Cambridge Assessment International Education

Cambridge International AS & A Level

MATHEMATICS **9709/42**

Paper 4 Mechanics **October/November 2020**

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 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.

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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, 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.

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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	Mark	Guidance
1(a)	Momentum = $0.2 \times 2 = 0.4$ kg ms^{-1}	**B1**	
		1	
1(b)	$0.4 = 0.2 \times 0.3 + 0.5v$	**M1**	Apply conservation of momentum, 3 terms
	$v = 0.68$ ms^{-1}	**A1 FT**	FT on answer in **1(a)**
		2	

Question	Answer	Mark	Guidance
2(a)	DF – 650 = 1800×0.5 [DF = 1550]	**M1**	Apply Newton's second law, 3 terms
	$\frac{P}{20} - 650 = 1800 \times 0.5$	**B1**	
	[Power $P = 1550 \times 20$ =] 31 000 W or 31 kW	**A1**	
		3	
2(b)	$\frac{31000}{v} - 650 = 0$	**M1**	Use $P = Fv$ with $F = 650$
	$v = 47.7$ ms^{-1}	**A1 FT**	FT on *their* $P \neq 13\,000$ Allow $\frac{620}{13}$
		2	

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Question	Answer	Mark	Guidance
3	$20 \cos 60 = T \cos 45$	**M1**	Resolve forces horizontally, 2 terms
	$T = 10\sqrt{2}$ or $T = 14.1$	**A1**	
	$20 \sin 60 + T \sin 45 = mg$ or W	**M1**	Resolve forces vertically, 3 terms
	$20 \sin 60 + T \sin 45 = mg$	**A1**	
	$m = 2.73$ [$= \sqrt{3} + 1$]	**A1**	
	Alternative method for question 3		
	$\left[\frac{T}{\sin 150} = \frac{mg \text{ or } W}{\sin 75} = \frac{20}{\sin 135}\right]$	**M1**	Attempt at one pair of terms using Lami's Method
	$\frac{T}{\sin 150} = \frac{mg}{\sin 75} = \frac{20}{\sin 135}$	**A1**	All terms correct in Lami's Method
	Attempt to solve for either T or m or W	**M1**	
	$T = 10\sqrt{2}$ or $T = 14.1$	**A1**	
	$m = 2.73$ [$= \sqrt{3} + 1$]	**A1**	
		5	

Question	Answer	Mark	Guidance
3	**Alternative method for question 3**		
	$\left[\frac{T}{\sin 30} = \frac{mg \text{ or } W}{\sin 105} = \frac{20}{\sin 45}\right]$	**M1**	Attempt the triangle of forces method and state one equation which involves any two of the forces T, m and 20.
	$\frac{T}{\sin 30} = \frac{mg}{\sin 105} = \frac{20}{\sin 45}$	**A1**	All correct
	Attempt to solve for either T or m or W	**M1**	
	$T = 10\sqrt{2}$ or $T = 14.1$	**A1**	
	$m = 2.73$ [$= \sqrt{3} + 1$]	**A1**	
		5	

Question	Answer	Mark	Guidance
4(a)	$\left[2=\frac{20}{T}\right] \rightarrow T=10$	**B1**	
		1	
4(b)	Distance travelled before constant speed = $½ \times 10 \times 20 + ½ \times (20 + V) \times 5$ $½ \times 10 \times 20 + ½ \times (20 - V) \times 5 + 5V$ $[= 150 + 2.5V]$	**B1 FT**	May be implied if seen within total distance FT on T value from **4(a)**
	Distance travelled after constant speed $= 27.5V + ½ \times 5V$ $[= 30V]$	**B1**	May be implied if seen within total distance
	$½ \times 10 \times 20 + ½ \times (20 + V) \times 5$ $= ⅓ [½ \times 10 \times 20 + ½ \times (20 + V) \times 5 + 27.5V + ½ \times 5V]$	**M1**	For attempting to use $\frac{1}{2}$ or $\frac{1}{3}$ correctly and for obtaining an equation for V which includes all parts of the journey. or $½ \times 10 \times 20 + ½ \times (20 + V) \times 5 = ½ [27.5V + ½ \times 5V]$
	$V = 12$	**A1**	
		4	

Question	Answer	Mark	Guidance
5(a)	$40 - gt = 0 \quad [t = 4]$	**M1**	Using $v = u + at$ with $u = 40$, $v = 0$ and $a = -g$ to find the time taken to reach the highest point.
	Time to top of building $= 4 - \frac{1}{2}(4) = 2$	**A1**	May see $t = 4 + 2 = 6$ for A1
	$h = 40 \times 2 - \frac{1}{2} \times 10 \times 2^2$ $h = 40 \times 6 - \frac{1}{2} \times 10 \times 6^2$	**M1**	Using $s = ut + \frac{1}{2} at^2$ with $u = 40$, $a = -g$ and $t = 2$ or $t = 6$ to set up an equation which enables the value of h, the height of the building, to be found.
	$h = 60$	**A1**	
	Alternative method for question 5(a)		
	$0 = 40^2 + 2 \times (-10) \times H$	**M1**	For using $v^2 = u^2 + 2as$ with $u = 40$, $v = 0$ and $a = -g$ in order to find H, the greatest height achieved
	$H = 80$	**A1**	
	$s = \frac{1}{2} \times 10 \times 2^2$	**M1**	Use either $s = vt - \frac{1}{2} at^2$ with $v = 0$, $a = -g$, $t = 2$ or use $s = ut + \frac{1}{2} at^2$ with $u = 0$, $a = g$, $t = 2$ to find the distance travelled either in the final 2 seconds going up or the first 2 seconds going down
	$s = 20$ and so $h = 80 - 20 = 60$	**A1**	
		4	

Question	Answer	Mark	Guidance
5(b)	Height of first particle above ground = $40t - ½ \times 10t^2$	**B1**	
	Height of second particle above top of building $= 20(t - 1) - ½ \times 10 \times (t - 1)^2$	**B1**	
	$60 + 20(t - 1) - ½ \times 10 \times (t - 1)^2 = 40t - ½ \times 10t^2$	**M1**	Set up an equation involving expressions for displacement to enable the time at which the particles reach the same height to be found.
	$t = 3.5$ seconds	**A1**	
	Alternative method for question 5(b)		
	$h_1 = 40 \times 1 - 5 \times 1^2$ [= 35] and $v_1 = 40 - 10 \times 1$ [= 30]	**B1**	Distance travelled **and** speed of first particle after 1 second
	$H_1 = 30T - 5 \times T^2$, $H_2 = 20T - 5 \times T^2$	**B1**	Distance travelled by both particles, T seconds after the second particle is projected.
	$30T - 5 \times T^2 = 20T - 5 \times T^2 + (60 - 35)$	**M1**	Set up an equation in T involving expressions for displacement to enable the time at which the particles are at the same height to be found.
	$T = 2.5$ and so time to meet = 2.5 + 1 = 3.5 seconds	**A1**	
		4	

Question	Answer	Mark	Guidance
6(a)	$R = 5g\cos 30$ [$= 25\sqrt{3}$]	**B1**	
	$40 - 5g\sin 30 - F > 0$	**M1**	State that the net force up the plane is positive, 3 terms
	$F = \mu \times 5g\cos 30$	**M1**	For using $F = \mu R$ with R as a component of $5g$ to obtain an equality/inequality in μ only with 3 terms
	$\mu < \frac{1}{5}\sqrt{3}$	**A1**	AG
	Alternative scheme for question 6(a)		
	$R = 5g\cos 30$ [$= 25\sqrt{3}$]	**B1**	
	$40 - 5g\sin 30 - F = 5a$	**M1**	Acceleration $a > 0$
	$F = \mu \times 5g\cos 30$ [$40 - 5g\sin 30 - \mu \times 5g\cos 30 = 5a$]	**M1**	For using $F = \mu R$ with R as a component of $5g$ to obtain an equality in μ and a
	$\mu < \frac{1}{5}\sqrt{3}$	**A1**	AG. From $\mu = \frac{1}{5}\sqrt{3} = \frac{a}{g}\cos 30$ with $a > 0$
		4	

Question	Answer	Mark	Guidance
6(b)	Attempt to resolve forces parallel to or perpendicular to the inclined plane, 3 relevant terms in either direction	**M1**	
	$R = 5g\cos 30 + 40\sin 30$ [$= 20 + 25\sqrt{3} = 63.3$]	**A1**	
	$F = 40\cos 30 - 5g\sin 30$ [$= 20\sqrt{3} - 25 = 9.64$]	**A1**	
	$\mu \geqslant 0.152$	**B1**	AG. Using $F \leqslant \mu R$
	Alternative method for question 6(b)		
	Attempt to resolve forces horizontally or vertically with 3 relevant terms in either direction	**M1**	
	$40 = R\sin 30 + F\cos 30$ [$40 = \frac{1}{2}R + \sqrt{3}/2F$]	**A1**	
	$5g = R\cos 30 - F\sin 30$ [$5g = \sqrt{3}/2R - \frac{1}{2}F$]	**A1**	
	$\mu \geqslant 0.152$	**B1**	AG. Solve for R and F and use $F \leqslant \mu R$

Question	Answer	Mark	Guidance
7(a)	$\int 0.1t^{3/2}dt$	***M1**	For integrating a
	$v = 0.04t^{5/2} + 1.72$	**A1**	
	$0.04t^{5/2} + 1.72 = 3$	**DM1**	For attempting to solve the equation $v = 3$, to obtain t
	$t = 4$	**A1**	
		4	

Question	Answer	Mark	Guidance
7(b)	$\int\left(0.04t^{5/2}+1.72\right)dt$ $[s=\frac{2}{175}t^{7/2}+1.72t\left(+C'\right)]$	***M1**	For integrating v which itself has come from integration
	For using correct limits correctly	**DM1**	
	Displacement when $t = 2$ is 3.57 m	**A1**	
		3	

Question	Answer	Mark	Guidance
8(a)	For A: $T = 0.3a$ For B: $3.5 + 0.5g \sin 30 - T = 0.5a$ System: $3.5 + 0.5g \sin 30 = (0.3 + 0.5)a$	**M1**	For applying Newton's 2nd law for either particle A or to particle B or to the system. Correct number of terms.
		A1	Two correct equations
	For solving either for T or for a	**M1**	
	$a = 7.5$ ms^{-2}	**A1**	
	$T = 2.25$ N	**A1**	
		5	
8(b)	$0.5g \sin 30 \times 0.6$ [= 1.5]	**B1**	PE loss by B
	Apply the work-energy equation to the system	**M1**	5 relevant terms, their PE for 0.5 kg, WD by 3.5 N, WD against friction and two relevant KE terms.
	$0.5g \sin 30 \times 0.6 + 3.5 \times 0.6 = ½ \times 0.8 \times v^2 + 1.1$	**A1**	
	$v = 2.5$ ms^{-1}	**A1**	
		4	

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