\sqrt{\frac{gL}{3}}\sin\omega t$ [4] $\sqrt{\frac{gL}{12}}=-\sqrt{\frac{gL}{3}}\cos\omega t$ [5] Correct expression for x: $\frac{gL}{12}=\omega^2\left(\frac{L^2}{4}-x^2\right) \Rightarrow x=L\frac{\sqrt{3}}{4}$ Accept answers from correct working which may include changing methods eg using [1] initially then switching to [3] in order to use an acute angle.	A1
	Correct expression for a relevant time. No need to replace ω [1] $t=\frac{1}{\omega}\sin^{-1}\left(-\frac{1}{2}\right) \left(=-\frac{\pi}{6\omega}\right)$ [2] $t=\frac{1}{\omega}\cos^{-1}\left(\frac{1}{2}\right) \left(=\frac{\pi}{3\omega}\right)$ [3] $t=\frac{1}{\omega}\sin^{-1}\left(\frac{1}{2}\right) \left(=\frac{\pi}{6\omega}\right)$ [4] $t=\frac{1}{\omega}\cos^{-1}\left(-\frac{1}{2}\right) \left(=\frac{2\pi}{3\omega}\right)$ [5] Correct for their approach above Accept answers from correct working which may include changing methods	A1
	Complete method to find the total time in terms of L and g [1] $-4t=-4\left(-\frac{\pi}{6}\right)\left(\frac{1}{2}\sqrt{\frac{3L}{g}}\right)$ [2] period $-4t=\pi\sqrt{\frac{3L}{g}}-4\left(\frac{\pi}{3}\right)\left(\frac{1}{2}\sqrt{\frac{3L}{g}}\right)$ [3] $4t=4\left(\frac{\pi}{6}\right)\left(\frac{1}{2}\sqrt{\frac{3L}{g}}\right)$	dM1

	[4] $4t - \text{period} = 4\left(\frac{2\pi}{3}\right)\left(\frac{1}{2}\sqrt{\frac{3L}{g}}\right) - \pi\sqrt{\frac{3L}{g}}$ [5] Correct for their approach above Accept answers from correct working which may include changing methods.	
	$\pi\sqrt{\frac{L}{3g}}$ o.e.	A1
		(6)
		(16)
Notes for question 7		
(a)		
M1	Equation of motion in a *general* position ie the tension expressions never take a fixed value. Allow *a* for acceleration here. Required terms present with no extras. Condone sign errors but must have a difference between T_{AP} and T_{BP}.	
M1	Use of Hooke's Law in an equation of motion in a general position with natural length and modulus of elasticity paired correctly. Accept extensions in terms of L and x if they sum to $2L$. Allow *a* for acceleration for the method mark only. Condone sign errors.	
A1	Unsimplified equation with at most one error. Acceleration must have the form $\ddot{x}$ seen at some stage. Incorrect acceleration notation is an accuracy error.	
A1	Fully correct unsimplified equation. Must use $\ddot{x}$ for acceleration at some stage.	
A1*	Correct SHM equation and conclusion. Equation must be in the required form, $\ddot{x} = -\omega^2 x$ with $\ddot{x}$ for acceleration and where ω is correct in terms of g and L. 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 a complete and correct solution. At least one line of working must be seen between $\ddot{x} = -\frac{4g}{3L}x$ and reaching the given period. **N.B.** The score of M1 DM1 A1 A1 A0* DM1 A1* is possible if there is no conclusion of 'SHM' The score of M1 DM1 A1 A0 A0* DM1 A1* is possible if $\ddot{x}$ is not used for acceleration.	
(b)		
B1	Amplitude $= 0.5L$, seen or implied	
M1	Complete correct method, amplitude $\times\sqrt{\frac{4g}{3L}}$. No need for amplitude to be substituted.	
A1	Correct answer in terms of L and g expressed as a single term then ISW.	

	i.e. For the final A, accept $\frac{1}{2}\sqrt{\frac{4gL}{3}}$ but not $\frac{1}{2}\times\sqrt{\frac{4gL}{3}}$ until expressed as a single term.	
(c)	**N.B.** A score of M0M1 is only possible for the first 2 marks if [5] is used to find x but this is never substituted correctly into an SHM displacement equation.	
M1	Method using SHM equation for displacement. Award if seen in part (c) with *their* amplitude substituted. This mark may be implied by using the SHM equation for velocity in terms of t.	
M1	Method using a relevant SHM equation with velocity, $v=\sqrt{\frac{gL}{12}}$	
A1	Correct equation in g, L , t (and ω) using $v=\sqrt{\frac{gL}{12}}$	
A1	Correct expression for a relevant time. No need to replace ω.	
dM1	Dependent on both previous M marks. Complete method to find the total time in terms of L and g only.	
A1	Correct answer in terms of L and g e.g $\pi\sqrt{\frac{L}{3g}}$, $\frac{\pi}{3}\sqrt{\frac{3L}{g}}$ Accept any equivalent expressed as a single term then ignore any subsequent surd manipulation. **N.B.** $4\times\left(\frac{\pi}{12}\sqrt{\frac{3L}{g}}\right)$ is not a single term until written without the multiplication sign i.e. $\frac{4\pi}{12}\sqrt{\frac{3L}{g}}$ Do not ISW if the method continues and is not complete at this stage.	

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