Pearson Edexcel

Mark Scheme (Results)

Summer 2025

Pearson Edexcel International Advanced Level
In Mechanics M3 (WME03) Paper 01

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL MATHEMATICS
General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN.

- bod – benefit of doubt
- ft – follow through
- the symbol $\sqrt{}$ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- d… or dep – dependent
- indep – independent
- dp decimal places

- sf significant figures
- ∗ The answer is printed on the paper or ag- answer given
- ⎾ or d… The second mark is dependent on gaining the first mark

4. All A marks are ‘correct answer only’ (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected. If you are using the annotation facility on ePEN, indicate this action by ‘MR’ in the body of the script.

6. If a candidate makes more than one attempt at any question:
   - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
   - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

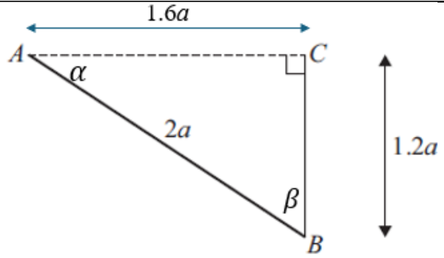
General Principles for Mechanics Marking

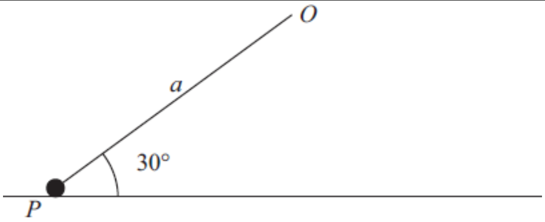
(NB specific mark schemes may sometimes override these general principles)

- Rules for M marks:
    - correct no. of terms
    - dimensionally correct
    - all terms that need resolving (i.e. multiplied by cos or sin) are resolved.
- Omission or extra g in a resolution is an accuracy error not method error.
- Omission of mass from a resolution is a method error.
- Omission of a length from a moments equation is a method error.
- Omission of units or incorrect units is not (usually) counted as an accuracy error.
- DM indicates a dependent method mark, i.e. one that can only be awarded if a previous specified method mark has been awarded.
- Any numerical answer which comes from use of g = 9.8 should be given to 2 or 3 SF.
- Use of g = 9.81 should be penalised once per (complete) question.
    - N.B. Over-accuracy or under-accuracy of correct answers should only be penalised *once* per complete question. However, premature approximation should be penalised every time it occurs.
- Marks must be entered in the same order as they appear on the mark scheme.
- In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c)…then that working can only score marks for that part of the question.
- Accept column vectors in all cases.
- Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft

Mechanics Abbreviations

M(A)	Taking moments about A
N2L	Newton's Second Law (Equation of Motion)
NEL	Newton's Experimental Law (Newton's Law of Impact)
HL	Hooke's Law
SHM	Simple harmonic motion
PCLM	Principle of conservation of linear momentum
RHS	Right hand side
LHS	Left hand side

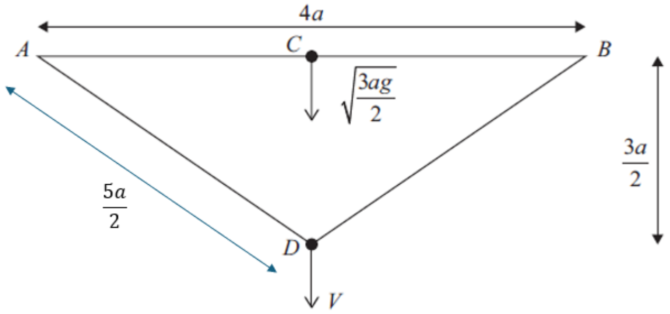
Question Number	Scheme	Marks
		
1(a)	M(A),	M1
	$Mg\times\frac{1}{2}AC = T\times AC$	A1
	$(T=)\ \frac{1}{2}mg$	A1
		(3)
1(b)	Use of HL with T	M1
	$\frac{1}{2}mg = \frac{2mg}{L}(1.2a - L)$	A1ft
	Solve for L	M1
	$(L=)\ 0.96a$ or $\frac{24}{25}a$	A1
		(4)
		(7)
Notes for question 1		
(a)		
M1	Take moments about A or another complete method to obtain a dimensionally correct equation in T and mg. All required terms present with no extras. Accept with consistent $\sin\theta$ or $\cos\theta$ present in both terms or neither. For example, $Mg\times\frac{1}{2}AC = T\times AC$, $Mga\cos\alpha = T2a\cos\alpha$, $0.8aMg = 1.6aT$, $Mga\sin\beta = T2a\sin\beta$	
A1	A correct unsimplified equation	
A1	Correct answer	
(b)		
M1	Use of Hooke's Law and their T to obtain a dimensionally correct equation in L and a only. Accept consistent omission of m and/or g. T must be of the form kmg where k is a constant. HL must be of the form $\frac{\lambda(1.2a-L)}{L}$ or $\frac{\lambda(L-1.2a)}{L}$ If HL is seen in (a) it must be used in (b) to earn the marks.	
A1ft	A correct equation, ft on their T	
M1	Complete method using their T and an attempt at HL to solve a dimensionally correct equation and find L in terms of a only. T must have the form kmg where k is a constant. HL must have the form $\frac{\lambda(1.2a-L)}{L}$ or $\frac{\lambda(L-1.2a)}{L}$ or $\frac{\lambda x}{L}$ where x is a multiple of a.	
A1	Correct solution including working from part (a).	

Question Number	Scheme	Marks
		
2.	Vertical equilibirum	M1
	$R + T\sin 30^o = mg$	A1
	N2L horizontally $T\cos 30° = mr\omega^2$	M1
	$T\cos 30^o = ma\cos 30^o\left(\dfrac{g}{2a}\right)$	A1 A1
	Solve for R	dM1
	$(R =)\dfrac{3mg}{4}$	A1
		(7)

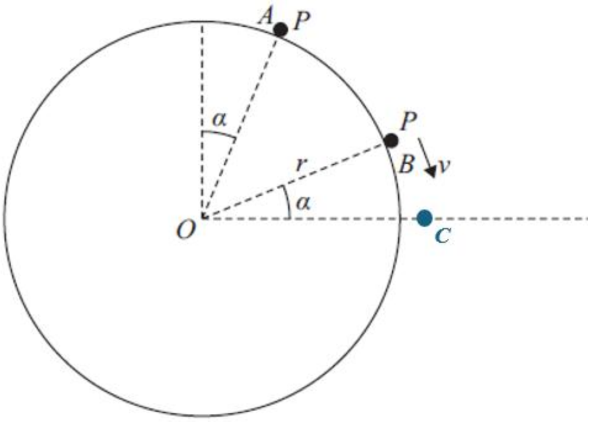
	Notes for question 2	
M1	Resolve vertically to form a dimensionally correct equation with all required terms present and no extras. Condone ± sign errors and sin/cos confusion on the *T*.	
A1	Correct unsimplified equation	
M1	Use N2L to form a dimensionally correct horizontal equation of motion. All required terms present with no extras. Accept any form of circular acceleration $r\omega^2$, $\dfrac{v^2}{r}$. Accept correct consistent omission of $\cos 30°$. Accept '*ma*' if acceleration is replaced correctly with a circular form in subsequent working. Condone sin/cos confusion. An incorrect expression for the radius is marked as an accuracy error and not a method error.	
A1	Correct equation in *T*, *m*, *g* (and *a*) with at most one error.	
A1	Correct equation in *T*, *m*, *g* (and *a*)	
dM1	Dependent on both previous M marks. Solve a dimensionally correct equation to find *R* in terms of *m* and *g* only.	
A1	Correct answer, accept $0.75mg$. Must be in terms of *m* and *g*,	

Question Number	Scheme	Marks
3(a)	Correct method to form a differential equation in v and x, separate the variables and integrate to the form $$\frac{1}{2}v^2 = Ax^2 + Bx \quad (+C) \quad \text{o.e.}$$	M1
	$\left(v\frac{\mathrm{d}v}{\mathrm{d}x} = 4x - 2 \quad \Rightarrow\right) \qquad \frac{1}{2}v^2 = 2x^2 - 2x \quad (+C)$	A1
	$$\frac{1}{2}v^2 = 2x^2 - 2x + \frac{1}{2} \quad \text{o.e}$$	A1
	$$v = 1 - 2x$$	A1
		(4)
3(b) ALT1	Method to form a differential equation in x and t , separate the variables and integrate to the form $$D\ln(1-2x) = t \quad (+C) \quad \text{o.e.}$$	M1
	$\left(\int \frac{1}{1-2x}\mathrm{d}x = \int \mathrm{d}t \quad \Rightarrow\right) \qquad -\frac{1}{2}\ln(1-2x) = t \ (+C)$	A1
	$(t = 1,\ x = \ 0 \ \Rightarrow C = -1)$ $$-\frac{1}{2}\ln(1-2x) = t - 1 \quad \text{o.e.}$$	A1
	Complete method to obtain v in terms of t For example • $-\frac{1}{2}\ln(v) = t - 1 \ (+C) \quad \Rightarrow \quad v = \ldots$ in terms of t • $x = \frac{1}{2}(1 - e^{2-2t})$ then differentiate wrt t to obtain $v = \ldots$ in terms of t	dM1
	$$(v =)e^{2-2t}$$	A1
		(5)
3(b) ALT2	Method to form a differential equation in v and t , separate the variables and integrate to the form $$\ln v = Et \ (+C) \quad \text{o.e.}$$	M1
	$\left(\int \frac{1}{v}\mathrm{d}v = -2\int \mathrm{d}t \quad \Rightarrow\right) \qquad \ln v = -2t \ (+C)$	A1
	$t \ (t = 1, v = \ 1 \ \Rightarrow C = \ 2)$ $$\ln(v) = 2 - 2t \quad \text{o.e.}$$	A1
	Obtain v in terms of t	dM1
	$$v = e^{2-2t}$$	A1
		(5)
		(9)
	Notes for question 3	
(a)		

M1	Method using $v\frac{\mathrm{d}v}{\mathrm{d}x}$ to form a differential equation in *v* and *x*, separate the variables and integrate to the form $\frac{1}{2}v^2 = Ax^2 + Bx \quad (+C)$ where *A* and *B* are non-zero constants. Condone a missing constant of integration. $\int v\,\mathrm{d}v$ may be implied by sight of $\frac{1}{2}v^2$. M0 for use of *suvat*	
A1	A correct equation with or without +*C*	
A1	A fully correct equation including the evaluated constant of integration.	
A1	Correct only	
	N.B. If the answer to (a) is $v = 2x - 1$, the maximum score for (b) is M1A1A0M1A0	
(b) ALT1		
M1	Method using $v = \frac{\mathrm{d}x}{\mathrm{d}t}$ to form a differential equation in *x* and *t*, separate the variables and solve to the reach the from $D\ln(1-2x) = t \quad (+C)$ where *D* is a non-zero constant. Condone a missing constant of integration. M0 for use of *suvat*	
A1	Correct equation in *x* and *t*, with or without *C* **N.B**. if they start with $v = 2x - 1$, allow M1A1 for $\frac{1}{2}\ln(2x-1) = t \ (+C)$	
A1	Correct equation in *x* and *t* with the evaluated constant of integration.	
dM1	Dependent on previous M. A complete method to obtain *v* as an exponential function in terms of *t* only. • $-\frac{1}{2}\ln(v) = t - 1 \quad \Rightarrow \quad v = ...$ in terms of *t* • $x = \frac{1}{2}(1 - e^{2-2t})$ then differentiate wrt *t* to obtain *v* = … in terms of *t*	
A1	Correct answer only	
(b) ALT 2		
M1	Method to form a differential equation in *v* and *t* , separate the variables and integrate to the form $\ln v = Et \ (+C)$ where *E* is a non-zero constant. Condone a missing constant of integration. $\left\{\frac{\mathrm{d}v}{\mathrm{d}t} = -2\frac{\mathrm{d}x}{\mathrm{d}t} \quad \Rightarrow \quad \frac{\mathrm{d}v}{\mathrm{d}t} = -2v \quad \Rightarrow \quad \ln v = -2t \ (+C)\right\}$ M0 for use of *suvat*	
A1	Correct equation in *v* and *t*, with or without *C* **N.B**. if they start with $v = 2x - 1$, allow M1A1 for $\ln v = Et \ (+C)$	
A1	A correct equation in *v* and *t*	
dM1	Dependent on previous M. A complete method to obtain *v* as an exponential function in terms of *t* only.	
A1	Correct answer only	

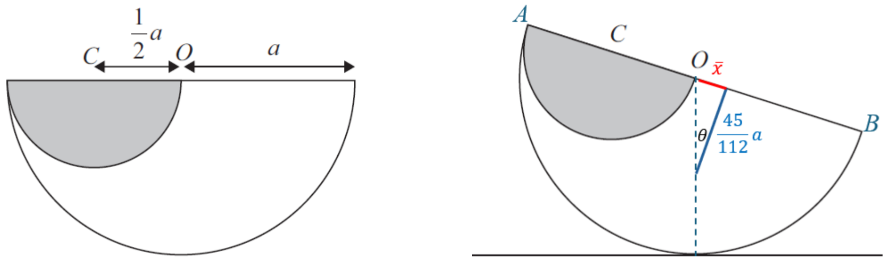
Question Number	Scheme	Marks
		
4(a)	$AD = 2.5a$ (seen or implied)	B1
	Method for the difference in 2 EPE terms (at C and D) Eg Considering the whole string $\frac{mg(5a-3a)^2}{2(3a)} - \frac{mg(4a-3a)^2}{2(3a)}$ Considering two half strings $2\times\left[\frac{mg\left(\frac{5}{2}a-\frac{3}{2}a\right)^2}{2(\frac{3}{2}a)} - \frac{mg\left(2a-\frac{3}{2}a\right)^2}{2(\frac{3}{2}a)}\right]$	M1
	$\frac{1}{2}mga$ *	A1*
		(3)
4(b)	GPE term, $mg\left(\frac{3a}{2}\right)$	B1
	Work-energy equation with all required terms	M1
	$mg\left(\frac{3a}{2}\right) = \frac{1}{2}mV^2 - \frac{1}{2}m\left(\sqrt{\frac{3ag}{2}}\right)^2 + \frac{1}{2}mga + \frac{1}{5}mg\left(\frac{3a}{2}\right)$	A1 A1
	$V = \sqrt{\frac{29ag}{10}}$	A1
		(5)
		(8)
	Notes for question 4	
(a)		
B1	Seen or implied eg $DB = 2.5a$ or $2.5a$ used correctly in EPE expression.	
M1	Complete method using 2 EPE terms to form an expression for the change in EPE, accept subtraction either way round. The EPE terms must have the form $\frac{\lambda x^2}{2l}$ where l is the relevant natural length, i.e. $\left(\frac{3}{2}a \text{ or } 3a\right)$ and x is the extension, in terms of a, at C or D respectively.	
A1*	Given answer obtained from fully correct working.	
(b)		
B1	Correct GPE term , $mg\left(\frac{3a}{2}\right)$ seen or implied	

M1	Complete method to form a dimensionally correct work-energy equation. All required terms present and no extra: GPE change, 2 KE and change in EPE. May use the EPE change from (a) or start again with 2 EPE terms of the correct structure (*kmg*). The work-done against resistance must have the form $\frac{1}{5}mg \times$ distance where distance is in terms of *a*. Condone ± sign errors on terms. Allow different rearrangements of the work-energy prinicple. For example, Loss = Gain + WD , Initial – Final = WD	
A1	Correct unsimplified equation with at most one error	
A1	Correct unsimplified equation	
A1	Correct answer in terms of *ag*. Accept $1.7\sqrt{ag}$ or better. If the answer is in decimal form it must be rounded correctly. Calculator display for $\sqrt{\frac{29}{10}}$ is 1.702938637	

Question Number	Scheme	Marks
		
5(a)	Form an energy equation from *A* to *B*	M1
	$\frac{1}{2}mv^2 = mgr\cos\alpha - mgr\sin\alpha$	A1
	$v^2 = 2gr(\cos\alpha - \sin\alpha)$ *	A1*
		(3)
5(b)	N2L towards *O* with *R* = 0	M1
	$mg\sin\alpha = \frac{mv^2}{r}$	A1
	Eliminate v^2 $\frac{1}{2}mgr\sin\alpha = mgr(\cos\alpha - \sin\alpha)$	M1
	$\left(3\sin\alpha = 2\cos\alpha \quad \Rightarrow\right) \quad \tan\alpha = \frac{2}{3}$ *	A1*
		(4)
5(c)	Expression for the horizontal component of the speed of *P* at *C*. Condone cos/sin confusion.	M1
	For example, $W\cos\theta$ or $W_{horiz} = v\sin\alpha \quad \left(= \sqrt{\frac{8gr}{13\sqrt{13}}}\right)$	A1
	Method to form relevant equation for the motion from *A* to *C* or *B* to C. Condone cos/sin confusion, consistent with their horizontal component.	M1
	[1] Energy from *A* to *C* $\frac{1}{2}mW^2 = mgr\cos\alpha$ [2] Energy from *B* to *C* $\frac{1}{2}mW^2 - \frac{1}{2}mv^2 = mgr\sin\alpha$ [3] Vertical motion under gravity from *B* to *C* $(w\sin\theta)^2 = (v\cos\alpha)^2 + 2gr\sin\alpha$	A1
	Dependent on the previous M only. Follow their notation. Use method [1] or [2] to find an expression for the speed of *P* at *C* in terms of *g* and *r* only.	dM1

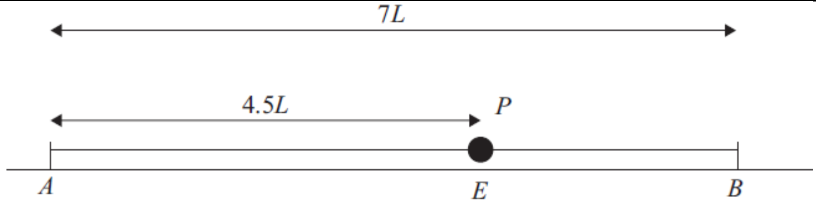
	$\left(W = \sqrt{\frac{6gr}{\sqrt{13}}}\right)$ Or Use method [3] to find the vertical component of the speed of *P* at *C* in terms of *g* and *r* only. For example, $W\sin\theta$ or $W_{vert} = \sqrt{\frac{70gr}{13\sqrt{13}}}$	
	Dependent on the first two M marks. Use the motion of *P* at *C* to form an expression in θ only.	dM1
	Obtain given answer from correct working $\cos\theta = \frac{2}{\sqrt{39}}$ *	A1*
		(7)
		(14)
Notes for question 5		
(a)		
M1	Complete method to form a dimensionally correct conservation of energy equation in (*m*), *g*, *r* and α (*m* must be seen at some stage). All required terms present and no extra. Condone sign errors and sin/cos confusion on GPE terms.	
A1	A correct equation	
A1*	Given answer correctly obtained and written exactly as printed.	
(b)		
M1	Use N2L to form a dimensionally correct equation of motion towards *O*. All required terms present with no extras. If *R* is present, must use *R* = 0 at some point. M0 if *R* is never zero. Condone sin/cos confusion.	
A1	A correct equation	
M1	Eliminate v^2 using the given answer in (a) to form an equation in *α* (*m* and *g*)	
A1*	Given answer correctly obtained. A line of working with terms collected must be seen before reaching the given answer.	
(c)		
	Note: $\cos\alpha = \frac{3}{\sqrt{13}}$, $\sin\alpha = \frac{2}{\sqrt{13}}$, $v = \sqrt{\frac{2gr}{\sqrt{13}}}$ $W_{horiz} = \sqrt{\frac{8gr}{13\sqrt{13}}}$, $W_{vert} = \sqrt{\frac{70gr}{13\sqrt{13}}}$, $W = \sqrt{\frac{6gr}{\sqrt{13}}}$	
M1	Use of constant horizontal velocity component at *C*, condone sin/cos confusion.	
A1	Correct equation (follow their notation)	
M1	Energy equation with the correct terms or use of $v^2 = u^2 + 2as$ vertically. Condone sin/cos confusion consistent with their horizontal component. If *t* is used in a *suvat* equation, a second *suvat* equation is also required to eliminate *t* correctly.	
A1	A correct equation (follow their notation)	
dM1	Dependent on the previous M mark only. Accept expressions for the speed or velocity squared. Follow their notation.	

	Use method [1] or [2] to find an expression for the speed of *P* at *C* in terms of *g* and *r* only. or Use method [3] to find the vertical component of the speed of *P* at *C* in terms of *g* and *r* only.	
dM1	Dependent on the first 2 method marks. Use the motion of *P* at *C* to form an expression in θ only. Accept the trig expression squared.	
A1*	Correctly obtain the given answer. A0* if the final answer comes from working with a decimal value of α	

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td></td><td>
</td><td></td></tr>
<tr><td rowspan="6">6(a)</td><td>Use of $\int xy^2 \mathrm{d}x$ with circle equation</td><td>M1</td></tr>
<tr><td>$$\int_0^a x(a^2 - x^2)\mathrm{d}x$$</td><td>A1</td></tr>
<tr><td>$$\left[\frac{a^2x^2}{2} - \frac{x^4}{4}\right]_0^a = \frac{a^4}{4}$$</td><td>A1</td></tr>
<tr><td>Use of $$\bar{x} = \frac{\pi\int_0^a x(a^2 - x^2)\mathrm{d}x}{\frac{2}{3}\pi a^3}$$</td><td>dM1</td></tr>
<tr><td>$\left\{\frac{\pi\frac{a^4}{4}}{\frac{2}{3}\pi a^3} \Rightarrow\right\}$ $$= \frac{3}{8}a \; *$$</td><td>A1*</td></tr>
<tr><td></td><td>(5)</td></tr>
<tr><td rowspan="5">6(b)</td><td>Mass ratios: 8 1 7</td><td>B1</td></tr>
<tr><td>Distances: $\frac{3}{8}a$ $\frac{3}{16}a$ $\bar{y}$</td><td>B1</td></tr>
<tr><td>$$8\times\frac{3a}{8} - 1\times\frac{3}{16}a = 7\bar{y}$$</td><td>M1</td></tr>
<tr><td>$$\left(\bar{y} =\right)\frac{45}{112}a \; *$$</td><td>A1*</td></tr>
<tr><td></td><td>(4)</td></tr>
<tr><td rowspan="2">6(c)</td><td>Form a moments equation about an axis perpendicular to OC
• Axis through O: $(8\times 0 +)\ 1\times\frac{a}{2} = 7\bar{x}$
• Axis through A: $8\times a - 1\times\frac{a}{2} = 7\bar{x}$
• Axis through B: $8\times a - 1\times\frac{3a}{2} = 7\bar{x}$
If equation is seen in earlier working, it must be used in (c) to earn the marks in (c)</td><td>M1</td></tr>
<tr><td>Correct $\bar{x}$ for their axis through
O: $(\bar{x} =)\frac{a}{14}$ A: $(\bar{x} =)\frac{15a}{14}$ B: $(\bar{x} =)\frac{13a}{14}$</td><td>A1</td></tr>
</table>

	Method to find an expression for tan of a relevant angle	dM1
	$\tan\theta = \dfrac{\bar{x}}{\frac{45}{112}a}$	A1ft
	$\tan\theta = \dfrac{8}{45}$	A1
		(5)
		(14)
	Notes for question 6	
(a)	N.B. M0 for a lamina	
M1	Use of $\int xy^2 \mathrm{d}x$ with their attempt at a circle equation. The equation for *y* must be substituted into the formula in terms of *x*. Allow use of alternative forms if their circle equation is substituted in correctly to give an equation with one variable (including the 'd*x*') For example use of $\int yx^2 \mathrm{d}y$ would need the circle equation substituted in for x^2 to give an integral in terms of *y*. Condone consistent use of *r* instead of *a*.	
A1	Correct expression with correct limits seen at some stage $\int_0^a x(a^2 - x^2)\mathrm{d}x$	
A1	Correct expression $\dfrac{a^4}{4}$. If $\dfrac{a^4}{4}$ is not explicitly stated, accept correct integrated expression with correct limits.	
dM1	Dependent on previous M mark. A complete method to find the required distance using the equation of a circle. They may use $\frac{2}{3}\pi a^3$ or integrate correctly to find the volume. $\bar{x} = \dfrac{\pi\int_0^a xy^2 \mathrm{d}x}{\frac{2}{3}\pi a^3}$ or $\bar{x} = \dfrac{\pi\int_0^a xy^2 \mathrm{d}x}{\pi\int_0^a y^2 \mathrm{d}x}$ If seen, ρ and/or π must be present in both numerator and denominator.	
A1*	Given answer obtained from complete and correct working. Must be positive and in terms of *a*. Condone *r* replaced with *a* at the final stage.	
(b)	N.B. For a lamina, max score 0100	
B1	Correct mass ratios seen or implied.	
B1	Correct distances, allow if measured from a parallel axis. Ignore signs.	
M1	Method to form a dimensionally correct moments equation (the small hemisphere must be subtracted from the large hemisphere). All required terms present.	
A1*	Given answer obtained from a fully correct moments equation.	
(c)	N.B. M0 for a lamina	
M1	Method to form a dimensionally correct moments equation about an axis perpendicular to *OC* (the small hemisphere must be subtracted from the	

	large hemisphere). All required terms present. Use of correct mass ratios. Both distances must be measured from the same axis.	
A1	Correct distance for their axis, accept ±	
dM1	Dependent on previous M. Find an expression for tan of a relevant angle $(\theta \text{ or} (90° - \theta))$. Must be dimensionally correct.Must use the given answer from (b) and $\bar{x}$ as the distance to the axis through *O*. The correct addition or subtraction is required if an alternative axis is used. Condone if expressed immediately as $\theta = \tan^{-1}\left(\frac{\bar{x}}{\frac{45}{112}a}\right)$ and condone the reciprocal.	
A1ft	Correct equation. Follow through their calculated $\lvert\bar{x}\rvert$ Do not condone the reciprocal. Must be $\tan\theta = \ldots$	
A1	Correct exact answer. Must be $\tan\theta = \ldots$ ISW Accept recurring decimal with correct notation. $0.1\dot{7}$	

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 $\text{period} = \frac{2\pi}{\omega}$	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 $\text{period} = \frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{\frac{4g}{3L}}} = \pi\sqrt{\frac{3L}{g}}$ • Clearly identify ω and state the period formula to reach the answer $\omega = \sqrt{\frac{4g}{3L}}$, $\text{period} = \frac{2\pi}{\omega} = \pi\sqrt{\frac{3L}{g}}$ $\Rightarrow (\text{period} =)\ \pi\sqrt{\frac{3L}{g}}$	A1*
		(7)
7(b)	$\text{amplitude} = 0.5L$	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*: $\frac{gL}{12}=\omega^2\left(\frac{L}{4}^2-x^2\right) \Rightarrow x=L\frac{\sqrt{3}}{4}$ 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] $t=\frac{1}{\omega}\sin^{-1}\left(-\frac{1}{2}\right)\quad\left(=-\frac{\pi}{6\omega}\right)$ [2] $t=\frac{1}{\omega}\cos^{-1}\left(\frac{1}{2}\right)\quad\left(=\frac{\pi}{3\omega}\right)$ [3] $t=\frac{1}{\omega}\sin^{-1}\left(\frac{1}{2}\right)\quad\left(=\frac{\pi}{6\omega}\right)$ [4] $t=\frac{1}{\omega}\cos^{-1}\left(-\frac{1}{2}\right)\quad\left(=\frac{2\pi}{3\omega}\right)$ [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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