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CAMBRIDGE
International Education

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.

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

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Generic Marking Principles

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

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

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

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

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

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

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

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

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

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Mathematics-Specific Marking Principles

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

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

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

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

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

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

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Mark Scheme Notes

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

Types of mark

M Method mark, awarded for a valid method applied to the problem. Method marks are not lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. Correct application of a formula without the formula being quoted obviously earns the M mark and in some cases an M mark can be implied from a correct answer.

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

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

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

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

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

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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

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

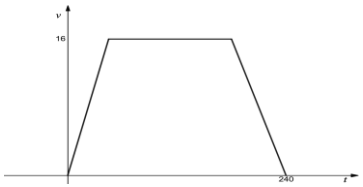
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Question	Answer	Marks	Guidance
2(b)	$KE_B = 0.5 \times 7.5 \times 8^2$ [= 240]	**B1**	
	$7.5 \times g \times 12.5 = 0.5 \times 7.5 \times 8^2 + F \times 25$	**M1**	Attempt at work energy equation; 3 terms; dimensionally correct; allow sign errors.
	$F = 27.9$	**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	

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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	

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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	

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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.
	$t = 14.9 + 3.5 = 18.4\text{s}$	**A1**	
		5	

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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	

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Question	Answer	Marks	Guidance
7(a)(i)	Power $= k \times 48^2 = 92160 \Rightarrow k = 40$	**B1**	**AG**
		1	
7(a)(ii)	$[DF =] \frac{92160}{45}$ $[= 2048]$	**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.
	$a = \frac{248}{1200} = \frac{31}{150}$ 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.
	$\frac{92160}{v} = 40v + 1200g \times 0.15$	**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.
	$v = 30.5$ ms^{-1}	**A1**	30.51179…
		4	

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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.
	$[(t-2)(t-7) = 0 \Rightarrow]\ t = 2, 7$	**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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