Cambridge International AS & A Level

MATHEMATICS **9709/41**

Paper 4 Mechanics **October/November 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.

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Cambridge International is publishing the mark schemes for the October/November 2024 series for most Cambridge IGCSE, Cambridge International A and AS Level components, and some Cambridge O Level components.

This document consists of **13** printed pages.

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.

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

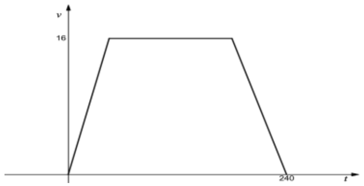
AEF/OE	Any Equivalent Form (of answer is equally acceptable) / Or Equivalent
AG	Answer Given on the question paper (so extra checking is needed to ensure that the detailed working leading to the result is valid)
CAO	Correct Answer Only (emphasising that no ‘follow through’ from a previous error is allowed)
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	Use of Newton's second law for either particle or system	*M1	Correct number of terms; allow sign errors. Dimensionally correct.
	$T-1.2g=1.2a$ $1.8g-T=1.8a$ $1.8g-1.2g=(1.2+1.8)a$	A1	For any 2 correct equations.
	For attempt to solve for T	DM1	From equations with the correct number of relevant terms. If a found first, then substituting into an equation with the correct number of relevant terms and solving.
	$a=2\,\text{ms}^{-2}$ $T=14.4\,\text{N}$	A1	Both correct.
		4	

Question	Answer	Marks	Guidance
2(a)	KE = $\frac{1}{2}\times 7.5\times v^2$ PE $=7.5\times g\times 12.5$ [= 937.5]	*B1	Either correct.
	$v=15.8\,\text{ms}^{-1}$	DB1	$5\sqrt{10}$. **SC B1** for $v^2=0^2+2\left(g\sin\theta\right)\left(\frac{12.5}{\sin\theta}\right)\Rightarrow v=15.8$ (or with cos). **B0** for $v^2=0^2+2g\times 12.5\Rightarrow v=15.8$ or correct answer with no working.
		2	

Question	Answer	Marks	Guidance
2(b)	$\text{KE}_B = 0.5 \times 7.5 \times 8^2$ [= 240]	**B1**	
	$7.5 \times g \times 12.5 = 0.5 \times 7.5 \times 8^2 + F \times 25$	**M1**	Attempt at work energy equation; 3 terms; dimensionally correct; allow sign errors.
	$F = 27.9$	**A1**	
	ALTERNATIVE FOR 2(b)		
	$8^2 = 0^2 + 2a \times 25 \Rightarrow a = 1.28$	**B1**	Finding the correct acceleration down the plane.
	$7.5g \times \frac{12.5}{25} - F = 7.5 \times a$	**M1**	Newton's second law parallel to the plane; allow sign errors and sin/cos mix on the weight component; dimensionally correct. Allow with their a, or just a .
	$F = 27.9$	**A1**	
		3	

Question	Answer	Marks	Guidance
3	Resolving in any direction to get an equation	***M1**	Allow sin/cos mix. only – or for $P^2 = 39^2 + 52^2$ **or** $\tan\theta = \frac{52}{39}$. (allow reciprocal for M mark).
	$P\cos\theta = 39 \quad P\sin\theta = 52$	**A1**	Both correct – or for both $P^2 = 39^2 + 52^2$ and $\tan\theta = \frac{52}{39}$.
	$P = \sqrt{39^2 + 52^2}$ $\theta = \tan^{-1}\left(\frac{52}{39}\right)$	**DM1**	Attempt to solve for either P or θ from equations with the correct number of relevant terms. OE using sin/cos with P
	$P = 65 \quad \theta = 53.1$	**A1**	Both correct; 53.13010…
		4	

Question	Answer	Marks	Guidance
4(a)		**B1**	Correct shape, starting at O and finishing on the t-axis.
		1	
4(b)	$t_1 = \frac{16}{a},\ t_2 = \frac{64}{3a}$	***B1**	Attempt at finding either the time for accelerating or for decelerating – must be in terms of a.
	$T = 240 - \left(\frac{16}{a} + \frac{64}{3a}\right)$	**DB1**	OE – allow un-simplified.
		2	

Question	Answer	Marks	Guidance
4(c)	$3000 = \frac{1}{2} \times 16 \times (T + 240)$ $[T = 135]$	*M1	Use distance is area under the graph.
	$3000 = \frac{1}{2} \times 16 \times \left[240 + 240 - \left(\frac{16}{a} + \frac{64}{3a}\right)\right]$ $135 = 240 - \left(\frac{16}{a} + \frac{64}{3a}\right)$	DM1	Get an expression in terms of a ONLY using their T from part **(b)** and solve for a – their T must have come from an expression of the form $240 - \frac{k_1}{a} - \frac{k_2}{a}$ where k_1 and k_2 are positive constants. OE e.g. $3000 = 16 \times 240 - \frac{1}{2} \times 16 \times \frac{16}{a} - \frac{1}{2} \times 16 \times \frac{64}{3a}$.
	$a = \frac{16}{45}$	A1	Allow 0.356 or better.
		3	

Question	Answer	Marks	Guidance
5(a)	$s_A = 80T - \frac{1}{2}gT^2$ $s_B = 100(T-1) - \frac{1}{2}g(T-1)^2$	*M1	For use of $s = ut + \frac{1}{2}at^2$ at least once with $a = \pm g$ and u = 80 or 100 – allow t, T, $t \pm 1$, $T \pm 1$.
	Two correct expressions for the displacement of both particles at time T	A1	Allow t for T.
	$100(T-1) - 5(T-1)^2 = 80T - 5T^2$	DM1	Equate and attempt to solve for T or t – must not be using the same time for both expressions (so must be using the equivalent of T in one and $T \pm 1$ in the other).
	Leading to $T = 3.5$	A1	**AG** – no errors seen (but allow all working in terms of t).
		4	

Question	Answer	Marks	Guidance
5(b)	$\left[s = 80 \times 3.5 - \frac{1}{2} g \times 3.5^2\right] = 218.75\,\text{m}$	**B1**	OR $100 \times 2.5 - \frac{1}{2} \times 10 \times 2.5^2$.
		1	
5(c)	$v_A = 80 - g \times 3.5$ [= 45] $v_B = 100 - g \times 2.5$ [= 75]	***M1**	For use of $v = u + at$ at least once to find the speed at collision with $a = \pm g$, u = 80 or 100 – with t = 2.5 or 3.5 only (but condone 2.5 with v_A and 3.5 with v_B).
	$45m + 75m = 2mv$	**DM1**	Use of conservation of momentum, 3 non-zero terms, allow sign errors. If total momentum before collision not correct then it must be clear where both terms came from.
	$v = 60$	**A1**	
	$-218.75 = 60t - \frac{1}{2} g \times t^2$	**DM1**	Complete method to find an equation in t using their v, their height from part **(b)** and $\pm g$ - dependent on both previous M marks.
	$t = 14.9 + 3.5$ = 18.4 s	**A1**	
		5	

Question	Answer	Marks	Guidance
6	Attempt at resolving perpendicular to the plane to get an equation	*M1	Correct number of relevant terms, allow sign errors, allow sin/cos mix, allow g missing. For reference $R = 1.2g \times \cos 16.26... + P \times \sin 16.26...$ - allow with an angle of 16 or better.
	$R = 1.2g \times \frac{24}{25} + P \times \frac{7}{25}$	A1	$R = 11.52 + 0.28P$ or $R = \frac{288}{25} + \frac{7}{25}P$.
	Attempt at resolving parallel to the plane to get an equation	*M1	Correct number of relevant terms, allow sign errors, allow sin/cos mix, allow g missing. For reference $F + P \times \cos 16.26... = 1.2g \times \sin 16.26...$ allow with an angle of 16 or better.
	$F + P \times \frac{24}{25} = 1.2g \times \frac{7}{25}$	A1	$F + 0.96P = 3.36$ or $F + \frac{24}{25}P = \frac{84}{25}$.
	Use of $F = 0.15R$ to get an equation in P only	DM1	Dependent on both previous **M** marks – where R is initially a linear combination of a P component and a weight component (or a mass component). $1.2g \times \frac{7}{25} - P \times \frac{24}{25} = 0.15 \times \left(1.2g \times \frac{24}{25} + P \times \frac{7}{25}\right)$.
	Solve to get $P = 1.63$	A1	Allow $\frac{272}{167}$,1.62874...
		6	

Question	Answer	Marks	Guidance
7(a)(i)	Power $= k \times 48^2 = 92160 \Rightarrow k = 40$	**B1**	**AG**
		1	
7(a)(ii)	$[DF =] \dfrac{92160}{45}\ [= 2048]$	**B1**	For any use of power = Fv e.g. $45 \times DF = 92160$.
	$2048 - 40 \times 45 = 1200a$	**M1**	Apply N2L using their $DF \neq 92160, 92.16, 1920$. 3 terms; allow sign errors. Dimensionally correct.
	$a = \dfrac{248}{1200} = \dfrac{31}{150}\ \text{ms}^{-2}$	**A1**	Allow 0.207 or better.
		3	
7(b)	$DF = 40v + 1200g \times 0.15$	***M1**	Two term expression for the driving force up the hill, allow sign errors and sin/cos mix – dimensionally correct.
	$\dfrac{92160}{v} = 40v + 1200g \times 0.15$	**DM1**	Set up an equation in v only – must be using $DF \times v = 92160$.
	$40v^2 + 1800v - 92160\ [= 0]$	**DM1**	Attempt to solve their 3TQ in v – dependent on both previous M marks.
	$v = 30.5\ \text{ms}^{-1}$	**A1**	30.51179…
		4	

Question	Answer	Marks	Guidance
8	$v = 0.3t^2 - 2.7t + c \quad [c = 4.2]$	*M1	Attempt to integrate *a* – increase power by 1 and a change in coefficient in at least one term (which must be the same term).
	$0.3t^2 - 2.7t + 4.2\,[= 0]$	DM1	Set up 3TQ in *t* with correct constant term.
	$\left[(t-2)(t-7) = 0 \ \Rightarrow\right]\ t = 2, 7$	A1	Both correct values of *t* (method not required).
	Attempt to integrate *v*	DM1	Attempt to integrate *v* – increase power by 1 and a change in coefficient in at least one term (which must be the same term) – expression for *v* must be at least two terms (so may not include a constant term) so dependent on first M mark only.
	$s = 0.1t^3 - 1.35t^2 + 4.2t\ [+c]$	A1	
	For use of their positive *t* limits in their cubic expression for *s*	M1	Dependent on all previous M marks. Using their two positive *t* values correctly in their three term cubic expressions for *s* (cubic must contain non-zero t^n terms where n = 1,2 and 3).
	Total distance = 6.25 m	A1	For reference: $(0.1\times 2^3 - 1.35\times 2^2 + 4.2\times 2)$ $- (0.1\times 7^3 - 1.35\times 7^2 + 4.2\times 7)$ If integration of *v* not explicitly shown, then this can score max ***M1 DM1 A1** then **SC B1** for correct answer of 6.25 (so 4 marks max.).
		7	

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WWW	Without Wrong Working
AWRT	Answer Which Rounds To

Question	Answer	Marks	Guidance
1(a)	Use of $v = u + at$ or use of acceleration is gradient of the line	**M1**	Use $v = 0$, $a = \pm\frac{5}{3}$ and $t = 10 - 4[= 6]$. $0 = V - \frac{5}{3}\times(10-4)$ OR $\frac{0-V}{10-4} = -\frac{5}{3}$ OR $\frac{V-0}{4-0} = \frac{5}{2}$.
	$V = 10$	**A1**	Make sure that 10 comes from a correct initial equation or equivalent, if not then A0, e.g. $\frac{0-V}{10-4} = \frac{5}{3}$ leading to $V = 10$ is M1A0.
		2	

Question	Answer	Marks	Guidance
1(b)	Distance in first 10 seconds $=\frac{1}{2}\times 10\times their\lvert V\rvert$	B1FT	SOI OE, e.g. $\frac{1}{2}\times 4\times their\ \lvert V\rvert+\frac{1}{2}\times(10-4)\times their\lvert V\rvert$ If correct distance is 50 m.
	$\frac{1}{2}\times(T-10)\times 3+\frac{1}{2}\times 10\times their\lvert V\rvert=68$ OR $\frac{1}{2}\times(T-10)\times 3+\frac{1}{2}\times 4\times their\lvert V\rvert+\frac{1}{2}\times(10-4)\times their\lvert V\rvert=68$	M1	Use distance (68) is total area under graph. Their 50 must be from $5\times their\lvert V\rvert$. Allow with -3. Allow $\frac{1}{2}\times X\times 3+\frac{1}{2}\times 10\times their\lvert V\rvert=68$ and use of $T=X+10$.
	$T=22$	A1	WWW Be aware that $V=10$ from wrong work in **(a)** can be awarded maximum of B1M1A0.
	Special Case for assumption of isosceles triangle for $t=10$ to $t=T$:		
	Distance in first 10 seconds $=\frac{1}{2}\times 10\times their\lvert V\rvert$	B1FT	SOI OE, e.g. $\frac{1}{2}\times 4\times their\ \lvert V\rvert+\frac{1}{2}\times(10-4)\times their\lvert V\rvert$. If correct distance is 50 m.
	$\left[\frac{1}{2}\times\left(\frac{T-10}{2}\right)\times 3=\frac{1}{2}\times(68-50)\rightarrow\right]T=22$	B1	WWW
	Special Case for assumption that particle returns to *O*:		
	$\left[\frac{1}{2}\times(T-10)\times 3=\frac{1}{2}\times 68\rightarrow\right]T=\frac{98}{3}$ or 32.7	B1	32.66666. AWRT 32.7.
		3	

Question	Answer	Marks	Guidance
2	Change in PE = $\pm 20g\sin 30\times 2$ $[=\pm 200]$	**B1**	
	$\pm\frac{1}{2}\times 20v^2$ $[=\pm 10v^2]$ $\pm\frac{1}{2}\times 20\times 5^2$ $[=\pm 250]$	**B1**	For either expression. Do not allow $\frac{1}{2}\times 20(v-5)^2$.
	$\frac{1}{2}\times 20v^2-\frac{1}{2}\times 20\times 5^2=20g\sin 30\times 2-50$ $[10v^2-250=200-50]$	**M1**	Attempt at work energy equation; 4 terms; dimensionally correct; allow sign errors; PE term must include a component (allow sin/cos mix). Do not allow with $\frac{1}{2}\times 20(v-5)^2$ for KE.
	Speed = $6.32\,\text{m s}^{-1}$ OR $\sqrt{40}$ m s^{-1}	**A1**	OE, e.g. $2\sqrt{10}$. 6.324555…. AWRT 6.32.
	Special case for assumption of constant resistance force:		
	$20a=20g\sin 30-\frac{50}{2}$ $[\to a=3.75]$	**B1**	
	$v^2=5^2+2\times 2\times 3.75\Rightarrow v=6.32$ m s^{-1} OR $\sqrt{40}$ m s^{-1}	**B1**	OE, e.g. $2\sqrt{10}$. 6.324555… AWRT 6.32.
		4	

Question	Answer	Marks	Guidance
3(a)	[Peddling force $= PF =$] $\dfrac{250}{5}$	B1	For use of power $= Fv$ e.g. $5 \times PF = 250$.
	$their\ PF - R = 90 \times 0.1$	M1	Using their $PF \neq 250$. 3 terms; allow sign errors. Dimensionally correct.
	Resistance $= 41$ N	A1	
		3	
3(b)	$\dfrac{250}{v} - their\ 41 - 90g\sin 2 = 0$	M1	For attempt at resolving up the hill; 3 terms; allow sign errors; Must be a component of weight (NOT mass) but allow sin/cos mix; allow use of *their* 41. Dimensionally correct. Oe eg $v = \dfrac{250}{their\ 41 + 90g\sin 2}$.
	Steady speed = 3.45 m s^{-1}	A1	3.45258… AWRT 3.45.
		2	

Question	Answer	Marks	Guidance
4(a)	$T_{AB}\sin 45 = 0.2g\cos 45$ OR $\tan 45 = \frac{T_{AB}}{0.2g}$ OR $\tan 45 = \frac{0.2g}{T_{AB}}$ OR $T_{AB} = T_{AP}\cos 45$ **and** $T_{AP}\sin 45 = 0.2g$	***B1**	BOD for using $\sin 45$ instead of $\cos 45$, particularly if using wrong components in **(b).**
	$T_{AB} = 2$ N	**DB1**	Condone $T_{AB} = 0.2g$ (with or without working) for full marks. WWW. DO NOT ISW.
	ALTERNATIVE for 4(a) using LAMI's THEOREM:		
	$\frac{T_{AB}}{\sin 135} = \frac{0.2g}{\sin 135}$	**B1**	
	$T_{AB} = 2$ N	**B1**	Condone $T_{AB} = 0.2g$ (with or without working) for full marks. WWW. DO NOT ISW.
		2	

Question	Answer	Marks	Guidance
4(b)	$T_{BQ}\cos\theta - their\,T_{AB} = 0$ $T_{BQ}\sin\theta - 0.1g = 0$	*M1	For resolving either horizontally OR vertically; 2 terms; allow sin/cos mix; allow their T_{AB}; M0 for any use of $T_{AB} = T_{BQ} = T_{AP}$.
		A1FT	For both. FT their T_{AB} ONLY; $T_{AB} \neq T_{BQ}$. Sight of $(their\,T_{AB})\tan\theta = 0.1g$ is M1 only without seeing an equation for T_{BQ}.
	$\theta = \tan^{-1}\left(\dfrac{0.1g}{their\,T_{AB}}\right)$ or $T_{BQ} = \sqrt{(0.1g)^2 + (their\,T_{AB})^2}$	DM1	Solve for θ or solve for T_{BQ} from equations with the correct number of relevant terms. Using their T_{AB}.
	$\theta = 26.6$ AND $T_{BQ} = \sqrt{5}$ or2.24	A1	$\theta = 26.56505\ldots$. $T_{BQ} = 2.236067\ldots$. AWRT 26.6 and 2.24.
	FIRST ALTERNATIVE for 4(b):		
	$T_{BQ} = (their\,T_{AB})\cos\theta + 0.1g\sin\theta$ $(their\,T_{AB})\sin\theta = 0.1g\cos\theta$	M1	For resolving either parallel to *BQ* or perpendicular to *BQ*; 2 terms; allow sign errors on 3 term equation only; allow sin/cos mix; allow their T_{AB}. Sight of $(their\,T_{AB})\tan\theta = 0.1g$ is M1 only without seeing an equation for T_{BQ}. M0 for any use of $T_{AB} = T_{BQ} = T_{AP}$.
		A1FT	For both. FT their T_{AB} ONLY; $T_{AB} \neq T_{BQ}$.
	$\theta = \tan^{-1}\left(\dfrac{0.1g}{(their\,T_{AB})}\right)$	DM1	Solve for θ (or solve for T_{BQ}) from equations with the correct number of relevant terms. Using their T_{AB}.

Question	Answer	Marks	Guidance
4(b)	$\theta = 26.6$ AND $T_{BQ} = \sqrt{5}$ or 2.24	A1	$\theta = 26.56505\ldots$ $T_{BQ} = 2.236067\ldots$ AWRT 26.6 and 2.24.
	SECOND ALTERNATIVE for 4(b) using triangle of forces:		
	$T_{BQ}^2 = (0.1g)^2 + (their\,T_{AB})^2$ OR $0.1g = T_{BQ}\sin(\theta)$ OR $(their\,T_{AB}) = T_{BQ}\cos(\theta)$	M1	Using their T_{AB} ONLY; M0 for any use of $T_{AB} = T_{BQ} = T_{AP}$.
		A1FT	For any 2 equations. FT their T_{AB} ONLY; $T_{AB} \neq T_{BQ}$. Sight of $(their\,T_{AB})\tan\theta = 0.1g$ is M1 only without seeing an equation for T_{BQ}.
	Solve for T_{BQ} or θ E.g. $T_{BQ} = \sqrt{(0.1g)^2 + (their\,T_{AB})^2}$ $\theta = \tan^{-1}\left(\dfrac{0.1g}{their\,T_{AB}}\right)$	DM1	Solve for θ or solve for T_{BQ} from equations with the correct number of relevant terms. Using their T_{AB}.
	$\theta = 26.6$ AND $T_{BQ} = \sqrt{5}$ or 2.24	A1	$\theta = 26.56505\ldots$ $T_{BQ} = 2.236067\ldots$ AWRT 26.6 and 2.24.
	THIRD ALTERNATIVE for 4(b) using LAMI's THEOREM:		
		*M1	For any 2 fractions correct; M0 for any use of $T_{AB} = T_{BQ} = T_{AP}$.

Question	Answer	Marks	Guidance
	$\frac{T_{BQ}}{\sin 90} = \frac{0.1g}{\sin(180-\theta)} = \frac{their\,T_{AB}}{\sin(90+\theta)}$ OR $\frac{T_{BQ}}{\sin 90} = \frac{0.1g}{\sin\theta} = \frac{their\,T_{AB}}{\cos\theta}$	A1FT	For all 3 fractions correct. FT their T_{AB} ONLY. Sight of $(their\,T_{AB})\tan\theta = 0.1g$ is M1 only without seeing an equation for T_{BQ}.
4(b)	$\theta = \tan^{-1}\left(\frac{0.1g}{their\,T_{AB}}\right)$	DM1	Solve for θ.
	$\theta = 26.6$ AND $T_{BQ} = \sqrt{5}$ or 2.24	A1	$\theta = 26.56505\ldots$ $T_{BQ} = 2.236067\ldots$ AWRT 26.6 and 2.24.
	FOURTH ALTERNATIVE for 4(b) for resolving on the whole system:		
	$T_{BQ}\sin\theta + (their\,T_{AP})\sin 45 = 0.2g + 0.1g$ $T_{BQ}\cos\theta = (their\,T_{AP})\cos 45$	M1	For resolving either horizontally or vertically on the whole system; using $their\,T_{AP}$. M0 for any use of $T_{AB} = T_{BQ} = T_{AP}$. If T_{AP} not found in part **(a)**, must have either $T_{AP}\sin 45 = 0.2g$ or $(their\,T_{AB}) = T_{AP}\cos 45$. Correct number of terms; allow sign errors on the 4 term equation ONLY; allow sin/cos mix.
		A1FT	Both equations correct. May see $T_{BQ}\sin\theta = 1$ and $T_{BQ}\cos\theta = 2$. Sight of $(their\,T_{AB})\tan\theta = 0.1g$ is M1 only without seeing an equation for T_{BQ}.

Question	Answer	Marks	Guidance
	$\theta = \tan^{-1}\left(\dfrac{0.1g + 0.2g - (their\,T_{AP})\sin 45}{(their\,T_{AP})\cos 45}\right)$ or $T_{BQ} = \sqrt{(0.1g + 0.2g - (their\,T_{AP})\sin 45)^2 + ((their\,T_{AP})\cos 45)^2}$	DM1	Solve for θ or solve for T_{BQ} from equations with the correct number of relevant terms. Using their T_{AP}.
	$\theta = 26.6$ AND $T_{BQ} = \sqrt{5}$ or 2.24	A1	$\theta = 26.56505\ldots$ $T_{BQ} = 2.236067\ldots$ AWRT 26.6 and 2.24.
		4	

Question	Answer	Marks	Guidance
5(a)	$\left[s_P \text{ up} =\right] \pm\left(2t - \frac{1}{2}gt^2\right)$ **OR** $\left[s_Q \text{ down} =\right] \pm \frac{1}{2}gt^2$	**M1**	For use of $s = ut + \frac{1}{2}at^2$ at least once with $a = \pm g$ and $u = 0$ or $u = \pm 2$. Seen anywhere.
	$2t - \frac{1}{2}gt^2 + \frac{1}{2}gt^2 = 2 - 1 \left[\Rightarrow t = \frac{1}{2}\right]$	**M1**	Use $s_P + s_Q = \pm(2-1)$ OR ± 1 ONLY with s_P and s_Q of the correct form
	$v_P = 2 - \frac{1}{2}g = -3 \text{ m s}^{-1}$ so speed = 3 m s^{-1}	**A1**	Must be positive.
	$v_Q = -\frac{1}{2}g = -5 \text{ m s}^{-1}$ so speed = 5 m s^{-1}	**A1**	Must be positive. If **A0A0**, allow **SCB1** if both are negative
		4	

Question	Answer	Marks	Guidance
5(b)	$2m\times\left(their\,3\left[v_P\right]\right)+m\times\left(their\,5\left[v_Q\right]\right)=2mv+m\times3.5$	*M1	Use of conservation of momentum; 4 non- zero terms; using $their\pm3$ m s^{-1} and $their\pm5$ m s^{-1}; allow sign errors and m missing ONLY. Do not allow with $v_P=\pm2$ or with $v_Q=0.$ Do not allow made up values for 3 and 5. Allow LHS of our equation to have only one term but only if getting $v_P=0$ in **(a)** from $s_P=s_Q$.
	$v=3.75$	A1	Allow $v=-3.75$ from correct work.
	$\left[\text{At } t=\frac{1}{2},\ s_p=\right]\pm\left(2\times\frac{1}{2}-\frac{1}{2}g\left(\frac{1}{2}\right)^2\right)\left[=\mp\frac{1}{4}\right]$ OR $\left[s_p=\right]\pm\left(-3\times\frac{1}{2}+\frac{1}{2}g\left(\frac{1}{2}\right)^2\right)\left[=\mp\frac{1}{4}\right]$ OR $\left[s_p=\right]\pm\left(\frac{(-3)^2-2^2}{2g}\right)\left[=\pm\frac{1}{4}\right]$ OR $\left[\text{At } t=\frac{1}{2},\ s_Q=\right]\pm\frac{1}{2}g\left(\frac{1}{2}\right)^2\left[=\pm\frac{5}{4}\right]$ OR $\left[\text{At } t=\frac{1}{2},\ s_Q=\right]\pm\left(5\times\frac{1}{2}-\frac{1}{2}g\left(\frac{1}{2}\right)^2\right)\left[=\pm\frac{5}{4}\right]$ OR $\left[s_Q=\right]\pm\left(\frac{5^2\left[-0^2\right]}{2g}\right)\left[=\pm\frac{5}{4}\right]$ $\left[\text{so height above ground}=\frac{3}{4}\right]$	*B1	This may be seen in part **(a)**, but do not award the mark until stated/used in part **(b).**

Question	Answer	Marks	Guidance
5(b)	$v^2=(their\,3.75)^2+2\times(\pm g)\times\left(\pm\frac{3}{4}\right)$ OR $0^2=(their\,3.75)^2-2\times(\pm g)\times s \Rightarrow s=\frac{45}{64}$ AND $v^2=\left[0^2+\right]2\times(\pm g)\times\left[\left(\frac{3}{4}\right)+\frac{45}{64}\right]$	**DM1**	Use of $v^2=u^2+2as$ using their v and $a=\pm g$; *their s* is either $\pm\left[1+\left(-\frac{1}{4}\right)\right]$ or $\pm\left[2-\frac{5}{4}\right]$ OE. Dependent on the previous M mark and B mark being awarded.
	$v=5.39\ \text{ms}^{-1}$	**A1**	Or $\frac{\sqrt{465}}{4}$; AWRT 5.39; 5.390964…
		5	

Question	Answer	Marks	Guidance
6(a)	Attempt to integrate a for $0\le t\le 1$	**M1**	Increase power by 1 and a change in coefficient in at least one term (which must be the same term); $v=at$ is M0. Expect $(v=)-t^{\frac{3}{2}}[+c]$.
	$(v=)-\frac{1.5}{1.5}t^{\frac{3}{2}}+6=-t^{\frac{3}{2}}+6$	**A1**	Allow for $-t^{\frac{3}{2}}+c$ and $c=6$ seen from CWO. Allow unsimplified.
	Velocity at t = 1 is 5 ms^{-1}	**A1**	CWO.
		3	

Question	Answer	Marks	Guidance
6(b)	Attempt to integrate a for $t > 1$ $\left[(v =)\frac{1.5}{3/2}t^{\frac{3}{2}} - \frac{3}{1/2}t^{\frac{1}{2}}[+c] = t^{\frac{3}{2}} - 6t^{\frac{1}{2}}[+c]\right]$	*M1	Increase power by 1 and a change in coefficient in at least one term (which must be the same term); $v = at$ is M0.
	Use $v = their\,5$ when $t = 1$ in attempt to find c $[5 = 1 - 6 + c]$	DM1	Must get a numerical expression for c; if no substitution seen, c must be correct for their expression for v. Their 5 must not be a made up value.
	$(v =)t^{\frac{3}{2}} - 6t^{\frac{1}{2}} + 10$	A1	OE, but must be a complete (possibly unsimplified) expression.
		3	

Question	Answer	Marks	Guidance
6(c)	For attempt at integration of *their* v for either section	*M1	Increase power by 1 and a change in coefficient in at least one term (which must be the same term); Their v 's have to come from integration. $s = vt$ is M0. Their v 's have to come from integration.
	$(s_1 =) -\frac{1}{5/2}t^{\frac{5}{2}} + 6t[+c] = -\frac{2}{5}t^{\frac{5}{2}} + 6t[+c]$ $(s_2 =) \frac{1}{5/2}t^{\frac{5}{2}} - \frac{6}{3/2}t^{\frac{3}{2}} + 10t[+c] = \frac{2}{5}t^{\frac{5}{2}} - 4t^{\frac{3}{2}} + 10t[+c]$	A1	For either correct. Allow unsimplified.
	For use of limits 0 and 1 for s_1 **and** 1 and 4 for s_2	DM1	Using correct limits correctly, in expressions that have come from integration (where all powers must have increased by 1 with a change in coefficient for non-linear terms) of a v that came from integration, and using the limits correctly would lead to 2 positive values when used in their expressions. s_1 and s_2 must have the correct number of non-constant terms and must include a linear term.
	Total distance $= 20\text{m}$	A1	$s_1 = \left(-\frac{2}{5}\times 1 + 6\times 1\right) - 0\left[= \frac{28}{5} = 5.6\right]$. $s_2 = \left(\frac{2}{5}\times 4^{\frac{5}{2}} - 4\times 4^{\frac{3}{2}} + 10\times 4\right) - \left(\frac{2}{5}\times 1^{\frac{5}{2}} - 4\times 1^{\frac{3}{2}} + 10\times 1\right)\left[= \frac{72}{5} = 14.4\right]$. If either displacement expression has a constant of integration and is given incorrectly, then award **A0** even if 20 m seen. For reference the constant of integration for s_2 is –0.8.

Question	Answer	Marks	Guidance
6(c)	**SC for integration not seen:**		
	$s_1 = \frac{28}{5}$ or $s_2 = \frac{72}{5}$	**B1**	
	Total distance $= 20\,\text{m}$	**B1**	
		4	

Question	Answer	Marks	Guidance
7(a)	$R = 0.2g \times 0.8[=1.6]$	B1	Allow $\cos 37$ or better for 0.8.
	$F = 1.125R[=1.8]$	*M1	Where R is a component of weight. Must have $1.125 \times 0.2g \times 0.8$ or $1.125 \times 0.2g \times 0.6$ or with using $\cos 37$ or $\sin 37$ or better for 0.8 and 0.6 respectively. These 2 marks may be embedded in the N2L equation(s).
	Use of Newton's second law for *A* or *B* or system	*M1	Correct number of terms; allow sign errors; allow sin/cos mix. Dimensionally correct.
	$0.3g - T = 0.3a$ $T + 0.2g \times 0.6 - F = 0.2a$ $0.3g + 0.2g \times 0.6 - F = 0.5a$	A1	For any 2 correct equations. Allow $\sin 37$ or better for 0.6. Allow their possibly incorrect F.
	$a = 4.8$ m s^{-2}	A1	Must be positive.
	For attempt to solve for T	DM1	From equations with the correct number of relevant terms. If a found first then substituting into an equation with the correct number of relevant terms and solving. If resolved equations incorrect and no working seen, then this mark is implied by the correct T value for their equations. Dependent on previous 2 M marks
	$T = 1.56$ N	A1	
		7	

Question	Answer	Marks	Guidance
7(b)	[For B or A] $v^2=0^2+2\times4.8\times0.25$ $\left[\Rightarrow v^2=2.4 \text{ or } v=\frac{2\sqrt{15}}{5}=1.549\ldots\right]$	*M1	Use of $v^2=u^2+2as$ with $u=0$ and using $s=0.25$, $\|their\ 4.8\|$, $a\neq\pm g$. Must be a complete method to get an expression for v or v^2.
	Attempt at Newton's 2nd Law on A when string becomes slack $[0.2g\times0.6-1.125\times0.2g\times0.8=0.2a]$	*M1	3 terms; allow sign errors; allow sin/cos mix; allow their non-zero F from part **(a)**; Dimensionally correct; must be using 0.2 for the mass. Allow $\theta=37$ or better. For reference $a=-3$ (or -2.99 if using $\theta=36.9$).
	$0^2=2.4+2\times(-3)\times s[\Rightarrow s=0.4]$	DM1	Using constant acceleration formula(e) using a negative acceleration to get an expression in s only. Dependent on previous 2 M marks.
	Total distance = 0.25 + 0.4 = 0.65 m	A1	AWRT 0.650. Allow 0.651 from use of $\theta=36.9$.
	ALTERNATIVE for 7(b) using energy:		
	[For B or A] $v^2=0^2+2\times4.8\times0.25$ $\left[\Rightarrow v^2=2.4 \text{ or } v=\frac{2\sqrt{15}}{5}=1.549\ldots\right]$	*M1	Use of $v^2=u^2+2as$ with $u=0$. Using $s=0.25$, $\|their\ 4.8\|$, $a\neq\pm g$. Must be a complete method to get an expression for v or v^2.
	For attempt at work energy equation	DM1	3 terms; dimensionally correct; allow sin/cos mix in PE term and work done against Friction term; allow sign errors; allow their non-zero F from part **(a)**.

Question	Answer	Marks	Guidance
7(b)	$\frac{1}{2}\times 0.2\times 2.4+0.2g\times 0.6\times d-1.125\times 0.2g\times 0.8\times d=0$ $[\Rightarrow d=0.4\text{m}]$	A1	For correct equation in d only; must be using 0.2 for the mass. Allow $\theta=37$ or better.
	Total distance = 0.25 + 0.4 = 0.65 m	A1	AWRT 0.650. Allow 0.651 from use of $\theta=36.9$.
		4	

CAMBRIDGE
International Education

Cambridge International AS & A Level

MATHEMATICS **9709/43**

Paper 4 Mechanics **October/November 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 October/November 2024 series for most Cambridge IGCSE, Cambridge International A and AS Level components, and some Cambridge O Level components.

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.

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	$\text{KE}_{before} = \frac{1}{2} \times m \times 5^2$ $\text{KE}_{after} = \frac{1}{2} \times m \times 6^2$	**B1**	For either correct. Do not allow $\frac{1}{2} \times m \times (6-5)^2$. Note: Difference = $\frac{1}{2} \times m \times 11$.
	WD against resistance $= 50 \times 24 \quad [=1200]$	**B1**	Do not allow if errors such as e.g. $(m-24) \times 50$.
	$\frac{1}{2} \times m \times (6^2 - 5^2) + 50 \times 24 = 1541$ $5.5m = 1541 - 1200$	**M1**	Attempt at work energy equation with 4 relevant terms; dimensionally correct. Allow sign errors. M0 for $\frac{1}{2} \times m \times (6-5)^2$.
	$m = \frac{341}{5.5} = 62$	**A1**	
	SC for constant acceleration method (question only gives total work done, and does not suggest constant force)		
	$a = 0.11$	**SCB1**	From $6^2 = 5^2 + 2 \times a \times 50$ SOI.
	$m = 62$	**SCB1**	From $\frac{1541}{50} - 24 = m \times 0.11$ or $30.82 - 24 = m \times 0.11$.
		4	

Question	Answer	Marks	Guidance
2	Resolving either direction	**M1**	With correct number of relevant terms. Allow sin/cos mix. Allow sign errors. Do not allow 'forces to the left = forces to the right' e.g. $12\cos30-8\sin30=16\sin30$ unless subsequently 'corrected'.
	$\pm(12\sin30+24+8\cos30-16\cos30)[=F_x \text{ or } F\cos\theta \text{ or } F\sin\alpha]$	**A1**	$F_x=\pm\left(30-4\sqrt{3}\right)$ $[=23.07\ldots]$.
	$\pm(12\cos30-8\sin30-16\sin30)[=F_y \text{ or } F\sin\theta \text{ or } F\cos\alpha]$	**A1**	$F_y=\pm\left(6\sqrt{3}-12\right)$ $[=-1.607\ldots]$.
	$F=\sqrt{\left(6\sqrt{3}-12\right)^2+\left(30-4\sqrt{3}\right)^2}$ $F=\dfrac{30-4\sqrt{3}}{\cos(\textit{their }\theta)}$ $F=\dfrac{6\sqrt{3}-12}{\sin(\textit{their }\theta)}$	**M1**	Attempt to find *F*. Must have correct number of relevant terms. (Forces must have or not have components as required). All forces resolved/not resolved as appropriate, but allow consistent sin/cos muddle. Allow use of their θ provided correctly derived from equations with the correct number of relevant terms.
	$\theta=\tan^{-1}\left(\dfrac{6\sqrt{3}-12}{30-4\sqrt{3}}\right)$ $\theta=\cos^{-1}\left(\dfrac{30-4\sqrt{3}}{\textit{their }F}\right)$ Note: this will not give the correct answer unless *F* given to several significant figures $\theta=\sin^{-1}\left(\dfrac{6\sqrt{3}-12}{\textit{their }F}\right)$	**M1**	Attempt to find θ. Must have correct number of relevant terms. (Forces must have or not have components as required). All forces resolved/not resolved as appropriate, but allow consistent sin/cos muddle. Allow upside down so $\tan^{-1}\left(\dfrac{30-4\sqrt{3}}{6\sqrt{3}-12}\right)$. Allow use of their F provided correctly derived from equations with the correct number of relevant terms. Note: watch for use of $\sin^{-1}\left(\dfrac{6\sqrt{3}-12}{30-4\sqrt{3}}\right)$ or $\sin^{-1}\left(\dfrac{1.607}{23.07}\right)$ which leads to correct answer of angle 4.0° scores M0A0.

Question	Answer	Marks	Guidance
2	$F = 23.1$ N $\theta = 3.99^{\circ}$ above the negative x-axis oe	**A1**	[23.1277…] Both correct Allow 4.0° but not simply 4° . $[3.986...]$ Allow answers about the direction such as 'Above the west', 'north of west' etc, or clockwise 183.99 from x axis, or resultant sketch with angle indicated. If not specified in working please check original diagram to see if direction specified there instead. Allow a bearing of $274.0°$. Allow explanation of direction that could be drawn uniquely. Or e.g. 86.0° to left of the y-axis or 176.0° from the positive x-axis.
		6	

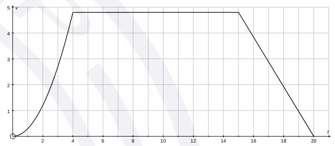
Question	Answer	Marks	Guidance
3(a)	Resolving up slope. If correct should see $\text{DF} = 240 + 1600g \times 0.08 \quad [= 240 + 1280 = 1520]$	**M1**	Must have correct number of relevant terms (weight component and 240 N resistance). Allow sign errors. Allow cos 4.58 or cos 4.6. Do not allow g missing. Using $\sin^{-1} 0.08$ or sin 0.08 scores M0B0A0. Must have either 0.08 or $\sin 4.58\ldots$ or sin 4.6, not just $\sin\theta$.
	$\text{Power} = their(1520) \times 32$	**B1**	OE. E.g. $\dfrac{\text{Power}}{32} = their\,1520$. Allow any driving force provided it has a resistance and a weight component.
	$\text{Power} = 48640$ W	**A1**	Allow 48 600 W or 48.64 kW or 48.6 kW. Must state units if given in kW.
		3	

Question	Answer	Marks	Guidance
3(b)	$\text{DF} = \dfrac{0.95 \times \textit{their}\ 48640}{24}$ or $\dfrac{46208}{24} = \dfrac{5776}{3}$ or $1925.3\ldots$	**B1FT**	$\text{DF} = \dfrac{\text{Power}}{v}$ oe e.g. $0.95 \times \textit{their}\ 48640 = \text{DF} \times 24$ FT their power from part **(a)** Do not allow if not using power from part **(a)** Note: candidates who use sin 0.08 in part **(a)** should get a DF of 332.3 N, which can score B1FT and use of $\sin^{-1} 0.08$ should get a DF of 93299 N, can score B1FT. If candidate uses 48600 DF = $\dfrac{46170}{24} = 1923.75$ Candidates who omit the weight component in part **(a)** should get a DF of 304 N, and can score B1FT
	$\textit{their}\ \text{DF} - 240 - 1600g \times 0.08 = 1600a$	**M1**	N2L Must have correct number of relevant terms (weight component and 240 N resistance). Allow sign errors. Must be dimensionally correct. Allow without using 95% or with using 5%. Must have either 0.08 or $\sin 4.58\ldots$ or sin 4.6, not just $\sin\theta$ or $\sin^{-1} 0.08$ or sin 0.08.
	$a = 0.253\ \ \text{m s}^{-2}$	**A1**	Allow $\dfrac{19}{75}$ Note: 0.25 scores A0. If candidate uses 48600 they <u>must</u> get 0.252(34…) rather than 0.253.
		3	

Question	Answer	Marks	Guidance
4	For attempt at use of conservation of momentum.	*M1	Must have three non-zero terms. Allow sign errors. Must have correct masses with relevant velocities. Their v may be in the opposite direction. If g included with the masses: Allow M1A0A1 for first three marks. Can then score M1M0A0 for final three marks.
	$3\times8=3\times2+6v$ Or $3\times8=-3\times2+6v$	A1	
	$v=3 \quad [v=5]$	A1	Allow finding only $v=3$, but if both speeds found they must both be correct
	KE_{after} $=0.5\times3\times2^2+0.5\times6\times \textit{their } v_B{}^2 \quad [=33]$ if correct	DM1	Allow use of any v_B even if <0 Using speed of5, $\text{KE}_{after}=0.5\times3\times2^2+0.5\times6\times \textit{their } 5^2 \quad [=81]$ Candidates may work out the loss for each particle separately which only scores DM1 when losses subsequently added together.
	$KE_{loss}=\pm\left(0.5\times3\times8^2-\left(0.5\times3\times2^2+0.5\times6\times \textit{their } 3^2\right)\right)$ $[=96-33]$ if correct	DM1	If two speeds found then FT their lower speed, even if later choose the wrong loss. If only one speed found then FT their speed. If the candidate thinks that the particles coalesce then score M0 here
	Loss = 63 [J]	A1	If both losses found, must state which is the greater. Only award this mark if no errors – e.g. the KE loss for $v=5$ should be 15 J. If wrong then A0. Allow -63 [J]. Can score full marks even if only $v=3$ is found.
		6	

Question	Answer	Marks	Guidance
5(a)	Attempt at resolving in at least one direction	*M1	Correct number of relevant terms with T resolved; allow sign errors; allow sin/cos mix. Can score M1 for any $F = T\cos 30$. Do not allow g missing in the equation for R. Must have 12, not just m. Could see R as part of an equation for F. E.g. $F = 0.5(12g - T\sin 30)$.
	$R + T\sin 30 = 12g$ $F = T\cos 30$	A1	Both correct.
	Use of $F = 0.5R$ to form an equation in T or R only	*DM1	Allow sign errors in R; allow consistent sin/cos mix in R but no other errors. Must be two term R as a linear combination of weight and a component of T, and F must be a single term which is a component of T. Do not allow g missing. If correct $T\cos 30 = 0.5(120 - T\sin 30)$ or $\frac{\sqrt{3}}{2}T = 60 - 0.25T$. If no working shown to eliminate T or R, then DM2 for getting T value correct for their equations and A1 if fully correct. Could use $0.5R = T\cos 30$ and solve simultaneously.
	Attempt to solve for T	DM1	Allow consistent sin/cos mix and allow sign errors. Must get to $'T='$. Dependent on both previous M1s.
	$T = 53.8$ N	A1	$[53.7622\ldots]$ Note: For sign errors: $R - T\sin 30 = 12g$ answer should be 97.3985… $R - T\sin 30 = -12g$ answer should be -97.3985… $R + T\sin 30 = -12g$ answer should be -53.7622…… Each of the above would usually get M1A0M1M1A0.
		5	

Question	Answer	Marks	Guidance
5(b)	$T\cos 30 - F = 12 \times 0.2$	*M1	Attempt at N2L; correct number of relevant terms with T resolved; allow sign errors; allow sin/cos mix, but can be F or any reasonable attempt at friction.
	Use of $F = 0.5R$ to form an equation in T and solve	DM1	Must be a two term R as a linear combination of weight and a component of T. Allow sign errors and consistent sin/cos mix. Must get to $'T='$. The equations if correct should be $T\cos 30 - 0.5(120 - T\sin 30) = 12 \times 0.2$ or $\frac{\sqrt{3}}{2}T - 60 + 0.25T = 2.4$ or $T\left(\frac{\sqrt{3}}{2} + 0.25\right) = 62.4$ and these must be solved. Any use of T or R from part (a) scores DM0 here.
	$T = 55.9$ N	A1	$T = 55.9127\ldots$ Note: For sign errors: $R - T\sin 30 = 12g$ answer should be 101.294… $R - T\sin 30 = -12g$ answer should be –93.5026… $R + T\sin 30 = -12g$ answer should be –51.6117… Each of the above would usually get M1M1A0.
		3	

Question	Answer	Marks	Guidance
6(a)	$v = \int 0.6t \text{ d}t = \frac{0.6}{2}t^2 \left[= 0.3t^2\right] [+0]$ $[t = 4]$ $V = 0.3 \times 4^2$ or $0.3 \times 16 = 4.8$	B1	**AG** Must see $\frac{0.6}{2}t^2$ or $0.3t^2$ and 4 must be actually shown substituted. Merely stating $t = 4$ is not enough to score this mark. Do not allow use of $s = ut + \frac{1}{2}at^2$ which leads to 4.8 if $a = 0.6$ is used.
		1	
6(b)	Quadratic with correct curvature starting from (0, 0) to (4, 4.8).	B1	 Note: the grid is for reference – not shown in QP. Their graph does not need to be to scale.
	Horizontal line at from (4, 4.8) to (15, 4.8)	B1	The points should be specified somehow, but for an accurate sketch allow a line just below 5 without specifying 4.8.
	Line from (15, 4.8) to (20, 0)	B1	The points should be specified somehow, but for an accurate sketch allow a line just below 5 without specifying 4.8. Allow all 3 marks if using V instead of 4.8. ISW any extra out of the range for t of 0 to 20. If no marks scored then SC B1 for a correct shaped graph with no numbers. If using a value of $v \neq 4.8$, allow SC B1 for the first section correct and SC B1 for the second and third both correct.
		3	

Question	Answer	Marks	Guidance
6(c)	Attempt to find acceleration	**M1**	For calculation $\frac{0-4.8}{20-15}$ oe $[=-0.96]$ Allow $+0.96$.
	$[v=]19.2-0.96t$	**A1**	Oe e.g. Allow $[v=]4.8-0.96(t-15)$.
		2	
6(d)	$\left[\int_0^4 0.3t^2 dt\right] \frac{0.3}{3}t^3 \left[=0.1t^3\right]$	***M1**	Attempt to integrate their v from part **(a)** provided this came from integration, but allow a restart here. The power of t must increase by 1 with a change of coefficient. Use of $s=vt$ scores M0. No need for limits. If no integration seen allow SCM1 for answer of 6.4 in place of M1M1.
	$0.1\times 4^3\left[-0.1\times 0^3\right]$	**DM1**	Correct use of correct limit(s) (expect 6.4).
	$4.8\times 11+0.5\times 4.8\times 5$ $[=52.8+12=64.8]$	**B1**	Both correct and added. May be done in one go using a trapezium $\frac{(11+16)\times 4.8}{2}$. Could do the last stage by integration. Maximum B1 for final answer 74.4 from thinking the first section is also straight.
	Distance = 71.2 m	**A1**	
		4	

Question	Answer	Marks	Guidance
7(a)	$T - 3g = \pm 3a$ $5g - T = \pm 5a$ $5g - 3g = \pm(3+5)a$	*B1	For one correct equation.
		*B1	For any two correct consistent equations. If tensions T_A and T_B both stated must at some point state or imply that they are equal to score the second B1.
	Attempt to solve for T	DM1	May find a first $[a = 2.5]$ Must get to $'T='$. Dep on both B marks.
	$T = 37.5\text{ N}$ or $\frac{75}{2}$ N	A1	Allow without working.
	Correct use of suvat with *their a* and solve for t	DM1	E.g. $2 = 0.5 \times 2.5 \times t^2$ Must get to $'t='$. Dep on both B marks or the B1 for the equation $5g - 3g = \pm(3+5)a$ if this used to find a, but not on first M1 mark. Could find $v = \sqrt{10}$ then use $2 = \frac{0 + their\sqrt{10}}{2}t$.
	$t = 1.26$ or $\frac{\sqrt{40}}{5}$ or $\frac{2\sqrt{10}}{5}$	A1	$t = 1.2649\ldots$ If candidates do not try to find T but do attempt to find the time, they can score B1B1M0A0M1A1. Do not allow if also give negative answer and do not discard. Note: $t = \sqrt{1.6}$ only, scores A0.

Question	Answer	Marks	Guidance
7(a)	**Alternative for final 2 marks, even if nothing scored earlier**		
	Use of energy to find velocity at plane and then suvat to find t	**M1**	PE loss = KE gain: $5g\times2-3g\times2=\frac{1}{2}\times5v^2+\frac{1}{2}\times3v^2$, Or PE loss – WD by tension = KE gain: $5g\times2-\textit{their}\,37.5\times2=\frac{1}{2}\times5v^2$, Or WD by tension – PE gain = KE gain: $\textit{their}\,37.5\times2-3g\times2=\frac{1}{2}\times3v^2$, $v=\sqrt{10}$ or $v=3.16$ then $2=\frac{0+v}{2}t$, Dependent on both B marks only if candidate uses tension, but otherwise not dependent on either B mark.
	$t\left[=\sqrt{1.6}\right]=1.26$ or $\frac{\sqrt{40}}{5}$ or $\frac{2\sqrt{10}}{5}$	**A1**	$t=1.2649\ldots$
		6	

Question	Answer	Marks	Guidance
7(b)	Correct use of suvat before B hits the plane or when *A* has risen 2 m, to attempt to find velocity of *A* when string becomes slack Using *their a* and/or *their t*.	*M1	$v^2 = 0 + 2\times 2.5\times 2$. Must use $s = 2$ and $u = 0$, OR $v = 0 + 2.5\times\sqrt{1.6}$ Must use $u = 0$, OR $2 = \frac{1}{2}(0+v)\sqrt{1.6}$ Must use $s = 2$ and $u = 0$. Must be complete method to find v or v^2 $\left[v = \sqrt{10}\right]$. Could have found $v = \sqrt{10}$ in part **(a)** and give M1 if used in part **(b).**
	Correct use of suvat for motion of *A* (between height of 3m and 3.25 m), to form an equation in *t*, using $a = -g$	*DM1	$3.25 - 3 = \left(\textit{their}\ \sqrt{10}\right)t + 0.5\times(-10)\times t^2$.
	Solving a 3 term quadratic for *t* to get at least one (unsimplified) value using their 2.5 (or using any other correct method)	DM1	If correct should get $t = 0.093, 0.540$ or $\frac{\sqrt{10}-\sqrt{5}}{10}$, $\frac{\sqrt{10}+\sqrt{5}}{10}$, 0.09262… or 0.53978… Could use formula and realise that the time for at least 3.25 m, $= 2\frac{\sqrt{b^2-4ac}}{2a} = 2\frac{\sqrt{10-4\times 5\times 0.25}}{2\times 5}$ which gets DM1.
	Time = 0.447 s or $\frac{\sqrt{5}}{5}$s or $\frac{1}{\sqrt{5}}$	A1	Time $= 0.53978\ldots - 0.09262\ldots = 0.44721\ldots$ $2\left(\frac{\sqrt{10}}{10} - \frac{\sqrt{10}-\sqrt{5}}{10}\right) = 0.44721\ldots$

Question	Answer	Marks	Guidance
7(b)	**Alternative for last 3 marks of Q7(b) finding max height**		
	For attempt to find max height using correct suvat with $a=-g$	***DM1**	$0^2=\left(their\sqrt{10}\right)^2+2\times(-10)s$ Where s is distance above 3 metres. (which leads to a maximum height of 3.5 m).
	For attempt to find time from .25 m below top to top	**DM1**	$t=\ \pm 0.224$ or $\frac{\sqrt{5}}{10}$ [0.22360….] probably from $\left[3.5-3.25=0t+0.5\times 10t^2\right]$. Dep on both previous M1s.
	Time = 0.447 s or $\frac{\sqrt{5}}{5}s$	**A1**	For doubling.
	Alternative for last 3 marks of Q7(b) by finding velocity at height of 3.25 m		
	Correct use of suvat for motion of A (between height of 3m and 3.25 m), to form an equation to find speed at height of 3.25 m	***DM1**	$w^2=their\sqrt{10}^2+2\times(-g)\times 0.25$. $\left[w^2=5\right]$ or $\left[w=\sqrt{5}\right]$.
	For correct use of suvat to find time to max height	**DM1**	$0=\sqrt{5}+(-g)\times t$ $\left[t=\frac{\sqrt{5}}{10}\right]$.
	Time = 0.447 s or $\frac{\sqrt{5}}{5}s$	**A1**	For doubling.

Question	Answer	Marks	Guidance
7(b)	**Alternative using energy**		
	Correct use of energy before B hits the plane or when *A* has risen 2 m, to attempt to find velocity of *A* when string becomes slack using *their T* if necessary.	***M1**	PE loss = KE gain: $5g\times2-3g\times2=\frac{1}{2}\times5v^2+\frac{1}{2}\times3v^2$, Or PE loss – WD by tension = KE gain: $5g\times2-\textit{their}\,37.5\times2=\frac{1}{2}\times5v^2$, Or WD by tension – PE gain = KE gain: $\textit{their}\,37.5\times2-3g\times2=\frac{1}{2}\times3v^2$. Must be complete method to find v or v^2 $\left[v=\sqrt{10}\text{ or }3.162\ldots\right]$. Do not allow sign errors.
	Correct use of energy to find velocity of *A* at height of 3.25 m	***DM1**	PE gain = KE loss: $3g\times0.25=\frac{1}{2}\times3\times\sqrt{10}^2-\frac{1}{2}\times3w^2$. Must be complete method to find w or w^2 $w=\sqrt{5}$ or $2.236\ldots$ Do not allow sign errors.
	For attempt to find time from .25 m below top to top	**DM1**	$t=\pm0.224$ or $\frac{\sqrt{5}}{10}$ [0.22360….] probably from $0=\sqrt{5}-10t$. Dep on both previous M1s. Do not allow sign errors.
	Time = 0.447 s or $\frac{\sqrt{5}}{5}s$	**A1**	For doubling.
		4	

CAMBRIDGE
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Cambridge International AS & A Level

MATHEMATICS **9709/41**

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.

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.

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(a)	Trapezium on the t-axis starting at (0, 0)	**B1**	
	Fully correct with correct labels	**B1**	With height 20, intersecting the t-axis at 60, horizontal line segment between 10 and 40. Axis need not be labelled with t and v but if they are they must be correct. If not labelled, then must assume t is on the horizontal axis.
		2	
1(b)	Area = $\frac{1}{2}(30+60)\times 20$ or Area $=\frac{1}{2}\times 10\times 20+30\times 20+\frac{1}{2}\times 20\times 20$	**M1**	Must be considering the area of a trapezium. Allow a single slip in one term only. Must be adding all terms together if considering two triangles and a rectangle. Using *their* 20 from **(a)**. If no value for the height shown on the graph in **(a)**, then it must be correct.
	$= 900\text{m}$	**A1FT**	FT *their* 20 $(= 45\times \textit{their}\ 20)$ but A0 FT if using 2.
		2	

Question	Answer	Marks	Guidance
2(a)	$F = 20\sin 60$	**M1**	Attempt to resolve in y-direction; 2 terms; must be 20 cos 60 or 20 sin 60 and must be linked to F (can be implied by the correct answer seen only).
	$= 17.3\text{N}$	**A1**	AWRT 17.3 (17.320508…) or $10\sqrt{3}$.
		2	

Question	Answer	Marks	Guidance
2(b)	For resolving in any direction	*M1	Correct number of terms; allow sin/cos mix; allow sign errors.
	(Horizontal component $= X = R\cos\theta) = \pm(20\cos 60)$ [± 10] (Vertical component $= Y = R\sin\theta) = \pm(20\sin 60 - 10)$ [$= \pm 7.3205\ldots$]	A1	For both correct.
	Magnitude = $\sqrt{(20\sin 60 - 10)^2 + (20\cos 60)^2}$ [=12.393136…]	DM1	OE – correct number of terms.
	Angle = $\tan^{-1}\left(\dfrac{20\sin 60 - 10}{20\cos 60}\right)$ [=36.206023…]	DM1	OE (e.g. reciprocal) - correct number of terms.
	Magnitude = 12.4 N and Direction = 36.2° above (positive) x-axis	A1	OE for direction e.g. 36.2° anticlockwise from (positive) x-direction, 36.2° above the horizontal. Possibly seen on a diagram. (Radians: 0.63191… to 3sf or better)
		5	

Question	Answer	Marks	Guidance
3	PE gained = $180000g \times 1500\sin 1.5$ [= 70677760.4…]	**B1**	$180000g \times 39.2654\ldots$
	$\text{KE}_{\text{Initial}} = \frac{1}{2}\times 180000\times 45^2$ [= 182 250 000] $\text{KE}_{\text{Final}} = \frac{1}{2}\times 180000\times 40^2$ [= 144 000 000]	**B1**	For initial KE or final KE (for reference: difference in KE is 38 250 000).
	For work energy equation: $WD = 180000g \times 1500\sin 1.5 + 12000000$ $-\left(\frac{1}{2}\times 180000\times 45^2 - \frac{1}{2}\times 180000\times 40^2\right)$	**M1**	Correct number of terms; dimensionally correct; allow sign errors and minor slip(s) in values; allow sin/cos mix on PE term. Work done $= (70677760.4\ldots + 12000000 - 38250000)$ $\text{J} = (70677.7\ldots + 12000 - 38250)\,\text{kJ}$
	= 44400 kJ [44427.7604…]	**A1**	Must be in kJ.
	Alternative Method for Question 3: Newton's second law and equations of motion		
	$a = -0.142$ [$= -0.141666\ldots$]	**(B1)**	Correct acceleration from $40^2 = 45^2 + 2a(1500)$. Allow AWRT –0.14 or exact $-\frac{17}{120}$.
	$1500(D - \frac{12000000}{1500} - 180000g\sin 1.5) = 180000 \times -\frac{17}{120} \times 1500$	**(M1)**	**M1** for applying Newton's second law parallel to the hill. Correct number of terms, allow sin/cos mix on weight component, dimensionally correct and multiplying both sides by 1500. Allow *their a* or *a* for acceleration (and minor slip(s) in values).
		(B1)	Correct weight component multiplied by 1500.
	$WD\ (= 1500D) = 44400\,\text{kJ}$ [44427.7604…]	**(A1)**	Must be in kJ.
		4	

Question	Answer	Marks	Guidance
4	Driving force = $\frac{14000}{20}$ $[=700]$	**B1**	OE, e.g. $20 \times DF = 14000$.
	Attempt at Newton's second law on car or trailer or system	***M1**	Correct number of relevant terms (e.g. correct masses); allow sign errors.
	$700-400-T=1700a$ $T-150=300a$ $700-400-150=(1700+300)a$	**A2**	A1 for one correct and A2 for any two correct. May have *DF* (or *their DF*) for 700 but A0 if using 14000 as *DF* without first stating *DF*. Must have same T if using first two equations for A2.
	Solving for a or T	**DM1**	From equations with the correct number of relevant terms.
	Acceleration = $\frac{3}{40}$ $= 0.075\,\text{m s}^{-2}$		For both correct answers.
	Tension = $172.5\,\text{N}$	**A1**	Condone 173.
		6	

Question	Answer	Marks	Guidance
5(a)	$a = 2.08$ $[2.07911\ldots]$	B1	From $mg\sin 12 = ma$. Allow exact (e.g. $a = g\sin 12$).
	$v^2 = 5^2 + 2a \times 60$	M1	For use of $v^2 = u^2 + 2as$ with $u = 5$ and $s = 60$. Allow sign errors but a must be either $g\sin 12$ or $g\cos 12$ only.
	Speed = $16.6\,\mathrm{m\,s^{-1}}$ $[16.567861\ldots]$	A1	AWRT 16.6
	Alternative Method for Q5(a)		
	For attempt at work energy equation	(M1)	3 terms, dimensionally correct. Allow sign errors; allow sin/cos mix on PE term – condone m missing from all terms. Must be a weight component.
	$\frac{1}{2}mv^2 = \frac{1}{2}m \times 5^2 + mg \times 60\sin 12$	(A1)	Correct equation. (for reference: $60\sin 12 = 12.4747\ldots$)
	Speed = $16.6\,\mathrm{m\,s^{-1}}$ $[16.567861\ldots]$	(A1)	AWRT 16.6
		3	

Question	Answer	Marks	Guidance
5(b)	$R = mg\cos 12$	B1	Resolving correctly perpendicular to the plane.
	$mg\sin 12 - F = ma$	*M1	Use of Newton's second law, correct number of terms; allow sign errors; allow sin/cos mix (must be a weight component).
	For use of $F = 0.03R$ to get equation in a (and m) only	DM1	Where R is a component of weight only (dimensionally correct but allow sin/cos mix). $\left[\Rightarrow a = 1.79\ [1.78567\ldots]\right]$
	$60 = 5t + \frac{1}{2}at^2$ and solve for t	DM1	Dependent on previous two M marks. For use of $s = ut + \frac{1}{2}at^2$ with $s = 60$, $u = 5$ and *their a* or other complete method to find positive value(s) of t.
	Time = 5.86s [5.86260…]	A1	AWRT 5.86 (from using $a = 1.79$ or better). AWRT 5.85 (from using $a = 1.8$). AWRT 5.87 (from correct working).

Question	Answer	Marks	Guidance
5(b)	**Alternative method for Question 5(b): Using energy**		
	$R = mg\cos 12$	**(B1)**	Resolving correctly perpendicular to the plane.
	$\frac{1}{2}mv^2 - \frac{1}{2}m \times 5^2 = 60 \times mg\sin 12 - 60 \times F$	**(*M1)**	Use of work-energy principle, correctly number of relevant terms; allow sign errors; allow sin/cos mix on PE term (must be a weight component).
	For use of $F = 0.03R$ to get equation in v (and m) only	**(DM1)**	Where R is a component of weight only (dimensionally correct but allow sin/cos mix) $\left[\Rightarrow v = 15.5\ [15.46870\ldots]\right]$.
	$60 = \frac{1}{2}(5+v)t$ and solve for t	**(DM1)**	Dependent on previous two M marks. Use of $s = \frac{1}{2}(u+v)t$ with $s = 60$, $u = 5$ and *their* v or other complete method to find positive value(s) of t.
	Time = 5.86 s [5.86260…]	**(A1)**	
		5	

Question	Answer	Marks	Guidance
6(a)	For an attempt at differentiation	*M1	Decrease power by 1 and a change in coefficient in at least one term (which must be the same term). Therefore, must see $\frac{\mathrm{d}}{\mathrm{d}t}(kt^{\frac{1}{2}}) = ct^{-\frac{1}{2}}$ with $c \neq k$.
	$a = \frac{1}{2}kt^{\frac{1}{2}-1} - 2t^{1-1} + 0 = \frac{1}{2}kt^{-\frac{1}{2}} - 2$	A1	May be unsimplified.
	$a = 0 \Rightarrow \frac{1}{2}kt^{-\frac{1}{2}} - 2 = 0 \left[t = \frac{k^2}{16}\right]$ or $k = 4t^{\frac{1}{2}}$	DM1	Equate a to 0 and attempt to solve for t or k. Must be of the correct form, e.g. $t = \lambda k^2$ or $k = \delta t^{\frac{1}{2}}$ (possibly implied by forming a correct equation in k).
	$(v =) k\left(\frac{k^2}{16}\right)^{\frac{1}{2}} - 2\frac{k^2}{16} - 8 = 4.5$	M1	Or complete method to find k or an equation involving k, e.g. $4t^{\frac{1}{2}} \times t^{\frac{1}{2}} - 2t - 8 = 4.5 \Rightarrow t = 6.25$ therefore $k = 4(6.25)^{\frac{1}{2}}$. Dependent on both previous M marks.
	$\Rightarrow \frac{k^2}{8} = 12.5 \quad \Rightarrow k = 10$	A1	AG - Allow verification. Any errors seen is A0.
	Alternative method for last two marks of Question 6(a): Completing the square method		
	(Let $x = t^{\frac{1}{2}}$) $v = -2\left(x^2 - \frac{k}{2}x + 4\right) = -2\left(x^2 - \frac{k}{2}x + \frac{k}{16}^2\right) + \frac{k^2}{8} - 8$	(M1)	Dependent on both previous M marks.
	so $\frac{k^2}{8} - 8 = 4.5$ so $k = 10$	(A1)	AG
		5	

Question	Answer	Marks	Guidance
6(b)(i)	$10\times 1^{\frac{1}{2}}-2\times 1-8=0$ and $10\times 16^{\frac{1}{2}}-2\times 16-8=0$ Or equate $v=0$ and solve for t to get $t=1$ and $t=16$.	**B1**	AG Any errors seen is B0.
		1	
6(b)(ii)	For integration (do not penalise missing c)	***M1**	Increase power by 1 and a change in coefficient in at least one term (which must be the same term).
	$(s=)\frac{10}{\frac{3}{2}}t^{\frac{3}{2}}-\frac{2t^2}{2}-8t\ [+c]=\frac{20}{3}t^{\frac{3}{2}}-t^2-8t\ [+c]$ or $(s=)\frac{k}{\frac{3}{2}}t^{\frac{3}{2}}-\frac{2t^2}{2}-8t\ [+c]=\frac{2k}{3}t^{\frac{3}{2}}-t^2-8t\ [+c]$	**A1**	Allow unsimplified; allow with k not substituted.
	$\left(\frac{20}{3}1^{\frac{3}{2}}-1^2-8\times 1\right)-0\left[=-\frac{7}{3}\right]$ and $\left(\frac{20}{3}16^{\frac{3}{2}}-16^2-8\times 16\right)-\left(\frac{20}{3}1^{\frac{3}{2}}-1^2-8\times 1\right)=$ $\left[\frac{128}{3}--\frac{7}{3}=45\right]$	**DM1**	Attempt at correct use of limits 0 and 1 or 1 and 16 – allow a single slip.
	For both set of limits applied correctly	**DM1**	Allow at most one slip in both.
	$\frac{142}{3}$ m	**A1**	Allow 47.3 or better (47.3333…) **SC** if no integration shown: **B1** for $\pm\frac{7}{3}$ or 45, **B1** for $\frac{142}{3}$ (so 2 marks max).
		5	

Question	Answer	Marks	Guidance
7(a)	$v^2 = 25^2 - 2g \times 20$	M1	For use of $v^2 = u^2 + 2as$ or equivalent to get an equation in v only with $u = 25,\ s = 20$ and $a = \pm g$.
	$\Rightarrow$ speed = 15 m s^{-1}	A1	AG Allow verification – at least one intermediate step from equation of motion to given result. Any errors seen is A0.
	Alternative method for Question 7(a):		
	$0.2g \times 20 = \frac{1}{2} \times 0.2 \times 25^2 - \frac{1}{2} \times 0.2 \times v^2$	(M1)	Attempt at energy with $m = 0.2,\ h = 20,\ u = 25$; correct number of terms, allow sign errors.
	$\Rightarrow$ speed = 15 m s^{-1}	(A1)	AG Allow verification - at least one intermediate step from conservation of energy to given result. Any errors seen is A0.
		2	
7(b)	$0.2 \times 15 - 0.1 \times 20 = 0 + 0.1v$ or $0.2 \times 15 - 0.1 \times 20 = 0 - 0.1V$	M1	OE Attempt at conservation of momentum; 3 non-zero terms; allow sign errors – use of 25 is M0.
	$v = 10$ m s^{-1} upwards	A1	Must have direction (possibly seen on diagram). If using *mgv* for momentum, then M1 A0 max.
		2	

Question	Answer	Marks	Guidance
7(c)	Speed of P at impact is $20\,\text{m s}^{-1}$	B1	From $v^2 = 0 + 2 \times g \times 20$ (OE) - possibly implied by speed of P after impact being stated at 10.
	Time to when P reaches ground = 2 s	B1	From $20 = 0 + \frac{1}{2} \times g \times t^2$ (OE).
	$s_P = 10t + \frac{1}{2} \times -g \times t^2$	M1	Distance travelled by P after impact with the ground. Must be using *their* 10 (speed of P after impact with the ground) and $a = \pm g$.
	$s_Q = 10t + \frac{1}{2} \times g \times t^2$	M1	Distance travelled by Q after P's impact with the ground. Must be using their ±10 (the speed/vel. of Q after *their* 2 s $(= \lvert '10' + (-g) \times 2 \rvert$ where '10' is the value from **(b)**) and $a = \pm g$.
	$s_P + s_Q = 20 \Rightarrow t = 1$	A1	Time after P hits the ground to next collision.
	Height = 5 m	A1	CWO

Question	Answer	Marks	Guidance
7(c)	**Alternative Method for last 4 marks:**		
	$s_Q = 10t + \frac{1}{2} \times -g \times t^2$	**(M1)**	Expression for the displacement of Q after first impact of P and Q. Must be using *their* 10 (from **(b)**) and $a = \pm g$.
	$s_P = 10 \times (t-2) + \frac{1}{2} \times -g \times (t-2)^2$	**(M1)**	Expression for the displacement of P (for values of $t \geqslant 2$) measured from point of first collision between P and Q. Must be using *their* 2 (time for P to reach ground), *their* 10 (speed of P after impact with the ground), $a = \pm g$.
	$s_Q + 20 = s_P \Rightarrow t = 3$	**(A1)**	Correct time between collisions of P and Q.
	Height = 5 m	**(A1)**	CWO
		6	

Cambridge International AS & A Level

MATHEMATICS **9709/42**

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.

This document consists of **21** printed pages.

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.

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	Initial KE $=\frac{1}{2}\times 72\times 8^2\,[=2304]$ OR Final KE $=\frac{1}{2}\times 72\times 16^2\,[=9216]$ OR Work done against resistance $=28\times 100[=2800]$	**B1**	Correct expression for either KE or correct expression for work done against resistance. For reference, $\frac{1}{2}\times 72\times\left(16^2-8^2\right)=6912$.
	Attempt at work-energy equation $\left[\frac{1}{2}\times 72\times 8^2+\text{WD}=\frac{1}{2}\times 72\times 16^2+28\times 100\right]$	**M1**	4 terms; allow sign errors; dimensionally correct.
	$\text{WD}=9712\text{ J}$	**A1**	OE. Condone 9710 J. Do not ISW.
	Alternative method for Question 1:		
	$\left[16^2=8^2+2\times 100\times a\Rightarrow\right]\ a=\frac{16^2-8^2}{2\times 100}=0.96$	**(B1)**	OE, e.g. $a=\frac{192}{200}$. Use of suvat in a complete method to find an expression for *a*. Must be of the form '$a=\ldots$'.
	Attempt at Newton's second law $\left[\text{DF}-28=72\times(\textit{their}\ 0.96)\right]$	**(M1)**	Three terms; dimensionally correct; allow sign errors; must be using *their* value of *a*.
	$\text{WD}[=97.12\times 100]=9712\text{ J}$	**(A1)**	OE. Condone 9710 J. Do not ISW.
		3	

Question	Answer	Marks	Guidance
2(a)	Attempt to differentiate given v	**M1**	Decrease power by 1 and a change in coefficient in at least one term (which must be the same term); allow unsimplified. Use of $a = \frac{v}{t}$ scores M0.
	$[44 - 12t > 0 \Rightarrow]\ t < \frac{11}{3}$	**A1**	OE, e.g. $\frac{44}{12}$, $3\frac{2}{3}$, 3.67 or better. Do not allow $t \leqslant \frac{11}{3}$. May solve $44 - 12t = 0$, but final answer must be $t < \frac{11}{3}$. If a lower limit included it must be 0. Allow $t > 0$ or $t \geqslant 0$. Allow $\left[0, \frac{11}{3}\right)$ or $\left(0, \frac{11}{3}\right)$.
	Alternative Method for Question 2(a):		
	Use completing the square to get $-6\left[\left(t - \frac{11}{3}\right)^2 + \ldots\right] + \ldots$	**(M1)**	OE
	$t < \frac{11}{3}$	**(A1)**	CWO If a lower limit included it must be 0. Allow $t > 0$ or $t \geqslant 0$. Allow $\left[0, \frac{11}{3}\right)$ or $\left(0, \frac{11}{3}\right)$.

Question	Answer	Marks	Guidance
2(a)	**Alternative Method 2 for Question 2(a):**		
	Solving $44t-6t^2-36=0$ and find $\frac{t_1+t_2}{2}$, or equivalent.	(M1)	Complete method for finding the value of t at maximum, or use $-\frac{b}{2a}$ with correct a and b. For reference, $t=\frac{11\pm\sqrt{67}}{3}$.
	$t<\frac{11}{3}$	(A1)	If a lower limit included it must be 0. Allow $t>0$ or $t\geqslant 0$. Allow $\left[0,\frac{11}{3}\right)$ or $\left(0,\frac{11}{3}\right)$.
		2	
2(b)	Attempt to integrate given v	M1	Increase power by 1 and a change in coefficient in at least one term (which must be the same term). Use of $s=vt$ is M0.
	$(s=)\frac{44}{1+1}t^{1+1}-\frac{6}{2+1}t^{2+1}-36t(+c)=22t^2-2t^3-36t(+c)$	A1	Allow unsimplified.
	$\left[22t^2-2t^3-36t=0\Rightarrow\right]\ t=2,\ 9(\text{and}\,0)$ ONLY	A1	CWO Ignore $t=0$ if not rejected.
		3	

Question	Answer	Marks	Guidance
3	Resolving either direction to get an equation	*M1	Correct number of relevant terms; allow sign errors; allow sin/cos mix.
	$10\cos 25 = 2\cos 40 + 16\sin\theta$ $\begin{bmatrix} 9.06307787 = 1.532088886 + 16\sin\theta \\ 7.530988984 = 16\sin\theta \\ \sin\theta = 0.4706868115 \end{bmatrix}$	A1	
	$P = 10\sin 25 + 16\cos\theta + 2\sin 40$ $\begin{bmatrix} P = 4.226182617 + 16\cos\theta + 1.285575219 \\ P = 5.511757837 + 16\cos\theta \end{bmatrix}$	A1	This may be with *their* θ.
	Attempt to solve for $\theta = \sin^{-1}\left(\frac{10\cos 25 - 2\cos 40}{16}\right)$	DM1	From equation(s) with correct number of relevant terms. Must be a numerical expression for θ.
	Attempt to solve for $P = 10\sin 25 + 16\cos(\textit{their}\ \theta) + 2\sin 40$	DM1	From equation(s) with correct number of relevant terms. Using *their* θ. Must be a numerical expression for P.
	$\theta = 28.1$ AND $P = 19.6$	A1	28.07888819 and 19.6285636. AWRT 28.1 and AWRT 19.6 from correct work.
		6	

Question	Answer	Marks	Guidance
4(a)(i)	$\left[k \times 24^2 = 480 \Rightarrow\right] k = \dfrac{5}{6}$	**B1**	OE, e.g. $\dfrac{480}{576}$, 0.833 or better.
		1	
4(a)(ii)	Attempt at Newton's second law $\left[DF = 480 + 1400g \times 0.12 \Rightarrow DF = 2160\right]$	***M1**	3 terms; allow sign errors; allow sin/cos mix. Allow $DF = 480 + 1400g \times \sin 6.9$ or better. May see $DF = \left(their\,\dfrac{5}{6}\right)24^2 + 1400g \times 0.12$.
	Power $= (their\,2160) \times 24$	**DB1**	For using $P = DF$ x v, where DF is numerical.
	51840 W	**A1**	Allow W missing, but if given in kW units must be present. Allow 51.84 kW. Allow 51800, 51.8 kW.
		3	
4(b)	$DF = \dfrac{54000}{v}$ and $DF = \left(their\,\dfrac{5}{6}\right)v^2$	***B1FT**	FT $their\,\dfrac{5}{6} > 0$.
	Get an equation of the form $av^3 = b$ and attempt to solve for v to get a positive value	**DM1**	a and b must both be positive or both negative. Must get to a value for v; if cubic not seen, the cubic may be implied by the correct answer for their equation.
	Speed = 40.2 m s^{-1}	**A1**	40.165977. AWRT 40.2 from correct work.
		3	

Question	Answer	Marks	Guidance
5	Attempt at resolving perpendicular to plane to get an equation	*M1	3 relevant terms; allow sign errors; allow sin/cos mix; allow g missing; $m=0.8$ must be used; correct angles must be used.
	$R+T\sin 35=0.8g\cos 28$ $\left[R+(0.57357\ldots)\ T=7.06358\right]$	A1	
	Attempt to resolve parallel to plane for one of the possible cases to get an equation	*M1	3 relevant terms; allow sign errors; allow sin/cos mix; allow g missing; $m=0.8$ must be used; correct angles must be used.
	$T\cos 35=0.8g\sin 28+F$ $\left[(0.81915\ldots)T=3.75577\ldots+F\right]$	A1	May use *their F*.
	$T\cos 35=0.8g\sin 28-F$ $\left[(0.81915\ldots)T=3.75577\ldots-F\right]$	A1	May use *their F*.
	Use of $F=0.2R$ to get an equation in T only	DM1	Dependent on previous 2 M marks. May be implied by correct T value. Allow g missing. If resolved equations incorrect and no working seen, then this mark is implied by the correct T value for their equations.
	Solve to get $T=5.53$	A1	5.534499898 AWRT 5.53 from correct work. Allow 5.54 from correct work.
	Solve to get $T=3.33$	A1	3.326141531 AWRT 3.33 from correct work. Allow 3.32 from correct work.
		8	

Question	Answer	Marks	Guidance
6(a)	Attempt at conservation of momentum for the 1st collision $\left[5\times 6=(5+1)v_D\right]$	*M1	3 non-zero terms; allow sign errors; using correct masses. For reference $v_D=5$. If *mgv* used, allow M1 M1 A0 max.
	Attempt at conservation of momentum for the 2nd collision $\left[(5+1)(\mathit{their}\ v_D)-2v=(5+1+2)v_E\right]$	DM1	6 non-zero terms; allow sign errors; using correct masses; allow their numerical v_D. Allow $v=v_E$ for this mark. Note: $5\times 6-2v=(5+1+2)v_E$ is M2. If *mgv* used, allow M1 M1 A0 max.
	$(v_E=)\ \dfrac{15-v}{4}$	A1	AG Must in terms of v, as v is given in the question or explicitly defined their letter used as v. Do not allow $v=v_E$ for this mark. Any error seen is A0 but condone saying 'divide by 2' or equivalent. If *mgv* used, allow M1 M1 A0 max.
		3	

Question	Answer	Marks	Guidance
6(b)	$\text{KE}_{initial} = \frac{1}{2}\times 5\times 6^2 + \frac{1}{2}\times 2\times v^2 \left[= 90 + v^2\right]$ $\text{KE}_{final} = \frac{1}{2}(5+1+2)\left(\frac{15-v}{4}\right)^2$	**B1**	For either $\text{KE}_{initial}$ or KE_{final} correct.
	Attempt difference in KE is 63 to get an equation $\left[\frac{1}{2}\times 5\times 6^2 + \frac{1}{2}\times 2\times v^2 - \frac{1}{2}(5+1+2)\left(\frac{15-v}{4}\right)^2 = 63\right]$	**M1**	Using $(\text{sum of two initial } KEs) - \text{KE}_{final} = \pm 63$. Correct number of relevant terms – correct masses, must be adding 2 KE terms for $\text{KE}_{initial}$. $(\text{sum of two initial } KEs)$ and KE_{final} coming from use of correct formula and of the correct form.
	Solve algebraically $3v^2 + 30v - 117 = 0$ OE to get $v = 3$ ONLY	**A1**	AG Any error seen is A0. Allow solving correct quadratic expression, rather than correct quadratic equation, for full marks. If $v = -13$ seen it must be discarded. Must see solving for this mark. A quadratic equation followed by the answer is insufficient.

Question	Answer	Marks	Guidance
6(b)	**Alternative Method for Question 6(b): Using loss of KE in second collision**		
	$\text{KE}_{after\ 1^{st}\ collision} = \frac{1}{2}\times 6\times 5^2 + \frac{1}{2}\times 2\times v^2\left[=75+v^2\right]$ $\text{KE}_{final} = \frac{1}{2}(5+1+2)\left(\frac{15-v}{4}\right)^2$	(B1)	For either $\text{KE}_{after\ 1^{st}\ collision}$ or KE_{final} correct.
	Attempt difference in KE is $63-\left(\frac{1}{2}\times 5\times 6^2 - \frac{1}{2}\times 6\times 5^2\right)\left[=63-15=48\right]$ to get an equation $\left[\frac{1}{2}\times 6\times 5^2 + \frac{1}{2}\times 2\times v^2 - \frac{1}{2}(5+1+2)\left(\frac{15-v}{4}\right)^2 = 63-15\right]$	(M1)	Using $\text{KE}_{after\ 1^{st}\ collision} - \text{KE}_{final} = \pm(63 - \mathit{their}\,15)$. Correct number of relevant terms. $\text{KE}_{after\ 1^{st}\ collision}$, KE_{final} and *their* 15 coming from use of correct formula and of the correct form.
	Solve algebraically $3v^2+30v-117=0$ OE to get $v=3$ ONLY	(A1)	AG Any error seen is A0. If $v=-13$ seen it must be discarded. Must see solving for this mark. A quadratic equation followed by the answer is insufficient.
	Alternative Method 2 for Question 6(b): Verifying that $v=3$		
	$\text{KE}_{initial} = \frac{1}{2}\times 5\times 6^2 + \frac{1}{2}\times 2\times 3^2 = 99$	(B1)	
	$\text{KE}_{final} = \frac{1}{2}(5+1+2)\left(\frac{15-3}{4}\right)^2 = 36$	(B1)	
	$\text{KE}_{initial} - \text{KE}_{final} = 63$, hence loss in KE is 63 J	(B1)	Must have a conclusion for this mark.
		3	

Question	Answer	Marks	Guidance
6(c)(i)	Time A to $B = 6$ s	**B1**	
	Distance $BC = 98 - 3 \times (\textit{their}\ 6)$ $[= 80]$	***B1FT**	FT *their* 6 which MUST come from $6t = 36$.
	Use sum of distance moved by D and distance moved by C is 80 m $\left[(\textit{their}\ 5)t + 3t = \textit{their}\ 80\right]$ OR use distance moved by C divided by relative velocity $\left[\dfrac{80}{(\textit{their}\ 5) + 3}\right]$	**DM1**	Using *their* v_D from part **(a)**. $v_D \neq 6$ or 3 and *their* $80 \neq 98$.
	Time = 10 s	**A1**	Do not ISW.
		4	
6(c)(ii)	$\left[6 + 10 + \dfrac{3 \times 10 + 3 \times 6}{3} = \right] 32$ s	**B1**	
		1	

Question	Answer	Marks	Guidance
7(a)	$R = 2.5g\cos 30\left[= \frac{25\sqrt{3}}{2} = 21.65063509\right]$	**B1**	Note: $F = 0.5g\cos 30 = \frac{5\sqrt{3}}{2} = 4.330127019$.
	Attempt at Newton's second law	***M1**	Correct number of dimensionally correct/relevant terms; allow sign errors; allow sin/cos mix. Using this twice to get equations for P and Q; allow different T's (equations with 0.5 and 2.5). Using once to get a system equation (equation with $0.5 + 2.5$).
	EITHER: $T - 0.5g = 0.5a$ AND $2.5g\sin 30 - F - T = 2.5a$ OR: $2.5g\sin 30 - F - 0.5g = (2.5 + 0.5)a$	**A1**	EITHER: Both correct; allow their F; must be the same T. OR: correct system equation; allow their F.
	Use $F = 0.2R$ to get an equation in a only $[2.5g\sin 30 - 0.2\times 2.5g\cos 30 - 0.5g = (2.5+0.5)a]$	**DM1**	Where R is a component of weight of P only; from equation(s) with the correct number of dimensionally correct/relevant terms.
	$a = 1.06\ \mathrm{m\,s^{-2}}$	**A1**	Allow $\frac{15 - 5\sqrt{3}}{6}$. 1.05662433. AWRT 1.06 from correct work.
		5	

Question	Answer	Marks	Guidance
7(b)	$\left[x\sin 30 = 2 - x \Rightarrow\right]\ x = \frac{4}{3}$ OR $\left[(2-y)\sin 30 = y \Rightarrow\right]\ y = \frac{2}{3}$ OR $\left[\frac{1}{2}\times 1.056\ldots\times t^2 + \frac{1}{2}\times 1.056\ldots\times t^2\times\sin 30 = 2 \Rightarrow t = 1.5886\ldots\right]$ $\Rightarrow x\left[=\frac{1}{2}\times 1.056\ldots\times(1.5886..)^2\sin 30\right] = \frac{2}{3}$ OR $\Rightarrow y\left[=\frac{1}{2}\times 1.056\ldots\times(1.5886..)^2\right] = \frac{4}{3}$	*B1	Where x is the distance P moves down the plane or Q moves vertically upwards, or where y is the vertical distance of Q below P's starting point. Allow $x = 1.3$ or better; allow $y = 0.67$ or better.
	Change in PE $= \pm\left(2.5g(\textit{their } x)\sin 30 - 0.5g(\textit{their } x)\right)$ $\left[= \pm\frac{3}{4}g(\textit{their } x)\right]$ OR $= \pm\left(2.5g(2 - \textit{their } y)\sin 30 - 0.5g(2 - \textit{their } y)\right)$ $\left[= \pm\left(3(\textit{their } y) - 1\right)g\right]$	B1	Using *their* $x(\neq 2 \text{ or } 1 \text{ or } 0)$, $0 < x < 2$; or *their* $y(\neq 2 \text{ or } 1 \text{ or } 0)$, $0 < y < 2$.
	WD against friction $= 0.2\times 2.5g\cos 30\times(\textit{their } x)$ $\left[= 4.33(\textit{their } x)\right]$ OR WD against friction $= 0.2\times 2.5g\cos 30\times\left(2 - (\textit{their } y)\right)$	B1	Using *their* $x(\neq 2 \text{ or } 1 \text{ or } 0)$, $0 < x < 2$; or *their* $y(\neq 2 \text{ or } 1 \text{ or } 0)$, $0 < y < 2$.
	$\frac{1}{2}\times 2.5\times v^2 + \frac{1}{2}\times 0.5\times v^2 =$ $2.5g\left(\frac{4}{3}\right)\sin 30 - 0.5g\left(\frac{4}{3}\right) - 0.2\times 2.5g\cos 30\times\left(\frac{4}{3}\right)$ OR $\frac{1}{2}\times 2.5\times v^2 + \frac{1}{2}\times 0.5\times v^2 =$ $2.5g\left(2-\frac{2}{3}\right)\sin 30 - 0.5g\left(2-\frac{2}{3}\right) - 0.2\times 2.5g\cos 30\times\left(2-\frac{2}{3}\right)$	DM1	Attempt at work energy equation; dimensionally correct; 5 relevant terms; allow sign errors; allow sin/cos mix. Must be using correct values of x or y.

Question	Answer	Marks	Guidance
	$v = 1.68$	A1	1.67859014 AWRT 1.68 from correct work.

Question	Answer	Marks	Guidance
7(b)	**Alternative Method for Question 7(b): Considering energy on *Q* only** **Must be using tension and mass 0.5 kg only to be awarded the last 4 marks**		
	$\left[x\sin 30 = 2 - x \Rightarrow\right]\ x = \frac{4}{3}$ OR $\left[(2-y)\sin 30 = y \Rightarrow\right]\ y = \frac{2}{3}$ OR $\left[\frac{1}{2}\times 1.056\ldots\times t^2 + \frac{1}{2}\times 1.056\ldots\times t^2 \times \sin 30 = 2 \Rightarrow t = 1.5886\ldots.\right]$ $\Rightarrow x\left[=\frac{1}{2}\times 1.056\ldots\times(1.5886..)^2\sin 30\right] = \frac{2}{3}$ OR $\Rightarrow y\left[=\frac{1}{2}\times 1.056\ldots\times(1.5886..)^2\right] = \frac{4}{3}$	**(*B1)**	Where x is the distance P moves down the plane or Q moves vertically upwards, or where y is the vertical distance of Q below P's starting point. Allow $x = 1.3$ or better; allow $y = 0.67$ or better.
	Change in PE $= \pm 0.5g \times (\textit{their}\ x)$ OR Change in PE $= \pm 0.5g \times (2 - (\textit{their}\ y))$	**(B1)**	Using *their* $x(\neq 2 \text{ or } 1 \text{ or } 0)$, $0 < x < 2$; or *their* $y(\neq 2 \text{ or } 1 \text{ or } 0)$, $0 < y < 2$.
	WD by tension $= (\textit{their}\ 5.528312164)\times(\textit{their}\ x)$ OR WD by tension $= (\textit{their}\ 5.528312164)\times(2-(\textit{their}\ y))$	**(B1)**	Using *their* tension from **7(a)** from equation(s) with the correct number of dimensionally correct/relevant terms. Using *their* $x(\neq 2 \text{ or } 1 \text{ or } 0)$, $0 < x < 2$; or *their* $y(\neq 2 \text{ or } 1 \text{ or } 0)$, $0 < y < 2$.
	$0.5g\left(\frac{4}{3}\right) + \frac{1}{2}\times 0.5 \times v^2 = (\textit{their}\ 5.528312164)\times\left(\frac{4}{3}\right)$ OR $0.5g\left(2-\frac{2}{3}\right) + \frac{1}{2}\times 0.5\times v^2 = (\textit{their}\ 5.528312164)\times\left(2-\frac{2}{3}\right)$	**(DM1)**	Using *their* tension from **7(a)** from equation(s) with the correct number of dimensionally correct/relevant terms. Attempt at work energy equation; dimensionally correct; 3 relevant terms; allow sign errors. Must be using correct values of x or y.
	$v = 1.68$	**(A1)**	1.67859014 AWRT 1.68 from correct work.

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td rowspan="6">7(b)</td><td colspan="3">Alternative Method 2 for Question 7(b): Considering energy on P only
Note: must be using tension and mass 2.5 kg only to be awarded the last 4 marks</td></tr>
<tr><td>$\left[x\sin 30 = 2 - x \Rightarrow\right]\ x = \frac{4}{3}$ OR $\left[(2-y)\sin 30 = y \Rightarrow\right]\ y = \frac{2}{3}$
OR $\left[\frac{1}{2}\times 1.056\ldots\times t^2 + \frac{1}{2}\times 1.056\ldots\times t^2 \times \sin 30 = 2 \Rightarrow t = 1.5886\ldots.\right]$
$\Rightarrow x\left[=\frac{1}{2}\times 1.056\ldots\times(1.5886..)^2 \sin 30\right] = \frac{2}{3}$
OR $\Rightarrow y\left[=\frac{1}{2}\times 1.056\ldots\times(1.5886..)^2\right] = \frac{4}{3}$</td><td>(*B1)</td><td>Where x is the distance P moves down the plane or Q moves vertically upwards, or where y is the vertical distance of Q below P's starting point.
Allow $x = 1.3$ or better; allow $y = 0.67$ or better.</td></tr>
<tr><td>Change in PE $= \pm 2.5g(\mathit{their}\ x)\sin 30$ OR $= \pm 2.5g(\mathit{their}\ y)$</td><td>(B1)</td><td>Using their $x(\neq 2 \text{ or } 1 \text{ or } 0)$, $0 < x < 2$;
or their $y(\neq 2 \text{ or } 1 \text{ or } 0)$, $0 < y < 2$.</td></tr>
<tr><td>WD by tension $= (\mathit{their}\ 5.528312164)\times(\mathit{their}\ x)$
OR WD against friction $= 0.2\times 2.5g\cos 30\times(\mathit{their}\ x)$</td><td>(B1)</td><td>Using their tension from 7(a) from equation(s) with the correct number of dimensionally correct/relevant terms.
Using their $x(\neq 2 \text{ or } 1 \text{ or } 0)$, $0 < x < 2$;
or their $y(\neq 2 \text{ or } 1 \text{ or } 0)$, $0 < y < 2$.</td></tr>
<tr><td>$2.5g\left(\frac{4}{3}\right)\sin 30 = \frac{1}{2}\times 2.5\times v^2 +$
$0.2\times 2.5g\cos 30\times\left(\frac{4}{3}\right) + (\mathit{their}\ 5.528312164)\times\left(\frac{4}{3}\right)$</td><td>(DM1)</td><td>Using their tension from 7(a) from equation(s) with the correct number of dimensionally correct/relevant terms.
Attempt at work energy equation; dimensionally correct; 4 relevant terms; allow sign errors; allow sin/cos mix.
Must be using correct values of x or y.</td></tr>
<tr><td>$v = 1.68$</td><td>(A1)</td><td>1.67859014
AWRT 1.68 from correct work.</td></tr>
</table>

Question	Answer	Marks	Guidance
7(b)	**Special Case for using constant acceleration: Maximum 2 marks**		
	$\left[x\sin 30 = 2 - x \Rightarrow\right]\ x = \frac{4}{3}$ OR $\left[(2-y)\sin 30 = y \Rightarrow\right]\ y = \frac{2}{3}$ OR $\left[\frac{1}{2}\times 1.056\ldots\times t^2 + \frac{1}{2}\times 1.056\ldots\times t^2 \times \sin 30 = 2 \Rightarrow t = 1.5886\ldots.\right]$ $\Rightarrow x\left[=\frac{1}{2}\times 1.056\ldots\times(1.5886..)^2 \sin 30\right] = \frac{2}{3}$ OR $\Rightarrow y\left[=\frac{1}{2}\times 1.056\ldots\times(1.5886..)^2\right] = \frac{4}{3}$	**(B1)**	Where x is the distance P moves down the plane or Q moves vertically upwards, or where y is the vertical distance of Q below P's starting point. Allow $x = 1.3$ or better; allow $y = 0.67$ or better.
	$\left[v^2 = 2\times 1.06 \times \frac{4}{3} \Rightarrow\right]\quad v = 1.68$	**(B1)**	1.67859014 AWRT 1.68 from correct work.
		5	

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.

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.

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. $v^2 = (11a)^2 + 2a(18 \times 11a + 162a)$ $[= 841a^2]$, $v = \sqrt{(11a)^2 + 2a(18 \times 11a + 162a)}$ $[= \sqrt{841a^2}]$.
	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.
	$v\left[= 3 \times \left(\dfrac{2}{3}\right)^2 - 4 \times \dfrac{2}{3} + 3\right] = \dfrac{5}{3}\ \mathrm{m\,s^{-1}}$	**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* $k\left(t - \dfrac{2}{k}\right)^2 - \dfrac{4}{k} + 3$.
	$v = \dfrac{5}{3}\ \mathrm{m\,s^{-1}}$	**(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: $T-300-750g\times 0.09=750a$ $[T-975=750a]$ Van: $9100-2500-4500g\times 0.09-T=4500a$ $[2550-T=4500a]$ System: $9100-2500-300-(4500+750)g\times 0.09=(4500+750)a$ $[1575=5250a]$	**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 $a=0.3\text{ ms}^{-2}$	**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: $\frac{1}{2} \times 4500(v^2 - 20^2) + 4500g \times 375 \times 0.09 = (9100 - 2500 - \textit{their}\, 1200)$ OR Trailer: $\frac{1}{2} \times 750(v^2 - 20^2) + 750g \times 375 \times 0.09 = (\textit{their}\, 1200 - 300) \times 375$	**(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.
	$\frac{1}{2}\times80v^2$ $[40v^2]$ 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.
	$120\times4+80g\times\frac{1}{20}\times32.2-1128=\frac{1}{2}\times80\left(v^2-7.5^2\right)$ $\left[480+1288-1128=40v^2-2250\right]$	A1	For correct equation.
	Speed = 8.5[0] 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 $F_{BC} = 0.1mg\left[= m\right]$ 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 ${v_C}^2 = 20 - 2 \times 1 \times 2\ [= 16]$ $1^2 = 16 - 2 \times (g\sin 30 + 0.1g\cos 30)d$ $\left[1 = 16 - 2\left(5 + \frac{\sqrt{3}}{2}\right)\text{d}\right]$	**(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.
	$d = 1.28\,\text{m}$ 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}: $-0.1mg = ma \quad a = -1$ 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 $\dfrac{4-\sqrt{3}}{13}$ $[0.174457\ldots]$	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 m s^{-1} [2.64164…]	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} $-\mu mg = ma\quad a = -\mu g$ so $v_C{}^2 = 20 - 2\mu g\times 2$ For a_{CD} $-mg\sin 30 - \mu mg\cos 30 = ma\left[a = -5.866\ldots = -\left(5 + \frac{\sqrt{3}}{2}\right)\right]$ $0 = 20 - 2\mu g\times 2 - 2(g\sin 30 + \mu g\cos 30)\times 1$ $\left[20 - 40\mu - 10 - 10\sqrt{3}\mu = 0\right]$	**(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**		
	$mg\times 2\sin 30-\left(\mu mg\times 2+\mu mg\cos 30\times 2\right)\ \left[=\frac{1}{2}mv^2\right]$	**(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	

Cambridge International AS & A Level

MATHEMATICS **9709/42**

Paper 4 Mechanics **February/March 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 February/March 2024 series for most Cambridge IGCSE, Cambridge International A and AS Level components, and some Cambridge O Level components.

This document consists of **22** printed pages.

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.

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.

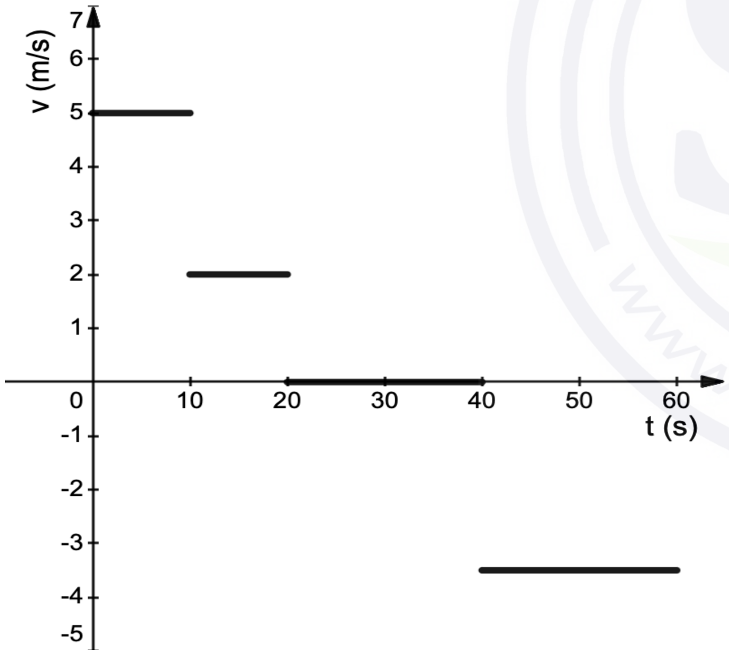
DM or **DB** When a part of a question has two or more 'method' steps, the M marks are generally independent unless the scheme specifically says otherwise; and similarly, when there are several B marks allocated. The notation DM or DB is used to indicate that a particular M or B mark is dependent on 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(a)	Total distance travelled = $50+2\times10\ [=70]$	B1	Any explicit expression for the distance, e.g. $\dfrac{x-50}{20-10}=2\rightarrow x=2(20-10)+50$.
	Velocity $=-\dfrac{70}{20}=-3.5\text{ m s}^{-1}$	B1FT	Oe. Ft *their* distance $\neq 50$. Must be negative. Do not ISW if (e.g.) velocity = 3.5. Do allow "3.5 m s^{-1}, directed towards O."
		2	
1(b)	Velocity 5 m s^{-1} for $0\leqslant t\leqslant 10$	B1	May be seen on diagram.
		B1	Stepped diagram with four horizontal lines segments. Ignore vertical line segments.
		B1FT	All correct. 10, 20, 40 and 60 indicated on the t-axis. *Their* 5, 2 and *their* –3.5 (allow –3 and –4 is acceptable too with line segment halfway between them) indicated on the v-axis, corresponding to the position of the horizontal line segments. FT *their* -3.5 m s^{-1} and/or FT their 5 m s^{-1}. If their answer to **(a)** is positive, allow use of negative their answer for this mark.
		3	

Question	Answer	Marks	Guidance
2(a)	$-5 = u - g \times 2$ or $5 = u + g \times 2$ or $5 = 0 + gt \Rightarrow t = 0.5$, so time to greatest height is $T = 2 - 0.5 = 1.5$. Hence $0 = u + (-g) \times 1.5$	M1	For use of constant acceleration to get an equation in u only. Using $v = -5$, $t = 2$ and $a = \pm g$.
	Speed = 15 m s^{-1}	A1	Must be positive.
		2	
2(b)	$0^2 = 10^2 - 2gs$ $[\Rightarrow s = 5]$ or $10^2 = [0^2 +]2gs$ $[\Rightarrow s = 5]$ or $10 = 0 + gt \Rightarrow t = 1$, so $s = 10 \times 1 - \frac{1}{2} g \times 1^2$ $[\Rightarrow s = 5]$ or $\frac{1}{2}(m) \times 10^2 = (m)gh$ $[\Rightarrow h = 5]$	M1	For use of constant acceleration formula(e) to find distance travelled from height with speed 10 m s^{-1} to maximum height with speed 0 m s^{-1}, $a = \pm g$. Must be a complete method, e.g. $0^2 = (\textit{their}\,15)^2 - 2gs_1$ $[\Rightarrow s_1 = 11.25]$ and $10^2 = (\textit{their}\,15)^2 - 2gs_2$ $[\Rightarrow s_2 = 6.25]$ or $10 = (\textit{their}\,15) - gt$ $[\Rightarrow t = 0.5]$, $s_2 = \frac{1}{2}(\textit{their}\,15 + 10) \times (\textit{their}\,0.5)$ and with an attempt at $s_1 - s_2 [= 5]$. Energy method with 2 terms, dimensionally correct.
	Total distance = 10 m	A1FT	FT *their* 15 m s^{-1} if used.
		2	

Question	Answer	Marks	Guidance
3	Driving force = $\frac{8000}{2}$ or 4000	**B1**	Use of $F = \frac{P}{v}$, oe. E.g. $DF \times 2 = 8000$.
	$R = 600g\cos 30\left[= 3000\sqrt{3} = 5196.152423\right]$	**B1**	
	their Driving force $- 600g\sin 30 - F = 0$ $\left[F = 4000 - 3000 = 1000\right]$	***M1**	For attempt to resolve parallel to the plane; 3 terms; allow sign errors; allow sin/cos mix; allow g missing; F not resolved. Allow with just DF.
	Use of $F = \mu R$	**DM1**	To form an equation in μ only where R is a component of weight or mass.
	$\mu = 0.192$ or $\frac{\sqrt{3}}{9}$	**A1**	Awrt 0.192 [0.1924500897]. Oe, e.g. $\frac{1}{3\sqrt{3}}$. Allow 2sf.
		5	

Question	Answer	Marks	Guidance
4	For resolving in either direction	*M1	Correct number of terms allow sign errors; allow sin/cos mix on θ. Forces that need resolving should be resolved.
	$F+2F\cos 45=30\sin\theta$	A1	
	$2F\sin 45+3F=30\cos\theta$	A1	
	$\theta=\tan^{-1}\left(\frac{1+2\cos 45}{2\sin 45+3}\right)$ or $\theta=\sin^{-1}\left(\frac{F+2F\cos 45}{30}\right)$ or $\theta=\cos^{-1}\left(\frac{2F\sin 45+3F}{30}\right)$	DM1	For attempt to find θ. Using their F which can be solved for θ. From equations with correct number of relevant terms, forces that need resolving should be resolved. If $\tan\theta=\frac{\cos\theta}{\sin\theta}$, so have $\theta=\tan^{-1}\left(\frac{2\sin 45+3}{1+2\cos 45}\right)$, then allow M1.
	$\left[F^2(3+2\sin 45)^2+F^2(1+2\cos 45)^2=30^2 \Rightarrow\right]$ $F=\sqrt{\frac{30^2}{(3+2\sin 45)^2+(1+2\cos 45)^2}}$ or $F=\frac{30\sin\theta}{1+2\cos 45}$ or $F=\frac{30\cos\theta}{3+2\sin 45}$	DM1	For attempt to find F. From equations with the correct number of relevant terms, forces that need resolving should be resolved. Using *their* θ.
	$F=5.96$ [5.96270…] and $\theta=28.7$ [28.6750…]	A1	Awrt to 5.96 and 28.7. Allow 5.97.
		6	

Question	Answer	Marks	Guidance
5(a)	For attempt at integration	*M1	Increase power by 1 and a change in coefficient in at least one term (which must be the same term). $s = vt$ is M0.
	$(s =)\dfrac{1}{(3+1)}t^{3+1} - \dfrac{9}{2\times(2+1)}t^{2+1} + t[+c] = \dfrac{1}{4}t^4 - \dfrac{3}{2}t^3 + t[+c]$	A1	May be unsimplified.
	Distance = $\left(\dfrac{1}{4}\times\left(\dfrac{1}{2}\right)^4 - \dfrac{3}{2}\left(\dfrac{1}{2}\right)^3 + \left(\dfrac{1}{2}\right)\right)[-(0)]$	DM1	Use limits 0 and $\frac{1}{2}$ correctly, or substitute $t = \frac{1}{2}$. M0 if including other regions.
	$= \dfrac{21}{64}$ m	A1	Oe, e.g. 0.328125. Condone 0.328.
	Special Case if no integration seen. Maximum 1/4		
	$\dfrac{21}{64}$ m	B1	Oe, e.g. 0.328125. Condone 0.328.
		4	

Question	Answer	Marks	Guidance
5(b)	Attempt to differentiate $\left[(a=)3t^2-9t\right]$	*M1	Decrease power by 1 and a change in coefficient in at least one term (which must be the same term). $a=\frac{v}{t}$ is M0.
	Solve $a=0$ to get $t=3$	A1	Ignore $t=0$ if not rejected.
	Distance from $t=\frac{1}{2}$ to $t=3$ = $\pm\left(\left(\frac{1}{4}\times3^4-\frac{3}{2}\times3^3+3\right)-\left(\frac{1}{4}\times\left(\frac{1}{2}\right)^4-\frac{3}{2}\left(\frac{1}{2}\right)^3+\left(\frac{1}{2}\right)\right)\right)=$ $\pm\left(\left(\frac{1}{4}\times3^4-\frac{3}{2}\times3^3+3\right)-\frac{21}{64}\right)\left[=\mp17\frac{37}{64}=\mp\frac{1125}{64}=\mp17.578125\right]$	DM1	Must be using an expression for s from integration. Allow missing minus sign at start; use limits $\frac{1}{2}$ and their 3 correctly, where $\frac{1}{2}<\textit{their}\,3\le4$. Or use limit 3 and find difference from *their* $\frac{21}{64}$ from part **(a)**. May see $2\times\left(\frac{1}{4}\times\left(\frac{1}{2}\right)^4-\frac{3}{2}\left(\frac{1}{2}\right)^3+\left(\frac{1}{2}\right)\right)-\left(\frac{1}{4}\times3^4-\frac{3}{2}\times3^3+3\right)$
	So total $\left[=\frac{21}{64}+17\frac{37}{64}\right]=17\frac{29}{32}$ m	A1FT	Oe, e.g. $\frac{573}{32}$, 17.90625. Condone 17.9. FT *their* positive integration value in part **(a)**, e.g. $17\frac{37}{64}+$ *their* **(a)** or $\frac{69}{4}+2\times$ *their* **(a)**.

Question	Answer	Marks	Guidance
5(b)	**Special Case if no integration seen. Maximum M1A1B1 for 3 marks**		
	Attempt to differentiate $\left[(a=)3t^2-9t\right]$	**M1**	Decrease power by 1 and a change in coefficient in at least one term (which must be the same term). $a=\frac{v}{t}$ is M0.
	Solve $a=0$ to get $t=3$	**A1**	
	$17\frac{29}{32}$ m	**B1**	Oe, e.g. $\frac{573}{32}$, 17.90625. Condone 17.9.
		4	

Question	Answer	Marks	Guidance
6(a)	Attempt at Newton's second law on car or trailer or system	*M1	Correct number of terms; allow sign errors; allow sin/cos mix; $\sin\alpha$ or $\alpha = 2.865\ldots$ needs to be substituted; allow with $\alpha = 2.87$ or 2.9 or better; allow g missing.
	Car: $3000 - 1800g \times 0.05 - 800 - T = 1800a$ $[3000 - 900 - 800 - T = 1800a \quad \to \quad 1300 - T = 1800a]$ Trailer: $T - 300g \times 0.05 - 100 = 300a$ $[T - 150 - 100 = 300a \quad \to \quad T - 250 = 300a]$ System: $3000 - 1800g \times 0.05 - 300g \times 0.05 - 800 - 100 = (1800 + 300)a$ $[3000 - 900 - 150 - 800 - 100 = 2100a \quad \to \quad 1050 = 2100a]$	A1	Any two equations correct.
	Solving for a or T	DM1	From equations with correct number of relevant terms, allow g missing. If no working seen, must be correct for their equations.
	Acceleration $= 0.5\ \text{m s}^{-2}$	A1	Oe. Allow 0.499 from $\alpha = 2.87$.
	Tension $= 400\ \text{N}$	A1	Allow awrt 400 to 3sf, www. Condone using car equation with 0.499 to get $T = 400.5$. Using exact a from an inexact angle gives $T = 400$.
		5	

Question	Answer	Marks	Guidance
6(b)	Work done against resistance on car = $800 \times 50 [= 40\,000]$ or Work done by driving force = $3000 \times 50 [= 150\,000]$	B1	
	PE change $= (1800 + 300) g \times 50 \times 0.05 [= 52\,500]$	B1	Allow $2100g \times 50 \times \sin 2.9$. Or $2100g \times 50 \times \sin 2.87$.
	Initial KE = $\frac{1}{2} \times (1800 + 300) \times 20^2 [420\,000]$	B1	
	$\frac{1}{2} \times (1800 + 300) v^2 = 3000 \times 50 - 800 \times 50 - 6000 - (1800 + 300) g \times 50 \times 0.05 + \frac{1}{2} \times (1800 + 300) \times 20^2$ $[1050v^2 = 150\,000 - 40\,000 - 6000 - 52\,500 + 420\,000]$ $[1050v^2 = 471500]$	M1	Attempt at work-energy equation; correct number of relevant terms; dimensionally correct; allow sign errors; allow sin/cos mix in relevant resolved terms. Only PE must be from a component. Allow $2100g \times 50 \times \sin 2.9$ or $2100g \times 50 \times \sin 2.87$.
	Speed = 21.2 m s^{-1} [21.1907…]	A1	Awrt 21.2 to 3sf. $\alpha = 2.87$ gives 21.18909187. $\alpha = 2.9$ gives 21.17674855.

Question	Answer	Marks	Guidance
6(b)	**Alternative Method for Question 6(b): Using energy on Car or Trailer only (Must be finding Tension for this method)**		
	Car: $3000-1800g\times0.05-800-T=1800a$ Trailer: $T-300g\times0.05-\frac{6000}{50}=300a$ Solve to get $T=\frac{2920}{7}=417.1428571$	**B1**	
	Work done against resistance on car = $800\times50[=40000]$ or Work done by driving force = $3000\times50[=150000]$ or Work done against tension = $\frac{2920}{7}\times50\left[=\frac{146000}{7}\right]$	**B1**	
	PE change $=1800g\times50\times0.05[=45000]$ or Initial KE = $\frac{1}{2}\times1800\times20^2\,[360000]$	**B1**	Or $300g\times50\times0.05[=7500]$. Allow $1800g\times50\times\sin2.9$ or $1800g\times50\times\sin2.87$. Or $\frac{1}{2}\times300\times20^2\,[60000]$.
	$\frac{1}{2}\times1800v^2=3000\times50-800\times50-\frac{2920}{7}\times50-1800g\times50\times0.05+\frac{1}{2}\times1800\times20^2$	**M1**	Attempt at work-energy equation; correct number of relevant terms; dimensionally correct; allow sign errors; allow sin/cos mix in relevant resolved terms. Only PE must be from a component. M0 if using T from part **(a)**.
	Speed = 21.2 m s^{-1} [21.1907…]	**A1**	Awrt 21.2 to 3sf.

Question	Answer	Marks	Guidance
6(b)	**Special case: use of constant acceleration. Maximum 2 marks**		
	$F=\frac{6000}{50}=120,\ 2100a=3000-\frac{6000}{50}-800-2100g\times 0.05\left[a=\frac{103}{210}\right]$	**B1**	Oe. Allow $2100a=3000-\frac{6000}{50}-800-2100g\times\sin 2.9$. Allow $2100a=3000-\frac{6000}{50}-800-2100g\times\sin 2.87$.
	$\left[v^2=20^2+2\times 50\times\frac{103}{210}\rightarrow\right]v=21.2\ \mathrm{m\,s^{-1}}$	**B1**	
		5	

Question	Answer	Marks	Guidance
7(a)	$(m)a = (m)g\sin\theta = (m)g \times 0.6\ [\Rightarrow a = 6]$	**M1**	For attempt at Newton's second law; 2 terms; allow sign errors; allow sin/cos mix, allow $\theta = 36.9$ or better. Allow $\theta = 37$. Allow for $a = 6$ seen/used.
	$v^2 = [0^2] + 2 \times 6 \times 0.75 \Rightarrow v = 3$	**A1**	AG.
	$3 = [0] + 6t \Rightarrow t = 0.5$	**A1**	AG. Allow A2 for use of $a = 6$ with any 2 of $v = 3$, $t = 0.5$ and $s = 0.75$ to get the third value.
	Alternative Method 1 for Question 7(a)		
	$(m)a = (m)g\sin\theta = (m)g \times 0.6\ [\Rightarrow a = 6]$	**M1**	For attempt at Newton's second law; 2 terms; allow sign errors; allow sin/cos mix, allow $\theta = 36.9$ or better. Allow $\theta = 37$. Allow for $a = 6$ seen/used.
	$0 + 6 \times 0.5 = 3$	**A1**	AG.
	$0 \times 0.5 + \frac{1}{2} \times 6 \times 0.5^2 = 0.75$ or $3 \times 0.5 - \frac{1}{2} \times 6 \times 0.5^2 = 0.75$	**A1**	AG. Allow A2 for $3 \times 0.5 - \frac{1}{2} \times 6 \times 0.5^2 = 0.75$.
	Alternative Method 2 for Question 7(a)		
	$\frac{1}{2}(m)v^2 = (m)g \times 0.75 \times 0.6$	**M1**	Attempt at conservation of energy, 2 terms, dimensionally correct, allow sin/cos mix, allow $\theta = 36.9$ or better. Allow $\theta = 37$.
	$v = 3$	**A1**	AG.
	Use constant acceleration to get $t = 0.5$	**A1**	AG. Must show $a = 6$.

Question	Answer	Marks	Guidance
7(a)	**Alternative Method 3 for Question 7(a)**		
	$(s=)\frac{1}{2}(0+3)\times 0.5$ or $0.75=\frac{1}{2}(0+v)\times 0.5$ or $0.75=\frac{1}{2}(0+3)t$	**M1**	Use $s=\frac{1}{2}(u+v)t$ with $u=0$ with any 2 of $v=3$, $t=0.5$ and $s=0.75$.
	Correctly identifies one value.	**A1**	
	$(s=)0.75$ or $v=3$ or $t=0.5$	**A1**	AG**.**

Question	Answer	Marks	Guidance
7(a)	**Alternative Method 4 for Question 7(a)**		
	$3^2 = (0^2 +)2a \times 0.75 \ \rightarrow a = 6$ or $3 = (0+)0.5a \ \rightarrow a = 6$ or $0.75 = (0 \times 0.5 +)\frac{1}{2}a \times 0.5^2 \ \rightarrow a = 6$ or $0.75 = 3 \times 0.5 - \frac{1}{2}a \times 0.5^2 \ \rightarrow a = 6$	**B1**	Use constant acceleration to get an equation in a only, using $u = 0$ and any 2 of $v = 3$, $t = 0.5$ and $s = 0.75$. Or using $v = 3$, $t = 0.5$ and $s = 0.75$.
	$3 = (0+)6t$, $0.75 = (0 \times t +)\frac{1}{2} \times 6 \times t^2$, $0.75 = 3t - \frac{1}{2} \times 6 \times t^2$ or $s = (0 \times 0.5 +)\frac{1}{2} \times 6 \times 0.5^2$, $s = 3 \times 0.5 - \frac{1}{2} \times 6 \times 0.5^2$ or $v = (0+)0.5 \times 6$; $v^2 = (0^2 +)2 \times 6 \times 0.75$; $0.75 = 0.5v - \frac{1}{2} \times 6 \times 0.5^2$ or $3 = u + 6 \times 0.5$, $3^2 = u^2 + 2 \times 6 \times 0.75$, $0.75 = 0.5u + \frac{1}{2} \times 6 \times 0.5^2$	**M1**	Use constant acceleration formula in an attempt to find the third unused value using $a = 6$. Or use constant acceleration formula in an attempt to find u using $a = 6$.
	Get correct unused value	**A1**	Or $u = 0$ if using all 3 values to find $a = 6$. AG.
		3	

Question	Answer	Marks	Guidance
7(b)	For BC $(m)a=(m)g\sin\theta-(m)g\times0.8\times0.25=(m)g\times0.6-(m)g\times0.8\times0.25$ $[\Rightarrow a=4]$	*M1	For attempt at Newton's second law; 3 terms; allow sign errors; allow g missing; allow sin/cos mix, allow $\theta=36.9$ or better.
	For P, $s_P=3t+\frac{1}{2}\times4t^2$ For Q, $s_Q=\frac{1}{2}\times4(t+0.5)^2$ Or for P, $s_P=3(T-0.5)+\frac{1}{2}\times4(T-0.5)^2$ For Q, $s_Q=\frac{1}{2}\times4T^2$	A1	For either s_P or s_Q. t is the time after P arrives at B. T is the time from when both particles released.
	$3t+\frac{1}{2}\times4t^2=\frac{1}{2}\times4(t+0.5)^2\left[\Rightarrow3t+2t^2=2t^2+2t+0.5\right]$ Or $3(T-0.5)+\frac{1}{2}\times4(T-0.5)^2=\frac{1}{2}\times4T^2$ $\left[\Rightarrow3T-1.5+2(T^2-T+0.25)=2T^2\right]$	DM1	For use of $s_P=s_Q$; s_P and s_Q of correct form. Using their $a\neq their\,6$ from part **(a)**, $a\neq\pm g$. Using same a in both s_P and s_Q.
	t = 0.5, so total time = 1 s or time $T=1$ s	A1	

Question	Answer	Marks	Guidance
7(b)	**Alternative Method for Question 7(b)**		
	For BC $(m)a=(m)g\sin\theta-(m)g\times0.8\times0.25=(m)g\times0.6-(m)g\times0.8\times0.25[\Rightarrow a=4]$	***M1**	For attempt at Newton's second law; 3 terms; allow sign errors; allow g missing; allow sin/cos mix, allow $\theta=36.9$ or better.
	For P $s_P=3t+\frac{1}{2}\times4t^2$ Or Q has speed 2 m s^{-1} after 0.5 s, so $s_Q=2t+\frac{1}{2}\times4t^2$	**A1**	For either. t is the time after P arrives at B.
	$3t+\frac{1}{2}\times4t^2=2t+\frac{1}{2}\times4t^2+\frac{1}{2}\times4\times0.5^2$	**DM1**	For use of $s_P=s_Q\pm their\frac{1}{2}\times4\times0.5^2$; s_P or s_Q of correct form. Using their $a\neq their\,6$ from part **(a)**, $a\neq\pm g$. Using same a in both s_P or s_Q.
	t = 0.5 so total time = 1 s	**A1**	
	Alternative Method 2 for Question 7(b): Using relative velocity		
	For BC $(m)a=(m)g\sin\theta-(m)g\times0.8\times0.25=(m)g\times0.6-(m)g\times0.8\times0.25$ $[\Rightarrow a=4]$	***M1**	For attempt at Newton's second law; 3 terms; allow g missing; allow sign errors; allow sin/cos mix.
	[In 0.5 s] Q has speed 2 m s^{-1} and has moved 0.5 m	**A1**	For both.
	$t=\frac{0.5}{3-2}$	**DM1**	Attempt at time from relative velocity using their 0.5 m and their 2 m s^{-1}.
	t = 0.5 so total time = 1 s	**A1**	
		4	

Question	Answer	Marks	Guidance
7(c)	Immediately before the collision speed of P $\left[=3+4\times\frac{1}{2}\right]=5\ \text{ms}^{-1}$ Speed of Q $[=0+4\times1]=4\ \text{m s}^{-1}$	B1	For either.
	$5(m)+4(m)=[(m)+(m)]\times v\ [\Rightarrow v=4.5]$	*M1	Use of conservation of momentum; 4 non-zero terms; allow sign errors; allow their 4m s^{-1} $(\neq 0 \text{ or } 2)$ and 5m s^{-1} $(\neq 3)$. Use of mg then withhold final A mark.
	Distance from B at collision $=\frac{1}{2}\times4\times1^2=2$ m OR $=3\times0.5+\frac{1}{2}\times4\times0.5^2=2$ m	B1	May be implied by 1.25 m.
	$1.25=4.5t+\frac{1}{2}\times4t^2$	DM1	Use of constant acceleration with $u=$ *their* 4.5, $a=$ *their* $4(\neq\pm g)$ and $s=3.25-$ *their* 2, $s\neq3.25$, $s\neq0.75$, $s\neq4$, $s\neq2.75$, $s\neq0.5$. If using two formulae, must be a complete method to get an equation in t only.
	$t=0.25$s only	A1	A0 if from use of mg in conservation of momentum.
		5	

Cambridge International AS & A Level

MATHEMATICS **9709/41**

Paper 4 Mechanics **October/November 2023**

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 October/November 2023 series for most Cambridge IGCSE, Cambridge International A and AS Level components, and some Cambridge O Level components.

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 descriptors 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.

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	$\pm 1.6g \times x \times \frac{3}{5}$ [$=9.6x$] or $\pm \frac{1}{2} \times 1.6 \times 20^2$ [$= 320$]	**B1**	For either the correct potential energy or kinetic energy term. Need not be evaluated.
	$\frac{1}{2} \times 1.6 \times 20^2 = 1.6g \times x \sin\alpha$ where $\sin\alpha = \frac{3}{5}$	**M1**	Attempt at energy equation; 2 relevant terms. Dimensionally correct but allow sign errors. Allow sin/cos mix and sin(36.869…) but $\sin\alpha$ (oe) must have been substituted. M0 for $1.6g \times x \times \frac{3}{4}$.
	$x = \frac{100}{3}$	**A1**	Allow 33.3.
		3	

Question	Answer	Marks	Guidance
2	Attempt to resolve horizontally or vertically to form an equation.	***M1**	Correct number of terms; allow sin/cos mix; allow sign errors – do not award this mark if using T for both (see **SC** later).
	$T_1 \cos 35 = T_2 \cos 40$	**A1**	Must be different Ts.
	$T_1 \sin 35 + T_2 \sin 40 = 2.4g$	**A1**	If same Ts, then **SC B2** only for this equation.
	Attempt to solve for either tension.	**DM1**	From equations with correct number of relevant terms. Must get a value for at least one tension. E.g. $T_2\left(\frac{\cos 40}{\cos 35} \times \sin 35 + \sin 40\right) = 24$
	$T_1 = 19.0\,\text{N}$ and $T_2 = 20.4\,\text{N}$	**A1**	$T_1 = 19.033621\ldots$ $T_2 = 20.353166\ldots$ awrt 19(.0) for T_1 www and 20.4 for T_2.
		5	

Question	Answer	Marks	Guidance
3(a)	Distance = $50.4\,\text{m}$	**B1**	Allow $\frac{252}{5}$.
		1	
3(b)	$v_1 = 12.6 - (62-48)a$	**M1**	Use of suvat for first section of deceleration. $12.6 \pm (62-48)a$ only.
	$0 = v_1 - 2a \times (70-62)$	**M1**	Use of suvat for second section of deceleration. An expression for the velocity at 62 seconds must be $\pm 2a \times (70-62)$.
	$a = 0.42$	**A1**	-0.42 scores A0.
		3	
3(c)	Speed at time $t = 62$ is $6.72\,\text{m}\,\text{s}^{-1}$	**B1**	This may be seen in part **(b)** but must be used in part **(c)** to get this mark.
	$s_2 = (48-8) \times 12.6\ [= 504]$ $s_3 = 0.5 \times (12.6 + \textit{their}\ 6.72) \times (62-48)\ \left[= 135.24 \text{ or } \frac{3381}{25} \text{ oe}\right]$ or $\textit{their}\ 6.72 \times (62-48) + 0.5 \times (62-48) \times (12.6 - \textit{their}\ 6.72)$ $s_4 = 0.5 \times \textit{their}\ 6.72 \times (70-62) \left[= 26.88 \text{ or } \frac{672}{25} \text{ oe}\right]$	**B2FT**	B2 FT for any 2 correct, B1 FT for any 1 correct – follow through *their* value of v_1 where $0 < v_1 < 12.6$ but must have come from the correct equations seen in part **(b)**. Allow correct value of v_1 from $a = -0.42$ where $v_1 = 12.6 + (62-48)a$ and $v_1 = -2a \times (70-62)$.
	Average speed $= 10.236\,\text{m}\,\text{s}^{-1}$	**B1**	Allow 10.2 or better oe e.g. $\frac{2559}{250}$, $10\frac{59}{250}$.
		4	

Question	Answer	Marks	Guidance
4(a)	$-0.4 \times 6g = 6a$	*B1	Resolve horizontally using Newton's second law; 2 relevant terms; must be either $-0.4 \times 6g = 6a$ or $0.4 \times 6g = 6a$.
	$v^2 = 20^2 + 2 \times (-4) \times 12.5$	DM1	Use complete suvat method to get an equation in v or v^2 – must be using $u = 20$, $s = 12.5$ and *their* a.
	$v^2 = 300 \Rightarrow v = 10\sqrt{3}$	A1	AG. Condone correct expression for v or v^2 followed by correct answer.
	Alternative method for Question 4(a)		
	$RF = 0.4 \times 6g$	*B1	Correct application of $F = \mu R$ for P.
	$0.5 \times 6 \times 20^2 - 0.5 \times 6 \times v^2 = 12.5 \times (0.4 \times 6g)$	DM1	3 relevant terms; dimensionally correct; allow sign errors only.
	$v^2 = 300 \Rightarrow v = 10\sqrt{3}$	A1	AG. Condone correct expression for v or v^2 followed by correct answer.
		3	
4(b)	$6 \times 10\sqrt{3} = (6+2)v'$	M1	For use of conservation of momentum, 3 non-zero terms, allow sign errors. Use of 20 is M0.
	$v' = 7.5\sqrt{3}$	A1	12.99038…
	Initial KE $= \frac{1}{2} \times 6 \times \left(10\sqrt{3}\right)^2 [= 900]$ Final KE $= \frac{1}{2} \times 8 \times \left(7.5\sqrt{3}\right)^2 [= 675]$	B1	Either initial kinetic energy or final kinetic energy correct. Allow unsimplified.
	Loss of KE = 225 J	A1	
		4	

Question	Answer	Marks	Guidance
4(c)	$0 = \left(their\, 7.5\sqrt{3}\right)^2 + 2\times\left(their\, -4\right)\times s$	M1	Use complete suvat method to find distance. This must be using *their* v' from part **(b)**, so it is dependent on scoring the first M mark in part **(b)** and either *their a* from part **(a)**, or from $\pm 0.4\times 8g = 8a$.
	[Distance =] 21.1 m	A1	21.1 or better (21.09375).
		2	

Question	Answer	Marks	Guidance
5	Resolving parallel to the slope at A or B to form an equation.	*M1	Correct number of terms; allow sign errors; allow sin/cos mix.
	$1.6g\sin 50 - T - F_B = 0$	A1	If using the same Fs, then M1A1A0B1 max.
	$T - F_A - 1.2g\sin 40 = 0$	A1	System equation (must be four different terms): $1.6g\sin 50 - F_B - F_A - 1.2g\sin 40 = 0$ only scores M1A1A1. Any sign errors scores M1 only.
	$R_A = 1.2g\cos 40$ or $R_B = 1.6g\cos 50$	*B1	Either correct. Must be explicitly linked to the correct contact (so could be seen on a diagram), or as part of a resolving parallel to the slope equation(s) (so must be combined with μ).
	$F_A = 1.2g\mu\cos 40$ or $F_B = 1.6g\mu\cos 50$	*M1	Use of $F = \mu R$ at either A or B. Must be explicitly linked to the correct contact (could be seen on a diagram) or as part of a resolving parallel to the slope equation(s). Allow sin/cos mix error only.
	$1.6g\sin 50 - 1.6g\mu\cos 50 = 1.2g\sin 40 + 1.2g\mu\cos 40$	DM1	Eliminating T, F_A and F_B to form an equation in μ only.
	$\left[\mu = \dfrac{1.6g\sin 50 - 1.2g\sin 40}{1.2g\cos 40 + 1.6g\cos 50} \Rightarrow\right] \mu = 0.233$	A1	0.23326119…
		7	

Question	Answer	Marks	Guidance
6(a)(i)	Power $= 19.5$ kW	**B2**	Or B1 for either 650×30 or 19 500.
		2	
6(a)(ii)	$their\,19500 + 9000 = DF \times 30$	**B1FT**	Oe FT *their* 19.5 in watts only.
	$DF - 650 = 1300a$	**M1**	Newton's second law horizontally; 3 relevant terms; dimensionally correct but allow sign errors; allow with *their* driving force or just *DF*.
	$a = \frac{3}{13} = 0.231\,\text{m}\,\text{s}^{-2}$	**A1**	0.23076923…
	Alternative scheme for 6(a)(ii)		
	$9000 = DF \times 30$	***B1**	oe e.g. $DF = \frac{9000}{30}$.
	$DF = 1300a$	**DM1**	Resolving horizontally using Newton's second law; 2 relevant terms; dimensionally correct but allow sign errors.
	$a = \frac{3}{13} = 0.231\,\text{m}\,\text{s}^{-2}$	**A1**	0.23076923…
		3	

Question	Answer	Marks	Guidance
6(b)	$DF = \frac{11500}{v}$	**B1**	oe e.g. $DF \times v = 11500$.
	Attempt at Newton's second law.	**M1**	4 relevant terms, *their DF* or just *DF*; allow sign errors: allow sin/cos mix; allow *g* missing.
	$\frac{11500}{v} + 1300 \times g \times 0.08 - (1000 + 20v) = 0$	**A1**	Correct equation.
	Speed = $25\,\mathrm{m\,s^{-1}}$	**A1**	
		4	

Question	Answer	Marks	Guidance
7	$30.6 - 0.9 \times 8 = \frac{1600}{8^2} + 8k$	*M1	Use velocity at $t = 8$ to set up a linear equation in k only. Allow a slip in one value or sign only.
	$k = -0.2$	A1	
	$\frac{1600}{t^2} + (\textit{their } k) \times t = 0 \Rightarrow t = \ldots$	DM1	Attempt to find the value of t when the particle comes to rest using the correct expression for v, set equal to zero with *their* negative value of k. Must find a positive value for t (for reference, $t = 20$).
	Attempt to integrate v for one of the 3 intervals	*M1	Increase power by 1 and a change in coefficient in at least one term (which must be the same term); $s = vt$ is M0.
	$s = \frac{7.2}{3}t^3 (+c)$	A1	May be unsimplified (for reference, limits are from 0 to 2).
	$s = 30.6t - \frac{0.9}{2}t^2 (+c)$	A1	May be unsimplified (for reference, limits are from 2 to 8).
	$s = \frac{1600}{-1}t^{-1} + \frac{k}{2}t^2 (+c)$	A1FT	May be unsimplified (for reference limits are from 8 to 20). Follow through *their* value of k or just k only.
	Either 19.2 or 156.6 or ± 86.4	B1	One correct distance found. Allow unsimplified e.g. $(216 - 59.4)$ or $\frac{1}{2} \times (8-2) \times (28.8 + 23.4)$ etc.
	Distance $= 19.2 + (216 - 59.4) + (-120 - (-206.4)) = 262.2$ m	B1	This mark can be awarded if no integration is shown oe. e.g. $\frac{1311}{5}$. Condone 262 www.
		9	

Cambridge International AS & A Level

MATHEMATICS **9709/42**

Paper 4 Mechanics **October/November 2023**

MARK SCHEME

Maximum Mark: 50

Published

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This document consists of **19** printed pages.

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Abbreviations

AEF/OE	Any Equivalent Form (of answer is equally acceptable) / Or Equivalent
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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	$\pm\frac{1}{2}\times 15\times 2^2\,[=\pm 30]\;\;\pm\frac{1}{2}\times 15\times 4^2\,[=\pm 120]$	B1	For KE at top or bottom. Need not be evaluated. $\frac{1}{2}\times 15\times(4-2)^2$ is B0.
	$\pm 15g\times 1.6\,[=\pm 240]$	B1	For PE change. Need not be evaluated.
	$240+30=120+W$	M1	Attempt at work energy equation; 4 relevant terms; dimensionally correct; allow sign errors. $\frac{1}{2}\times 15\times(4-2)^2$ is M0. If $W = F$ times a numerical distance seen, then M0.
	Work done = 150 J	A1	

Question	Answer	Marks	Guidance
1	**Alternative method for Q1**		
	$4^2 = 2^2 + 2a \times \frac{1.6}{\sin\theta}$	***M1**	Attempt to use $v^2 = u^2 + 2as$ with $s = \frac{1.6}{\sin\theta}$ or $\frac{1.6}{\cos\theta}$ but not $s = 1.6\sin\theta$ or $1.6\cos\theta$ or 1.6. If θ is given a value, then M0. Must be using speeds 2 and 4 here.
	$15g\sin\theta - R = 15a$	**DM1**	3 terms; allow sign errors; allow sin/cos mix but weight must be resolved; dimensionally correct.
	$R = 93.75\sin\theta$	**A1**	$R = 93.75\cos\theta$ Must be consistent with their s.
	Work done $\left[= 93.75\sin\theta \times \frac{1.6}{\sin\theta}\right] = 150$ J	**A1**	
		4	

Question	Answer	Marks	Guidance
2	Attempt to resolve in at least one direction to form an equation.	*M1	Correct number of terms; allow sign errors; allow sin/cos mix; allow with different T 's.
	$T\sin 30 + T\sin 40 - 2 = 0$	A1	If different T's then allow M1A1A0 max.
	$T\cos 30 - T\cos 40 - mg = 0$	A1	Allow with their T.
	Attempt to solve for T or m	DM1	From equation(s) with correct number of relevant terms.
	Tension T = 1.75, m = 0.0175	A1	$T = 1.7501\ldots$ $m = 0.017497\ldots$ awrt 1.75 for T www, and awrt 0.0175 for m www.
		5	

Question	Answer	Marks	Guidance
3	Work done by 120 N force = $120 \times 5\cos 20 [= 563.81557....]$	**B1**	
	$(\text{PE change} =) 10g \times 5\sin 30 [= 250]$	**B1**	For PE change.
	Attempt at work energy equation	**M1**	4 relevant terms; dimensionally correct; allow sign errors; allow sin/cos mix in relevant resolved terms.
	$120 \times 5\cos 20 - 10g \times 5\sin 30 - 200 = \frac{1}{2} \times 10 \times v^2$ $\left[563.815... - 250 - 200 = 5v^2\right]$	**A1**	
	Speed = 4.77 m s^{-1}	**A1**	awrt 4.77.

Question	Answer	Marks	Guidance
3	**Alternative method for Question 3**		
	Resistive force = $\frac{200}{5}[=40]$	***B1**	oe e.g. $5 \times RF = 200$.
	$120\cos 20 - RF - 10g\sin 30 = 10a$	***M1**	4 relevant terms; dimensionally correct; allow sign errors; allow sin/cos mix; allow with their resistive force or just *RF*.
	$a = 2.276\ldots$	**A1**	Allow arwt 2.3 to 2sf from correct work.
	$v^2 = 0 + 2 \times (2.276\ldots) \times 5$	**DM1**	Use of $v^2 = u^2 + 2as$ using $u = 0$, $s = 5$ and their positive a which has come from a resistive force using work done.
	Speed = $4.77\,\text{m s}^{-1}$	**A1**	awrt 4.77.
		5	

Question	Answer	Marks	Guidance
4(a)	$R = 0.2g$	**B1**	
	$1.2 = \mu \times 0.2g$	**M1**	Resolve horizontally and using $F = \mu R$ to get an equation in μ; 2 relevant terms.
	$\mu = 0.6$	**A1**	oe
		3	
4(b)	$1.2 - 0.3 \times 0.2g = 0.2a$	***M1**	Resolve horizontally using Newton's Second Law; 3 relevant terms; allow sign errors; $R = 0.2g$ only.
	$a = 3$	**A1**	$0.6 = 0.2a$ only seen, allow with BOD, but if 0.6 as friction being used as resultant force, this is M0A0.
	$s_3 = 0 + \frac{1}{2} \times 3 \times 3^2\ [= 13.5]\ s_2 = 0 + \frac{1}{2} \times 3 \times 2^2\ [= 6]$	**DM1**	For use of $s = ut + \frac{1}{2}at^2$ (or a complete method) to find a distance at least once with $u = 0$ and their positive a and $t = 2$ or $t = 3$.
	Distance = $13.5 - 6 = 7.5$ m	**A1**	www
		4	

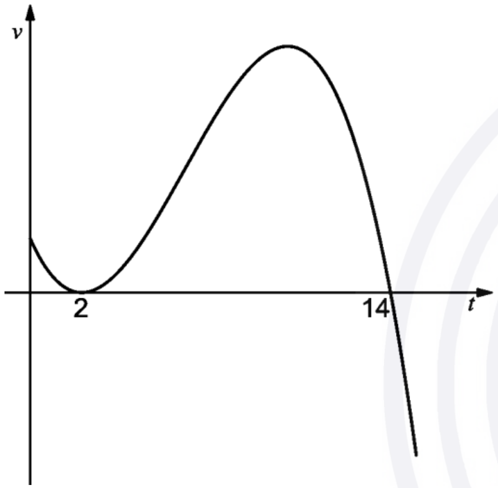
Question	Answer	Marks	Guidance
5(a)	$v^2 = 25^2 + 2(-g) \times 20$ OR $\frac{1}{2} \times 0.5 \times v^2 = \frac{1}{2} \times 0.5 \times 25^2 - 0.5 \times g \times 20$	**M1**	Use of $v^2 = u^2 + 2as$ with $u = 25$, $s = 20$ and $a = \pm g$. OR using change in KE = ± change in PE.
	Speed $= 15 \text{ m s}^{-1}$	**A1**	
		2	
5(b)	Taking up as positive direction: $0.5 \times 15 + 0.3 \times (-32.5) = 0.5v + 0$ or Taking down as positive direction: $0.5 \times (-15) + 0.3 \times 32.5 = 0.5v + 0$	**M1**	For use of conservation of momentum, 3 non-zero terms, allow sign errors, using their speed 15 m s^{-1}. Must show how ± 2.25 is obtained.
	[Taking up as positive direction: velocity of $A = -4.5 \text{ m s}^{-1}$] [Taking down as positive direction: velocity of $A = 4.5 \text{ m s}^{-1}$] Speed = 4.5 m s^{-1} direction downwards	**A1**	Any error seen in calculating v is A0. Must explicitly say 4.5 m s^{-1} and downwards.
		2	

Question	Answer	Marks	Guidance
5(c)	Downwards to be positive, for A $20 = 4.5t_A + \frac{1}{2}gt_A{}^2$ and solve for t_A Upwards to be positive, for A $-20 = -4.5t_A - \frac{1}{2}gt_A{}^2$ and solve for t_A	**M1**	Using constant acceleration formula(e) to get a correct equation in t_A and solve for t_A. If using quadratic formula, must be the correct formula. If factorising, when brackets expanded, 2 terms correct.
	For B $20 = 0 + \frac{1}{2}gt_B{}^2$ $[t = 2]$ and solve for t_B	**M1**	Using constant acceleration formula(e) to get a correct equation in t_B and solve for t_B.
	$t_A = 1.6$ or $t_B = 2$	**A1**	
	Difference = 0.4 s only	**A1**	
		4	

Question	Answer	Marks	Guidance
6(a)	Engine: $125000-120000g\times0.02-22000-T=120000a$ $125000-120000g\sin(1.145\ldots..)-22000-T=120000a$ $[125000-24000-22000-T=120000a \Rightarrow 79000-T=120000a]$ Coach: $T-60000g\times0.02-13000=60000a$ $T-60000g\sin(1.145\ldots..)-13000=60000a$ $[T-12000-13000=60000a \Rightarrow T-25000=60000a]$ System: $125000-120000g\times0.02-60000g\times0.02-22000-13000=(120000+60000)a$ $125000-120000g\sin(1.145\ldots..)-60000g\sin(1.145\ldots..)-22000-13000=(120000+60000)a$ $[125000-24000-12000-22000-13000=(120000+60000)a \quad \Rightarrow 54000=180000a]$	*M1	Attempt at Newton's second law at least once; correct number of relevant terms; allow sign errors; allow sin/cos mix; allow g missing; a value for α or $\sin\alpha$ must be substituted. Allow with $\alpha=1.1$ or better $[\alpha=1.145991998]$.
		A1	Any equations correct.
		A1	Two equations correct. If using separate equations for engine and coach and different T's, then allow M1A1A0 max.
	Solve for T or a	DM1	Using equations with the correct number of relevant terms. If no working seen, must be solutions to their equation(s) to be awarded M1.
	Acceleration = $0.3\,\text{m s}^{-2}$ and Tension = $43\,000$ N	A1	Allow 0.299 from use of $\alpha=1.15$. Awrt 43000 to 3sf from correct work.
		5	

Question	Answer	Marks	Guidance
6(b)	Driving force, $DF = \frac{4500000}{30}\left[=150000\right]$	B1	Use of $F = \frac{P}{v}$, oe e.g. $DF \times 30 = 4500000$.
	Attempt to resolve parallel to the track once if using system equation, twice if using equations for engine and coach separately	M1	Correct number of relevant terms; allow sign errors; allow sin/cos mix; allow g missing. Must be correct number of equations depending on method.
	System: $150000 - 120000g\sin\beta - 60000g\sin\beta - 22000 - 13000 = 0$ or for Engine: $150000 - 120000g\sin\beta - 22000 - T' = 0$ and Coach: $T' - 60000g\sin\beta - 13000 = 0$	A1	Allow *DF* or their *DF*. Must be using same T'.
	Solve to get $\beta = 3.7°$	A1	3.663058552 awrt 3.7° www.
		4	

Question	Answer	Marks	Guidance
7(a)	Attempt to differentiate v	*M1	Decrease power by 1 and a change in coefficient in at least one term (which must be the same term); allow unsimplified; allow p or q for t. $a = \frac{v}{t}$ is M0.
	$\left(a = \frac{dv}{dt} =\right) 3 \times -0.1t^{3-1} + 2 \times 1.8t^{2-1} - 6t^{1-1} = -0.3t^2 + 3.6t - 6$	A1	May be unsimplified. Allow p or q for t.
	Setting $a = \frac{dv}{dt} = 0$ and attempt to solve a 3 term quadratic for t. $\left[a = \frac{dv}{dt} = 0 \Rightarrow 3t^2 - 36t + 60 = 0 \Rightarrow t^2 - 12t + 20 = 0\right]$	DM1	Allow p or q for t. Must get 2 values or numerical expressions for t from their three term quadratic. If using quadratic formula, must be the correct formula. If factorising, when brackets expanded, 2 terms correct.
	$p = 2,\ q = 10$	A1	
		4	

Question	Answer	Marks	Guidance
7(b)	Velocities are $0\,\mathrm{m\,s^{-1}}$ and $25.6\,\mathrm{m\,s^{-1}}$	**B1**	SOI
	Curve with single minimum turning point followed by single maximum turning point	***B1**	Ignore placement of graph on axes Not a cusp for the minimum point or maximum point.
		**DB1**	All correct in 1st and 4th quadrant. Must go from convex to concave. Need to label 2 and 14 on the *t*-axis where the curve meets the *t*-axis. Do not need to show exact velocities at t = 0 or t = 10 or t = 15. Ignore graph outside $0 \leqslant t \leqslant 15$.
		3	

Question	Answer	Marks	Guidance
7(c)	Attempt to integrate v	*M1	Increase power by 1 and a change in coefficient in at least one term (which must be the same term); $s = vt$ is M0.
	$(s =) -\frac{0.1}{4}t^{3+1} + \frac{1.8}{3}t^{2+1} - \frac{6}{2}t^{1+1} + 5.6t(+c)$ $= -0.025t^4 + 0.6t^3 - 3t^2 + 5.6t\ [+c]$	A1	May be unsimplified.
	Attempt distance from $t = 0$ to $t = 14$ [= 176.4]	DM1	Correct use of limits 0 and 14 for their s, i.e. $F(14) - F(0)$ May see limits 0 to 2 and 2 to 14 used but must be $\left(F(14) - F(2)\right) + \left(F(2) - F(0)\right)$.
	Attempt distance from $t = 14$ to $t = 15$ [= (-) 8.025]	DM1	Correct use of limits 14 and 15 for their s, i.e. $\pm\left(F(15) - F(14)\right)$. For reference $F(2) = \frac{18}{5} = 3.6$, $F(14) = \frac{882}{5} = 176.4$ and $F(15) = \frac{1347}{8} = 168.375$.
	Total distance $= 176.4 + 8.025 = 184.425$ m $= \frac{7377}{40}$	A1	www Condone 184 or better.

Question	Answer	Marks	Guidance
7(c)	**SC for those who show no integration. Max 3 marks.**		
	$\int_0^{14}\left(-0.1t^3+1.8t^2-6t+5.6\right)dt=176.4$	**B1**	
	$\int_{14}^{15}\left(-0.1t^3+1.8t^2-6t+5.6\right)dt=-8.025$ OR $\left\|\int_{14}^{15}\left(-0.1t^3+1.8t^2-6t+5.6\right)dt\right\|=8.025$	**B1**	
	Total distance $=176.4+8.025=184.425$ m $=\frac{7377}{40}$	**B1**	Condone 184 or better.
	SC for those who show no integration and don't consider the 2 areas. Max 1 mark.		
	$\int_0^{15}\left\|-0.1t^3+1.8t^2-6t+5.6\right\|dt=184.425$ m $=\frac{7377}{40}$	**B1**	Condone 184 or better.
		5	

Cambridge International AS & A Level

MATHEMATICS **9709/43**

Paper 4 Mechanics **October/November 2023**

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ISW	Ignore Subsequent Working
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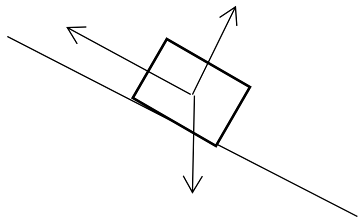
SC	Special Case (detailing the mark to be given for a specific wrong solution, or a case where some standard marking practice is to be varied in the light of a particular circumstance)
WWW	Without Wrong Working
AWRT	Answer Which Rounds To

Question	Answer	Marks	Guidance
1	Use of suvat to find expressions for s	**M1**	
	$s = 3u - 5 \times 9$ $s = 4u - 5 \times 16$	**A1**	
	$u = 35, s = 60$	**A1**	
	Alternative method for Question 1:		
	Use of suvat to find expressions for u at max height	**M1**	
	$0 = u - 10 \times 3.5$	**A1**	
	$u = 35, s = 60$	**A1**	
		3	

Question	Answer	Marks	Guidance
2(a)	Attempt at conservation of momentum $[1.2v = (1.2 + 0.004) \times 40]$	**M1**	
	$v = \frac{602}{15}$	**A1**	oe
		2	
2(b)	$0^2 = (40)^2 + 2 \times 0.04 \times a \quad [a = -20000]$ or $0.04 = \frac{0+40}{2}t$ gets $t = 0.002$, so $0 = 40 + 0.002a\,[a = -20000]$	**M1**	Use of a 'suvat' method to get an equation in a. Allow sign errors. Allow ± 20000. Do not allow 4 in place of 0.04. Allow use of 40.1 or $\frac{602}{15}$ for velocity in place of 40.
	Attempt to use Newton's Second Law vertically. $[-R + (1.2 + 0.004)g = (1.2 + 0.004) \times a]$ $[-R + 12.04 = 1.204a]$	**M1**	Must have the correct number of relevant terms. Allow sign errors, but terms including masses must be effectively added. Do not allow any mass other than (1.2 + 0.004).
	R = 24 100 N [24 092.04 = $\frac{602301}{25}$]	**A1**	WWW. Note: use of wrong sign for g leads to answers 24 067.96 which gets max M1M1A0. Note: Missing weight term gets 24 080 which gets Max M1M0A0.
		3	

Question	Answer	Marks	Guidance
2(b)	**Alternative method for Question 2(b) using energy**		
	[Change in PE =] $1.204g \times 0.04[=0.4816]$ or [change in KE =] $\frac{1}{2} \times 1.204 \times (40)^2 [=963.2]$	**B1**	Allow use of 40.1 or $\frac{602}{15}$ for velocity in place of 40. B0 for kinetic energy, if extra kinetic energy terms present.
	$1.204g \times 0.04 + \frac{1}{2} \times 1.204 \times (40)^2 = 0.04R$	**M1**	Attempt at work energy equation. Must have correct number of relevant terms. dimensionally correct; allow sign errors. Do not allow 4 in place of 0.04. Allow use of 40.1 or $\frac{602}{15}$ for velocity in place of 40.
	R = 24 100 N [24 092.04 = $\frac{602301}{25}$]	**A1**	WWW Note: use of wrong sign for g leads to answers 24 067.96 which gets max B1M1A0. Note: Missing potential energy term gets 24 080, which gets maximum of B1M0A0.

Question	Answer	Marks	Guidance
3(a)	Correct force diagram with 3 forces in the correct directions. 	**B1**	No labels required on the 3 forces and ignore wrong labels. Arrows needed. Allow either or both components of weight if fully labelled. Allow sin/cos mix. If forces are not connected to the block, then the line of action of each force must go through the block.
		1	
3(b)	$R = 8g\cos 30 \ \left[= 40\sqrt{3} = 69.282\ldots\right]$	**B1**	Resolving perpendicular to the plane.
	Resolving parallel to the plane and attempt to apply Newton's second law. $\left[8g\sin 30 - F = 8\times 2.4 \quad \Rightarrow F = 20.8\right]$	**M1***	3 terms. Allow sign errors, sin/cos mix. Allow g missing, otherwise dimensionally correct.
	Use of $F = \mu R$ to get an equation in μ only. $\left[8g\sin 30 - 8g\mu\cos 30 = 8\times 2.4 \qquad 40 - 40\sqrt{3}\mu = 19.2\right]$	**DM1**	Allow g missing in either or both of F and R. Allow sign errors, consistent sin/cos mix. R must be a single component of a force. Allow the 3 masses to be cancelled.
	$\mu = 0.3[0\ldots]$ $\left[\text{May first see } \frac{20.8}{40\sqrt{3}} \text{ or } \frac{20.8}{69.282\ldots}\right]$	**A1**	Allow exact value $\frac{13\sqrt{3}}{75}$ or $\frac{104\sqrt{3}}{600}$ oe.
		4	

Question	Answer	Marks	Guidance
3(c)	[$v^2 = 2 \times 2.4 \times 3 \Rightarrow$ greatest speed =] 3.79 ms^{-1} $= \frac{6\sqrt{10}}{5}$	**B1**	3.79473… (3.8 without a more accurate value seen gets B0 and should be annotated SF).
		1	

Question	Answer	Marks	Guidance
4(a)	$P = 480 \times 24$ or, e.g. $\frac{P}{24} - 480 = 0$	**M1**	For $\frac{P}{v} - F = 0$ or $P = Fv$ oe.
	$P = 11.52$ [kW]	**A1**	Allow 11.5 M1A0 for 11 520 or 11 500.
		2	

Question	Answer	Marks	Guidance
4(b)	$\left[\mathrm{KE}_{before}\right] = \frac{1}{2} \times 1600 \times 24^2 \left[= 460\,800\right]$ $\left[\mathrm{KE}_{after}\right] = \frac{1}{2} \times 1600 \times 32^2 \left[= 819\,200\right]$	**B1**	For either correct. Do not allow $\frac{1}{2} \times 1600 \times (32 - 24)^2$.
	$\left[\mathrm{PE}_{loss}\right] = 1600g \times 280 \times 0.09 \left[= 1600g \times 25.2 = 403\,200\right]$	**B1**	Allow $1600g \times 280 \times \sin 5.16°$ or $1600g \times 280 \times \sin 5.2°$ but not simply $1600g \times 280 \times \sin\theta$ (unless implied by correct final answer).
	$\text{Total WD} = 12\,000 \times 10 \left[= 120\,000\right]$	**B1**	oe, e.g. $12\,000 = \frac{\mathrm{WD}}{10}$.
4(b)	Work done against resistance = or $280F =$ or WD = or W = oe $12\,000 \times 10 + 1600g \times 280 \times 0.09 - \frac{1}{2} \times 1600 \times 32^2 + \frac{1}{2} \times 1200 \times 24^2$ $\left[= 120\,000 + 403\,200 - 819\,200 + 460\,800\right]$	**M1**	Attempt at work energy equation with 5 relevant terms (4 relevant terms plus work done against resistance); dimensionally correct. Allow sign errors. M0 for use of constant acceleration. Do not allow $\frac{1}{2} \times 1600 \times (32 - 24)^2$.
	WD = 164 800 [J]	**A1**	Or 164.8 kJ CAO but condone 165 kJ or 165 000 [J] Not from use of constant acceleration or Newton's second law. ISW attempt to find force after correct WD found.
		5	

Question	Answer	Marks	Guidance
5(a)	Attempt to resolve in one direction and form equation.	**M1**	Must have correct number of relevant terms (forces must have components as required). Allow sin/cos mix. Allow sign errors. If only one equation shown and it involves 32, it must be 32, not *P*.
	$T\sin\theta = 32$ and $T\cos\theta = 80$ or $0 = 80\sin\theta - 32\cos\theta$ and $T = 80\cos\theta + 32\sin\theta$	**A1**	For both horizontal and vertical, or both parallel and perpendicular.
	Attempt to solve for T or θ	**M1**	Must get to T or θ; e.g. $T = \sqrt{32^2 + 80^2}$ or $\theta = \tan^{-1}\left(\frac{32}{80}\right)$. Condone, e.g. $\theta = \tan^{-1}\left(\frac{80}{32}\right)$. Must come from equations with correct number of relevant terms.
	$T = 86.2$ [N 86.1626….] or $16\sqrt{29}$ or $\sqrt{7424}$ and $\theta = 21.8$ [21.801…]	**A1**	For both.
		4	

Question	Answer	Marks	Guidance
5(a)	**Alternative method using triangle of forces**		
	$T^2 = 80^2 + 32^2 [-2 \times 80 \times 32 \cos 90]$ or $T \sin\theta = 32$ or $T\cos\theta = 80$	**M1**	For any of the five; allow sign errors.
	$80\tan\theta = 32$ or $T = 80\cos\theta + 32\sin\theta$ oe	**A1**	For any two equations.
	Attempt to solve for T or θ	**M1**	Must get to T or θ; e.g. $T = \sqrt{32^2 + 80^2}$ or $\theta = \tan^{-1}\left(\frac{32}{80}\right)$.
	$T = 86.2$ [N 86.1626….] or $16\sqrt{29}$ or $\sqrt{7424}$ and $\theta = 21.8$ [21.801…]	**A1**	
	Alternative Triangle of forces method using sine rule		
	$\frac{T}{\sin 90} = \frac{32}{\sin(\theta)} = \frac{80}{\sin(90-\theta)}$	**M1**	For any two.
		A1	For all three.
	Attempt to solve for T or θ	**M1**	e.g. $\theta = \tan^{-1}\left(\frac{32}{80}\right)$.
	$T = 86.2$ [N 86.1626….] or $16\sqrt{29}$ or $\sqrt{7424}$ and $\theta = 21.8$ [21.801…]	**A1**	For both.

Question	Answer	Marks	Guidance
5(b)	Attempt to resolve in one direction and form equation	**M1**	Must have correct number of relevant terms (forces must have components as required). Allow sin/cos mix. Allow sign errors. Must use 120, not *T*.
	$120\sin\theta = P$ and $120\cos\theta = 80$ or $0 = 80\sin\theta - P\cos\theta$ and $120 = 80\cos\theta + P\sin\theta$	**A1**	For both horizontal and vertical, or both parallel and perpendicular.
	Attempt to solve for P or θ	**M1**	Must get to P or θ; e.g. $P = \sqrt{120^2 - 80^2}$ or $\theta = \cos^{-1}\left(\frac{80}{120}\right)$. Must come from equations with correct number of relevant terms.
	$P = 89.4\ [89.4427]$ or $40\sqrt{5}$ or $\sqrt{8000}$ $\theta = 48.2\ [48.1896\ldots]$	**A1**	For both; allow $P = 89.5$ (from $120\sin 48.2$).
		4	
	Alternative method using triangle of forces		
	$120^2 = P^2 + 80^2 [-2 \times 80 \times P\cos 90]$ or $120\sin\theta = P$ or $120\cos\theta = 80$	**M1**	For any of the five; allow sign errors.
	or $80\tan\theta = P$ or $120 = 80\cos\theta + P\sin\theta$ oe	**A1**	For any two equations.
	Attempt to solve for P or θ	**M1**	Must get to P or θ; e.g. $P = \sqrt{120^2 - 80^2}$ or $\theta = \cos^{-1}\left(\frac{80}{120}\right)$, oe.
	$P = 89.4\ [89.4427]$ or $40\sqrt{5}$ or $\sqrt{8000}$ $\theta = 48.2\ [48.1896\ldots]$	**A1**	For both; allow $P = 89.5$ (from $120\sin 48.2$).

Question	Answer	Marks	Guidance
5(b)	**Alternative Triangle of forces method using sine rule**		
	$\frac{120}{\sin 90} = \frac{P}{\sin(\theta)} = \frac{80}{\sin(90-\theta)}$	**M1**	For any two.
		A1	For all three.
	Attempt to solve for P or θ	**M1**	Must get to P or θ; e.g. $\theta = 90 - \sin^{-1}\left(\frac{80}{120}\right)$ or $\theta = \cos^{-1}\left(\frac{80}{120}\right)$.
	$P = 89.4\ [89.4427]$ or $40\sqrt{5}$ or $\sqrt{8000}$ $\theta = 48.2\ [48.1896\ldots]$	**A1**	For both; allow $P = 89.5$ (from $120\sin 48.2$).
6(a)	Attempt to integrate a	**M1***	The power of t must increase by 1 with a change of coefficient in the t^2 term. Do not penalise missing c. Use of $v = at$ scores M0.
	$[v=]36t-3t^2[+c]$ or $[v=]36t-\frac{6t^2}{2}[+c]$	**A1**	Condone an integral sign in front of correct answer.
	$0 = 36t - 3t^2 - 33$ $\left[27 = 36\times 2 - 3\times 2^2 + c \quad \Rightarrow c = -33\right]$	**DM1**	Use $t=2$ and $v=27$ to find c. Must get to c = and set 3 term quadratic equal to zero.
	Solve $0 = 36t - 3t^2 - 33$ to get $t=1$ and $t=11$	**A1**	Allow $t=1$ or $t=11$; $t=1$, $t=11$ oe.
		4	

Question	Answer	Marks	Guidance
6(b)	Attempt to integrate an expression of the form $at+bt^2[+c]$ with non-zero a and b. If correct $[s=]\frac{36t^2}{2}-\frac{3t^3}{3}-33t[+c']$ or $[s=]18t^2-t^3-33t\ [+c']$	**M1***	The power of t must increase by 1 with a change of coefficient in the same term. Use of $s=vt$ scores M0.
	Attempt to evaluate *their* $\left[18t^2-t^3-33t\right]$ for $t=0$ to $t=1$ or $t=1$ to $t=11$ or $t=11$ to $t=12$ 0 to 1: –16 – 0 = –16 1 to 11: 484 – (–16) = 500 11 to 12: 468 – 484 = –16	**DM1**	Attempt using their limits (at least one strictly between 0 and 12) correctly.
	For all three	**DM1**	Allow 11 to 12 implied by symmetry instead of found separately.
	Distance $=[16+500+16]=532\,\text{m}$	**A1**	
		4	

Question	Answer	Marks	Guidance
7(a)	Resolving for both particles or for the system to form equation(s)	**M1***	Must have correct number of terms. Allow sign errors. Allow sin/cos mix. Allow g missing. M0 if acceleration included unless subsequently equated to zero. Masses must be appropriate for their equation(s). Forces must have components (or not) as required.
	Either $T - F - 2.4g\sin 30 = 0$ AND $3.3g - T = 0$ Or $3.3g - F - 2.4g\sin 30 = 0$	**A1**	Both correct or system correct. May get F = 21. Can be with a wrong non-zero F.
	$R = 2.4g\cos 30$ $\left[= 12\sqrt{3} = 20.7846\ldots\right]$	**B1**	
	Use of $F = \mu R$ to get an equation in μ only $\left[3.3g - 2.4g\mu\cos 30 - 2.4g\sin 30 = 0\right]$	**DM1**	Must be from F dimensionally correct and single term R which is equal to a component the 2.4 kg weight. Allow consistent sin/cos mix but must be different components of weight. F and R must be numerical expressions.
	$\mu = 1.01$ [sight of 1.01036… or 1.0104]	**A1**	AG perhaps from one of $\mu = \dfrac{3.3g - 24\sin 30}{2.4g\cos 30} = \dfrac{33-12}{12\sqrt{3}} = \dfrac{21}{12\sqrt{3}} = \dfrac{7\sqrt{3}}{12} = \dfrac{21}{20.7846\ldots} = \dfrac{21}{20.8}$ Do not allow unless evidence of 30 substituted for θ. E.g.: sight of 1.01036… or 1.0104.
		5	

Question	Answer	Marks	Guidance
7(b)	Using Newton's second law for both particles or the system	M1*	Must have correct number of 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.
	Either $3.3g - T = 3.3a$ and $T - F - 2.4g\sin 20 = 2.4a$ $[T - 22.778 - 8.208 = 2.4a]$ or $[T - 30.986 = 2.4a]$ or $3.3g - F - 2.4g\sin 20 = (2.4 + 3.3)a$ $[2.013367\ldots = 5.7a]$	A1	Both correct or system equation correct. Can be with a wrong non-zero F.
	$F = 1.01 \times 2.4g\cos 20$ $[= 22.778]$	B1	For correct expression for F.
	Attempt to solve for a $a = 0.353$ $[0.353222\ldots]$	DM1	Using their F Must get to 'a ='. If sin/cos mix must be consistent.
	$v^2 = 2 \times 0.353 \times 1$ $[= 0.706444\ldots]$ or $[v = 0.841]$ Or $1 = 0 + \frac{1}{2} \times 0.353t^2 \Rightarrow t = 2.3795 \Rightarrow v = 0.353 \times 2.38$	A1FT	FT their value of $a \neq \pm g$ to get an expression for v^2 or v. Can be implied by awrt 0.84 for v or awrt 0.71 for v^2. This mark does not depend on previous A or B mark, but both Ms must have been awarded.
	Using Newton's second law on A after B reaches the ground $-F - 2.4g\sin 20 = 2.4a$ $[-1.01 \times 2.4g\cos 20 - 2.4g\sin 20 = 2.4a]$ $[-22.78814\ldots - 8.20848\ldots = 2.4a]$	M1*	Must have correct number of terms. Allow sign errors. Allow sin/cos mix. Allow g missing. $[\Rightarrow a = -12.911\ldots]$
	Use of suvat to find s $[0 = \textit{their}\ 0.841^2 + 2 \times \textit{their}\ -12.911\ldots \times s \Rightarrow s = 0.027358\ldots]$	DM1	Using their $a \neq \pm g$. Must get to 's ='. May find and use t = 0.0651.

Question	Answer	Marks	Guidance
7(b)	Total distance = 1.03 m	**A1**	
		8	
	Alternative method using energy for first 5 marks		
	$\left[\text{KE gained} =\right]\frac{1}{2}\times(2.4+3.3)v^2\left[=2.85v^2\right]$	**B1**	
	$\left[\text{PE lost} =\right]3.3g\times1-2.4g\times1\sin20\left[=24.791\ldots\right]=$	**B1**	Allow omission of 1 in either or both terms.
	[Friction =] $1.01\times2.4g\cos20\left[=22.778\ldots\right]$	**B1**	For correct expression for *F*.
	$\frac{1}{2}\times(2.4+3.3)v^2=3.3g\times1-2.4g\times1\sin20-1.01\times2.4g\cos20\times1$ Or $2.85v^2=24.791\ldots-22.778\ldots$	**M1**	For attempt at energy equation. Allow sign errors, allow sin/cos mix but must have sin/cos where needed. Correct number of terms, dimensionally correct. Allow omission of 1 in any or all the three relevant terms. Must have $\cos20$ and $\sin20$.
	To get a correct expression for v^2 $\left[v^2=0.706444\ldots \text{ or } v=0.841\ldots\right]$	**A1**	Can be implied by awrt 0.84 for v or awrt 0.71 for v^2 if expression not seen.

Question	Answer	Marks	Guidance
7(b)	**Alternative method using energy for final 3 marks**		
	KE = $\frac{1}{2} \times 2.4 \times 0.841^2$	**M1**	Using their v^2.
	$1.01 \times 2.4g\cos 20 \times s + 2.4g\sin 20 \times s = \frac{1}{2} \times 2.4 \times 0.841^2$ $[\Rightarrow s = 0.027358..]$	**M1**	For attempt at 3 term energy equation and solved to get to ‘s =’. Allow sign errors, allow consistent sin/cos mix but must have sin/cos where needed. Correct number of terms, dimensionally correct.
	Total distance = 1.03 m	**A1**	

Cambridge International AS & A Level

MATHEMATICS **9709/41**

Paper 4 Mechanics **May/June 2023**

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 2023 series for most Cambridge IGCSE, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

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 descriptors 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, 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 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 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.

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(a)	$m \times 5 + 0 = m \times 2 + 0.3v$	M1	Attempt at conservation of momentum; 3 non-zero terms (with m appearing in two terms); allow sign errors.
	Speed $= 10m$ (m s^{-1})	A1	M1A0 if using g in momentum terms. $v = -10m$ is A0.
		2	
1(b)	$0.3 \times 10m + 0 = 0 + 0.6 \times 1.5$ $[3m = 0.9]$	M1	Attempt at conservation of momentum between Q and R (so must be using correct masses of 0.3 and 0.6) to form a linear equation in m using their answer from **(a)**; 2 non-zero terms; allow sign errors.
	$m = 0.3$	A1FT	FT $\dfrac{3}{\textit{their} \text{ +ve coefficient of } m \text{ from } \textbf{(a)}}$ Condone including kg in answer.
		2	

Question	Answer	Marks	Guidance
2(a)	$0 = 10^2 + 2(-g)s \Rightarrow s = \ldots$	M1	For use of $v^2 = u^2 + 2as$ with $v = 0$, $u = \pm 10$ and $a = \pm g$ or ± 10 and solve for s (or any other complete SUVAT method). Or using an energy method: $0.4gh = \frac{1}{2}(0.4)(10)^2$ and solve for h (with two terms using correct given values – condone lack of masses in conservation of energy equation).
	Max. height $= 5$ (m)	A1	
		2	

Question	Answer	Marks	Guidance
2(b)	KE before impact $= \frac{1}{2} \times 0.4 \times 10^2 \, [= 20]$	**B1FT**	Or loss of PE = $\pm\, 0.4 \times g \times 5$ using their maximum height from **(a)**.
	$\frac{1}{2} \times 0.4 \times v^2 = 20 - 7.2 \, [v = 8]$ or $0.4gh = 20 - 7.2 \, [h = 3.2]$	***M1**	M1 for $\frac{1}{2} \times 0.4v^2 =$ KE/PE before impact $- 7.2$ (must be correct method of subtracting 7.2 (OE)). Or, for finding the maximum height after first impact. Need not solve for v (or h) for this mark.
	$-8 = 8 + (-g)t \Rightarrow t = \ldots$ or $0 = 8t + \frac{1}{2} \times -g \times t^2 \Rightarrow t = \ldots$	**DM1**	For use of a complete method to find t. Condone sign errors but $a = \pm g$. If calculating the time to the maximum height between the first and second impacts, then candidates must double this answer (OE). E.g., $0 = 8 + (-g)T$, $t = 2T = \ldots$ or $3.2 = 0 - 0.5 \times -g \times T^2 \Rightarrow t = 2T = \ldots$.
	Time = 1.6(s)	**A1**	
		4	

Question	Answer	Marks	Guidance
3	For an attempt at differentiation.	*M1	Decrease power by 1 and a change in coefficient in at least one term. $v = \frac{s}{t}$ is M0.
	$(v =)\frac{5}{2}t^{\frac{3}{2}} - \frac{45}{8}t^{\frac{1}{2}}$	A1	Allow unsimplified, including indices (including a $+c$ is A0).
	$v = 0 \Rightarrow \frac{1}{8}t^{\frac{1}{2}}(20t - 25) = 0 \Rightarrow t = ...$	DM1	Attempting to find t by equating v to 0 and attempt to solve a linear equation for t (if correct $t = 2.25$). Must be of the form $t = \ldots$.
	$s = \frac{15}{16}[= 0.9375]$	A1	Condone 0.938 .
		4	

Question	Answer	Marks	Guidance
4(a)	Distance $= \frac{1}{2}(6+10)\times 0.9$	M1	Completely correct method for finding the total area underneath the velocity-time graph from $t = 0$ to 10 only. Can be done as two triangles and a rectangle e.g., $\frac{1}{2}\times 3\times 0.9 + (9-3)\times 0.9 + \frac{1}{2}\times 1\times 0.9$ (allow a slip in one value); need not see all three components added together.
	Distance = 7.2(m)	A1	
		2	

Question	Answer	Marks	Guidance
4(b)	$\frac{1}{2}(12-10)v_{\min} = -7.2$	**M1**	Setting $\frac{1}{2}(12-10)v_{\min}$ equal to ± their **(a)**.
	Minimum velocity = -7.2 $(\mathrm{m\,s^{-1}})$	**A1**	Must be negative – allow those who solve $\frac{1}{2}(12-10)v_{\min} = 7.2$ and obtain $v_{\min} = 7.2$ and then change to -7.2 without justification. **SC B1** for assuming the triangle is isosceles.
		2	
4(c)	$\frac{1}{2}\times(T-10)\times 3 = 7.2$ or $\frac{1}{2}\times t\times 3 = 7.2$	***M1**	Correct method for finding T or t. Condone sign errors but must equate to their answer to **(a)**.
	$T = 14.8$	**A1**	OE (e.g. from $t + 10 = 4.8 + 10 = 14.8$).
	$\frac{14.4}{14.8}$	**DM1**	**M1** for $\frac{2(\textit{their}\ \textbf{(a)})}{\textit{their}\ T}$ or $\frac{2(\textit{their}\ \textbf{(a)})}{10+\textit{their}\ T}$.
	Average speed = $\frac{36}{37}$ $(\mathrm{m\,s^{-1}})$	**A1**	OE 0.973 [For reference: 0.97297…]. **SC *B1** (for $T = 14.8$). DM1A1 for assuming the triangle is isosceles.
		4	

Question	Answer	Marks	Guidance
5(a)	Resolving either direction.	**M1**	3 terms; allow sign errors and allow sin/cos mix. Must be an equation with either = 0 or with an attempt to balance forces.
	Vertical: $F\sin\theta + 40\sin 60 - 50 = 0$	**A1**	$\left[F\sin\theta = 50 - 20\sqrt{3} = 15.358...\right]$
	Horizontal: $F\cos\theta + 10 - 40\cos 60 = 0$	**A1**	$\left[F\cos\theta = 10\right]$
	$\theta = \tan^{-1}(5 - 2\sqrt{3})$	**M1**	Attempt to solve for θ; one missing term in total $\theta = \tan^{-1} 1.535898...$.
	$F = \sqrt{15.358...^2 + 10^2}$	**M1**	Attempt to solve for F: one missing term in total.
	$\theta = 56.9$, $F = 18.3$	**A1**	Both correct (18.327530…, 56.932462…).
		6	
5(b)	$(Y =) \pm(10\sqrt{2}\sin 45 + 40\sin 60 - 50)\ [= \pm(20\sqrt{3} - 40)]$	**B1**	Allow non-exact values for $\sqrt{2}$ etc. in correct expression.
	$(X =) \pm(10\sqrt{2}\cos 45 + 10 - 40\cos 60)\ [= 0]$	**B1**	Allow non-exact values for $\sqrt{2}$ etc. in correct expression. Could be implied by correct answer.
	Resultant force is $40 - 20\sqrt{3}$ (N) in the same direction as the 50(N) force.	**B1**	Allow vertically downwards, south, 180°, negative y-direction. Resultant force must be exact and positive (so $20\sqrt{3} - 40$ is B0).
		3	

Question	Answer	Marks	Guidance
6(a)	$R = 0.1g\cos 60 [= 0.5]$	**B1**	Correctly resolving perpendicular to the plane for Q.
	$F = 0.7 \times 0.1g\cos 60\ [= 0.35]$	**M1**	Use of $F = \mu R$ for Q where R is a component of weight but not mass; allow sin/cos mix.
	For whole system: LHS of Newton's second law: $0.2g\sin 60 - 0.1g\sin 60 - F\ \ [= 0.866... - F]$ Or separately for P and Q: $0.2g\sin 60 - T(= 0.2a)$ and $T - 0.1g\sin 60 - F(= 0.1a)$, and eliminate T to get $0.2g\sin 60 - 0.1g\sin 60 - F(= 0.3a)$	**M1**	Complete method to determine the resultant force for the whole system. Allow sign errors and sin/cos mix, but must include all required terms and be dimensionally correct. If considering either the while system or P and Q separately then ignore the RHS of their Newton's second law equations.
	As $\frac{\sqrt{3}}{2} - 0.35 > 0$ the particles do move.	**A1**	Correct indication (with no incorrect working) that the resultant force is positive (e.g. $0.8660... - 0.35 > 0$ or $0.516...$ (to at least 1 sf) which is positive) together with a correct conclusion. Candidates may calculate the acceleration which is $\frac{10\sqrt{3} - 7}{6} = 1.72008...$ and then say that the particles are moving.
		4	

Question	Answer	Marks	Guidance
6(b)	Attempt to use Newton's second law for P: $0.2g\sin 60-(\sqrt{3}-1)=0.2a$	**M1**	Allow sign errors, sin/cos mix. but must be dimensionally consistent.
	$a=5\,(\mathrm{m\,s^{-2}})$	**A1**	
	Newton's second law for system: $0.2g\sin 60-0.1g\sin\theta=0.3(5)$ or Newton's second law for Q: $(\sqrt{3}-1)-0.1g\sin\theta=0.1(5)$	**M1**	Attempt Newton's second law for Q, or for the whole system. Allow sign errors, sin/cos mix, but must be dimensionally consistent.
	$\theta=13.4$	**A1**	13.41784…
		4	

Question	Answer	Marks	Guidance
7(a)	Driving force $F=\dfrac{16000}{20}[=800]$	**B1**	OE e.g. $16000=20\times F$
	$F-500=1200a$	**M1**	Use of Newton's second law; allow sign errors but must be 3 terms. Allow F or any non-zero value for the driving force (allow 0.8 from using 16 rather than 16000) but not 16000, 16, 20 or 500 for F.
	$a=0.25\,(\mathrm{m\,s^{-2}})$	**A1**	
		3	

Question	Answer	Marks	Guidance
7(b)	$\frac{16000}{v} - 500 = 0$	**M1**	Allow sign errors but must be 2 terms. Condone $\frac{16}{v} - 500 = 0$ for M1.
	$v = 32$ (m s^{-1})	**A1**	
		2	
7(c)	Work done by engine $= 16000 \times 15 [= 240000]$	**B1**	Or $16000 = \frac{\text{WD}}{15}$.
	KE change $= \pm\left(\frac{1}{2} \times 1200 \times v^2 - \frac{1}{2} \times 1200 \times 20^2\right)$	**B1**	$\pm(600v^2 - 240000)$
	PE change $= \pm\left(1200 \times g \times 316 \times \frac{1}{60}\right)[= \pm 63200]$	**B1**	Allow $1200 \times g \times 316 \times \sin 0.955$ or $1200 \times g \times 316 \times \sin 0.95$ or $1200 \times g \times \frac{79}{15}$ or $1200 \times g \times 5.266...$.
	Attempt at work-energy equation.	**M1**	Use of work-energy principle with 5 terms; dimensionally correct. Allow sign errors and sin/cos mix on PE term
	$16000 \times 15 - 128400 = \frac{1}{2} \times 1200 \times v^2 - \frac{1}{2} \times 1200 \times 20^2 + 1200g \times 316 \times \frac{1}{60}$ $(240000 - 128400 = 600v^2 - 240000 + 63200)$	**A1**	Allow a value in the interval [62870,63600] for the PE term from using non-exact values for the given angle (but not if from incorrect working).
	$v = 21.9$ (m s^{-1})	**A1**	21.924111…
		6	

Cambridge International AS & A Level

MATHEMATICS **9709/42**

Paper 4 Mechanics **May/June 2023**

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 2023 series for most Cambridge IGCSE, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

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 descriptors 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, 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 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 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.

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	$12^2 = 2 \times 9 \times a$. **OR** $a = 8$.	**M1**	Use of suvat to get an equation in *a*.
	$1.6g - R = 1.6a$. [may see $R = 3.2$]	**M1**	Use Newton's second law with 3 terms, allow sign errors. Allow *their a* ≠ *g*. Allow *a* if it isn't subsequently replaced with *g*.
	WD $[= 3.2 \times 9] = 28.8$ J	**A1**	
	Alternative method for Question 1		
	(KE =) $\frac{1}{2} \times 1.6 \times 12^2$ **OR** 115.2	**B1**	Allow for the expression for KE.
	(Loss of PE =) $\pm 1.6g \times 9$ **OR** ± 144	**B1**	Allow for the expression for PE.
	WD $= 28.8$ J	**B1**	Allow if get –28.8 and then say 28.8 without explanation. Do not allow –28.8 as final answer to working, so if get 28.8 and state –28.8 then ISW.
		3	

Question	Answer	Marks	Guidance
2(a)	$\pm[3.2v + 2.4 \times (-6)] = 0$	**M1**	Attempt at conservation of momentum; 2 non-zero terms; allow sign errors.
	$v = 4.5$	**A1**	M1A0 for use of *mgv*. $v = -4.5$ is A0.
		2	

Question	Answer	Marks	Guidance
2(b)	KE $= \pm\frac{1}{2}\times 3.2\times(\textit{their }\ 4.5)^2$ OR $\pm\frac{1}{2}\times 2.4\times 6^2$	**M1**	Attempt at either KE term, using *their v*. Do not allow $\frac{1}{2}\times 3.2\times(\textit{their }\ 4.5\pm 6)^2$, or $\frac{1}{2}\times 2.4\times(\textit{their }\ 4.5\pm 6)^2$, or $\frac{1}{2}\times(3.2+2.4)\times(\textit{their }\ 4.5\pm 6)^2$, or $\frac{1}{2}\times 3.2\times(\textit{their }\ 4.5-0)^2$, or $\frac{1}{2}\times 2.4\times(6-0)^2$.
	$KE_{loss} = 75.6$ J	**A1**	Allow –75.6. Note $\frac{1}{2}\times(3.2+2.4)\times 6^2$ or $\frac{1}{2}\times(3.2+2.4)\times(\textit{their } 4.5)^2$ is M1A0.
		2	

Question	Answer	Marks	Guidance
3(a)	Resolving either direction.	**M1**	Correct number of terms, allow sign errors, allow sin/cos mix. Do not allow with just $\sin\alpha$ and $\cos\alpha$.
	$(33+15)\times\frac{3}{5}=P\cos\theta+30\cos\theta$ OR $(33+15)\cos\left(\tan^{-1}\frac{4}{3}\right)=P\cos\theta+30\cos\theta$ OR $19.8+9=P\cos\theta+30\cos\theta$	**A1**	OE, but see note for final A1. Allow: $28.8=(P+30)\cos\theta$ $(33+15)\cos53(.1)=P\cos\theta+30\cos\theta$ $19.81+9.01=P\cos\theta+30\cos\theta$ $19.86+9.03=P\cos\theta+30\cos\theta$.
	$15\times\frac{4}{5}+30\sin\theta=33\times\frac{4}{5}+P\sin\theta$ OR $15\sin\left(\tan^{-1}\frac{4}{3}\right)+30\sin\theta=33\sin\left(\tan^{-1}\frac{4}{3}\right)+P\sin\theta$ OR $12+30\sin\theta=26.4+P\sin\theta$	**A1**	OE, but see note for final A1. Allow: $14.4=(30-P)\sin\theta$ $15\sin53(.1)+30\sin\theta=33\sin53(.1)+P\sin\theta$ $12.00+30\sin\theta=26.39+P\sin\theta$ $11.98+30\sin\theta=26.35+P\sin\theta$.
	[Use $\cos^2\theta+\sin^2\theta=1$ with] $\cos\theta=\frac{28.8}{P+30}$ and $\sin\theta=\frac{14.4}{30-P}$ to get $\left(\frac{14.4}{30-P}\right)^2+\left(\frac{28.8}{P+30}\right)^2=1$	**A1**	AG. Must have evidence of where 28.8 and 14.4 come from. A0 for any error seen. A0 if use of inexact angles seen. Any inexact decimals seen for force components, i.e. if 14.4 and/or 28.8 have come from rounding to 3sf, scores M1A1A1A0 max 3/4. If exact values of $\sin\alpha$ and $\cos\alpha$ not shown (e.g. $28.8=(P+30)\cos\theta$ or $14.4=(30-P)\sin\theta$ from no working), this scores M1A1A1A0 max 3/4 marks.
		4	

Question	Answer	Marks	Guidance
3(b)	Sub $P = 6$ into $\left(\frac{14.4}{30-P}\right)^2 + \left(\frac{28.8}{P+30}\right)^2$ to get $\left[\left(\frac{14.4}{24}\right)^2 + \left(\frac{28.8}{36}\right)^2\right] = \left(\frac{3}{5}\right)^2 + \left(\frac{4}{5}\right)^2 = 0.36 + 0.64 = 1$	**B1**	Must see either $\left(\frac{3}{5}\right)^2 + \left(\frac{4}{5}\right)^2 = 1$ or $0.36 + 0.64 = 1$ as minimum working.
	$\theta = 36.9$	**B1**	AWRT 36.9 .
		2	

Question	Answer	Marks	Guidance
4(a)	$\left(\text{Resistive force} = DF = \frac{60}{3} = \right) 20\text{ N}$	**B1**	
		1	

Question	Answer	Marks	Guidance
4(b)	PE $= \pm 84g \times 150 \sin 0.8$	**B1**	$\pm 1759.23\ldots$
	KE change $= \pm\left(\frac{1}{2}\times 84v^2 - \frac{1}{2}\times 84\times 3^2\right)$	**B1**	$\pm\left(\frac{1}{2}\times 84v^2 - 378\right)$
	Work Done $= \pm(24\times 150 - 13\times 150)$	**B1**	$\pm(3600-1950) = \pm 1650$
	Attempt at work-energy equation.	**M1**	5 terms, dimensionally correct, allow sign errors, sin/cos mix on PE term, PE must include $\sin 0.8$ or $\cos 0.8$.
	$84g\times 150\sin 0.8 + \frac{1}{2}\times 84v^2 - \frac{1}{2}\times 84\times 3^2 = 24\times 150 - 13\times 150$ $\left[1759.23\ldots + 42v^2 - 378 = 3600 - 1950 \rightarrow 42v^2 = 268.765\ldots\right]$	**A1**	
	$[v =]$ 2.53 $\mathrm{m\,s^{-1}}$	**A1**	AWRT 2.53; 2.5296…
		6	
	Special case for use of constant acceleration: Maximum 4 marks		
	Resolve parallel to slope and use Newton's second law	***M1**	Four terms, allow sign errors, allow sin/cos mix.
	$24 - 13 - 84g\sin 0.8 = \pm 84a$	**A1**	For reference $a = \pm 0.008669\ldots$
	Use constant acceleration formula to get an equation in v or v^2	**DM1**	E.g. $v^2 = 3^2 + 2\times(\textit{their } a)\times 150$.
	$[v =]$ 2.53 $\mathrm{m\,s^{-1}}$	**A1**	AWRT 2.53; 2.5296…
		4	

Question	Answer	Marks	Guidance
5	Attempt at resolving parallel or perpendicular to the plane.	*M1	3 terms, allow sign errors, allow sin/cos mix, allow g missing. Forces that need resolving should be resolved, forces that do not need resolving should not be resolved.
	$R = P\sin 35 + 0.6g\cos 35 \ \left[R = (0.573\ldots)P + 4.914\ldots\right]$	A1	
	$F + P\cos 35 = 0.6g\sin 35 \ \left[F + (0.819\ldots)P = 3.441\ldots\right]$	A1	Their F.
	Use of $F = 0.4R$	*M1	Where R is initially a linear combination of a P component and a weight component (or a mass component).
	Solve for P.	DM1	From equations with the correct number of relevant resolved terms. $R = \dfrac{0.6g}{\cos 35 + 0.4\sin 35} = 5.7222$. Must get to $P = \ldots$, e.g. $P = \dfrac{0.6g\sin 35 - 0.4\times 0.6g\cos 35}{\cos 35 + 0.4\sin 35}$ If no working seen, allow this mark if correct solution for their equations. If $F \leqslant 0.4R$ used, it should be used correctly. e.g. $0.6g \sin 35 - P \cos 35 \leqslant 0.4(P \sin 35 + 0.6g \cos 35)$.
	$P = 1.41$	A1	AWRT 1.41 . If $P \geqslant 1.41$ seen, must then state the least value explicitly for A1.

Question	Answer	Marks	Guidance
5	**Alternative for Question 5: Resolving vertically and horizontally**		
	Attempt at resolving vertically or horizontally.	***M1**	3 terms, allow sign errors, allow sin/cos mix, allow g missing. Forces that need resolving should be resolved, forces that do not need resolving should not be resolved.
	$R\cos 35 + F\sin 35 = 0.6g$	**A1**	*Their F* or *R*.
	$P + F\cos 35 = R\sin 35$	**A1**	*Their F* or *R*.
	Use of $F = 0.4R$	***M1**	To get 2 equations, one in R (or F) and the other in P and R (or P and F) from resolved equations with correct number of relevant terms. Allow g missing.
	Solve for P	**DM1**	From equations with the correct number of relevant resolved terms. May see $R = \dfrac{0.6g}{\cos 35 + 0.4\sin 35} = 5.7222$; Must get to $P = \ldots$, e.g. $P = \dfrac{0.6g\sin 35 - 0.4 \times 0.6g\cos 35}{\cos 35 + 0.4\sin 35}$. If no working seen, allow this mark if correct solution for *their* equations.
	$P = 1.41$	**A1**	AWRT 1.41 .
		6	

Question	Answer	Marks	Guidance
6(a)	$4b+4^{\frac{3}{2}}c=8\left[\rightarrow 4b+8c=8\right]$ and $9b+9^{\frac{3}{2}}c=13.5\left[\rightarrow 9b+27c=13.5\right]$ State $b=3$ and $c=-0.5$ OR $3\times 4+(-0.5)\times 4^{\frac{3}{2}}=8$ AND $3\times 9+(-0.5)\times 9^{\frac{3}{2}}=13.5$	B1	Must have 2 correct equations, which do not have to be simplified. Allow to just state the values of b and c. Allow substitution of $b=3$ and $c=-0.5$ in both equations to verify. No further calculation required. B0 if any incorrect work seen.
		1	
6(b)	$\left(a=\frac{\mathrm{d}v}{\mathrm{d}t}=\right)3-0.5\times\frac{3}{2}\times t^{\frac{1}{2}}$ OR $b+c\times\frac{3}{2}\times t^{\frac{1}{2}}$	M1	Attempt to differentiate, decrease power by 1 and a change in coefficient in at least one term (which must be the same term); allow unsimplified; $a=\frac{v}{t}$ is M0.
	acceleration = $2.25\ \mathrm{m\,s^{-2}}$	A1	OE, e.g. $\frac{9}{4}$ or $2\frac{1}{4}$. **SC B1** for 2.25 if no differentiation seen.
		2	

Question	Answer	Marks	Guidance
6(c)	Equate v to 0 and attempt to solve for t	**M1**	Must get to $t = \ldots$ and must be positive.
	$t = 36$ ONLY	**A1**	WWW. Allow if $t = 0$ seen and not rejected.
	Attempt to integrate	**M1**	Increase power by 1 and a change in coefficient in at least one term (which must be the same term). $s = vt$ is M0.
	$s = \frac{3}{2}t^2 - 0.5\times\frac{2}{5}\times t^{\frac{5}{2}}\left(+D\right) = \frac{3}{2}t^2 - \frac{1}{5}t^{\frac{5}{2}}\left(+D\right)$ OR $s = \frac{b}{2}t^2 + c\times\frac{2}{5}\times t^{\frac{5}{2}}\left(+D\right)$	**A1**	Allow unsimplified (including indices).
	Sub $t = 36$ (or use limits 36 and 0) to get distance = 388.8 m ONLY	**A1**	Allow 389 m. If no integration seen for the last 3 marks, allow **SC B1** for 388.8 m. Max M1A1B1 for 3/5 marks.
		5	
6(d)	$\frac{3}{2}t^2 - 0.5\times\frac{2}{5}\times t^{\frac{5}{2}} = 0$	**M1**	Equate *their s* (that has come from an integration attempt) to 0 and attempt to solve for *t*. Must get to $t = \ldots$
	$t = 56.25$	**A1**	WWW. OE, e.g. $\frac{225}{4}$. Allow 2sf or better. Allow any correct unsimplified expression equivalent to 56.25 e.g. $\frac{15^2}{2^2}$ or 7.5^2.
	Speed = 42.2 $\mathrm{m\,s^{-1}}$ ONLY	**A1**	AWRT 42.2 . Speed = −42.2 is A0. Allow A1 if negative sign dropped without justification.
		3	

Question	Answer	Marks	Guidance
7(a)(i)	Particle P: $2g\sin 30 - F - T = 2a\ [10 - F - T = 2a]$ Particle Q: $T - 0.25g = 0.25a$ System: $2g\sin 30 - F - 0.25g = (2 + 0.25)a$	**M1**	Newton's second law on either particle or for the system with correct masses; correct number of terms, allow sin/cos mix, allow sign errors. Allow with *their F*.
		A1	Both particle equations correct (with the same T) or system equation correct. Allow with *their F*. If *their a* direction is different to ours, allow if *their a* is consistently used e.g. $-2g\sin 30 + F + T = 2a'$ and $0.25g - T = 0.25a'$.
	$F = 0.3R = 0.3 \times 2g\cos 30\left[= 3\sqrt{3} = 5.1961\ldots\ldots\right]$	**M1**	Use of $F = 0.3R$, where R is a component of weight.
	Acceleration from A to B = 1.02 m s^{-2}	**A1**	Solving for the acceleration from A to B. Allow $\frac{10 - 4\sqrt{3}}{3}$; AWRT 1.02 . May see $T = \frac{10 - \sqrt{3}}{3} = 2.7559\ldots$
		4	

Question	Answer	Marks	Guidance
7(a)(ii)	Use of suvat from *A* to *B* to get an equation in v^2 or v.	*M1	Using $u=0$ and *their* $\lvert a \rvert$ from **(a)(i)** to get a positive v^2. E.g. $v^2 = 2\times 0.8\times(\textit{their}\ 1.02)$ or $v^2 = 2\times(-0.8)\times(-\textit{their}\ 1.02)$.
	$v^2 = \left[\dfrac{80-32\sqrt{3}}{15}\right] = 1.64$ OR $v = 1.28$	A1	Not $v = 1.29$. Allow 2sf or better without wrong work, i.e. $v^2 = 1.6$ or $v = 1.3$.
	Find the acceleration from *B* to *C*: $2g\sin 30 - 0.25g = (2+0.25)a$	*M1	Resolving on both particles and eliminate *T* (if *their a* direction is different to ours, allow if *their a* is consistently used) OR for the system to get an equation in *a* only. Correct number of relevant terms, allow sin/cos mix, allow sign errors. For reference $a = \dfrac{10}{3}$ or 3.33. May see $T = \dfrac{10}{3}$.
	$v^2 = (\textit{their}\ 1.28)^2 + 2\times\left(\textit{their}\ \dfrac{10}{3}\right)\times 1.2$	DM1	Use of suvat from *B* to *C*, allow *their* positive $a \neq g$ from **(a)(ii)** not *their a* from **(a)(i)** and *their* 1.28. Dependent on previous two marks.
	Velocity = 3.1(0) $\mathrm{m\,s^{-1}}$	A1	AWRT 3.1(0) to 3sf.

Question	Answer	Marks	Guidance
7(a)(ii)	**Alternative Method for Question 7(a)(ii): using suvat in first stage and energy in second stage**		
	Use of suvat from A to B to get an equation in v^2 or v.	***M1**	Using *their* positive a from **(a)(i)** E.g. $v^2 = 2 \times 0.8 \times (\textit{their}\ 1.02)$.
	$v^2 = \left[\frac{80-32\sqrt{3}}{15}\right] = 1.64$ OR $v = 1.28$	**A1**	Allow 2sf or better, i.e. $v^2 = 1.6$ or $v = 1.3$.
	Change in PE $= \pm(2g \times 1.2\sin 30 - 0.25g \times 1.2)$ OR Change in KE $= \pm\left[\frac{1}{2}(2+0.25)v^2 - \frac{1}{2}(2+0.25)(\textit{their}\ 1.28)^2\right]$	**B1**	
	$\frac{1}{2}(2+0.25)v^2 - \frac{1}{2}(2+0.25)(\textit{their}\ 1.28)^2 = 2g \times 1.2\sin 30 - 0.25g \times 1.2$	**DM1**	Use of work-energy 6 terms; dimensionally correct. Allow sign errors. Allow sin/cos mix on PE. Dependent on previous M.
	Velocity = 3.1(0) m s^{-1}	**A1**	AWRT 3.1(0) to 3sf.

Question	Answer	Marks	Guidance
7(a)(ii)	**Alternative Method for Question 7(a)(ii): using energy for complete motion**		
	Change in PE $= \pm(2g \times 2\sin 30 - 0.25g \times 2)$	**B1**	
	Work done against friction $= 0.3 \times 2g\cos 30 \times 0.8$	**B1**	
	Change in KE $= \frac{1}{2}(2 + 0.25)v^2$	**B1**	
	$\frac{1}{2}(2+0.25)v^2 + 0.3 \times 2g\cos 30 \times 0.8 = (2g \times 2\sin 30 - 0.25g \times 2)$	**M1**	Use of work-energy 5 terms; dimensionally correct. Must be considering both particles. Allow sign errors. Allow sin/cos mix on PE and/or WD against friction.
	Velocity = 3.1(0) m s^{-1}	**A1**	AWRT 3.1(0) to 3sf.

Question	Answer	Marks	Guidance
7(a)(ii)	**Alternative Method for Question 7(a)(ii): using energy in two stages**		
	$\frac{1}{2}(2+0.25)v^2+0.3\times 2g\cos 30\times 0.8=2g\times 0.8\sin 30-0.25g\times 0.8$ OR $\frac{1}{2}\times 2\times v^2+(\textit{their}\ 2.7559\ldots)\times 0.8+0.3\times 2g\cos 30\times 0.8=2g\times 0.8\sin 30$ OR $\frac{1}{2}\times 0.25\times v^2+0.25g\times 0.8=(\textit{their}\ 2.7559\ldots)\times 0.8$	*M1	Use of work-energy 5 terms; dimensionally correct. Allow sign errors. Allow sin/cos mix on PE. OR Use of work-energy 4 terms; dimensionally correct. Allow sign errors. Allow sin/cos mix on PE. OR Use of work-energy 3 terms; dimensionally correct. Allow sign errors.
	$v^2=\left[\frac{80-32\sqrt{3}}{15}\right]=1.64$ OR $v=1.28$	A1	Allow 2sf or better, i.e. $v^2=1.6$ or $v=1.3$.
	Change in PE $=\pm(2g\times 1.2\sin 30-0.25g\times 1.2)$ OR Change in KE $=\pm\left[\frac{1}{2}(2+0.25)v^2-\frac{1}{2}(2+0.25)1.28^2\right]$	B1	
	$\frac{1}{2}(2+0.25)v^2-\frac{1}{2}(2+0.25)1.28^2=2g\times 1.2\sin 30-0.25g\times 1.2$	DM1	Use of work-energy 6 terms; dimensionally correct. Allow sign errors. Allow sin/cos mix on PE. Dependent on previous 2 marks.
	Velocity = 3.1(0) m s^{-1}	A1	AWRT 3.1(0) to 3sf.
		5	

Question	Answer	Marks	Guidance
7(b)	$0.8 = 0 + \frac{1}{2} \times$ (*their* positive answer to **(a)(i)**) $\times t_1^2$ and solve for t_1 OR $0.8 = \frac{1}{2}$(0 + *their* positive 1.28 from **(a)(ii)**) t_1 and solve for t_1 OR (*their* positive 1.28 from **(a)(ii)**) = (*their* positive answer to **(a)(i)**) t_1 and solve for t_1	**M1**	Use of suvat from A to B to find t_1, using $s = 0.8$ and *their* positive $a \neq g$ from **(a)(i)**. Must get to $t_1 = \ldots$ OR using their positive 1.28 . OR using their positive $a \neq g$ from **(a)(i)** and positive 1.28 .
	$1.2 =$ (*their* 1.28 from **(a)(ii)**) $t_2 + \frac{1}{2} \times \left(their\ \frac{10}{3} \right) \times t_2^2$ and solve for t_2 OR $1.2 = \frac{1}{2}$ ((*their* 1.28 from **(a)(ii)**) + (*their* answer to **(a)(ii)**)) t_2 and solve for t_2 OR (*their* answer to **(a)(ii)**) = (*their* 1.28 from **(a)(ii)**) $+ \left(their\ \frac{10}{3} \right) t_2$ and solve for t_2	**M1**	Use of suvat from B to C to find t_2, using $s = 1.2$ and *their* positive $a \neq g$ from **(a)(ii)** (not *their a* from **(a)(i)**) and *their* 1.28 which would lead to a positive t_2 value. Must get to $t_2 = \ldots$ OR using *their* 1.28 and/or *their* answer to **(a)(ii)** which would lead to a positive t_2 value. OR using *their* 1.28 and/or *their* answer to **(a)(ii)** and *their* $a \neq g$ from **(a)(ii)** (not *their a* from **(a)(i)**) which would lead to a positive t_2 value.
	$t_1 = 1.25$ or $t_2 = 0.547$	**A1**	These can be seen as an expression. Allow $t_1 = \frac{0.8}{0.64}$ $t_2 = \frac{1.2}{2.19}$ OE. Allow 2sf or better, e.g. $t_1 = 1.3$ or $t_1 = 0.55$.
	Total time = 1.8(0) s	**A1**	WWW. AWRT 1.8(0) to 3sf.
		4	

Cambridge Assessment International Education

Cambridge International AS & A Level

MATHEMATICS **9709/43**

Paper 4 Mechanics **May/June 2023**

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 2023 series for most Cambridge IGCSE, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

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 descriptors 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, 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 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 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.

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	For attempt at use of conservation of momentum in one case	**M1**	$0.1\times 4+0=0.4v+0.1v$ or $0.1\times 4+0=0.4v+0.1(-v)$ OE. Must have correct number of terms. Allow sign errors.
	Speed = 0.8 [$\mathrm{m\,s^{-1}}$] or $\frac{4}{5}$	**A1**	Must be positive. Allow Max M1A1A0 if g included with the masses.
	Speed = $\frac{4}{3}$ [$\mathrm{m\,s^{-1}}$] Allow 1.33	**A1**	Must be positive.
		3	

Question	Answer	Marks	Guidance
2	Attempt to use Newton's second law	**M1**	Must have correct number of terms. Allow sign errors. Must use 300 and 1.25, not T and a.
	Trailer $300-200=m\times 1.25$ or Car $3200-F-300=1500\times 1.25$ System $3200-F-200=(1500+m)\times 1.25$	**A1**	Any 2 equations. Third equation could be with *their* m substituted if found already.
	Solve for m or F	**M1**	Must get to 'm =' or 'F ='. Must have correct number of terms. Allow sign errors. Can be implied by correct answers.
	$m = 80$ and $F = 1025$	**A1**	
		4	

Question	Answer	Marks	Guidance
3	For attempt to resolve in one direction	M1	Must use 0.2 substituted for m if just awarding M1 for vertical equation. Must have correct number of relevant terms (forces must have components as required). Allow sin/cos mix. Allow sign errors. Allow g missing.
	$X\sin 60 + T\sin 30 - 0.2g = 0$	A1	OE. Correct vertical.
	$X\cos 60 - T - T\cos 30 = 0$	A1	OE. Correct horizontal. If the two Ts are different, they can get max M1A1A0M0A0, unless they subsequently state that the two Ts are equal.
	For attempt to solve for tension or X	M1	Must have correct number of relevant terms in both equations. Must get to '$T =$' or '$X =$'. Allow g missing. Can be implied by correct answers. If no working shown their values must follow from their equations.
	$X = 2$, tension in string = 0.536 [N]	A1	Allow exact value of tension = $4 - 2\sqrt{3}$. Allow awrt 2.00 for X.

Question	Answer	Marks	Guidance
3	**Alternative method for Question 3: Resolving parallel and perpendicular to the X N force**		
	For attempt to resolve in one direction, with 0.2 substituted for m	**M1**	Must have correct number of relevant terms (forces must have components as required). Allow sin/cos mix. Allow sign errors. Allow g missing.
	$X - 0.2g\cos 30 - T\cos 60 = 0$	**A1**	OE. Correct parallel to X.
	$T + T\cos 30 - 0.2g\cos 60 = 0$	**A1**	OE. Correct perp to X. If the two Ts are different, they can get max M1A1A0M0A0 unless they subsequently state that the two Ts are equal.
	For attempt to solve for the tension or for X	**M1**	Must have correct number of relevant terms in both equations. Must get to '$T =$' or '$X =$'. Allow g missing. Can be implied by correct answers. If no working shown their values must follow from their equations.
	$X = 2$, Tension in string = 0.536[N] [0.53589…]	**A1**	Allow exact value of tension = $4 - 2\sqrt{3}$. Allow awrt 2.00 for X.
		5	

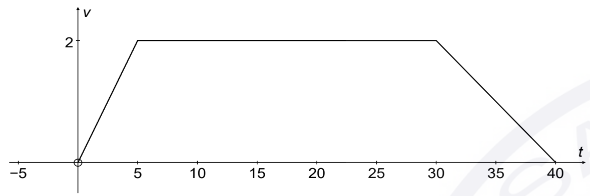
Question	Answer	Marks	Guidance
4(a)	For use of $P = Fv$	**B1**	$P = 20F$ or $P = 25F$ OE (e.g. $F = \frac{P}{20}$ or $F = \frac{P}{25}$). But not with wrong F substituted (e.g. 6000).
	Attempt to use Newton's second law in at least one case	**M1**	Must have 3 terms. Allow sign errors. Allow F.
	$\frac{P}{20} - 6000 = 15000a$ and $\frac{P}{25} - 6000 = 15000\left(\frac{1}{2}a\right)$	**A1**	OE for both. Allow $2a'$ and a'. Must be the same P for both.
	For solving simultaneously	**M1**	Dependent on 2 equations of the correct form with the correct number of relevant terms. Must get to '$P =$' or '$a =$', but $P =$ 200 kW or 200 000 W with no attempt at a gets M0. Must be the same P for both.
	Power [= 200 000W] = 200 kW, $a = \frac{4}{15}$ [ms^{-2}]	**A1**	AG. OE awrt 0.267. Do not allow 200 000 [W] as final answer. Must show some working when they find P.
	Alternative Method for Question 4(a): Using two expressions for P		
	For use of $P = Fv$	**B1**	$P = 20F$ or $P = 25F$ OE (e.g. $F = \frac{P}{20}$ or $F = \frac{P}{25}$). But not with wrong F substituted (e.g. 6000).
	For one expression for P in terms of a only	**M1**	Allow sign errors. Need 2 term expression.
	$(15000a + 6000) \times 20 = (15000 \times 0.5a + 6000) \times 25$	**A1**	Correct equation.
	For solving for a	**M1**	Must get to '$a =$'.
	Power [= 200 000W] = 200 kW, $a = \frac{4}{15}$ [ms^{-2}]	**A1**	AG. OE awrt 0.267. Do not allow 200 000 [W] as final answer. Must show some working when they find P.

Question	Answer	Marks	Guidance
4(a)	**Alternative Method for Question 4(a): Using the given value of *P* = 200 kW**		
	For use of $P = Fv$	**B1**	e.g. 200 000 = 20*F* or 200 000 = 25*F* OE. e.g. $F = \frac{200000}{20}[=10000]$ or $F = \frac{200000}{25}[=8000]$.
	Attempt to use Newton's second law in at least one case	**M1**	Must have 3 terms. Allow sign errors. Allow with *F*. Allow 200 in place of 200 000.
	$\frac{200000}{20} - 6000 = 15000a$ and $\frac{200000}{25} - 6000 = 15000\left(\frac{1}{2}a\right)$	**A1**	For both. Allow 2*a*' and *a*' here.
	For solving for *a* in both cases.	**M1**	
	For showing that both equations lead to $a = \frac{4}{15}$ [m s^{-2}]	**A1**	awrt 0.267.
		5	
4(b)	For attempt at resolving up hill $\frac{200000}{v} - 6000 - 15000g\sin 1 = 0$	**M1**	Or $\frac{200000}{v} - 6000 - 2618 = 0$. May see $\frac{200000}{8618}$. Must have correct number of terms. Allow sin/cos mix. Allow sign errors. Allow *g* missing, but not a different acceleration. Do not allow *F*.
	Steady speed = 23.2 [m s^{-1}]	**A1**	
		2	

Question	Answer	Marks	Guidance
5(a)	For attempt at integration	**M1**	The power of t must increase by 1 with a change of coefficient. Do not penalise missing c. Use of $v = at$ scores M0.
	$v = \frac{2}{3}kt^{\frac{3}{2}}\left[+c\right]$	**A1**	Allow unsimplified e.g. $v = \frac{1}{1.5}kt^{\frac{1}{2}+1}\left[+c\right]$.
	$1.8 = \frac{2}{3}k \times 9^{\frac{3}{2}} \quad \Rightarrow k = \left[\frac{3}{2} \times 1.8 \div 27 = \right]0.1$	**B1**	AG. Must show values substituted OE (e.g. $1.8 = 18k$).
		3	

Question	Answer	Marks	Guidance
5(b)	For attempt at integration of either $\int\left(\frac{2}{3}kt^{\frac{3}{2}}\right)\mathrm{d}t$ or $\int\left(0.2(t-9)^2+1.8\right)\mathrm{d}t$ or $\int\left(0.2t^2-3.6t+18\right)\mathrm{d}t$	**M1**	The power of t or $(t-9)$ must increase by 1 with a change of coefficient in at least one term. Use of $s = vt$ is M0.
	$\left[\frac{4}{150}t^{\frac{5}{2}}\right]_0^9$ and $\left[\left(\frac{0.2}{3}(t-9)^3+1.8t\right)\right]_9^{18}$ or $\left[\left(\frac{0.2}{3}t^3-\frac{3.6}{2}t^2+18t\right)\right]_9^{18}$	**A1**	Allow unsimplified. No need for limits. Could include '+c' with either or both.
	$=\frac{4}{150}\times 9^{\frac{5}{2}}\ \left[=6.48 \text{ or } \frac{162}{25}\right]$ or $=\frac{0.2}{3}(18-9)^3+1.8\times18-1.8\times9=\left[64.8 \text{ or } \frac{324}{5}\right]$ or $\left(\frac{0.2}{3}\times18^3-\frac{3.6}{2}\times18^2+18\times18\right)-\left(\frac{0.2}{3}\times9^3-\frac{3.6}{2}\times9^2+18\times9\right)$ $\left[=\frac{648}{5}-\frac{324}{5}=\frac{324}{5}\right]$	**M1**	Correct use of limits 0, 9 or limits 9, 18. Can be implied by either answer following integration "+c" method is as follows: $s=\frac{0.2}{3}(t-9)^3+1.8t-\frac{243}{25}$, or $s=\frac{0.2}{3}t^3-\frac{3.6}{2}t^2+18t-\frac{1458}{25}$, then substitute $t = 18$ to get $\frac{1782}{25}$, subtract $\frac{162}{25}$, so distance = $\frac{324}{5}$.
	$6.48=\frac{1}{10}\times64.8$ or $64.8=10\times6.48$ or $\frac{324}{5}=10\times\frac{162}{25}$	**A1**	AG OE. Check working as can get answer from wrong working NFWW (not from wrong working).

Question	Answer	Marks	Guidance
5(b)	**Alternative Method for Question 5(b): Special Case for those who use a calculator to integrate. Award max 2/4**		
	Either $\int_0^9 \left(\frac{2}{3}kt^{\frac{3}{2}}\right)\mathrm{d}t = 6.48$ or $\frac{162}{25}$ Or $\int_9^{18} \left(0.2(t-9)^2 + 1.8\right)\mathrm{d}t = 64.8$ or $\frac{324}{5}$	**SC B1**	
	$6.48 = \frac{1}{10} \times 64.8$ or $64.8 = 10 \times 6.48$ or $\frac{324}{5} = 10 \times \frac{162}{25}$	**SC B1**	OE.
		4	
5(c)	For differentiation Should get $a = 0.4(t-9)$ or $a = 0.4t - 3.6$	**M1**	The power of t or $(t-9)$ must decrease by 1 with a change of coefficient. M0 for $a = \frac{v}{t}$.
	0.4 [ms^{-2}] [at $t = 10$]	**A1**	**SC B1** for 0.4 with no differentiation seen.
	0.3 seen (from the first phase) and state that 0.4 is final answer	**B1**	No working needed. If M1A0 or M0A0 scored, then **SC B1** for 0.3 without mention of the maximum acceleration.
		3	

Question	Answer	Marks	Guidance
6(a)	Greatest speed = $2\,[\mathrm{m\,s^{-1}}]$ $[0.4\times 5]$	**B1**	This can be seen on the graph and not stated explicitly.
	Trapezium shape	**B1**	Sitting on t-axis, starting at origin.
		**B1**	All correct including height of 2 and t-values of 5, 30, 40 on the horizontal axis. Labels not needed. Does not need to be to scale.
		3	
6(b)	Distance = $\frac{1}{2}(25+5+25+their\,10)\times their\,2$ or $\frac{1}{2}\times 5\times their\,2+25\times their\,2+\frac{1}{2}\times their\,10\times their\,2$	**M1**	Allow M1 for finding total area under their trapezium or appropriate 'suvat' in each phase. If presented as 3 areas, they do not need to be added for M1. Allow one wrong value but must represent all 3 phases of motion.
	Distance = $65\,[\mathrm{m}]$	**A1**	
		2	
6(c)	Attempt at Newton's second law	**M1**	Must have correct number of terms (5). Allow sign errors. Allow g missing. Use of $a = g$ is M0A0A0 but condone use of $a = 0.4$ (from wrong phase).
	$12250-1200g-mg=(1200+m)\times(-0.2)$ Or $1200g+mg-12250=(1200+m)\times 0.2$	**A1**	Correct equation. Note that taking $a = 0.2$ and omitting mg gets M0A0A0.
	$m = 50$	**A1**	
		3	

Question	Answer	Marks	Guidance
6(d)	Realise that this is when accelerating and attempt Newton's second law for the crate only	**M1**	Must have correct number of terms (3). Allow sign errors. Allow g missing. Must use $a = \pm 0.4$, M0A0A0 otherwise.
	$R - 50g = 50 \times 0.4$ or $50g - R = 50 \times (-0.4)$	**A1FT**	Correct equation using their 50.
	Force $R = 520$ [N], **upwards**	**A1**	Must include 'upwards' OE.
		3	

Question	Answer	Marks	Guidance
7(a)	PE lost = $mgh = 25g \times 1.8 [= 450]$	**B1**	
	For work energy equation	**M1**	Must have correct number of terms. Allow sign errors. Dimensionally correct. Must use 25, not m. Candidates who try to use constant acceleration can only score B1.
	$25g \times 1.8 - 50 = \frac{1}{2} \times 25v^2$	**A1**	OE. Must be correct.
	$v = 4\sqrt{2}$ [$\mathrm{m\,s^{-1}}$] or 5.66 [5.6568…]	**A1**	Allow $\sqrt{32}$.
		4	

Question	Answer	Marks	Guidance
7(b)	PE gained/lost = $\pm 25g \times 2 \times 0.28 [= \pm 140]$ or KE gained/lost = $\pm\frac{1}{2} \times 25\left(\textit{their}\ 4\sqrt{2}\right)^2$ [KE = ± 400]	**B1FT**	For either. FT from *their* v for KE. Must have α substituted for PE. Allow $25g \times 2\sin 16.26°$ or $25g \times 2\sin 16.3°$.
	For work energy equation	***M1**	Must have correct number of terms. Allow sign errors. Dimensionally correct. Allow sin/cos mix Do not allow with WD instead of $F \times 2$. Must have substituted α and v.
	$F \times 2 = 25g \times 2 \times 0.28 + \frac{1}{2} \times 25\left(4\sqrt{2}\right)^2$ $[\Rightarrow F = 270]$	**A1FT**	FT *their* v^2 or v.
	$R = 25g \times 0.96$ [= 240]	**B1**	Allow $25g\cos 16.26°$ or $25g\cos 16.3°$.
	Use of $F = \mu R$ to form an equation in μ only	**DM1**	Must be from 3 term F, dimensionally correct and single term R. Allow sin/cos mix but must be different components of weight. F and R must be numerical expressions.
	$\mu = \frac{9}{8}$	**A1**	CAO. Allow $1\frac{1}{8}$, but no other answer.
	Alternative method 1 for first 3 marks: Using energy from the initial position (use existing scheme for final 3 marks).		
	PE lost = $\pm 25g \times (1.8 + 2 \times 0.28) [= \pm 590]$	**B1**	Allow $25g \times (1.8 + 2\sin 16.26°)$ or $25g \times (1.8 + 2\sin 16.3°)$.
	For work energy equation	***M1**	Must have correct number of terms. Allow sign errors. Dimensionally correct. Allow sin/cos mix. Do not allow with WD instead of $F \times 2$. Must have substituted α.
	$F \times 2 = 25g \times (1.8 + 2 \times 0.28) - 50$ $[\Rightarrow F = 270]$	**A1**	

Question	Answer	Marks	Guidance
7(b)	**Special Case: Use of constant acceleration. Award max 4/6**		
	$0=\left(4\sqrt{2}\right)^2+2(\pm a)\times 2$		Use of $v^2=u^2+2as$.
	$a=\pm 8$	**SC B1FT**	FT *their* v^2 or v. Note: 8.01 or 8.0089 from use of 5.66.
	$R=25g\times 0.96$	**SC B1**	Allow $25g\cos 16.26°$ or $25g\cos 16.3°$.
	Use of $F=\mu R$ and attempt at N2L If correct should get $25g\sin 16.3°-\mu\times 25g\cos 16.3°=25\times(-8)$ $[\Rightarrow 70-240\mu=-200]$	**SC M1**	To form an equation in μ only. Using *their a.* Allow sign errors. Allow sin/cos mix but must be different components of weight. *F* and *R* must be numerical expressions. Must have substituted *α*.
	$\mu=\dfrac{9}{8}$	**SC A1**	CAO. Allow $1\dfrac{1}{8}$, but no other answer.
		6	

Cambridge Assessment International Education

Cambridge International AS & A Level

MATHEMATICS **9709/42**

Paper 4 Mechanics **February/March 2023**

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 February/March 2023 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

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 descriptors 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, 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 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 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.

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(a)	$4500 = \frac{600 \times 15}{t}$	M1	Use of power = ΔW / Δt to get an equation in t. May see $600v = 4500 \Rightarrow v = 7.5$ followed by $7.5t = 15$.
	$t = 2$ s	A1	
		2	
1(b)	$\pm 600 = 200a \left[\Rightarrow a = \pm 3\right]$	*M1	Use of Newton's second law; 2 terms only.
	$0 = \frac{15}{their\,2} + (their - 3)t$	DM1	Use of constant acceleration to set up an equation that would lead to a positive t, e.g. $v = u + at$ with *their* $t = 2$ and *their* negative a (and possibly *their* 7.5 from **(a)**).
	$t = 2.5$s	A1	
		3	

Question	Answer	Marks	Guidance
2(a)	Use constant acceleration in an attempt to find v or v^2 $[v^2 = 15^2 - 2g \times 10]$	M1	e.g. $v^2 = u^2 + 2as$ with $a = \pm g$.
	Speed = $5\,\text{m s}^{-1}$	A1	
		2	

Question	Answer	Marks	Guidance
2(b)	$(s_P =)\pm\left(15t-\frac{1}{2}gt^2\right)$, $(s_Q =)\pm\frac{1}{2}gt^2$	*B1	Use of $s = ut+\frac{1}{2}at^2$ for either. Allow if a not substituted, need both expressions with opposite sign of t^2 term and the same a.
	Use $s_P + s_Q = 18$ and solve for t	DM1	Allow $s_P + s_Q = \pm 18$. Must have s_P and s_Q of the correct form.
	So height = 10.8 m	A1	
	Alternative method for Question 2(b): Using relative velocity		
	$\pm 15t$	*B1	Use of relative velocity (no acceleration).
	Use $15t = 18$ and solve for t	DM1	Allow $15t = \pm 18$.
	So height = 10.8 m	A1	Not from $t = -1.2$ made positive without justification.
		3	

Question	Answer	Marks	Guidance
3(a)	Attempt to integrate $\left[(v=)\frac{4}{1.5}t^{\frac{3}{2}} = \frac{8}{3}t^{\frac{3}{2}}(+c)\right]$	M1	Increasing power by 1 and a change in coefficient in at least one term; may be unsimplified. $v = at$ M0.
	Substitute $t = 9$ to get speed = 72 m s^{-1}	A1	Or use limits $t = 0$ and $t = 9$.
		2	

Question	Answer	Marks	Guidance
3(b)	Attempt at integration of *their* v $\left[(s=)=\frac{8/3}{2.5}t^{\frac{5}{2}}=\frac{16}{15}t^{\frac{5}{2}}(+c')\right]$	*M1	Increasing power by 1 and a change in coefficient in at least one term; may be unsimplified. $s=vt$ M0 *Their* v, which has come from integration in part **(a)**.
	Equate *their* v and *their* s and attempt to solve for t $\left[\frac{16}{15}t^{\frac{5}{2}}=\frac{8}{3}t^{\frac{3}{2}}\Rightarrow\frac{16}{15}t-\frac{8}{3}=0\right]$	DM1	*Their* v must have come from integration. Allow if *their* c from **(a)** is not 0.
	$\text{time}=\frac{5}{2}\text{ s}$	A1	Must discard $t=0$ and $t=-\frac{5}{2}$.
		3	

Question	Answer	Marks	Guidance
4(a)	Tension = 0 N	B1	May be implied.
		1	
4(b)	Power $[=0.2\times 2]=0.4\text{ W}$	B1	Use of power = Fv. Allow without units.
		1	

Question	Answer	Marks	Guidance
4(c)	Driving force = 1.2/2 [= 0.6 N]	**B1**	
	Use of Newton's second law for locomotive or truck or system	**M1**	Correct number of relevant terms.
	For locomotive: $\text{DF} - 0.2 - T = 0.8a$ For truck: $T = 0.4a$ For system: $\text{DF} - 0.2 = 1.2a$	**A1**	For any two correct.
	For attempt to solve for T	**M1**	From equations with correct number of relevant terms. Using *their* dimensionally correct DF. May see $a = \frac{1}{3}$.
	$T = \frac{2}{15}\text{N}$	**A1**	Allow awrt 0.133 .
		5	

Question	Answer	Marks	Guidance
5(a)	Attempt to resolve vertically	**M1**	4 terms; allow with T_A and T_B; allow sign errors; allow g missing.
	$500 + T\cos 45 + T\cos 45 - 100g = 0$ OR $500 + T_A\cos 45 + T_B\cos 45 - 100g = 0$ AND $T_A(\sin 45) = T_B(\sin 45)$	**A1**	Must have $T_A = T_B = T$. Allow if $500 - 2T\cos 45 - 100g = 0$. Allow $500 - T_A\cos 45 - T_B\cos 45 - 100g = 0$ AND $T_A(\sin 45) = T_B(\sin 45)$.
	$T = 354\text{N}$	**A1**	Allow $250\sqrt{2}$, $\frac{500}{\sqrt{2}}$. Allow if $500 - 2T\cos 45 - 100g = 0$ to obtain $T = -354$ and then state magnitude is 354. If T_A and T_B are different values then A0.
	Alternative Method 1 for Question 5(a): Resolving perpendicular to a strut		
	Resolve perpendicular to T_A or T_B	**M1**	3 terms; allow sign errors; allow g missing.
	$T_A(\text{or}\,T_B) + 500\cos 45 = 100g\cos 45$	**A1**	Allow $T_A(\text{or}\,T_B) + 100g\cos 45 = 500\cos 45$.
	$T_A = T_B = 354$	**A1**	Allow $250\sqrt{2}$, $\frac{500}{\sqrt{2}}$.

Question	Answer	Marks	Guidance
5(a)	**Alternative Method 2 for Question 5(a): Using triangle of forces**		
	Attempt Pythagoras on a right-angled triangle of forces or use of trigonometry $\left[\begin{array}{c} T_A{}^2 + T_B{}^2 = (100g - 500)^2 \\ \text{OR } \sin 45 \text{ or } \cos 45 = \frac{100g-500}{T_A} \text{ or } \frac{100g-500}{T_B} \end{array}\right]$	**M1**	4 terms; allow with T_A and T_B; allow sign errors; allow g missing.
	$T^2 + T^2 = (100g - 500)^2$ OR $T_A{}^2 + T_B{}^2 = (100g-500)^2$ AND $T_A(\sin 45) = T_B(\sin 45)$ OR $\sin 45 = \frac{T_A(\text{or } T_B)}{100g-500}$ OR $\cos 45 = \frac{T_A(\text{or } T_B)}{100g-500}$	**A1**	Allow $\sin 45 = \frac{T_A(\text{or } T_B)}{500-100g}$ OR $\cos 45 = \frac{T_A(\text{or } T_B)}{500-100g}$.
	$T_A = T_B = 354$	**A1**	Allow $250\sqrt{2}$, $\frac{500}{\sqrt{2}}$.
	Alternative Method 3 for Question 5(a): Using Lami's Theorem		
	Attempt at Lami	**M1**	Allow with T_A and T_B; allow sign errors; allow g missing.
	$\frac{100g-500}{\sin 90} = \frac{T_A(\text{or } T_B)}{\sin 135}$	**A1**	Allow $\frac{500-100g}{\sin 90} = \frac{T_A(\text{or } T_B)}{\sin 135}$. Allow $\frac{100g-500}{\sin 270} = \frac{T_A(\text{or } T_B)}{\sin 45}$.
	$T_A = T_B = 354$	**A1**	Allow $250\sqrt{2}$, $\frac{500}{\sqrt{2}}$.
		3	

Question	Answer	Marks	Guidance
5(b)	Attempt to resolve vertically **and** horizontally	**M1**	3 terms vertically and 2 terms horizontally; allow sign errors; allow g missing. Must have $T_A = 0$.
	$T_B \cos 45 + 500 - 100g = 0$ and $F - T_B \sin 45 = 0$	**A1**	Allow $-T_B \cos 45 + 500 - 100g = 0$ and $F + T_B \sin 45 = 0$ OR $T_B \cos 45 + 500 - 100g = 0$ and $F + T_B \sin 45 = 0$ OR $-T_B \cos 45 + 500 - 100g = 0$ and $F - T_B \sin 45 = 0$. For both equations correct.
	$F = 500$	**A1**	awrt 500 to 3sf.
	Alternative Method 1 for Question 5(b): Resolving perpendicular to T_B		
	Attempt to resolve perpendicular to T_B	**M1**	3 terms; allow sign errors; allow g missing. Must have $T_A = 0$.
	$F \cos 45 + 500 \cos 45 = 100g \cos 45$	**A1**	Allow $-F \cos 45 + 500 \cos 45 = 100g \cos 45$.
	$F = 500$	**A1**	awrt 500 to 3sf.

Question	Answer	Marks	Guidance
5(b)	**Alternative Method 2 for Question 5(b): Using Lami's Theorem**		
	Attempt at Lami	**M1**	Allow sign errors.
	$\frac{100g-500}{\sin 135}=\frac{F}{\sin 135}\left(=\frac{T_B}{\sin 90}\right)$	**A1**	Allow $\frac{500-100g}{\sin 135}=\frac{F}{\sin 135}$ or $\frac{100g-500}{\sin 45}=\frac{F}{\sin 45}$ or $\frac{100g-500}{\sin 45}=\frac{F}{\sin 225}$ or $\frac{100g-500}{\sin 225}=\frac{F}{\sin 45}$.
	$F=500$	**A1**	awrt 500 to 3sf.
	Alternative Method 3 for Question 5(b): Using triangle of forces		
	Attempt use of trigonometry on right angled triangle	**M1**	Allow sign errors; allow g missing.
	$\tan 45=\frac{F}{100g-500}$	**A1**	Allow $\tan 45=\frac{F}{500-100g}$
	$F=500$	**A1**	awrt 500 to 3sf.
		3	

Question	Answer	Marks	Guidance
6(a)(i)	Attempt to resolve parallel to the plane	**M1**	4 terms; allow sin/cos mix; allow sign errors; allow g missing.
	$T\cos 20-5-2g\sin 30=2\times 1.2$	**A1**	Correct equation.
	$T=18.5$	**A1**	awrt 18.5 .
		3	

Question	Answer	Marks	Guidance
6(a)(ii)	Attempt resolve perpendicular to the plane $R = 2g\cos 30 - T\sin 20$	**M1**	3 terms; allow sin/cos mix: allow sign errors; allow with T or their T; allow g missing.
	Use of $5 = \mu R$ to get an equation in μ only $\left[5 = \mu \times (2g\cos 30 - T\sin 20)\right]$	**M1**	Where R is a two term expression with a component of $2g$ and a component of *their* T; allow g missing.
	$\mu = 0.455$	**A1**	awrt 0.455; allow 0.46 or 0.45; do not allow $\frac{5}{11}$.
		3	
6(b)	Max $F = 0.8 \times (2g\cos 30 - 15\sin 20)$ $[= 0.8 \times 12.1902\ldots\ldots = 9.7521\ldots\ldots]$	***B1**	
	Net force up the plane $= 15\cos 20 - 2g\sin 30 [= 4.0953\ldots\ldots]$	***B1**	OR $15\cos 20 - 2g\sin 30 - 0.8 \times (2g\cos 30 - 15\sin 20)$ $[= 2a] \Rightarrow -5.6567\ldots\ldots [= 2a] \Rightarrow a = -2.8283\ldots\ldots$ If max F incorrect and use $F = ma$ then allow B1 for $15\cos 20 - 2g\sin 30 - \textit{their}\max F$.
	[State $4.0953\ldots\ldots < 9.7521\ldots\ldots$,] hence the block does not move [up the plane]	**DB1**	Must have correct values (to at least 1 sf) to compare for this mark. No incorrect statement seen.
	Alternative Method 1 for Question 6(b)		
	Max force down plane $= 0.8 \times (2g\cos 30 - 15\sin 20) + 2g\sin 30$ $[= 0.8 \times 12.1902 + 10\ldots\ldots = 19.7521\ldots\ldots]$	***B1**	
	Force up plane $= 15\cos 20 [= 14.0953\ldots\ldots]$	***B1**	i.e. using it to compare with their max force down the plane.
	[State 1 $4.0953\ldots\ldots < 19.7521\ldots\ldots$,] hence the block does not move [up the plane]	**DB1**	Must have correct values (to at least 1 sf) to compare for this mark. No incorrect statement seen.

Question	Answer	Marks	Guidance
6(b)	**Alternative Method 2 for Question 6(b)**		
	$F = 15\cos 20 - 2g\sin 30 [= 4.9053......]$ Or $R = 2g\ \cos 30 - 15\sin 20 [= 12.1902......]$	***B1**	
	Get $\mu = \dfrac{15\cos 20 - 2g\sin 30}{2g\ \cos 30 - 15\sin 20} [= 0.3359......]$	***B1**	
	[State $0.3359...... < 0.8$,] hence the block does not move [up the plane]	**DB1**	Must have correct value of μ (to at least 1 sf) to compare for this mark. No incorrect statement seen.
		3	

Question	Answer	Marks	Guidance
7(a)	Attempt to use conservation of energy $\left[\frac{1}{2}\times 0.5v^2 = 0.5g\times 1.8\right]$ or $\left[\frac{1}{2}\times mv^2 = mg\times 1.8\right]$	**M1**	2 terms, dimensionally correct. Do not allow from use of constant acceleration.
	$v=6$	**A1**	Do not allow from use of constant acceleration.
	Attempt at conservation of momentum $\left[0.5\times 6(+0) = 0.5\times 4 + 0.1w\right]$	**M1**	3 terms; allow sign errors; allow *their* $v=6$ or just v; allow if using mgv (consistently in all terms).
	Speed of Q $(=w)$=10 $\mathrm{m\,s^{-1}}$	**A1**	AG Do not allow from use of constant acceleration. Do not allow if using mgv. Use of constant acceleration gets M0 A0 M1 A0 maximum.
		4	**SC Assuming elastic collision** **M1A1** $0.5g\times 1.8 = \frac{1}{2}\times 0.1w^2 + \frac{1}{2}\times 0.5\times 4^2$ **M1** For attempt at conservation of energy, 3 terms; allow sign errors. **B1** Speed of Q $(=w)$=10 $\mathrm{m\,s^{-1}}$

Question	Answer	Marks	Guidance
7(b)	Attempt at conservation of momentum $\left[0.1\times10=(0.1+0.4)\times z\ (\Rightarrow z=2)\right]$	***M1**	3 terms, allow sign errors, allow if using mgv.
	Attempt to use conservation of energy $\left[\frac{1}{2}\times(0.1+0.4)\times(\textit{their}\,2)^2=(0.1+0.4)gh\ \ (\Rightarrow h=0.2)\right]$	***DM1**	Dependent on previous M mark. 4 terms, dimensionally correct. Do not allow from use of constant acceleration. $\textit{their}\,2\neq10$.
	Use trigonometry to get an equation in θ and solve for θ $\left[\theta=\sin^{-1}\left(\frac{\textit{their}\,0.2}{0.4}\right)\right]$	**DM1**	Dependent on previous 2 M marks. Using *their* h and 0.4. Allow sin/cos mix.
	$\theta = 30$	**A1**	Do not allow if using mgv.
	Alternative method for Question 7(b): Using constant acceleration		
	Attempt at conservation of momentum $\left[0.1\times10=0.5\times z\ (\Rightarrow z=2)\right]$	***M1**	2 terms, allow sign errors, allow if using mgv.
	Attempt at use of constant acceleration $\left[0^2=(\textit{their}\,2)^2\pm2\times a\times0.4\ \ (\Rightarrow a=\mp5)\right]$	***DM1**	Dependent on previous M mark. Uses constant acceleration with $u=\textit{their}\,2$ and $s=0.4$ to get an equation in a; $\textit{their}\,2\neq10$.
	Use N2L to get an equation in θ leading to a positive value of θ and solve for θ $\left[(0.5)\lvert\textit{their}\,a\rvert=(0.5)g\sin\theta\right]$	**DM1**	Dependent on previous 2 M marks. Using *their* a; May have m for 0.5. Allow sin/cos mix.
	$\theta = 30$	**A1**	Do not allow if using mgv.
		4	

Question	Answer	Marks	Guidance
7(c)	Q takes 0.7 s to travel from B to C	B1	
	$0.4 = \frac{(\textit{their}\ 2)+0}{2}t \Rightarrow t = 0.4$	B1FT	SOI FT *their* 2 from (b), $t = \frac{0.8}{\textit{their}\ 2}$. For use of $s = \left(\frac{u+v}{2}\right)t$ to get a time up the slope. Allow for total time on slope from $0 = (\textit{their}\ 2)t - \frac{1}{2}(\textit{their}\ a)t^2 \Rightarrow t = 0.8$.
	Distance between P moved is $(0.7+0.8)\times 4 (=6)$	B1	Allow 1 m from point *C*.
	Set up equation in t using $4t$, $(\textit{their}\ 2)t$ and *their* 6 and solve for t $[4t + (\textit{their}\ 2)t = (\textit{their}\ 1) \text{ OR } (\textit{their}\ 6) + 4t + (\textit{their}\ 2)t = 7]$	M1	Must have considered all parts of motion to find times from relevant equations.
	Distance from B = $6\frac{2}{3}$ m	A1	

Question	Answer	Marks	Guidance
7(c)	**Alternative method for last 3 marks of Question 7(c)**		
	[Time for P =] $\frac{b}{4}$ **and** [Time for QR =] $\frac{7-b}{2}$ OR [Time for P =] $\frac{7-c}{4}$ **and** [Time for QR =] $\frac{c}{2}$	**B1**	Where b is distance from B OR Where c is distance from C.
	Attempt to form an equation from use of total time and solve for b (or c) $\left[\frac{7-b}{2}+0.7+0.4+0.4=\frac{b}{4}\left[\Rightarrow b=6\frac{2}{3}\right]\right.$ $\left.OR\,\frac{c}{2}+0.7+0.4+0.4=\frac{7-c}{4}\left[\Rightarrow c=\frac{1}{3}\right]\right]$	**M1**	Where b is distance from B OR Where c is distance from C. Must have considered all parts of motion to find times from relevant equations.
	Distance from B = $6\frac{2}{3}$ m	**A1**	
		5	

Cambridge International AS & A Level

MATHEMATICS **9709/41**

Paper 4 Mechanics **October/November 2022**

MARK SCHEME

Maximum Mark: 50

Published

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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.

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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.

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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	Attempt at resolving horizontally or vertically	M1	Allow sign errors, allow sin/cos mix. 3 terms.
	$P\cos 25 = 22 + 16\cos 55$	A1	
	$Q + 16\sin 55 = P\sin 25$	A1	Allow *their P*.
	Attempt to solve for P or Q	M1	No missing/extra terms.
	$P = 34.4 \quad Q = 1.43$	A1	$P = 34.40025941,\ Q = 1.431745128$.
		5	

Question	Answer	Marks	Guidance
2	Use conservation of momentum $6\times5+2\times(-3)=6v_A+2v_B$	*M1	4 dimensionally correct terms. Allow sign errors, v_A and v_B must be different.
	Use $v_B=v_A+2$ or $v_A=v_B-2$ with their momentum equation and solve for v_A or v_B	DM1	Allow $v_B=v_A\pm2$ or $v_A=v_B\pm2$.
	$v_A=2.5$ or $v_B=4.5$	A1	
	Attempt at initial KE, or final KE, or change in KE for A, or change in KE for B Initial KE $=\frac{1}{2}\times6\times5^2+\frac{1}{2}\times2\times(-3)^2\ [=84]$ Final KE $=\frac{1}{2}\times6\times(their\,2.5)^2+\frac{1}{2}\times2\times(their\,4.5)^2$ Change in KE for $A=\pm\left(\frac{1}{2}\times6\times5^2-\frac{1}{2}\times6\times(their\,2.5)^2\right)$ Change in KE for $B=\pm\left(\frac{1}{2}\times2\times(-3)^2-\frac{1}{2}\times2\times(their\,4.5)^2\right)$	M1	Allow use or their v_A and/or v_B. Allow if 2 KE equations seen.
	Loss of KE = 45J	A1	Allow –45J. Allow if mgv used in momentum equation.
		5	

Question	Answer	Marks	Guidance
3(a)	Power $= 1400 \times 28$	**B1**	
	Power = 39.3 kW	**B1**	
		2	
3(b)	$DF = \dfrac{43500}{v}$	**B1**	oe
	Attempt to resolve parallel to the hill $\left[\begin{array}{c} DF = 1400 + 1250g \times 0.12 = 2900 \\ \text{or } DF = 1400 + 1250g \times \sin 6.89 = 2899.544602 \end{array}\right]$	**M1**	3 terms, no need for *DF* in terms of v. Allow sign errors, sin/cos mix. Allow use of 6.89º or 6.9º.
	Speed $= 15$ m s^{-1}	**A1**	Awrt 15.0
		3	
3(c)	Attempt at N2L on either car, trailer or the system Car: $5000 - 1400 - 1250g \times 0.12 - T = 1250a$ Trailer: $T - 300 - 600g \times 0.12 = 600a$ System: $5000 - 1400 - 300 - 1250g \times 0.12 - 600g \times 0.12 = (1250 + 600)a$	**M1**	Allow sign errors, sin/cos mix. Correct number of relevant terms. Allow use of 6.89º or 6.9º. Allow with *g* missing.
		A1	For any 2 equations correct.
	Solve for a or T	**M1**	From equation(s) with at most 1 term. missing/extra in total. Allow with *g* missing.
	Acceleration $= \dfrac{108}{185} = 0.584$ ms^{-2}, Tension $= \dfrac{50700}{37} = 1370$ N	**A1**	Awrt 0.584 and 1370. $a = 0.583787838$, $T = 1370.27027$.
		4	

Question	Answer	Marks	Guidance
4(a)	Attempt at N2L parallel to the plane	*M1	4 terms. Allow sign errors, sin/cos mix, allow g missing.
	$T\cos 26 - 8g\sin 18 - F = 8 \times 0.2$	A1	Allow with *their* F.
	Attempt at resolving perpendicular to the plane	*M1	3 terms Allow sign errors, sin/cos mix, allow g missing.
	$R + T\sin 26 = 8g\cos 18$	A1	
	Use of $F = 0.65R$ to get an equation in T only	DM1	R is a linear combination of a component of T and a component of weight. Using equations with no missing terms.
	Solve for T	M1	Dependent on all 3 previous M marks.
	$T = 64(.0)$ N	A1	
		7	
4(b)	Complete method to find s using constant acceleration formula(e) $\left[s = \frac{1}{2} \times 0.2 \times 4^2 - \frac{1}{2} \times 0.2 \times 3^2 \text{ OR } s = \frac{1}{2}(0 + 0.2 \times 4) \times 4 - \frac{1}{2}(0 + 0.2 \times 3) \times 3\right]$	M1	Finding distance moved between $t = 3$ and $t = 4$, must be using $a = 0.2$
	Distance = 0.7 m	A1	If 0 marks scored then SCB1 for $s\left[= \frac{1}{2} \times 0.2 \times 4^2\right] = 1.6$
		2	

Question	Answer	Marks	Guidance
5(a)	Attempt to integrate $12-2t$	**M1**	For integration, the power of t must increase by 1 in at least 1 term with a change of coefficient in the same term. No $+c$ required for this mark. $s=vt$ is M0.
	$v\left[=12t-\frac{2t^2}{2}(+c)\right]=12t-t^2(+c)$	**A1**	No $+c$ required for this mark. Allow unsimplified.
	Use boundary conditions to get $c=-20$	**B1**	
	Solve $12t-t^2-20=0$ to get $t=2$ and $t=10$	**B1**	soi
	Correct graph inverted quadratic starting at $(0,-20)$ and ending at $(12,-20)$	**B1**	Ignore anything outside $0\leqslant t\leqslant 12$. $t=2$ and $t=10$ need not be shown.
		5	

Question	Answer	Marks	Guidance
5(b)	Attempt to integrate *their* $12t - t^2 - 20$	*M1	Integrating their 2 or 3 term expression for *v* from **(a)** which has come from integration. For integration, the power of *t* must increase by 1 in at least 1 term with a change of coefficient in the same term.
	$s = \left[\frac{12}{2}t^2 - \frac{1}{3}t^3 - 20t(+d) = \right] 6t^2 - \frac{1}{3}t^3 - 20t(+d)$	A1ft	ft their $+c \neq 0$. Allow unsimplified.
	Attempt to evaluate *their* $\left[6t^2 - \frac{1}{3}t^3 - 20t\right]$ for any of $t = 0$ to $t = their\,2$ or $t = their\,2$ to $t = their\,10$ or $t = their\,10$ to $t = 12$	DM1	Correct use of correct limits for one time interval.
	Attempt to evaluate *their* $\left[6t^2 - \frac{1}{3}t^3 - 20t\right]$ for all of $t = 0$ to $t = their\,2$ or $t = their\,2$ to $t = their\,10$ or $t = their\,10$ to $t = 12$	DM1	Correct use of correct limits for all 3 time intervals, ignore signs here.
	$s = -\left(-\frac{56}{3}[-0]\right) + \left(\frac{200}{3} - \left(-\frac{56}{3}\right)\right) - \left(48 - \frac{200}{3}\right) = \frac{368}{3} \approx 123$ m	A1	Awrt 123

Question	Answer	Marks	Guidance
5(b)	Either $s = \left\|\int_0^2 \left(6t^2 - \frac{1}{3}t^3 - 20t\right)\mathrm{d}t\right\| = \frac{56}{3} = 18.7$ Or $s = \int_2^{10} \left(6t^2 - \frac{1}{3}t^3 - 20t\right)\mathrm{d}t = \frac{256}{3} = 85.3$ Or $s = \left\|\int_{10}^{12} \left(6t^2 - \frac{1}{3}t^3 - 20t\right)\mathrm{d}t\right\| = \frac{56}{3} = 18.7$	**B1**	Allow $\int_{10}^{20} \left\|0.25t^2 - 8t + 60\right\| \mathrm{d}t = 26$.
	$s = \left[\frac{56}{3} + \frac{256}{3} + \frac{56}{3}\right] = \frac{368}{3} \approx 123$ m	**B1**	Awrt 123 Allow $s = \int_0^{12} \left\|6t^2 - \frac{1}{3}t^3 - 20t\right\| \mathrm{d}t = \frac{368}{3} \approx 123$ m for B2.
		5	

Question	Answer	Marks	Guidance
6(a)	$T = 4g$	**B1**	soi
	$R = 3g\cos 30$	**B1**	
	Attempt to resolve parallel to the plane	**M1**	3 terms, allow g missing. Allow sign errors, sin/cos mix.
	$F = T - 3g\sin 30$	***A1**	May see $F = 25$.
	Eliminate T and use $F = \mu R$ to get an equation in μ only	**DM1**	Where R is a component of *their* weight.
	Coefficient of friction = 0.962	**A1**	allow $\frac{5\sqrt{3}}{9}$. allow 0.96. If F negative must say why using positive for this mark.
		6	

Question	Answer	Marks	Guidance
6(b)	Find height gained by *B* relative to height lost by *A*	**M1**	*A* loses x m in height, *B* gains $x\sin 30$ OR *B* gains y m in height and *A* loses $\dfrac{y}{\sin 30}$.
	EITHER $x + x\sin 30 = 1 \Rightarrow x = \dfrac{2}{3}$ OR $y + \dfrac{y}{\sin 30} = 1 \Rightarrow y = \dfrac{1}{3}$	**A1**	
	Change in KE $= \dfrac{1}{2}\times 4\times v^2 + \dfrac{1}{2}\times 3\times v^2 \left[= \dfrac{1}{2}\times 7\times v^2\right]$	**B1**	
	Change in PE $\pm(4gx - 3gx\sin 30)$ or $\pm\left(4g\dfrac{y}{\sin 30} - 3gy\right)$ OR $\pm(4gx - 3gy)$	**B1**	x or y need not be substituted.
	Conservation of energy $4gx - 3gx\sin 30 = \dfrac{1}{2}\times 4\times v^2 + \dfrac{1}{2}\times 3\times v^2$ OR $4g\dfrac{y}{\sin 30} - 3gy = \dfrac{1}{2}\times 4\times v^2 + \dfrac{1}{2}\times 3\times v^2$ OR $4gx - 3gy = \dfrac{1}{2}\times 4\times v^2 + \dfrac{1}{2}\times 3\times v^2$	**M1**	4 terms. x or y need not be substituted. Must be same v for both particles.
	Speed $= \sqrt{\dfrac{100}{21}} = \dfrac{10\sqrt{21}}{21} = 2.18$ ms^{-1}	**A1**	2.182178902 **SC B1 B1 M1** 3/6 max for using $x = y = 0.5$

Question	Answer	Marks	Guidance
6(b)	**Alternative method 1 for final 4 marks of question 6(b)**		
	$T-3g\sin 30=3a$ $4g-T=4a$ $4g-3g\sin 30=(4+3)a$	**M1**	Attempt at 2 equations from N2L on either particle or the system. Allow sign errors. Allow sin/cos mix. Correct number of terms.
	Solve to get $T=\frac{18}{7}g\approx 25.7$	**A1**	May see $a=\frac{5}{14}g=\frac{25}{7}\approx 3.57$
	$T\times\frac{y}{\sin 30}=\frac{1}{2}\times 3\times v^2+3gy$ OR $4gx=Tx+\frac{1}{2}\times 4\times v^2$	**M1**	Attempt at work energy using their $T(\neq 4g \text{ or } 3g\sin 30)$. May be in terms of *x* and/or *y*.
	Speed $=\sqrt{\frac{100}{21}}=\frac{10\sqrt{21}}{21}=2.18$ ms^{-1}	**A1**	

Question	Answer	Marks	Guidance
6(b)	**Alternative method 2 for final 4 marks of question 6(b): Special case where constant acceleration assumed. Score maximum 4/6**		
	Find height gained by *B* relative to height lost by *A*	**M1**	*A* loses x m in height, *B* gains $x\sin 30$ OR *B* gains y m in height and *A* loses $\frac{y}{\sin 30}$.
	EITHER $x + x\sin 30 = 1 \Rightarrow x = \frac{2}{3}$ OR $y + \frac{y}{\sin 30} = 1 \Rightarrow y = \frac{1}{3}$	**A1**	
	$T - 3g\sin 30 = 3a$ and $4g - T = 4a \Rightarrow a = \frac{25}{7} = 3.57$ OR $4g - 3g\sin 30 = (4+3)a \Rightarrow a = \frac{25}{7} = 3.57$	**B1**	
	Uses constant acceleration to get speed $= \sqrt{\frac{100}{21}} = \frac{10\sqrt{21}}{21} = 2.18$ m s^{-1}	**B1**	
		6	

Cambridge International AS & A Level

MATHEMATICS	**9709/42**
Paper 4 Mechanics	**October/November 2022**
MARK SCHEME	
Maximum Mark: 50	

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AWRT	Answer Which Rounds To

Question	Answer	Marks	Guidance
1	Work done by cyclist = 50 × 100 (= 5000 J)	**B1**	
	Their $5000 - 3560 = \frac{1}{2} m \times 6^2$	**M1**	Work energy equation. Three terms. Allow sign errors. Dimensionally correct.
	mass = 80 kg	**A1**	
		3	
	SC: Acceleration considered as a constant		
	$6^2 = 0 + 2a \times 50$ $[\Rightarrow a = 0.36]$ $100 - \frac{3560}{50} = m \times \mathit{their}\ 0.36$	**M1**	From use of $v = 6$, $u = 0$, $s = 50$. Must be using correct suvat formulae. For equation involving mass using N2L with three terms. Allow sign errors in N2L.
	mass = 80 kg	**A1**	

Question	Answer	Marks	Guidance
2(a)	$R = 0.4g\cos 30\ \left[=2\sqrt{3}\right]$ or F or $\mu R = 0.4g\sin 30\ [=2]$	**B1**	Use of *m* instead of 0.4 condoned.
	$0.4g\sin 30 - \mu\, 0.4g\cos 30 = 0$	**M1**	For using $F = \mu R$. Allow sin/cos mix. Both must be different components of their weight only, not a 2 term *R*. Allow sign errors. Allow *g* omitted.
	$\mu\left[=\frac{4\sin 30}{4\cos 30}\right] = \frac{1}{3}\sqrt{3}$ or $\frac{\sqrt{3}}{3}$.	**A1**	**AG** (exact answer only) If zero scored then **SC B1** for [Angle of friction = 30° so] $\mu = \tan 30 = \frac{1}{3}\sqrt{3}$. Allow full marks if using *m* in place of 0.4 or *W* in place of *mg* or 0.4*g* A0 for $\mu = 0.577\ldots = \frac{1}{3}\sqrt{3}$, but A1(ISW) for $\mu = \frac{1}{3}\sqrt{3} = 0.577\ldots$
		3	

Question	Answer	Marks	Guidance
2(b)	$7.2 - 0.4g\sin 30 - F = 0.4a$	**M1**	Newton's second law. Four terms. Second term must be a component of their weight. $F \neq 0$ and $F \neq \mu$. Allow sin/cos mix. Allow sign errors. F must be a numerical expression May use their F from part **(a)**.
	$a = 8$	**A1**	
	$1 = 0 + \frac{1}{2} \times (\textit{their}\text{ positive } 8) \times t^2$	**M1**	For use of constant acceleration formula(e) and solving for t. $a \neq \pm 10, a \neq \pm g$. Allow if a is negative in part **(a)** and use $\lvert a \rvert$ here.
	Time = 0.5 s	**A1**	
		4	

Question	Answer	Marks	Guidance
3	Attempt to resolve either direction	M1	Correct number of terms. Allow sin/cos mix. Allow sign errors. Allow g missing.
	$0.3g + T\cos\alpha° - 4\sin 60° = 0$ ($T\cos\alpha° = 0.464\ldots$)	A1	OE
	$T\sin\alpha° - 4\cos 60° = 0$ ($T\sin\alpha° = 2$)	A1	OE If the two Ts are different, award maximum A1A0 unless subsequently stated that the two Ts are the same.
	$\alpha = \tan^{-1}\left(\frac{4\cos 60°}{4\sin 60° - 0.3g}\right) = \tan^{-1}\left(\frac{2}{0.464\ldots}\right)$	M1	Attempt to solve for α. No missing/extra terms. Allow g missing. Must get to '$\alpha =$'.
	$T = \frac{4\cos 60}{\sin(their\alpha)} = \sqrt{(4\cos 60°)^2 + (4\sin 60° - 0.3g)^2} = \sqrt{2^2 + (0.464\ldots)^2}$	M1	OE Attempt to solve for T. No missing/extra terms. Allow g missing. Must get to '$T =$'.
	Tension = 2.05 N $\alpha = 76.9$	A1	For both AWRT 2.05, 76.9 (Tension = 2.05314… N $\alpha = 76.9356\ldots$)
	Alternative method for Q3 using triangle of forces		
	Attempt at cosine rule from triangle of forces	M1	Must use lengths 4 and $0.3g$ with a suitable angle. Allow g missing.
	$T^2 = 4^2 + (0.3g)^2 - 2\times 4\times(0.3g)\times\cos 30$	A1	
	Tension = 2.05	A1	Tension = 2.05314… AWRT 2.05
	Attempt at sin rule	M1	Must have angle 30° and another angle in terms of α with correct numerators, but allow g missing.
	$\frac{Their\,T}{\sin 30} = \frac{4}{\sin(180-\alpha)}$ or $\frac{Their\,T}{\sin 30} = \frac{0.3g}{\sin(\alpha - 30)}$	A1	Correct. Allow $\sin\alpha$ instead of $\sin(180-\alpha)$.
	$\alpha = 76.9$	A1	$\alpha = 76.9356\ldots$ AWRT 76.9

Question	Answer	Marks	Guidance
3	**Alternative method for Q3 using Lami's theorem**		
	Attempt at Lami's theorem	**M1**	Must have numerators correct and at least one angle correct. Allow *g* missing.
	$\dfrac{4}{\sin\alpha}=\dfrac{0.3g}{\sin(210-\alpha)}=\dfrac{T}{\sin(150)}$	**A1 A1**	A1 for two parts second A1 for all three.
	$\alpha=\tan^{-1}\left(\dfrac{4\sin 210}{0.3g+4\cos 210}\right)$	**M1**	For solving for *α* using compound angle formula. Must be correct for their angles. Allow *g* missing.
	$T=\dfrac{4\sin(150)}{\sin\alpha}$ or $T=\dfrac{0.3g\sin(150)}{\sin(210-\alpha)}$	**M1**	For solving for *T* using their *α*. Allow *g* missing.
	Tension = 2.05 N α = 76.9	**A1**	For both AWRT 2.05, 76.9
		6	
	SC: Tension and the 4 N force considered in the wrong directions		
	Attempt to resolve either direction	**M1**	Correct number of terms. Allow sin/cos mix. Allow sign errors. Allow *g* missing.
	$T\cos 60° - 4\sin\alpha° = 0$ And: $T\sin 60° - 4\cos\alpha° - 0.3g = 0$	**A1**	For both OE If the two *T*s are different, they get **SC A0** unless they subsequently state that the two *T*s are the same.
	$\left(\dfrac{T\cos 60°}{4}\right)^2+\left(\dfrac{T\sin 60° - 0.3g}{4}\right)^2=1\Rightarrow\dfrac{1}{4}T^2+\dfrac{3}{4}T^2-3\sqrt{3}T+9=16$ $\Rightarrow T^2-3\sqrt{3}T-7=0\Rightarrow T=6.31(\text{or } -1.11)$ OR: $4\sqrt{3}\sin\alpha-4\cos\alpha=3\ \Rightarrow\ 8\sin(\alpha-30)=3\ \Rightarrow\ \alpha=\sin^{-1}\dfrac{3}{8}+30$	**M1**	OE Attempt to solve for *T or* α. No missing/extra terms. Allow *g* missing. Must get to '*T* =' or 'α='.

Question	Answer	Marks	Guidance
3	$T = 6.31\text{N}\quad \alpha = 52.0$	A1	(T = 6.30617…, α=52.0243…)
		6	

Question	Answer	Marks	Guidance
4(a)	$P = D \times 15$	**B1**	For any D. OE including $\frac{P}{15}$.
	$D - 500 = 1200 \times 0.8$ $(\Rightarrow D = 1460)$	**M1**	Attempt at Newton's second law with three terms. Allow sign errors.
	Power = 21900 W	**A1**	Allow 21900 without units or 21.9 kW, but not simply 21.9 without units or with wrong units.
		3	
4(b)	[Change in KE =] $\frac{1}{2}\times1200\times32^2 - \frac{1}{2}\times1200\times15^2$ $[= 614400 - 135000 = 479400]$	**B1**	Sight of both KEs.
	Work done by engine = 21900 × 53 (= 1160700)	**B1ft**	OE e.g. $21900 = \frac{WD}{53}$ FT *their* 21900.
	Distance AB = 1362.6 m	**B1**	AG Must come from 1160700 – 500d = 479400 OE e.g. $500d = 681300$.
		3	

Question	Answer	Marks	Guidance
5(a)	$T - 40g\sin 20 - 50 = 40a$ $[T - 136.8\ldots - 50 = 40a]$ $500\cos 15 - 80g\sin 20 - T = 80a$ $[482.96\ldots - 273.61\ldots - T = 80a]$ $500\cos 15 - 80g\sin 20 - 40g\sin 20 - 50 = (80+40)a$ $[482.96\ldots - 273.61\ldots - 136.8\ldots - 50 = 120a]$	**M1**	Attempt at Newton's second law for at least one case. Allow sign errors. Do not allow g missing. Correct number of terms. Allow sin/cos mix.
		A1	Any 2 equations.
	For attempt to solve for T or a	**M1**	From equation(s) with no missing/extra terms. Allow g missing. Must get to 'T =' or 'α ='.
	Acceleration = 0.188 ms^{-2}	**A1**	Allow AWRT 0.19.
	Tension = 194 N	**A1**	
		5	
5(b)	[1.2 = 0 + 0.188t]	**M1**	For use of constant acceleration formula(e) and solving for t with *their* positive a, leading to a positive value of t $a \neq \pm 10, a \neq \pm g$ Allow if a is negative in part **(a)** and use $\lvert a \rvert$ here.
	Time = 6.39 s	**A1**	Allow 6.38 Allow 6.32 from a = 0.19
		2	

Question	Answer	Marks	Guidance
6(a)	$0.3\times 2[+0]=0.3\times 0.6+0.4\times v$	**M1**	For use of conservation of momentum. Must be 3 terms. Allow sign errors.
	Speed of B = 1.05 ms^{-1}	**A1**	AG Allow M1 A0 if g included with the masses.
		2	
6(b)	$0.4\times 1.05[+0]=(0.4+m)\times 0.5$	**M1**	For use of conservation of momentum. Must be 3 terms. Allow sign errors.
	m = 0.44 or $\frac{11}{25}$	**A1**	Allow M1 A0 if g included with the masses.
		2	

Question	Answer	Marks	Guidance
6(c)	1.2 [m] or 0.9 [m]	**B1**	Must be a distance as some candidates get 1.2 from $\frac{0.6}{0.5}$.
	$0.5t$	**B1**	Seen but not $+\frac{1}{2}at^2$ unless later state that $a=0$. B0 if only $0.5t = 2.1$ (may see solving to find $t = 3.5$).
	$0.6t$	**B1**	Seen but not $+\frac{1}{2}at^2$ unless later state that $a=0$. Allow B2 in place of second and third B1 marks for 'difference in speeds is 0.1 [ms^{-1}]'.
	Distances equal so $0.6t - 0.9 = 0.5t$ and solve for t Or $t = \frac{0.9}{0.6-0.5}$	**M1**	OE Must get to '$t =$'. Allow ± *their* 0.9 but not ±1.2 or ± 2.1 or ±1.5. Do not allow $0.6t + 0.5t = \pm 0.9$. Do not allow M1 if either or both terms include $+\frac{1}{2}at^2$ unless they state $a = 0$.
	Time = 9 s	**A1**	CWO

Question	Answer	Marks	Guidance
6(c)	**Alternative method for question 6(c) using time from start of motion**		
	1 [m] or 1.1 [m]	**B1**	
	$0.6T$	**B1**	Seen but not $+\frac{1}{2}aT^2$ unless later state that $a = 0$.
	$0.5T$	**B1**	Seen but not $+\frac{1}{2}aT^2$ unless later state that $a = 0$. Allow **B2** in place of second and third B1 marks for 'difference in speeds is 0.1 [ms^{-1}]'.
	Distances equal so $0.6T - 1.1 = 0.5T$ and solve for T Or $T = \frac{1.1}{0.6 - 0.5}$	**M1**	OE Must get to '$T =$'. Allow ± *their* 1.1 but not ±1.0 or ± 2.1. Do not allow $0.6T + 0.5T = \pm 1.1$. Do not allow M1 if either or both terms include $+\frac{1}{2}aT^2$ unless they state $a = 0$
	⇒ Time from *BC* collision = $11 - 2 = 9$ s	**A1**	CWO

Question	Answer	Marks	Guidance
6(c)	**Alternative method for question 6(c) using distance travelled from time when *B* and *C* collide**		
	1.2 [m] or 0.9 [m]	**B1**	
	Time taken for *A* is $\frac{d+0.9}{0.6}$ Or $d+0.9=0.6t$	**B1 FT**	Allow ± *their* 0.9 but not ±1.2 or ± 2.1 or ±1.5.
	Time taken for *BC* is $\frac{d}{0.5}$ Or $d=0.5t$	**B1**	
	$\frac{d+0.9}{0.6}=\frac{d}{0.5}\Rightarrow d=4.5\Rightarrow \text{Time}=\frac{4.5}{0.5}$	**M1**	Must get to '$t=$'. Allow ± *their* 0.9 but not ±1.2 or ± 2.1.
	Time = 9 s	**A1**	CWO
		5	

Question	Answer	Marks	Guidance
7(a)	$v=\frac{0.3}{1.5}t^{\frac{3}{2}}(+c)\left[=0.2t^{\frac{3}{2}}(+c)\right]$	**M1**	For integration (do not penalise missing *c*) The power of *t* must increase by 1 with a change of coefficient. Use of $v=at$ scores M0.
	Velocity = 1.6 $\left[=\frac{8}{5}\right]$ ms^{-1}	**A1**	ISW any extra work using the second equation for *a*.
		2	

Question	Answer	Marks	Guidance
7(b)	$v = \frac{-k}{-0.5}t^{-\frac{1}{2}}[+d]\left[= 2kt^{-\frac{1}{2}}[+d]\right]$	*M1	For integration. No need for constant. Allow use of given value of $k = 2.6$. The power of t must increase by 1 with a change of coefficient. Use of $v = at$ scores M0.
	$\mathit{Their}\,1.6 = \frac{-k}{-0.5} \times 4^{-\frac{1}{2}} + d \left[= 2k \times 4^{-\frac{1}{2}} + d\right]$ $[\mathit{Their}\,1.6 = k + d]$ $0.3 = \frac{-k}{-0.5} \times 16^{-\frac{1}{2}} + d \left[= 2k \times 16^{-\frac{1}{2}} + d\right]$ $\left[0.3 = \frac{k}{2} + d\right]$	A1 FT	For both equations in k and d (Allow unsimplified).
	Attempt to solve for k or d	DM1	Or substitute k = 2.6 into both equations and solve both for d (with $d \neq 0$). Must get to '$k =$' or '$d =$'.
	k = 2.6 $[v =]5.2t^{-\frac{1}{2}} - 1$ or $[v =]\frac{-2.6}{-0.5}t^{-\frac{1}{2}} - 1$	A1	AG (AG for k, not for the expression). Allow unsimplified expression for v and/or in terms of k. If k is substituted then both equations must be shown to give a value of $d = -1$ and getting $v = 5.2t^{-\frac{1}{2}} - 1$ **SC B1** for solving the correct equations simultaneously with no working seen and getting correct expression for v. **SC A1** for correct expression for v if only the first M1 is scored.

Question	Answer	Marks	Guidance
7(b)	**Alternative method for question 7(b) from using limits**		
	$v=\dfrac{-k}{-0.5}t^{-\frac{1}{2}}[+d]\left[=2kt^{-\frac{1}{2}}[+d]\right]$	***M1**	For integration No need for constant. Allow use of given value of $k=2.6$. The power of t must increase by 1 with a change of coefficient. Use of $v=at$ scores M0.
	$\dfrac{-k}{-0.5}\times 4^{-\frac{1}{2}}-\dfrac{-k}{-0.5}\times 16^{-\frac{1}{2}}=1.6-0.3$ or $2k\times 4^{-\frac{1}{2}}-2k\times 16^{-\frac{1}{2}}=1.6-0.3$	**A1 FT**	OE For correct unsimplified equation in k from using limits for v as their 1.6 and 0.3 and limits for t as 4 and 16.
	Attempt to solve for k	**DM1**	Must be an equation using 0.3 and their k, and 16 and 4, Must be subtracting the limits to form the equation in k, but may have sign errors in their $1.6-0.3$.
	$k=2.6$, $v=5.2t^{-\frac{1}{2}}-1$ or $v=\dfrac{-2.6}{-0.5}t^{-\frac{1}{2}}-1$	**A1**	**AG** (AG for k, not for the expression). Allow unsimplified expression for v and/or in terms of k.
		4	
7(c)	$\pm 5.2T^{-\frac{1}{2}}-their1=0$	**M1**	For solving for T. Must get to '$T=$'. Must come from integration, with *their* 1 from part **(b)** or found here not equal to zero. Do not allow made up value of d.
	$T=\dfrac{676}{25}$ or 27.04	**A1**	OE Must be exact. Allow both marks as long as expression for v is correct, however obtained in **Q7(b)**.
		2	

Question	Answer	Marks	Guidance
7(d)	$\int_0^4 0.2t^{\frac{3}{2}}\mathrm{d}t = \frac{0.2}{2.5}t^{\frac{5}{2}}$ or $\int_4^{27.04}\left(5.2t^{-\frac{1}{2}} - \mathit{their}\,1\right)\mathrm{d}t = \frac{5.2}{0.5}t^{\frac{1}{2}} - \mathit{their}\,1\times t$	**M1**	For integration of $0.2t^{\frac{3}{2}}$ oe or $5.2t^{-\frac{1}{2}} - \mathit{their}\ 1$. May be in terms of *k*. Not from any other expression. *Their* 1 may be zero (or replaced by zero). *Their* 1 may came from either part **(b)** or part **(c)** The power of *t* must increase by 1 with a change of coefficient in at least one term.
	$= \left[\frac{0.2}{2.5}t^{\frac{5}{2}}\right]_0^4 + \left[\frac{5.2}{0.5}t^{\frac{1}{2}} - t\right]_4^{27.04} \left[= \left[0.08t^{\frac{5}{2}}\right]_0^4 + \left[10.4t^{\frac{1}{2}} - t\right]_4^{27.04}\right]$	**A1ft**	For both integrals (unsimplified) No need for limits FT non-zero value of *d*. May be in terms of *k*. *Their* 1 may came from either part **(b)** or part **(c)**.
	$= 0.08\times 32 + (10.4\times 5.2 - 27.04) - (10.4\times 2 - 4)\ [= 2.56 + 10.24]$	**M1**	For correct use of limits (0 and 4 then 4 and *their* 27.04) in both of their integrals, which have come from integration of $0.2t^{\frac{3}{2}}$ and $5.2t^{-\frac{1}{2}} - \mathit{their}\,1$. Not from any other expression. *Their* 1 may be zero (or replaced by zero). *Their* 1 may came from either part **(b)** or part **(c)**. Allow M1 for d = 0 (the final answer is 35.8).
	$= \frac{64}{5}$ or 12.8	**A1**	oe Awrt 12.8 Allow if using 27(.0) rather than 27.04 Allow all 4 marks as long as expression for v is correct, however obtained in **Q7(b)**.

Question	Answer	Marks	Guidance
7(d)	**SC for using a calculator to integrate.**		
	Either $\int_0^4 0.2t^{\frac{3}{2}}\mathrm{d}t = 2.56$ Or $\int_4^{27.04}\left(5.2t^{-\frac{1}{2}} - 1\right)\mathrm{d}t = 10.24$	**B1**	AWRT 2.56 Allow 10.2 Must use 27.04 or 27(.0) if latter integral.
	Total distance = 12.8 m	**B1**	AWRT 12.8. Allow if using 27(.0) rather than 27.04 Allow both B marks as long as expression for v is correct, however obtained in **Q7(b)**.
		4	

Cambridge International AS & A Level

MATHEMATICS **9709/43**

Paper 4 Mechanics **October/November 2022**

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 October/November 2022 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

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 descriptors 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, 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 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 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.

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(a)	$u = 30$	**B1**	From $v = u + at$ or equivalent.
		1	
1(b)	$0 = 30^2 - 2\times 10\times s$	**M1**	Use of *suvat* formulae.
	Greatest height $= 45\,\text{m}$	**A1 FT**	FT $u^2/2g$ with *their* u from **(a)**.
		2	

Question	Answer	Marks	Guidance
2(a)	PE = $5g\times 15\times 1.8\sin 20$	**M1**	Attempt to find PE gain.
	PE = 462 J	**A1**	From 461.727…
		2	
2(b)	WD = $5g\times 15\times 1.8\sin 20 + 40\times 15\times 1.8$ **or** WD = $(5g\sin 20 + 40)\times 15\times 1.8$	**M1**	Uses WD by pulling force = PE gain + WD against friction or WD = Fs.
	WD = 1540 J	**A1 FT**	From 1541.727… FT '1080 + PE from **(a)**'.
		2	

Question	Answer	Marks	Guidance
3	$T \cos 25 = 40 + R \cos 50$	**M1**	Resolving in any direction e.g. horizontal, vertical, along radius or tangent.
	$R \sin 50 = T \sin 25$	**M1**	Resolving in a second direction.
	Radially: $T \cos 25 = R + 40 \cos 50$ Tangentially: $T \sin 25 = 40 \sin 50$ Parallel to T: $T = R \cos 25 + 40 \cos 25$ Perpendicular to T: $R \sin 25 = 40 \sin 25$ Vertically: $T \cos 25 = 40 + R \cos 50$ Horizontally: $R \sin 50 = T \sin 25$	**A1**	Two correct equations.
	Solving equation(s) to find either T or R	**M1**	
	$T = 72.5$ N	**A1**	From 72.504….
	$R = 40$ N	**A1**	
		6	

Question	Answer	Marks	Guidance
4(a)	$52 = u(2) + 0.5a(2)^2 - \left(u(1) + 0.5a(1)^2\right)$ **or** $64 = u(4) + 0.5a(4)^2 - (u(3) + 0.5a(3)^2$	**M1**	Use of $s = ut + ½ at^2$ or equivalent to form equation for 2nd **or** 4th second .
		M1	Second equation in u and a.
	$52 = u + 1.5a$ and $64 = u + 3.5a$	**A1**	Two correct equations in u and a.
	$12 = 2a$ leading to $a = 6$	**M1**	Solves simultaneous equations to find either u or a.
	Initial speed $= 43 \text{ ms}^{-1}$ and acceleration $= 6 \text{ ms}^{-2}$	**A1**	
		5	
4(b)	$s = 43 \times 10 + 0.5 \times 6 \times 10^2$	**M1**	Use of $s = ut + ½ at^2$ or equivalent.
	Distance $= 730 \text{ m}$	**A1 FT**	FT $10u + 50a$ with u and a from part **(a)**.
		2	

Question	Answer	Marks	Guidance
5(a)	$v=\int 12t+12\ \mathrm{d}t$, $v_X=6t^2+12t$ **or** $v=\int 24t-8\ \mathrm{d}t$, $v_Y=12t^2-8t$	**M1**	Uses $v=\int a\,\mathrm{d}t$.
	$v_X=6t^2+12t$ $v_Y=12t^2-8t$	**A1**	All correct.
	$6t^2+12t=12t^2-8t$ leading to $t=\dfrac{10}{3}$	**B1**	Solves $v_X=v_Y$.
	$s_X=\int 6t^2+12t\,\mathrm{d}t$ $s_X=2t^3+6t^2$ $s_Y=\int 12t^2-8t\,\mathrm{d}t$ $s_Y=4t^3-4t^2$	***M1**	Uses $s=\int v\,\mathrm{d}t$.
	$s_X=2\left(\dfrac{10}{3}\right)^3+6\left(\dfrac{10}{3}\right)^2$ $s_Y=4\left(\dfrac{10}{3}\right)^3-4\left(\dfrac{10}{3}\right)^2$	**DM1**	Evaluates $s\left(\dfrac{10}{3}\right)$ for each particle.
	$AB=\dfrac{3800}{27}-\dfrac{2800}{27}=\dfrac{1000}{27}$ Distance *AB* = 37 m	**A1**	
		6	
5(b)	$AB=-2t^3+10t^2=-2\times3^3+10\times3^2$	**M1**	Calculates distance *AB*.
	$[t=3]$, AB = 36 m	**A1**	AG
		2	

Question	Answer	Marks	Guidance
6(a)(i)	$P = (650 + 150) \times 24$	**M1**	Use of $P = \text{DF} \times v$.
	$19\,200$ W or 19.2 kW	**A1**	
		2	
6(a)(ii)	$40\,000 = \text{DF} \times 24$	**B1**	Correct use of $P = \text{DF} \times v$.
	$\frac{40000}{24} - 800 = 2250a$	**M1**	Use of Newton's Second Law for the system or for the caravan or for the car.
	$T - 150 = 500a$	**A1**	Two correct equations.
	$a = \left(\frac{40000}{24} - 800\right) \div 2250$ leading to $a = \ldots$	**M1**	Solves for a or for T.
	Acceleration $= 0.385\ \text{ms}^{-2}$ and Tension $= 343\,\text{N}$	**A1**	From $a = \frac{52}{135} = 0.38518\ldots$ and $T = \frac{9250}{27} = 342.59\ldots$
		5	
6(b)	$\text{DF} = 800 + 2250 \times g \times 0.14$	**M1**	Resolving up hill using DF = Total resistances.
	$\frac{31000}{v} = 800 + 2250 \times g \times 0.14$	**M1**	Use of $P = \text{DF} \times v$ to form equation in v.
	$v = 7.85$	**A1**	From $v = \frac{620}{79} = 7.848\ldots$
		3	

Question	Answer	Marks	Guidance
7(a)	$R = 3g\cos\alpha = 3\times10\times0.8$	**B1**	
	$F = 3g\sin\alpha = 3\times10\times0.6$	**M1**	Resolving parallel to plane.
	$\mu = \frac{18}{24} = 0.75$ **or** $\mu = \frac{3g\sin\alpha}{3g\cos\alpha} = \tan\alpha = 0.75$	**A1**	Uses $\mu = \frac{F}{R}$ AG.
		3	
7(b)	$a = g\sin\alpha$ or PE loss $= 1.5gx\sin\alpha$ for AB **and** $a = 0$ for BC $4.5g\times\sin\alpha - 0.75\times4.5g\cos\alpha = 4.5a$ leading to $a = 0$	**B1**	Accelerations for *AB* and *BC*.
	$v_1^2 = 2\times g\sin\alpha\times x$] **or** [$1.5g\times x\sin\alpha = 0.5\times1.5\times v_1^2$	**M1**	Uses '*suvat*' or PE loss = KE gain for *AB*.
	$v_1^2 = 20x\sin\alpha = 12x$ leading to $v_1 = \sqrt{12x}$	**A1**	
	$1.5\times\sqrt{12x} + 0 = 4.5\times v_2$ leading to $v_2 = \frac{1}{3}\sqrt{12x}$	**M1**	Conservation of momentum.
	$4 = \frac{2}{3}\times\sqrt{12x}$	**M1**	Use of $s = vt$ on *BC* since a = 0.
	$x = 3$	**A1**	

Question	Answer	Marks	Guidance
7(b)	**Alternative Method for 7(b)**		
	$a = g\sin\alpha$ or PE loss $= 1.5gx\sin\alpha$ for *AB* **and** $a = 0$ for *BC* $4.5g \times \sin\alpha - 0.75 \times 4.5g\cos\alpha = 4.5a$ leading to $a = 0$	**B1**	Accelerations for *AB* and *BC*.
	$4 = 2v_2$ leading to $v_2 = 2$	**M1**	Uses $s = vt$ on *BC* since $a = 0$.
	$1.5 \times v_1 + 0 = 4.5 \times 2$	**M1**	Conservation of momentum.
	$v_1 = 6$	**A1**	Velocity before collision.
	$6^2 = 2 \times g\sin\alpha \times x$ **or** $1.5g \times x\sin\alpha = 0.5 \times 1.5 \times 6^2$	**M1**	Uses *suvat* or PE loss = KE gain for *AB*.
	$x = 3$	**A1**	
		6	
7(c)	KE = $0.5 \times 4.5 \times 2^2 = 9\text{J}$	**B1**	KE gain for *AC*.
	PE loss = $15 \times (4+3) \times \frac{3}{5} + 30 \times 4 \times \frac{3}{5} = 135\text{J}$	**M1**	Evaluates PE loss for *AC*.
	Loss of energy = 126 J	**A1**	
		3	