



Cambridge International AS & A Level

MATHEMATICS

9709/41

Paper 4 Mechanics

May/June 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.

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

PUBLISHED**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.

PUBLISHED**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

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Question	Answer	Marks	Guidance
1(a)	$200 = \frac{(0 + 25)}{2}t$	M1	For use of $s = \frac{(u + v)}{2}t$ or other complete method to find t e.g. $v^2 = u^2 + 2as$ followed by $v = u + at$ N.B. $a = 1.5625$
	$t = 16\text{s}$	A1	
		2	
1(b)	Trapezium	B1	Through (0, 0) and positive t -axis
	All correct through (0, 0), (16, 25), (32, 25), (37, 0)	B1	FT <i>their</i> value of t from part (a) ($t + 16 + 5$)
		2	
1(c)	Total distance = $200 + 400 + \frac{1}{2} \times 25 \times 5$ [= 662.5]	M1	Or trapezium $\frac{1}{2} \times 25(16 + 37)$ [= 662.5] Or $200 + 400 + \frac{25 + 0}{2} \times 5$ Allow <i>their</i> value of t from part (a) in calculating 200 and <i>their</i> time from the constant speed section from part (b) in calculating 400 Allow <i>their</i> a from part (a) if used in calculating 200
	Average speed = $\frac{662.5}{37} = 17.9 \text{ ms}^{-1}$ (3 s.f.)	A1	Allow $\frac{1325}{74} = 17\frac{67}{74}$
		2	

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Question	Answer	Marks	Guidance
2	Use of Newton's second law for P or Q or system	M1	Allow sign errors. Do not allow g missing
	For P : $10 - 0.5g - T = 0.5a$, For Q : $T - 0.3g = 0.3a$, For system: $10 - 0.5g - 0.3g = 0.8a$	A1	For any two correct
	For attempt to solve for either a or T	M1	From equation(s) with no missing or extra terms. Allow g missing.
	$a = 2.5 \text{ ms}^{-2}$	A1	
	$T = 3.75 \text{ N}$	A1	
		5	

Question	Answer	Marks	Guidance
3	For attempt at resolving horizontally or vertically	M1	Allow sin/cos mix. Allow sign error. Allow g missing. Correct number of terms.
	$R = 300g - 0.28X$ or $R = 300g - X \sin 16.3$	A1	$\alpha = 16.26\dots$
	$0.96X - F = 0$ or $0.96X - 0.5(300g - X \sin \alpha) = 0$ Or $X \cos 16.3 - F = 0$ or $X \cos 16.3 - 0.5(300g - X \sin \alpha) = 0$	A1	Or using <i>their</i> F
	Use of $F = 0.5R$	M1	Use to get an equation in X only. Allow sin/cos mix. Allow sign error. Allow g missing. Must be from 2 term R , which is a linear combination of $300(g)$ and a component of X
	$X = 1360$ [1363.63...]	A1	
		5	

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Question	Answer	Marks	Guidance
4	Attempt to resolve in any direction	M1	For resolving. Allow sin/cos mix. Allow sign error. Correct number of terms.
	$F \cos \alpha - 20 \cos 40 - 100 \sin 20 = 0$ [$F \cos \alpha = 15.320\dots + 34.202\dots = 49.5229\dots$]	A1	
	$F \sin \alpha + 20 \sin 40 - 100 \cos 20 = 0$ [$F \sin \alpha = 93.969\dots - 12.855\dots = 81.1135\dots$]	A1	
	$F = \sqrt{(49.5229\dots)^2 + (81.1135\dots)^2}$	M1	OE; Attempt to solve for F ; one term missing in total
	$\alpha = \tan^{-1}\left(\frac{81.1135\dots}{49.5229\dots}\right)$	M1	OE; Attempt to solve for α ; one term missing in total
	$F = 95(.0), \alpha = 58.6$	A1	$F = 95.0364\dots$ and $\alpha = 58.5943\dots$
	Alternative mark scheme for question 4: For candidates who use cosine and/or sine rule		
	Attempt at cosine rule from triangle of forces	M1	Must use lengths 100 and 20 with a suitable angle
	$F^2 = 100^2 + 20^2 - 2 \times 100 \times 20 \cos 70$	A1	Correct
	$F = 95[.0]$	A1	
	$\frac{95.0364}{\sin 70} = \frac{20}{\sin \beta}$ OR $\frac{95.0364}{\sin 70} = \frac{100}{\sin \gamma}$	M1	Attempt at sin rule
		A1	where $\beta = (70 - \alpha)$ where $\gamma = (40 + \alpha)$
	$\alpha = 58.6$	A1	$\alpha = 58.5943\dots$

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Question	Answer	Marks	Guidance
4	Alternative mark scheme for question 4: For candidates who resolve in other directions		
	Attempt to resolve (e.g. parallel or perpendicular to 100 N)	M1	For resolving. Allow sin/cos mix. Allow sign error. Correct number of terms.
	$F \sin(\alpha + 20) + 20 \sin 20 - 100 = 0$ [$F \sin(\alpha + 20) = 93.159\dots$]	A1	
	$F \cos(\alpha + 20) - 20 \cos 20 = 0$ [$F \cos(\alpha + 20) = 18.793\dots$]	A1	
	$F = \sqrt{93.159\dots^2 + 18.793^2}$	M1	OE; Attempt to solve for F ; one term missing in total
	$\alpha = \tan^{-1}\left(\frac{93.159\dots}{18.793\dots}\right) - 20$	M1	OE; Attempt to solve for α ; one term missing in total
	$F = 95[.0], \alpha = 58.6$	A1	$F = 95.0364\dots$ and $\alpha = 58.5943\dots$
		6	

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Question	Answer	Marks	Guidance
5(a)	For attempt at work energy equation	M1	3 terms. Allow sign errors. M0 for (constant) acceleration method
	$4500d - 75\,000 = \frac{1}{2} \times 1200 \times 25^2$ [= 375 000]	A1	Correct equation
	$d = 100$	A1	AG Accept verification with d substituted in above line to show LHS = 375 000 or LHS – RHS = 0 If no marks scored allow SCB1 for $\frac{1}{2} \times 1200 \times 25^2$
		3	
5(b)	$25^2 = 0 + 2a \times 100$ [leading to $a = 3.125$]	B1	Allow B1 if acceleration found in part (a) as 3.125 and used or stated here
	$3200 - 1200 = m \times 3.125$	M1	Newton's second law with 3 terms. Allow sign errors and <i>their a</i> .
	Mass of car $B = 640$ kg	A1	
	Alternative mark scheme for question 5(b)		
	For attempt at work energy equation	M1	3 terms. Allow sign errors.
	$(3200 - 1200) \times 100 = \frac{1}{2} \times m \times 25^2$	A1	Correct equation
	Mass of car $B = 640$ kg	A1	
		3	

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Question	Answer	Marks	Guidance
5(c)	At P power = 3200×25 [= 80 000]	B1	For use of power = Fv
	$\frac{80000}{v} - 1200 = 0$	M1	Attempt Newton's second law for car B with $a = 0$ Allow <i>their</i> 80 000 (dimensionally correct)
	Steady speed = 66.7 ms^{-1}	A1	Allow $\frac{200}{3} = 66\frac{2}{3}$
		3	

Question	Answer	Marks	Guidance
6(a)	For attempt at integration	*M1	The power of t must increase by 1 with a change of coefficient in at least 1 term. Allow if k is omitted.
	$k\left(t^3 - \frac{1}{2}t^4\right)[+C]$	A1	Allow unsimplified
	$k\left(8 - \frac{1}{2} \times 16\right)[-0]$	DM1	For use of limits 0 and 2 or substituting $t = 2$ OR equate to 0, then solve a quartic equation in t . Allow if k is omitted.
	0	A1	AG, CWO including stating $C = 0$ if not using limits
		4	

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Question	Answer	Marks	Guidance
6(b)	$v = 0$ when $k(3t^2 - 2t^3) = 0$	M1	For solving for t
	Leading to $t = 1.5$ [or $t = 0$]	A1	A0 for other solutions not discarded
	$a = k(6t - 6t^2)$	M1	For differentiation, the power of t must decrease by 1 with a change of coefficient in at least 1 term. Allow if k is omitted
	$[-13.5 = k(6 \times 1.5 - 6 \times 1.5^2) \Rightarrow -13.5 = k(9 - 13.5) \Rightarrow] k = 3$	A1	
	Distance from $t = 0$ to $t = 1.5$ is $\left[3 \left(t^3 - \frac{1}{2} t^4 \right) \right]_0^{1.5} = 3 \left(1.5^3 - \frac{1}{2} \times 1.5^4 \right) - 0$	DM1	For use of limits. $2 \times \int_0^{1.5} \dots$ or $2 \times \int_{15}^2 \dots$ or both integrals. Dependent on first M in part (a), unless they restart
	$[= 2.53125]$ So total distance $= 2 \times 2.53125 = 5.06$ m	A1	Allow distance $= \frac{81}{16} = 5 \frac{1}{16}$ If DM0 then SCB1 for 5.06 without working
		6	

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Question	Answer	Marks	Guidance
7(a)	$0.4 \times 3 + 0.2 \times 2 = 0.4 \times 2.5 + 0.2v$	M1	Use of conservation of momentum with 4 terms. Allow sign errors.
	$v = 3 \text{ ms}^{-1}$	A1	Allow M1A0 if g included with the masses.
		2	
7(b)	For A $\pm 0.4g \sin 30^\circ = 0.4a$ or for B $\pm 0.2g \sin 30^\circ = 0.2a$ or $\pm mg \sin 30^\circ = ma$	M1	For either. Allow sin/cos mix.
	$a = \pm 5$ or $\pm g \sin 30^\circ$	A1	Allow $g \sin 30^\circ$ without working for M1A1
	For B when hits barrier $v^2 = 3^2 + 2 \times 5 \times 1.6 \Rightarrow v = 5$ OR $v = u + at \Rightarrow v = 3 + 5 \times 0.4 \Rightarrow v = 5$	M1	Using <i>their</i> $a \neq \pm g$ and <i>their</i> v from part (a) OR: use of $s = \frac{u+v}{2}t$ $1.6 = \frac{3+v}{2} \times 0.4 \Rightarrow v = 5$ OR $\frac{1}{2} \times 0.2 \times v^2 - \frac{1}{2} \times 0.2 \times 3^2 = 0.2 \times 1.6 \times g \sin 30$
	Speed after hitting barrier $= 0.1 \times 5 = 0.5$	A1	AG
	$v_A = 2.5 + 5 \times 0.44 [= 4.7]$ $v_B = -0.5 + 5 \times 0.04 [= -0.3]$ or $v_B = 0.5 + (-5) \times 0.04 [= 0.3]$	*M1	Use of $v = u + at$ for either with correct t -value, with initial speeds ± 2.5 or ± 0.5 <i>their</i> $\pm a \neq \pm g$
	$0.4 \times 4.7 + 0.2 \times (-0.3) = 0.6 v_{\text{comb}}$	DM1	Use of $v = u + at$ for BOTH with correct t -values, initial speeds $\pm 2.5, \pm 0.5$ and $\pm$ <i>their</i> acceleration (same for both) and use of conservation of momentum with correct number of terms. Allow sign errors.
	$v_{\text{comb}} = 3.03 \text{ ms}^{-1}$	A1	Allow $v = \frac{91}{30} = 3 \frac{1}{30}$ Allow DM1A0 if g included with the masses.
		7	



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WWW	Without Wrong Working
AWRT	Answer Which Rounds To

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Question	Answer	Marks	Guidance
1(a)	Conservation of momentum	M1	3 terms; allow M1 if speed of <i>A</i> after collision is $\frac{1}{4} \times 8.5$. Allow $5 \times 8.5 = 5X + 3Y$ where $ X $ and $ Y $ are different which may be seen by later work. If $ X $ and $ Y $ are subsequently used as being equal then M0.
	$5 \times 8.5 = 5 \times 0.25v + 3v$	A1	OE e.g. $5 \times 8.5 = 5V + 3 \times 4V$
	Speed of <i>B</i> = 10 ms^{-1}	A1	Do not award if 10 from using <i>mgv</i> , maximum 2/3 –10 is A0 as speed required not velocity
		3	
1(b)	$\text{KE before} = \frac{1}{2} \times 5 \times 8.5^2 [= 180.625]$ $\text{KE after} = \frac{1}{2} \times 5 \times 2.5^2 + \frac{1}{2} \times 3 \times 10^2 [= 15.625 + 150 = 165.625]$	1	Attempt at any of the 3 terms for KE, using their 10 ms^{-1} Not $\frac{1}{2} \times (5+3) \times 8.5^2$, not $\frac{1}{2} \times (5+3) \times 2.5^2$ not $\frac{1}{2} \times (5+3) \times 10^2$ unless $ X = Y $ seen
	KE loss $[= 180.625 - 165.625] = 15 \text{ J}$	A1	Accept –15, AWR ± 15.0
		2	

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Question	Answer	Marks	Guidance
2	Resolving either direction	M1	3 terms; allow sign errors and allow sin/cos mix
	$(X =) \pm (20 \cos 60 - 14 - 16 \cos 50) \quad [= \mp 14.2846 \dots]$	A1	
	$(Y =) \pm (60 - 20 \sin 60 - 16 \sin 50) \quad [= \pm 30.42278 \dots]$	A1	
	$R = \sqrt{(14.2846 \dots)^2 + (30.42278 \dots)^2}$	M1	Attempt to solve for R ; one missing term in total
	$\theta = \tan^{-1} \left(\frac{30.42278 \dots}{14.2846 \dots} \right) [= \tan^{-1} (2.1297 \dots)]$ OR $\alpha = \tan^{-1} \left(\frac{14.2846 \dots}{30.42278 \dots} \right) [= \tan^{-1} (0.4596 \dots)]$	M1	Attempt to solve for θ or α ; one missing term in total
	$R = 33.6 \text{ N}$ Direction is 64.8° above the 14 N force or 25.2° above the negative x -axis or 25.2° left of the 60 N force or bearing 335° or 115° anticlockwise from the positive x -axis	A1	Both correct. OE; allow 64.9 , 25.1 Giving an angle only is insufficient. Direction may be seen on a diagram, with minimum of arrow on resultant. Arrows on both components only is A0 as it doesn't show the direction of the resultant. However the direction is stated, it must be able to be drawn uniquely.
		6	

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Question	Answer	Marks	Guidance
3(a)	$2.4g - T = 2.4a$ $T - 1.2g = 1.2a$ $2.4g - 1.2g = (2.4 + 1.2)a$	M1	Attempt at Newton's second law on either particle or the system with correct number of terms; allow sign errors.
		A1	Any 2 consistent and correct May have an a in opposite direction to our a
	Attempt to solve for a or T	M1	From equation(s) with correct number of relevant terms. If g missing then M0A0M1A0, maximum 1/4. Must get $a =$ or $T =$ Must not assume $T = 16$. May attempt to verify a value of a using $T = 16$ in 2 equations
	$T = 16 \text{ N and } a = \frac{10}{3} \text{ ms}^{-2}$	A1	Both correct; allow $a = 3.33$. AG for $T = 16$. Assuming $T = 16$ and only one equation is M1A0M0A0 maximum 1/4. Withhold A mark if $T = 15.9... \approx 16$, but condone $T = 1.2 \times 3.33 + 12 = 16$ or $T = 24 - 2.4 \times 3.33 = 16$
		4	

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Question	Answer	Marks	Guidance
3(b)	$v^2 = 2 \times \frac{10}{3} \times 2.1 \quad [=14] \quad \left[v = \sqrt{14} = 3.741\dots \right]$ OR $\frac{1}{2} \times 2.4 \times v^2 = 2.4g \times 2.1 - 16 \times 2.1$ OR $\frac{1}{2} \times 2.4 \times v^2 + \frac{1}{2} \times 1.2 \times v^2 = 2.4g \times 2.1 - 1.2g \times 2.1$	M1	Use of suvat or use energy to find v or v^2 , using their $a \neq \pm g$ (unless 10 comes from their attempt at a) from (a), $s = 2.1$
	$0 = 14 - 2 \times g \times s \rightarrow s = \dots$ or $\frac{1}{2}(1.2)(\sqrt{14})^2 = (1.2) \times g \times h \rightarrow h = \dots$	M1	Attempt to use $v^2 = u^2 + 2as$ (or other complete method), using $a = -g$, to find additional height after string slack, using their v or v^2 .
	$s = [1.5 + 2.1 + 0.7 =] 4.3 \text{ m}$	A1	AWRT 4.3(0); Allow use of $a = 3.33$ to give $s = 4.2993 \approx 4.3(0)$ Allow use of $v = 3.74$ to give $s = 4.29938 \approx 4.3(0)$
	Alternative for question 3(b) - using energy on particle B		
	$16 \times 2.1 = 1.2gH$	M1	Apply energy to B, 2 terms
	$H = 2.8$	A1	
	$s = [1.5 + 2.8 =] 4.3 \text{ m}$	A1	
		3	

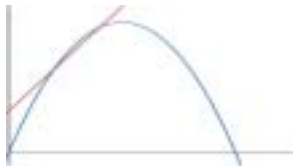
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Question	Answer	Marks	Guidance
4(a)	Use suvat to find expressions for s_A or s_B	M1	For s_A must be using $u = 8$ and time of $t \pm 4$ For s_B , using $s = ut + \frac{1}{2}at^2$ with $u = 20$ and $a = \pm 2$
	$(s_A =) 8(4 + t) [= 32 + 8t]$	A1	Any unsimplified expression; ISW
	$(s_B =) 20t - \frac{1}{2} \times 2 \times t^2$	A1	Any unsimplified expression; ISW If 0 marks scored then allow SC: B1 for $(s_A =) 8t$ and B1 for $(s_B =) 20(t - 4) - \frac{1}{2} \times 2 \times (t - 4)^2$ maximum 2/3
		3	

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Question	Answer	Marks	Guidance
4(b)	$8(4+t) = 20t - \frac{1}{2} \times 2 \times t^2$	*M1	Equating their expressions for s_A and s_B to form an equation in t where s_A is of the form $\pm 8t \pm 32$ and s_B is of the form $\pm 20t \pm \frac{1}{2} \times 2 \times t^2$
	Attempt to solve a 3-term quadratic to find at least one t value	DM1	For reference $t^2 - 12t + 32 = 0$ Allow if no working seen and have correct real solution(s) to <i>their</i> 3-term quadratic. If working shown and if using the formula, it must be using the correct formula. If factorising must have 3 of the 4 terms correct of $(t-4)(t-8)$
	$t = 4$ and 8	A1	If 0 marks scored then allow SC: M1 for $\pm 8t = \pm 20(t \pm 4) \pm \frac{1}{2} \times 2 \times (t \pm 4)^2$ and A1 for $t = 8$ and 12 maximum 2/3.
		3	

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Question	Answer	Marks	Guidance
4(c)	Straight line	B1 FT	Positive gradient, intersecting positive s axis. Full domain not required. FT if they get $s_A = 8t$ using the SC in (a)
	Inverted quadratic, passing through origin.	B1 FT	Full domain not required but must clearly go beyond the maximum. FT if they get $s_B = 20(t-4) - \frac{1}{2} \times 2 \times (t-4)^2$ using the SC in (a) , with curve though positive t axis before turning point.
	All correct, line through (0, 32), quadratic through (20, 0), intersections indicated at $t = 4$ and $t = 8$. 	B1	Intersections must occur before the turning point.
		3	

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Question	Answer	Marks	Guidance
5	Attempt at resolving parallel to the plane	*M1	3 terms. Allow sign errors, sin/cos mix. Allow g missing, otherwise dimensionally correct.
	$65 \cos 36 = 12g \times \sin 24 + F$	A1	$F = 3.777707\dots$
	Attempt at resolving perpendicular to the plane	*M1	3 terms. Allow sign errors, sin/cos mix. Allow g missing, otherwise dimensionally correct.
	$12g \times \cos 24 = R + 65 \sin 36$	A1	$R = 71.419\dots$
	Use $F = \mu R$ $\left[\mu = \frac{65 \cos 36 - 12g \times \sin 24}{12g \times \cos 24 - 65 \sin 36} = \frac{52.586 - 48.808}{109.625 - 38.206} = \frac{3.777\dots}{71.419\dots} \right]$	DM1	To get an equation in μ only. Dependent on two previous M marks. Allow g missing
	$\mu = 0.0529$	A1	Allow AWRT 0.053 Do not accept fractional equivalent.
		6	

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Question	Answer	Marks	Guidance
6(a)	$\text{KE change} = \pm(0.5 \times 900 \times 16^2 - 0.5 \times 900 \times 11^2)$ $[= \pm(115200 - 54450) = \pm 60750]$	B1	
	$\text{PE} = 900g \times 150 \times 0.12 \quad [= 162000]$	B1	Allow $900g \times 150 \times \sin 6.89^\circ$ or $900g \times 150 \times \sin 6.9^\circ$ Not from use of constant acceleration/Newton's second law.
	$[\text{Work done by car's engine} =] 24000 \times 12 \quad [= 288000]$	B1	OE e.g. $24000 = \frac{\text{WD}}{12}$
	$\begin{aligned} &\text{Work done against resistive forces} \\ &= 24000 \times 12 - 900g \times 150 \times 0.12 - 0.5 \times 900 \times 16^2 + 0.5 \times 900 \times 11^2 \\ &= 288000 - 162000 - 115200 + 54450 \end{aligned}$	M1	Use of work-energy 5 terms; dimensionally correct. Work done by car's engine not from using one of the given speeds. Allow sign errors.
	$\text{Work done} = 65\,250 \text{ J}$	A1	or 65.25 kJ Allow AWR 65300 J or 65.3 kJ from correct work
		5	

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Question	Answer	Marks	Guidance
6(b)	Driving Force = $\frac{32000}{v}$	B1	OE e.g. $32000 = DF \times v$
	$\frac{32000}{v} = 1520 + 4v$	M1	Apply N2L to the car with $a = 0$ (3 terms) and attempt to solve a 3-term quadratic in v . For reference $4v^2 + 1520v - 32000 = 0$ Allow if no working seen and have correct real solution(s) to <i>their</i> 3-term quadratic. If working shown and if using the formula, it must be using the correct formula. If factorising must have 3 of the 4 terms correct of $(v - 20)(v + 400)$
	Speed = 20ms^{-1}	A1	Only.
		3	

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Question	Answer	Marks	Guidance
7(a)	$(a =) \frac{dv}{dt} = 0.5$	B1	For acceleration during the first 10 seconds
	Differentiate to get $(a =) \frac{dv}{dt} = 2 \times 0.25t - 8 \quad [= 0.5t - 8]$	B1	Allow unsimplified
	$a [= 0.5 \times 10 - 8] = -3$	B1	CWO. Do not award final B mark if more than 2 accelerations seen and not discarded, 2/3 maximum Ignore any comments, correct or incorrect
		3	

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Question	Answer	Marks	Guidance
7(b)	Get distance in first 10 seconds as 25	B1	From suvat or from $\int_0^{10} 0.5t \, dt$
	$v = 0$ when $t = 12$ and $t = 20$	B1	SOI
	Attempt to integrate v $\left[s = \int (0.25t^2 - 8t + 60) dt \right]$	*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. $s = vt$ is M0
	$s = \frac{0.25}{3}t^3 - \frac{8}{2}t^2 + 60t(+c) \quad \left[= \frac{1}{12}t^3 - 4t^2 + 60t(+c) \right]$	A1	Allow unsimplified
	Attempt to evaluate their $\left[\frac{1}{12}t^3 - 4t^2 + 60t \right]$ for $t = 10$ to $t = 12$ and $t = 12$ to $t = 20$	DM1	Using the correct limits correctly
	$s = \left[25 + 288 - \frac{850}{3} - \left(\frac{800}{3} - 288 \right) = 25 + \frac{14}{3} - \left(-\frac{64}{3} \right) \right] = 51 \text{ m}$	A1	

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Question	Answer	Marks	Guidance
7(b)	Special Case for those who use a calculator to integrate. Maximum 4/6		
	Get distance in first 10 seconds as 25	B1	From suvat or $\int_0^{10} 0.5t \, dt$
	$v = 0$ when $t = 12$ and $t = 20$	B1	SOI
	Either $s = \int_{10}^{12} (0.25t^2 - 8t + 60) \, dt = \frac{14}{3} = 4.67$ Or $s = \left \int_{12}^{20} (0.25t^2 - 8t + 60) \, dt \right = \frac{64}{3} = 21.3$	B1	Allow $\int_{10}^{20} 0.25t^2 - 8t + 60 \, dt = 26$
	$s = \left[25 + \frac{14}{3} + \frac{64}{3} \right] = 51 \text{ m}$	B1	Allow if $t = 12$ and $t = 20$ not found for 3 marks
		6	



Cambridge International AS & A Level

MATHEMATICS

9709/43

Paper 4 Mechanics

May/June 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 May/June 2022 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 **11** printed pages.

PUBLISHED**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.

PUBLISHED**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

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Question	Answer	Marks	Guidance
1(a)	$0.3 \times 4 + 0 = 0.3v + 0.2 \times 3$	M1	For attempt at use of conservation of momentum
	Speed = 2 ms^{-1}	A1	
		2	
1(b)	$0.2 \times 3 + 0 = (0.2 + m) \times 2$	M1	For attempt at use of conservation of momentum
	$m = 0.1$	A1	
		2	

Question	Answer	Marks	Guidance
2(a)	$0 = u^2 - 2g \times 45$	M1	For use of $v^2 = u^2 + 2as$ OE complete method that would lead to finding u
	Speed = 30 ms^{-1}	A1	
		2	
2(b)	$10 = 30 - gt$ leading to $t = 2$	M1	For use of $v = u + at$ to find time to 10 ms^{-1} or use of ‘ <i>suvat</i> ’ to find time for one stage of motion
	$2 \times 2 \text{ s}$	M1	$2 \times$ time to 10 ms^{-1} OE
	Total time = 4 s	A1	
		3	

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Question	Answer	Marks	Guidance
3(a)	Speed = 20 ms^{-1}	B1	
		1	
3(b)	$20 = 0 + a \times 5$	M1	Use of $v = u + at$ OE
	$a = 4 \text{ ms}^{-2}$	A1	
		2	
3(c)	$\frac{50+100+50+200}{20}$	M1	Use of $\frac{\text{total distance}}{\text{total time}}$ OE
	Average speed = 20 ms^{-1}	A1	
		2	

Question	Answer	Marks	Guidance
4(a)	$T_A \times 0.8 - T_B \times 0.6 - 20 = 0$ or $T_A \times 0.6 + T_B \times 0.8 - 10g = 0$	M1	Resolving horizontally or vertically
	$T_A \times 0.8 - T_B \times 0.6 - 20 = 0$	A1	
	$T_A \times 0.6 + T_B \times 0.8 - 10g = 0$	A1	
	$0.8T_A - \frac{0.6(10g - 0.6T_A)}{0.8} = 20 \rightarrow T_A = \dots$	M1	Attempt to solve simultaneously
	$T_A = 76 \text{ N}, T_B = 68 \text{ N}$	A1	
		5	

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Question	Answer	Marks	Guidance
4(b)	$T_A \times 0.6 - 10g = 0 \Rightarrow T_A = \frac{500}{3}$	B1	From using $T_B = 0$
	$T_A \times 0.8 - F = 0$	M1	
	$F = \frac{400}{3}$	A1	Allow $F = 133$ to 3 s.f.
		3	

Question	Answer	Marks	Guidance
5(a)	$F - 30 = 70 \times 0.3$	M1	Use of Newton's Second law
	$P = 4F$	B1	Using $P = Fv$
	$[= 51 \times 4] = 204 \text{ W}$	A1	
		3	
5(b)	Change in KE = $\frac{1}{2} \times 70 \times 12^2 - \frac{1}{2} \times 70 \times 6^2$	M1	
	3780 J	A1	
		2	
5(c)	For work energy equation	M1	
	$70g \times d \sin 5 - 30d = 3780$	A1 FT	FT change in kinetic energy from (b)
	$d = 122$	A1	
		3	

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Question	Answer	Marks	Guidance
6(a)	Attempt to use Newton's Second law	M1	
	For P : $0.3g \sin 60 - T = 0.3a$	A1	For any one equation
	For Q : $T + 0.2g \sin 30 = 0.2a$	A1	For any second equation
	System: $0.3g \sin 60 + 0.2g \sin 30 = 0.5a$		
	$\frac{0.3g \sin 60 - T}{0.3} = \frac{0.2g \sin 30 + T}{0.2}$		
	$0.3g \sin 60 + 0.2g \sin 30 = 0.5a \quad a = \dots$	M1	For solving for a or T
6(b)	Magnitude of acceleration = 7.20 ms^{-2} Tension = 0.439 N	A1	
		5	
	$R = 0.2g \cos 30$	B1	
	$[0.3g \sin 60 - T = 0] \quad T = \frac{3\sqrt{3}}{2} \quad \text{or} \quad T = 2.598\dots$	B1	Equilibrium for P
	$T + 0.2g \sin 30 - F - 3 = 0$	M1	Equilibrium for Q on the point of moving down
	$\frac{3\sqrt{3}}{2} + 0.2g \sin 30 - \mu(0.2g \cos 30) - 3 = 0$	M1	Use of $F = \mu R$
	$\mu = 0.345$	A1	
		5	

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Question	Answer	Marks	Guidance
7(a)	$0 = \frac{9}{4} + \frac{b}{(5+1)^2} - c \times 5^2$	B1	Use of $v(5) = 0$ to form equation in b and c
	$a = -2 \frac{b}{(t+1)^3} - 2ct$	M1	For use of $a = \frac{dv}{dt}$ and $a(5) = -\frac{13}{12}$
	$-\frac{13}{12} = -2 \frac{b}{(5+1)^3} - 2c \times 5$	A1	
	$\frac{b}{36} - 25c = -\frac{9}{4}$ and $-\frac{b}{108} - 10c = -\frac{13}{12}$ leading to $b = \dots$ or $c = \dots$	M1	Attempts to solve simultaneous equations
	$b = 9$ and $c = 0.1$	A1	$b = 9$ (AG)
		5	

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Question	Answer	Marks	Guidance
7(b)	$\int \left(\frac{9}{4} + \frac{9}{(t+1)^2} - 0.1t^2 \right) dt = \dots$	M1	For use of $s = \int v dt$
	$= \frac{9}{4}t - \frac{9}{(t+1)} - \frac{1}{30}t^3 [+K]$	A1 FT	FT <i>their</i> value of c from (a)
	$\left[\frac{9}{4}t - \frac{9}{(t+1)} - \frac{1}{30}t^3 \right]_5^{10} = \left[\left(\frac{9}{4} \times 10 - \frac{9}{(10+1)} - \frac{1}{30} \times 10^3 \right) - \left(\frac{9}{4} \times 5 - \frac{9}{(5+1)} - \frac{1}{30} \times 5^3 \right) \right]$	M1	For evaluation from 0 to 5 or from 5 to 10
	$=$ $\left[\left(\frac{9}{4} \times 5 - \frac{9}{(5+1)} - \frac{1}{30} \times 5^3 \right) - (-9) \right] - \left[\left(\frac{9}{4} \times 10 - \frac{9}{(10+1)} - \frac{1}{30} \times 10^3 \right) - \left(\frac{9}{4} \times 5 - \frac{9}{(5+1)} - \frac{1}{30} \times 5^3 \right) \right]$ $= 5.583 + 9 + 11.651 + 5.583 \quad \text{or} \quad \frac{175}{12} + \frac{2275}{132}$	M1	For evaluation from 0 to 5 and from 5 to 10 to find distance travelled
	$= 31.8 \text{ m}$	A1	or $\frac{350}{11}$
		5	