Oxford Cambridge and RSA

GCE

Further Mathematics A

Y543/01: Mechanics

Advanced GCE

Mark Scheme for November 2020

Oxford Cambridge and RSA Examinations

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

Text Instructions

Annotations and abbreviations

Annotation in RM assessor	Meaning
✓ and ✗	
BOD	Benefit of doubt
FT	Follow through
ISW	Ignore subsequent working
M0, M1	Method mark awarded 0, 1
A0, A1	Accuracy mark awarded 0, 1
B0, B1	Independent mark awarded 0, 1
SC	Special case
^	Omission sign
MR	Misread
BP	Blank Page
Seen	
Highlighting	
Other abbreviations in mark scheme	**Meaning**
dep*	Mark dependent on a previous mark, indicated by *. The * may be omitted if only one previous M mark
cao	Correct answer only
oe	Or equivalent
rot	Rounded or truncated
soi	Seen or implied
www	Without wrong working
AG	Answer given
awrt	Anything which rounds to
BC	By Calculator
DR	This question included the instruction: In this question you must show detailed reasoning.

Subject-specific Marking Instructions for A Level Mathematics A

a Annotations must be used during your marking. For a response awarded zero (or full) marks a single appropriate annotation (cross, tick, M0 or ^) is sufficient, but not required.

For responses that are not awarded either 0 or full marks, you must make it clear how you have arrived at the mark you have awarded and all responses must have enough annotation for a reviewer to decide if the mark awarded is correct without having to mark it independently.

It is vital that you annotate standardisation scripts fully to show how the marks have been awarded.

Award NR (No Response)

- if there is nothing written at all in the answer space and no attempt elsewhere in the script
- OR if there is a comment which does not in any way relate to the question (e.g. 'can't do', 'don't know')
- OR if there is a mark (e.g. a dash, a question mark, a picture) which isn't an attempt at the question.

Note: Award 0 marks only for an attempt that earns no credit (including copying out the question).

If a candidate uses the answer space for one question to answer another, for example using the space for 8(b) to answer 8(a), then give benefit of doubt unless it is ambiguous for which part it is intended.

b An element of professional judgement is required in the marking of any written paper. Remember that the mark scheme is designed to assist in marking incorrect solutions. Correct solutions leading to correct answers are awarded full marks but work must not always be judged on the answer alone, and answers that are given in the question, especially, must be validly obtained; key steps in the working must always be looked at and anything unfamiliar must be investigated thoroughly. Correct but unfamiliar or unexpected methods are often signalled by a correct result following an apparently incorrect method. Such work must be carefully assessed. When a candidate adopts a method which does not correspond to the mark scheme, escalate the question to your Team Leader who will decide on a course of action with the Principal Examiner.
If you are in any doubt whatsoever you should contact your Team Leader.

c The following types of marks are available.

M
A suitable method has been selected and *applied* in a manner which shows that the method is essentially understood. Method marks are not usually lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. In some cases the nature of the errors allowed for the award of an M mark may be specified.
A method mark may usually be implied by a correct answer unless the question includes the DR statement, the command words "Determine" or "Show that", or some other indication that the method must be given explicitly.

A
Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated Method mark is earned (or implied). Therefore M0 A1 cannot ever be awarded.

B
Mark for a correct result or statement independent of Method marks.

Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored. Sometimes this is reinforced in the mark scheme by the abbreviation isw. However, this would not apply to a case where a candidate passes through the correct answer as part of a wrong argument.

d When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. (The notation 'dep*' is used to indicate that a particular mark is dependent on an earlier, asterisked, mark in the scheme.) Of course, in practice it may happen that when a candidate has once gone wrong in a part of a question, the work from there on is worthless so that no more marks can sensibly be given. On the other hand, when two or more steps are successfully run together by the candidate, the earlier marks are implied and full credit must be given.

e The abbreviation FT implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A and B marks are given for correct work only – differences in notation are of course permitted. A (accuracy) marks are not given for answers obtained from incorrect working. When A or B marks are awarded for work at an intermediate stage of a solution, there may be various alternatives that are equally acceptable. In such cases, what is acceptable will be detailed in the mark scheme. If this is not the case please, escalate the question to your Team Leader who will decide on a course of action with the Principal Examiner.
Sometimes the answer to one part of a question is used in a later part of the same question. In this case, A marks will often be 'follow through'. In such cases you must ensure that you refer back to the answer of the previous part question even if this is not shown within the image zone. You may find it easier to mark follow through questions candidate-by-candidate rather than question-by-question.

f We are usually quite flexible about the accuracy to which the final answer is expressed; over-specification is usually only penalised where the scheme explicitly says so.

- When a value **is given** in the paper only accept an answer correct to at least as many significant figures as the given value.
- When a value **is not given** in the paper accept any answer that agrees with the correct value to **3 s.f.** unless a different level of accuracy has been

asked for in the question, or the mark scheme specifies an acceptable range.
NB for Specification B (MEI) the rubric is not specific about the level of accuracy required, so this statement reads "2 s.f".

Follow through should be used so that only one mark in any question is lost for each distinct accuracy error.
Candidates using a value of 9.80, 9.81 or 10 for *g* should usually be penalised for any final accuracy marks which do not agree to the value found with 9.8 which is given in the rubric.

g Rules for replaced work and multiple attempts:

- If one attempt is clearly indicated as the one to mark, or only one is left uncrossed out, then mark that attempt and ignore the others.
- If more than one attempt is left not crossed out, then mark the last attempt unless it only repeats part of the first attempt or is substantially less complete.
- if a candidate crosses out all of their attempts, the assessor should attempt to mark the crossed out answer(s) as above and award marks appropriately.

h For a genuine misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain unaltered, mark according to the scheme but following through from the candidate's data. A penalty is then applied; 1 mark is generally appropriate, though this may differ for some units. This is achieved by withholding one A or B mark in the question. Marks designated as cao may be awarded as long as there are no other errors.
If a candidate corrects the misread in a later part, do not continue to follow through. Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

i If a calculator is used, some answers may be obtained with little or no working visible. Allow full marks for correct answers, provided that there is nothing in the wording of the question specifying that analytical methods are required such as the bold "In this question you must show detailed reasoning", or the command words "Show" or "Determine". Where an answer is wrong but there is some evidence of method, allow appropriate method marks. Wrong answers with no supporting method score zero. If in doubt, consult your Team Leader.

j If in any case the scheme operates with considerable unfairness consult your Team Leader.

Question			Answer	Marks	AOs	Guidance	
1	(a)		$\begin{pmatrix}2\\10\end{pmatrix}\cdot\begin{pmatrix}50\\140\end{pmatrix}$	M1	1.1	Using WD = **F.x**	
			$2\times50+10\times140=1500$ J	A1	1.1		
				[2]			
1	(b)		1500/5 = 300 W	B1ft	1.1a	Their 1500	Must be a scalar value
				[1]			
1	(c)		$\frac{1}{2}\times1.25v^2=\frac{1}{2}\times1.25\times10^2+1500$	M1	1.1	Correct use of work-energy principle	Can use their WD for M mark
			50 ms^{-1}	A1	1.1	Not ±	
			Alternative method				
			$\begin{pmatrix}50\\140\end{pmatrix}=5\mathbf{u}+\frac{1}{2}.\begin{pmatrix}\frac{8}{5}\\8\end{pmatrix}.5^2\Rightarrow\mathbf{u}=\begin{pmatrix}6\\8\end{pmatrix}$	M1		*complete* method involving constant acceleration formula(e)	
			Then $\mathbf{v}=\begin{pmatrix}6\\8\end{pmatrix}+\begin{pmatrix}\frac{8}{5}\\8\end{pmatrix}.5=\begin{pmatrix}14\\48\end{pmatrix}$				
			$\lvert\mathbf{v}\rvert=50$ ms^{-1}	A1			
				[2]			

Question			Answer	Marks	AOs	Guidance	
2			Initial energy = $80g(x+4)$ where x is the final extension of the rope	M1	3.3	Attempt GPE	Or $80gd$ where d is the distance below the bridge
			Elastic PE = $\frac{470x^2}{2\times 4}$	M1	3.3	Attempt EPE	$\frac{470(d-4)^2}{2\times 4}$
			Energy lost (work done by air resistance) $=32(x+4)$	M1	3.3	Attempt Work done	
			$80g(x+4)=\frac{470x^2}{2\times 4}+32(x+4)$	A1	3.4	Initial energy = Final Elastic PE + energy lost	$80gd=\frac{470(d-4)^2}{8}+32d$
			$235x^2-3008x-12032=0$ soi	M1	1.1	Can be multiple of this Only from W-E principle with three terms	$235d^2-4888d+3760=0$
			$x = 16$ She falls 20 m before first coming to rest	A1 **[6]**	2.3	–3.2 rejected	$d = 20$ (and 0.8 rejected)

Question			Answer	Marks	AOs	Guidance	
3	(a)		$\frac{1}{2}\times 2.8\times 6^2 + 2.8\times 9.8(0.75-0.75\cos\theta) = \frac{1}{2}\times 2.8v^2$	M1 M1	3.3 1.1	Attempt at GPE $0.75\cos 2.8g$ with correct theta and length Conservation of energy, allow sign errors	In this solution θ is the angle between OA and the upwards vertical through O
			$50.4+20.58-20.58\cos\theta = 1.4v^2$ $v^2 = 50.7-14.7\cos\theta$	A1 [3]	2.1	AG An intermediate step must be shown	
3	(b)		$T+2.8\times 9.8\cos\theta = 2.8\times\frac{v^2}{0.75}$	M1 A1	3.3 1.1	Using $F = ma$ in radial direction with tension, resolved weight and an expression for centripetal acceleration	Allow sin instead of cos
			$200+2.8\times 9.8\cos\theta = 2.8\times\frac{50.7-14.7\cos\theta}{0.75}$	M1	2.2a	Using their expression for v^2 and breaking tension of string	
			$\theta = 97.5°$ or 1.70 rad	A1 [4]	1.1	$\cos\theta = -\frac{134}{1029} = -0.1802...$	

Question			Answer	Marks	AOs	Guidance	
4	(a)		[Force] = MLT^{-2} [Viscosity] = $MLT^{-2}L^{-2}T = ML^{-1}T^{-1}$	M1 A1 [2]	1.2 1.1		
4	(b)		No it is not possible since a multiplicative constant does not affect the dimensions of the quantity it is multiplying.	B1 [1]	2.4		Or equivalent statement about dimensional analysis only applying to dimensioned quantities
4	(c)		$MLT^{-2} = (ML^{-1}T^{-1})^{\alpha}L^{\beta}(LT^{-1})^{\gamma}$ From M, $\alpha = 1$ L: $1 = \beta + \gamma - \alpha$, T: $-2 = -\alpha - \gamma$ $\beta = 1$, $\gamma = 1$	M1 B1 M1 A1 [4]	3.3 1.1 1.1 1.1	Setting up a dimensional equation (using their [Force] and [Viscosity]) Using their equation to derive 2 equations in β and γ	$MLT^{-2} = M^{\alpha}L^{\beta+\gamma-\alpha}T^{-\alpha-\gamma}$ NB – B1 to allow this from M0
4	(d)		$mg - 6\pi\eta rv = m\frac{\mathrm{d}v}{\mathrm{d}t}$ $\int \mathrm{d}t = \int \frac{1}{g-kv}\,\mathrm{d}v$ $t + c = -\frac{1}{k}\ln(g-kv)$ $t = 0, v = 0 \Rightarrow c = -\frac{1}{k}\ln g$ $t - \frac{1}{k}\ln g = -\frac{1}{k}\ln(g-kv) \Rightarrow -kt = \ln(g-kv) - \ln g$ $\Rightarrow -kt = \ln\left(\frac{g-kv}{g}\right) \Rightarrow e^{-kt} = \frac{g-kv}{g}$	M1 A1 M1 M1 A1	3.3 1.1 1.1 3.4 1.1	Using $F = ma$ with two forces Correct Correctly separating variables in v and t Integrating and substituting initial values to find c AG. Must see some intermediate working	any differential expression for a no need for k to be substituted yet

Question			Answer	Marks	AOs	Guidance	
			Alternative method 1	M1		Using $F = ma$ with two forces	
			$mg - 6\pi\eta rv = m\frac{\mathrm{d}v}{\mathrm{d}t}$	A1			any differential expression for a
			$g = kv + \frac{\mathrm{d}v}{\mathrm{d}t}$ so Integrating Factor $\mathrm{e}^{\int k\,\mathrm{d}t} = \mathrm{e}^{kt}$ $g\mathrm{e}^{kt} = kv\mathrm{e}^{kt} + \frac{\mathrm{d}v}{\mathrm{d}t}\mathrm{e}^{kt} = \frac{\mathrm{d}}{\mathrm{d}t}\left(v\mathrm{e}^{kt}\right)$ $v\mathrm{e}^{kt} = \int g\mathrm{e}^{kt}\,\mathrm{d}t = \frac{g}{k}\mathrm{e}^{kt} + c$	M1		Rearrange and find IF	no need for k to be substituted yet
			$t = 0,\ v = 0 \Rightarrow c = -\frac{g}{k}$	M1		Substituting initial values to find c	
			$v\mathrm{e}^{kt} = \frac{g}{k}\mathrm{e}^{kt} - \frac{g}{k} \Rightarrow \mathrm{e}^{kt}\left(\frac{g}{k} - v\right) = \frac{g}{k}$ $\Rightarrow \mathrm{e}^{-kt} = \frac{\frac{g}{k} - v}{\frac{g}{k}} = \frac{g - kv}{g}$	A1		AG. Must see some intermediate working	
			Alternative method 2	M1		Using $F = ma$ with two forces	
			$mg - 6\pi\eta rv = m\frac{\mathrm{d}v}{\mathrm{d}t}$	A1			any differential expression for a
			$g = kv + \frac{\mathrm{d}v}{\mathrm{d}t}$ CF: $\frac{\mathrm{d}v}{\mathrm{d}t} + kv = 0 \Rightarrow \frac{\mathrm{d}v}{\mathrm{d}t} = -kv \Rightarrow \int \frac{1}{v}\mathrm{d}v = -\int k\mathrm{d}t$ $\Rightarrow \ln v = -kt + c \Rightarrow v = A\mathrm{e}^{-kt}$ PI: try $v = \alpha \Rightarrow k\alpha = g \Rightarrow \alpha = \frac{g}{k}$, so GS: $v = A\mathrm{e}^{-kt} + \frac{g}{k}$	M1		Rearrange and find CF and PI	no need for k to be substituted yet
			$t = 0,\ v = 0 \Rightarrow 0 = A + \frac{g}{k} \Rightarrow A = -\frac{g}{k}$	M1		Substituting initial values to find c	
			So $v = -\frac{g}{k}\mathrm{e}^{-kt} + \frac{g}{k} \Rightarrow \mathrm{e}^{-kt} = \frac{k}{g}\left(\frac{g}{k} - v\right) = \frac{g - kv}{g}$	A1		AG. Must see some intermediate working	
				[5]			

Question			Answer	Marks	AOs	Guidance	
4	(e)		$e^{-kt} = \frac{g-kv}{g}$ so $t \to \infty$, $\Rightarrow v_T = \frac{g}{k}$	B1	3.4		
			Alternative method $\frac{dv}{dt} = 0 \Rightarrow mg - 6\pi\eta r v_T = 0 \Rightarrow v_T = \frac{mg}{6\pi\eta r} = \frac{g}{k}$	B1			
				[1]			
4	(f)		As the viscosity increases the terminal velocity decreases… …and as the viscosity tends to infinity the terminal velocity tends to 0	B1 B1 [2]	2.2a 2.2a		

Question			Answer	Marks	AOs	Guidance	
5	(a)		$\bar{x} = \frac{\int_0^5 x(6+\sin x)\,dx}{\int_0^5 (6+\sin x)\,dx} = \frac{72.622...}{30.716...}$	M1	1.1	BC Attempt to use formula and either top or bottom correct soi	
			$= \frac{72.622...}{30.716...} = 2.36$ (3 sf)	A1 [2]	1.1	AG. Both must be seen, or correct 2.364… seen	
5	(b)		$\bar{y} = \frac{\int_0^5 \frac{1}{2}(6+\sin x)^2\,dx}{\int_0^5 (6+\sin x)\,dx} = \frac{95.616...}{30.716...}$	M1	1.1	BC Attempt to use formula and either top or bottom correct soi	
			3.11 (3 sf)	A1 [2]	1.1		
5	(c)		The (part of the) binding (attached to the cover) is light oe	B1	3.5b	eg The binding has no mass or the binding is very small so that the mass is concentrated at the hinge or the binding is smooth	
			The CoM of the badge is at A oe	B1 [2]	3.5b	eg The badge is modelled as a particle or the badge is uniform	
5	(d)		$6\times 2.36\cos\frac{\pi}{3} + 2\times 3\cos\frac{\pi}{3}$	M1	3.4	Total 'clockwise' moment about binding axis (allow inclusion of g if consistent)…	May use new $\bar{x}$=2.523... $8\cos\frac{\pi}{3}\times\bar{x}$
			$= P\times 5$	M1	3.4	…equals 'anticlockwise' moment	=5P
			$P = 2.02$	A1 [3]	1.1		

Question			Answer	Marks	AOs	Guidance	
6	(a)		$u_{Ay} = \sqrt{3}$ or awrt 1.73	B1	3.1b	Correct perpendicular component of velocity of A before collision	
			$v_{Ay} = u_{Ay}\ (= \sqrt{3})$	B1	3.1b	This component of A's velocity is unchanged by collision	or $v_A = 2\sqrt{3}$ seen
			$\begin{pmatrix}1\\ \sqrt{3}\end{pmatrix}\cdot\begin{pmatrix}v_{Ax}\\ \sqrt{3}\end{pmatrix} = 0 \Rightarrow v_{Ax} = -3$	M1	2.2a	Or $\tan 30° = \dfrac{\sqrt{3}}{v_{Ax}}$. Using perpendicularity of A's velocities to derive a value for v_{Ax}	Could be positive if shown in diagram
			$3\times 2\cos 60° + 4\times -5 = 3\times -3 + 4v_{Bx}$	M1	3.1b	Conservation of momentum with 4 terms	Allow one sign slip
			$v_{Bx} = -2$	A1	1.1		Could be positive
			$e = \dfrac{-2 - -3}{2\cos 60° - -5}$	M1	3.1b	Restitution	Allow one sign slip
			$e = \dfrac{1}{6}$ or awrt 0.17	A1	1.1		
			Alternative method for last 5 marks				
			$3\times 2\cos 60° + 4\times -5 = 3v_{Ax} + 4v_{Bx}$	M1		Conservation of momentum	$3v_{Ax} + 4v_{Bx} = -17$
			$e = \dfrac{v_{Bx} - v_{Ax}}{2\cos 60° - -5}$	M1		Restitution	$v_{Bx} - v_{Ax} = 6e$
			$v_{Ax} = \dfrac{-17 - 24e}{7}$	A1		$v_{Bx} = \dfrac{-17 + 18e}{7}$	
			$\begin{pmatrix}1\\ \sqrt{3}\end{pmatrix}\cdot\begin{pmatrix}\dfrac{-17-24e}{7}\\ \sqrt{3}\end{pmatrix} = 0$	M1		Or $\tan 30° = \dfrac{\sqrt{3}}{\left(\dfrac{17+24e}{7}\right)}$. Using perpendicularity of A's velocities.	
			$e = \dfrac{1}{6}$ or awrt 0.17	A1			
				[7]			

Question			Answer	Marks	AOs	Guidance	
6	(b)		$v_A^2 = (\sqrt{3})^2 + (-3)^2$ soi	M1	3.1b	Attempt to find final speed (squared) of *A* vectorially	$v_A^2 = 12$
			$\frac{1}{2}\times 4\times 5^2 + \frac{1}{2}\times 3\times 2^2$	M1	1.1	Attempt to find total initial KE	
			$\frac{1}{2}\times 4\times 2^2 + \frac{1}{2}\times 3\times 12$	M1	1.1	Attempt to find total final KE	
			56 or 26	A1	1.1	Either correctly calculated	Can be implied by correct expressions and 30 seen.
			56 – 26 = 30 J	A1	1.1	Not –30	
			Alternative method for last 4 marks				
			$\frac{1}{2}\times 4\times 5^2 - \frac{1}{2}\times 4\times 2^2$	M1		Attempt to find KE change for *B*	
			$\frac{1}{2}\times 3\times 2^2 - \frac{1}{2}\times 3\times 12$	M1		Attempt to find KE change for *A*	
			42 or 12 so loss = 42 + (–12)	M1		Either correctly calculated and correctly used to find total energy change	Can be implied by correct expressions and 30 seen.
			= 30 J	A1		Not –30	
				[5]			

Question			Answer	Marks	AOs	Guidance	
7	(a)		The central radius is a line of symmetry of the shape.	B1 [1]	2.4	Allow equal area each side	
7	(b)		Area/mass of sector $\frac{1}{2}r^2 \times 2\theta$ and CoM of sector at $\frac{2r\sin\theta}{3\theta}$ from centre used	B1	1.2	Must be used	
			Area/mass of triangle $(-)\frac{1}{2}r^2\sin(2\theta)$ and CoM of triangle at $\frac{2}{3}r\cos\theta$ from centre used	B1	1.2		
			$\dfrac{\frac{1}{2}r^2 \times 2\theta \times \frac{2r\sin\theta}{3\theta} - \frac{1}{2}r^2\sin 2\theta \times \frac{2}{3}r\cos\theta}{\frac{1}{2}r^2 \times 2\theta - \frac{1}{2}r^2\sin 2\theta}$	M1	3.1b	Using $\bar{x} = \frac{\Sigma m_i x_i}{\Sigma m_i}$ with sector and triangle of –ve mass, oe	
			$= \dfrac{4r\sin\theta - 2r\sin 2\theta\cos\theta}{3(2\theta - \sin 2\theta)}$ $= \dfrac{2r(\sin\theta - \sin\theta\cos^2\theta)}{3(\theta - \sin\theta\cos\theta)} = \dfrac{2r\sin\theta(1-\cos^2\theta)}{3(\theta - \sin\theta\cos\theta)}$ $= \dfrac{2r\sin^3\theta}{3(\theta - \sin\theta\cos\theta)}$	A1 [4]	1.1	AG At least one intermediate step must be seen.	Must see change from double angle
7	(c)		Sector angle is $2\cos^{-1}\frac{2}{3}$ or $\theta = \cos^{-1}\frac{2}{3}$	B1	2.2a	1.682…	0.841…
			Area/Mass of component: $\pi \times 5^2 - \frac{1}{2} \times 3^2(1.682 - \sin 1.682)$	M1	1.1	Attempting to find mass of component using 'negative' mass	Allow use of 0.841
			= 75.44	A1	1.1		
			$\bar{y} = \dfrac{(-3.097... \times 2.406...)}{75.44...}$	M1	3.1b	Their 3.097, 2.406 and 75.44	If $\theta = 2\cos^{-1}\frac{2}{3}$ used this gives 1.095… instead of 2.406...
			= –0.0988 (3 sf)	A1 [5]	1.1		
7	(d)		$-0.0988M + 5m = 0$ So the mass of the component is 50.6*m* kg	M1 A1 [2]	1.1 1.1	May see *Mg* and *mg*	

Question			Answer	Marks	AOs	Guidance	
8	(a)		$T=\frac{\lambda x}{l}$ and $r=l+x$ both used in solution	M1	3.3		
			$T=\frac{mv^2}{l+x}$	M1	3.3	Use of $F=ma$ with centripetal acceleration	
			$\frac{\lambda x}{l}=\frac{mv^2}{l+x}\Rightarrow \lambda x(l+x)=lmv^2$ $\Rightarrow \lambda x^2+\lambda lx-lmv^2=0$	A1 [3]	3.3	AG	
8	(b)		$x=\frac{-\lambda l+\sqrt{(\lambda l)^2-4\lambda(-lmv^2)}}{2\lambda}$ $x=\frac{l}{2}\left(\left(1+\frac{4mv^2}{\lambda l}\right)^{\frac{1}{2}}-1\right)$	M1	2.1	Use of the quadratic equation formula Reject negative route and rearranging to form with $\sqrt{1+\ldots}$	
			$x=\frac{l}{2}\left(1+\frac{1}{2}\frac{4mv^2}{\lambda l}+\ldots-1\right)$	M1	3.1b	Use of binomial series	No need to mention $\left\|\frac{4mv^2}{\lambda l}\right\|<1$
			$x\approx\frac{l}{2}\left(\frac{1}{2}\frac{4mv^2}{\lambda l}\right)=\frac{mv^2}{\lambda}\Rightarrow \lambda x\approx mv^2$	A1 [3]	1.1	AG	
8	(c)		$\lambda x\approx mv^2\Rightarrow\frac{\lambda x}{l}=T\approx\frac{mv^2}{l}$ and if the string were inextensible, corresponding to an infinite value of λ and x being 0, then l would be the radius of the motion and so the RHS would be the centripetal force	B1 [1]	3.5a		
8	(d)		$v\approx\sqrt{\frac{260\times0.03}{0.16}}$ = awrt 7.0	B1 [1]	3.4	(6.982…)	

Question			Answer	Marks	AOs	Guidance	
8	(e)		While v in this situation is slightly below 7 nevertheless it is an estimate so we cannot be certain that the modelled value does not exceed 7 in which case the assumption would not be justified	B1 [1]	2.2b		

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