CAMBRIDGE
International Education

Cambridge International AS & A Level

MATHEMATICS **9709/43**

Paper 4 Mechanics **May/June 2024**

MARK SCHEME

Maximum Mark: 50

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the May/June 2024 series for most Cambridge IGCSE, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

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Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptions for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:
Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:
Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:
Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:
Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

GENERIC MARKING PRINCIPLE 5:
Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).

GENERIC MARKING PRINCIPLE 6:
Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

Mathematics-Specific Marking Principles

1 Unless a particular method has been specified in the question, full marks may be awarded for any correct method. However, if a calculation is required then no marks will be awarded for a scale drawing.

2 Unless specified in the question, non-integer answers may be given as fractions, decimals or in standard form. Ignore superfluous zeros, provided that the degree of accuracy is not affected.

3 Allow alternative conventions for notation if used consistently throughout the paper, e.g. commas being used as decimal points.

4 Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored (isw).

5 Where a candidate has misread a number or sign in the question and used that value consistently throughout, provided that number does not alter the difficulty or the method required, award all marks earned and deduct just 1 A or B mark for the misread.

6 Recovery within working is allowed, e.g. a notation error in the working where the following line of working makes the candidate's intent clear.

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Mark Scheme Notes

The following notes are intended to aid interpretation of mark schemes in general, but individual mark schemes may include marks awarded for specific reasons outside the scope of these notes.

Types of mark

M Method mark, awarded for a valid method applied to the problem. Method marks are not 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. Correct application of a formula without the formula being quoted obviously earns the M mark and in some cases an M mark can be implied from a correct answer.

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).

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

DM or **DB** When a part of a question has two or more 'method' steps, the M marks are generally independent unless the scheme specifically says otherwise; and similarly, when there are several B marks allocated. The notation DM or DB is used to indicate that a particular M or B mark is dependent on an earlier M or B (asterisked) mark in the scheme. When two or more steps are run together by the candidate, the earlier marks are implied and full credit is given.

FT Implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A or B marks are given for correct work only.

- A or B marks are given for correct work only (not for results obtained from incorrect working) unless follow through is allowed (see abbreviation FT above).
- For a numerical answer, allow the A or B mark if the answer is correct to 3 significant figures or would be correct to 3 significant figures if rounded (1 decimal place for angles in degrees).
- The total number of marks available for each question is shown at the bottom of the Marks column.
- Wrong or missing units in an answer should not result in loss of marks unless the guidance indicates otherwise.
- Square brackets [ ] around text or numbers show extra information not needed for the mark to be awarded.

Abbreviations

AEF/OE	Any Equivalent Form (of answer is equally acceptable) / Or Equivalent
AG	Answer Given on the question paper (so extra checking is needed to ensure that the detailed working leading to the result is valid)
CAO	Correct Answer Only (emphasising that no 'follow through' from a previous error is allowed)
CWO	Correct Working Only
ISW	Ignore Subsequent Working
SOI	Seen Or Implied
SC	Special Case (detailing the mark to be given for a specific wrong solution, or a case where some standard marking practice is to be varied in the light of a particular circumstance)
WWW	Without Wrong Working
AWRT	Answer Which Rounds To

Question	Answer	Marks	Guidance
1	$0.2\times6+0=0.2\times1+0.5v$ or $0.2\times6+0=0.2\times-1+0.5v$	**M1**	For attempt at use of conservation of momentum in at least one case. Must have three non-zero terms. Allow sign errors. Must have correct masses with relevant velocities. *Their v* may be in opposite direction.
	Speed $=2\,\text{m s}^{-1}$	**A1**	Do not allow negative.
	Speed $=2.8[0]\,\text{m s}^{-1}$ or $\frac{14}{5}\,\text{m s}^{-1}$ or $2\frac{4}{5}\,\text{m s}^{-1}$	**A1**	OE Do not allow negative.
		3	

Question	Answer	Marks	Guidance
2	$X\cos 30 - T\sin 30 = 0$	**M1**	Must have correct number of relevant terms (forces must have components as required). Allow sin/cos mix. Allow sign errors.
	$X\sin 30 + T\cos 30 - 0.2g = 0$	**M1**	Must have correct number of relevant terms (forces must have components as required). Allow sin/cos mix but must be consistent with their other equation. Allow sign errors.
	$X = 1$, Tension = 1.73 N [1.7320..] or $\sqrt{3}$ N	**A1**	For both.
	Alternative Method for Question 2: Resolving in directions of *X* and *T* or triangle of forces		
	$X - 0.2g\cos 60 = 0$	**(M1)**	Must have correct number of relevant terms (forces must have components as required). Allow sin/cos mix. Allow sign errors.
	$T - 0.2g\sin 60 = 0$	**(M1)**	Must have correct number of relevant terms (forces must have components as required). Allow sin/cos mix but must be consistent with their other equation. Allow sign errors.
	$X = 1$, Tension = 1.73 N [1.7320..] or $\sqrt{3}$ N	**(A1)**	For both.
	Alternative Method for Question 2: Using Lami's theorem		
	$\frac{0.2g}{\sin 90} = \frac{X}{\sin 150} = \frac{T}{\sin 120}$	**(M1M1)**	First M1 for any two fractions. Second M1 for all three fractions or another pair of fractions. Allow $\frac{X}{\sin 120}$ and $\frac{T}{\sin 150}$ for M1 marks.
	$X = 1$, Tension = 1.73 N [1.7320..] or $\sqrt{3}$ N	**(A1)**	For both.
		3	

Question	Answer	Marks	Guidance
3(a)	$AB: [s =] u \times 8 + \frac{1}{2} a \times 8^2$ $[= 8u + 32a]$ or $\frac{u + u + 8a}{2} \times 8$ $BC: [2s =] (u + 8a) \times 10 + \frac{1}{2} a \times 10^2 \quad [= 10u + 130a]$ or $\frac{u + 8a + u + 8a + 10a}{2} \times 10$ $AC: [3s =] u \times 18 + \frac{1}{2} a \times 18^2$ $[= 18u + 162a]$ or $\frac{u + u + 18a}{2} \times 18$	**B1B1**	For use of $s = ut + \frac{1}{2} at^2$ or $s = \frac{u + v}{2} t$. B1 for any one correct expression, B2 for two correct expressions.
	Attempt to solve simultaneously $(u + 8a) \times 10 + \frac{1}{2} a \times 10^2 = 2\left(u \times 8 + \frac{1}{2} a \times 8^2 \right)$ $[\Rightarrow 10u + 130a = 2(8u + 32a)]$ OR $u \times 18 + \frac{1}{2} a \times 18^2 = 3\left(u \times 8 + \frac{1}{2} a \times 8^2 \right)$ $[\Rightarrow 18u + 162a = 3(8u + 32a)]$ $u \times 18 + \frac{1}{2} a \times 18^2 = \frac{3}{2}\left((u + 8a) \times 10 + \frac{1}{2} a \times 10^2 \right)$ $\left[\Rightarrow 18u + 162a = \frac{3}{2}(10u + 130a) \right]$	**M1**	To obtain an equation in u and a only. Must have come from correct expressions but allow $\times \frac{1}{3}$ instead of $\times 3$ or $\times \frac{1}{2}$ instead of $\times 2$ or $\times \frac{2}{3}$ instead of $\times \frac{3}{2}$. Note: M0 for $u \times 10 + \frac{1}{2} a \times 10^2 = 2\left(u \times 8 + \frac{1}{2} a \times 8^2 \right)$ leading to $u = -\frac{7}{3} a$. Note: M0 for distance $AC = 2AB$ leading to $u = -49a$.
	$u = 11a$	**A1**	

Question	Answer	Marks	Guidance
3(a)	**Alternative Method for Question 3(a): Using $v^2 = u^2 + 2as$**		
	$[s =]\ \dfrac{(u+8a)^2 - u^2}{2a}$ or $[2s =]\ \dfrac{(u+18a)^2 - (u+8a)^2}{2a}$ or $[3s =]\ \dfrac{(u+18a)^2 - u^2}{2a}$	**(B1B1)**	B1 for any one correct expression, B2 for two correct expressions.
	$\dfrac{(u+18a)^2 - u^2}{2a} = 3\left(\dfrac{(u+8a)^2 - u^2}{2a}\right)$ or $\dfrac{(u+18a)^2 - (u+8a)^2}{2a} = 2\left(\dfrac{(u+8a)^2 - u^2}{2a}\right)$ or $\dfrac{(u+18a)^2 - u^2}{2a} = \dfrac{3}{2}\left(\dfrac{(u+18a)^2 - (u+8a)^2}{2a}\right)$	**(M1)**	To obtain an equation in u and a only.
	$u = 11a$	**(A1)**	
		4	

Question	Answer	Marks	Guidance
3(b)	$v = 11a + a \times 18$	**M1**	For use of $v = u + at$ or other complete suvat method Using *their u* in terms of *a,* e.g. $v^2 = (11a)^2 + 2a(18 \times 11a + 162a)$ $\left[= 841a^2\right]$, $v = \sqrt{(11a)^2 + 2a(18 \times 11a + 162a)}$ $\left[= \sqrt{841a^2}\right]$.
	Speed $= 29a$	**A1FT**	FT *their* expression for *v* so *their u* + 18*a.* Note: If answer to part **(a)** is $u = -\frac{7}{3}a$, then speed = $\frac{47}{3}a$.
		2	

Question	Answer	Marks	Guidance
4(a)	For attempt at integration	**M1***	The power of *t* must increase by 1 with a change of coefficient in the same term. Use of $s = vt$ scores M0.
	$\frac{1}{2+1}kt^{2+1} - \frac{4}{2}t^{1+1} + 3t$ $\left[= \frac{1}{3}kt^3 - 2t^2 + 3t\right]$ $[+c]$	**A1**	Allow unsimplified.
	$\frac{1}{3}k \times 2^3 - 2 \times 2^2 + 3 \times 2[-0] = 6$	**DM1**	Use of limits 0 and 2 with 6 to form an equation in *k* only (without *c* but allow with $+c - c$).
	$k = 3$	**A1**	
		4	

Question	Answer	Marks	Guidance
4(b)	$2\times 3t-4$ Or at min value $t=\dfrac{-b}{2a}=\dfrac{4}{2\times 3}$	**M1**	For attempt at differentiation. Must have expression of the form $at+b$ with $a\neq 3$, unless their $k=\frac{3}{2}$. Allow $2kt-4$.
	$\left[2\times 3t-4=0\Rightarrow\right]\ t=\dfrac{2}{3}$	**A1FT**	OE FT *their k* $t=\dfrac{2}{\textit{their k}}$. Allow without working.
	$v\left[=3\times\left(\dfrac{2}{3}\right)^2-4\times\dfrac{2}{3}+3\right]=\dfrac{5}{3}\ \text{m s}^{-1}$	**A1**	OE Allow 1.67 or better for *v*.
	Alternative Method for Question 4(b): Using completing the square		
	Attempt at completing the square	**(M1)**	Must have $\left(t-\dfrac{2}{3}\right)^2$ OE, or $\left(t-\dfrac{2}{\textit{their k}}\right)^2$.
	$3\left(t-\dfrac{2}{3}\right)^2-\dfrac{4}{3}+3$	**(A1FT)**	FT *their k* $k\left(t-\dfrac{2}{k}\right)^2-\dfrac{4}{k}+3$.
	$v=\dfrac{5}{3}\ \text{m s}^{-1}$	**(A1)**	OE Allow 1.67 or better.
		3	

Question	Answer	Marks	Guidance
5(a)	Use of Newton's second law for van or trailer or system Note: Trailer has 4 terms Van has 5 terms System has 7 terms (or 5 if counting van and trailer as one body)	**M1***	Must have correct number of relevant terms. Allow sign errors. Allow sin/cos mix. Allow g missing. Masses must be correct for their equation(s). Forces must have components (or not) as required. Must have either 0.05 or $\sin 2.86\ldots$ or sin 2.9, not just $\sin\theta$.
	Trailer: $450 + 750g \times 0.05 - 300 = 750a$ $[525 = 750a]$ Van: $D + 4500g \times 0.05 - 2500 - 450 = 4500a$ $[D - 700 = 4500a]$ System: $D + 4500g \times 0.05 + 750g \times 0.05 - 2500 - 300 = (4500 + 750)a$ $[D - 175 = 5250a]$	**A1**	For any two correct equations.
	For attempt to solve for a or D	**DM1**	Must get to '$a =$' or '$D =$'. Must have correct number of relevant terms in the equation(s) which they are using to find a or D. g must be present. Allow sign errors. Allow sin/cos mix. If no working shown to solve their equations, then their answers should be correct for their equations.
	$a = 0.7$ m s^{-2} and $D = 3850$ N	**A1**	
		4	

Question	Answer	Marks	Guidance
5(b)(i)	Use of Newton's second law for van or trailer or system Note: Trailer has 4 terms Van has 5 terms System has 7 terms (or 5 if counting van and trailer as one body)	**M1***	Must have correct number of relevant terms Allow sign errors. Allow sin/cos mix. Allow g missing. Masses must be appropriate for their equation(s). Forces must have components (or not) as required. Must have either 0.09 or $\sin 5.16\ldots$ or sin 5.2 not just $\sin\theta$.
	Trailer: $T - 300 - 750g \times 0.09 = 750a$ $\left[T - 975 = 750a\right]$ Van: $9100 - 2500 - 4500g \times 0.09 - T = 4500a$ $\left[2550 - T = 4500a\right]$ System: $9100 - 2500 - 300 - (4500 + 750)g \times 0.09 = (4500 + 750)a$ $\left[1575 = 5250a\right]$	**A1A1**	A1 for one correct equation, second A1 for another correct equation. If using Van and Trailer equations, must be using the same T for both to get the second A1.
	For attempt to solve for a or T	**DM1**	Must get to '$a =$' or '$T =$'. Must have correct number of relevant terms in the equation(s) which they are using to find a or T. g must be present. Allow sign errors. Allow sin/cos mix. If no working shown to solve their equations, then their answers should be correct for their equations.
	$T = 1200$ N and $a = 0.3\ \text{m s}^{-2}$	**A1**	
		5	

Question	Answer	Marks	Guidance
5(b)(ii)	$v^2 = 20^2 + 2 \times \textit{their}\, 0.3 \times 375$	**M1**	For use of $v^2 = 20^2 + 2a \times 375$ or other complete method to find v^2 or v. For info time taken $t = \frac{50}{3}$.
	$v = 25\,\text{m s}^{-1}$	**A1FT**	FT *their* value of a, i.e. $v = \sqrt{400 + 750 \times \textit{their}\, a}$. Provided it does not lead to root of negative value.
	Alternative Method for Question 5(b)(ii): Using energy		
	System: $\frac{1}{2} \times (4500 + 750)(v^2 - 20^2) + (4500 + 750) g \times 375 \times 0.09 = (9100 - 25$ or Van: $\frac{1}{2} \times 4500(v^2 - 20^2) + 4500 g \times 375 \times 0.09 = (9100 - 2500 - \textit{their}\, 1200)$ OR Trailer: $\frac{1}{2} \times 750(v^2 - 20^2) + 750 g \times 375 \times 0.09 = (\textit{their}\, 1200 - 300) \times 375$	**(M1)**	Must include all appropriate terms. Allow sign errors. g must be present. Allow their value of T in place of 1200.
	$v = 25\,\text{m s}^{-1}$	**(A1FT)**	FT their value of T if using Van or Trailer.
		2	

Question	Answer	Marks	Guidance
6(a)	$DF = \frac{P}{7}$	**B1**	For $P = DF \times 7$ OE seen at any point in working. Allow any force term or simply DF, e.g. $32, 80 \times 0.1$, $32 - 80 \times 0.1$, 80×10 etc.
	$D - 32 = 80 \times 0.1$	**M1**	For use of Newton's second law. Must have correct number of terms. Allow sign errors.
	[Power =] 280 W	**A1**	
		3	
6(b)	[At steady speed driving force =] $32 = \frac{280}{v}$	**M1**	Attempt at equilibrium equation ($a = 0$) with their power.
	Steady speed $= 8.75\ \text{m s}^{-1}$ or $\frac{35}{4}\ \text{m s}^{-1}$	**A1FT**	OE FT *their* power from part **(a)** $\frac{\textit{their}\ 280}{32}$.
		2	

Question	Answer	Marks	Guidance
6(c)	120×4 $[480]$	**B1**	Work done by cyclist.
	$\frac{1}{2}\times80v^2$ $\left[40v^2\right]$ or $\frac{1}{2}\times80\times7.5^2$ $[2250]$	**B1**	For at least one KE term.
	$80g\times\frac{1}{20}\times32.2$ $[1288]$ $[80\times10\times1.61]$	**B1**	Change in PE.
	Attempt at work-energy equation	**M1**	Attempt at work energy equation with five relevant terms (four relevant terms plus work done against resistance); dimensionally correct. Allow sign errors. Allow sin/cos mix.
	$120\times4+80g\times\frac{1}{20}\times32.2-1128=\frac{1}{2}\times80\left(v^2-7.5^2\right)$ $\left[480\ +1288\qquad -1128=40v^2-2250\right]$	**A1**	For correct equation.
	Speed = $8.5[0]\,\text{m s}^{-1}$ or $\frac{17}{2}$	**A1**	OE Use of constant acceleration scores M0 and cannot score B marks if the method leading to their answer only uses constant acceleration.
		6	

Question	Answer	Marks	Guidance
7(a)	For CD $R = mg\cos 30$	**B1**	May be seen in later working without.
	Use of $F = 0.1R$ for either BC or CD $F_{BC} = 0.1mg\,[= m]$ OR $F_{CD} = 0.1mg\cos 30\left[= \frac{\sqrt{3}}{2}m\right]$	**M1**	Note: The first two marks are often gained in the work-energy equation.
	$0.1mg\cos 30d + mgd\sin 30$ $\left[\left(\frac{\sqrt{3}}{2}+5\right)md\right]$	**A1**	For sum of work done by friction and the change in PE. Note: Allow terms on different sides of a work energy equation as long as they have different signs.
	$mg\times 2\sin 30 = 0.1mg\times 2 + 0.1mg\cos 30d + mgd\sin 30 + \frac{1}{2}m\times 1^2$ $\left[10m = 2m + m\cos 30d + 5md + \frac{1}{2}m\right]$	**M1**	Attempt at work energy equation with five relevant terms (dimensionally correct). Allow sign errors. Allow sin/cos errors but must be consistent. Note: Initial PE = mg.
	$d = 1.28$ m or $\frac{15\left(10-\sqrt{3}\right)}{97}$ [1.27854…]	**A1**	ISW if go on to find total distance = 2 + 2 + 1.28 having already found 1.28.

Question	Answer	Marks	Guidance
7(a)	**Alternative Method for Question 7(a): Using Newton's second law and equations of motion**		
	For CD $R = mg\cos 30$	**(B1)**	May be seen in later working without m. If not seen in working check diagram but must be a reaction force, not a downward component of the weight.
	Use of $F = 0.1R$ for either BC or CD $F_{BC} = 0.1mg\,[= m]$ or $F_{CD} = 0.1mg\cos 30\left[= \frac{\sqrt{3}}{2}m\right]$	**(M1)**	
	For a_{CD} $-mg\sin 30 - 0.1mg\cos 30 = ma$ $\left[a = -g\sin 30 - 0.1g\cos 30 = -5.866\ldots = -\left(5 + \frac{\sqrt{3}}{2}\right)\right]$	**(A1)**	For correct equation for a or ma in section CD Note: Allow if acceleration in the opposite sense and both signs positive.
	For a_{AB} $mg\sin 30 = ma \implies a = 5 \implies v_B{}^2 = 0 + 2\times 5\times 2\ [= 20]$ For a_{BC} $-0.1mg = ma$ $a = -1$ so $v_C{}^2 = 20 - 2\times 1\times 2\ [= 16]$ $1^2 = 16 - 2\times(g\sin 30 + 0.1g\cos 30)d$ $\left[1 = 16 - 2\left(5 + \frac{\sqrt{3}}{2}\right)\mathrm{d}\right]$	**(M1)**	Attempt to find d. Allow sign errors in Newton's second law. Allow sin/cos errors but must be consistent. Should include a valid attempt at $v_C{}^2$ to get M1. Must get to final line of working. Note: this mark can be earned even if A0 above. Must have 2 term acceleration though could have sign error.
	$d = 1.28\,\mathrm{m}$ or $\frac{15\left(10 - \sqrt{3}\right)}{97}$ [1.27854…]	**(A1)**	ISW if go on to find total distance = 2 + 2 + 1.28 having already found 1.28.

Question	Answer	Marks	Guidance
7(a)	**Alternative Method for the last 2 marks: Using an energy method for the third phase**		
	For a_{AB}: $mg\sin 30 = ma \implies a = 5 \implies v_B^{\,2} = 0 + 2\times 5\times 2$ $[= 20]$ For a_{BC}: $-0.1mg = ma$ $a = -1$ so $v_C^{\,2} = 20 - 2\times 1\times 2$ $[= 16]$ $\frac{1}{2}m\left(1^2 - 4^2\right) = -mgd\sin 30 - 0.1mg\cos 30\times d$	**(M1)**	Attempt at work energy equation for the third phase with four relevant terms (dimensionally correct). Allow sign errors. Allow sin/cos errors but must be consistent. Must get to final line.
	$d = 1.28\,\text{m}$ or $\frac{15\left(10-\sqrt{3}\right)}{97}$ [1.27854…] ignore units	**(A1)**	ISW if go on to find total distance = 2 + 2 + 1.28 having already found 1.28.
		5	

Question	Answer	Marks	Guidance
7(b)	$mg \times 2\sin 30 = 2\mu mg + 1 \times \mu mg\cos 30 + mg \times 1\sin 30$ $\left[10m = 20m\mu + 10m\cos 30\mu + 5m \text{ OR } 10m = 20m\mu + m5\sqrt{3}\mu + 5m\right]$	**M1**	Attempt at work energy equation with four relevant terms (dimensionally correct). Allow sign errors. Allow sin/cos errors but must be consistent.
	$\mu = 0.174$ or $\frac{4-\sqrt{3}}{13}$ $[0.174457\ldots]$	**A1**	
	$mg \times 1\sin 30 - 1 \times \mu mg\cos 30$ $\left[5m - 5\sqrt{3}m\mu\right]$	**M1**	For difference between the change in PE and the work done by friction. Note: Allow terms on different sides of a work energy equation as long as both have the same sign. Allow sin/cos errors but must be consistent. Using μ, their μ or the correct value of μ to at least 2 sf. Must be as part of an attempt to find speed, not μ, although this could be the first step.
	$mg \times 1\sin 30 - 1 \times \mu mg\cos 30 = \frac{1}{2}mv^2$ $\left[5m - 5\sqrt{3}m\mu = \frac{1}{2}mv^2\right]$ Speed = $2.64\,\text{m s}^{-1}$ $[2.64164\ldots]$	**A1**	

Question	Answer	Marks	Guidance
7(b)	**Alternative Method for Question 7(b): Newton's second law and equations of motion**		
	For a_{AB} $mg\sin 30 = ma \implies a = 5 \implies v_B^{\,2} = 0 + 2\times 5\times 2$ $[= 20]$ For a_{BC} $-\mu mg = ma$ $a = -\mu g$ so $v_C^{\,2} = 20 - 2\mu g \times 2$ For a_{CD} $-mg\sin 30 - \mu mg\cos 30 = ma$ $\left[a = -5.866\ldots = -\left(5 + \frac{\sqrt{3}}{2}\right)\right]$ $0 = 20 - 2\mu g \times 2 - 2\left(g\sin 30 + \mu g\cos 30\right)\times 1$ $\left[20 - 40\mu - 10 - 10\sqrt{3}\mu = 0\right]$	**(M1)**	For attempt at equation for μ. Allow sign errors. Allow sin/cos errors but must be consistent. Must get to fourth line for M1.
	$\mu = 0.174$ or $\frac{4-\sqrt{3}}{13}$ [0.174457...]	**(A1)**	
	$a = g\sin 30 - \mu g\cos 30$ $\left[= 5 - 5\sqrt{3}\mu\right]$	**(M1)**	For correct equation for a or ma in section CD down plane (weight component − friction). Allow sin/cos errors but must be consistent. Using μ, *their* μ or the correct value of μ to at least 2sf. Must be as part of an attempt to find speed, not μ, although this could be the first step.
	$v^2 = 0 + 2(g\sin 30 - \mu g\cos 30)\times 1 \Rightarrow$ Speed $= 2.64\,\text{m s}^{-1}$ [2.64164…]	**(A1)**	

Question	Answer	Marks	Guidance
7(b)	**Alternative method for last 2 marks of Question 7(b): Using energy at the start – total work done against friction**		
	$mg \times 2\sin 30 - (\mu mg \times 2 + \mu mg\cos 30 \times 2)$ $\left[= \frac{1}{2}mv^2\right]$	**(M1)**	For PE_A − total work done against friction [= KE_C]. Allow sin/cos errors but must be consistent. Using μ, *their* μ or the correct value of μ to at least 2sf.
	$\left[10m - (20m\mu + 20m\cos 30\mu = \frac{1}{2}mv^2\right]$ $\left[10m - (20m\mu + 10m\sqrt{3}\mu = \frac{1}{2}mv^2\right]$ Speed = $2.64\,\text{m s}^{-1}$ [2.64164…]	**(A1)**	
		4	