Cambridge International AS & A Level

MATHEMATICS **9709/42**

Paper 4 Mechanics **March 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.

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

[Turn over

Generic Marking Principles

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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.
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Mathematics-Specific Marking Principles	
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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.
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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.

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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.

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.

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
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WWW	Without Wrong Working
AWRT	Answer Which Rounds To

Question	Answer	Marks	Guidance
1(a)	Power = 750000/10 = 75000 W or 75 kW	**B1**	Power = WD/Time
		1	
1(b)	Driving force DF = 75000/25	**B1FT**	Using $P = \text{DF} \times v$
	[DF – 2400 = 16000a]	**M1**	Using Newton's 2nd law
	$a = 0.0375\ \text{ms}^{-2}$	**A1**	Allow $a = \dfrac{3}{80}$
		3	

Question	Answer	Marks	Guidance
2(a)	$[1.44 = 0 + \frac{1}{2} \times 2t^2]$	M1	For using a complete method which would lead to an equation for finding a value of t such as $s = ut + \frac{1}{2}at^2$ with $u = 0$, $s = 1.44$ and $a = 2$
	$t = 1.2$ s	A1	
		2	
2(b)	$R = 0.4g - 3 \times \frac{3}{5} = 0.4g - 3\sin 36.9$ [= 2.2]	B1	
	$[3 \times \frac{4}{5} - F = 3\cos 36.9 - F = 0.4 \times 2]$ $[F = 1.6]$	M1	Use Newton's 2nd law, 3 terms, to find F.
	$\left[\mu = \dfrac{3\times\frac{4}{5} - 0.4\times 2}{0.4g - 3\times\frac{3}{5}} = \dfrac{1.6}{2.2}\right]$	M1	Use of $\mu = \dfrac{F}{R}$
	$\mu = 0.727$	A1	Allow $\mu = \dfrac{8}{11}$
		4	

Question	Answer	Marks	Guidance
3(a)	Initial KE = $\frac{1}{2} \times 0.2 \times 5^2$ or Final KE = $\frac{1}{2} \times 0.2 \times 3^2$	**B1**	
	$\frac{1}{2} \times 0.2 \times 5^2 = 0.2gh + \frac{1}{2} \times 0.2 \times 3^2$	**M1**	Use conservation of energy
	$h = 0.8$	**A1**	
		3	
3(b)	Apply work-energy equation from A to C	**M1**	
	$\frac{1}{2} \times 0.2 \times 5^2 - 3.1 + 0.2g \times 0.5 = \frac{1}{2} \times 0.2v^2$	**A1**	Correct work-energy equation
	Speed = 2 ms^{-1}	**A1**	
		3	

Question	Answer	Marks	Guidance
4(a)	Use the constant acceleration equations to obtain an expression for either s_{AB} or s_{BC} in terms of a	M1	
	$s_{AB} = 2 \times 4.5 - ½ \times a \times 2^2$	A1	**or** $s_{AB} = ½(v_A + v_B) \times 2 = 9 - 2a$
	$s_{BC} = 2 \times 4.5 + ½ \times a \times 2^2$	A1	**or** $s_{BC} = ½(v_B + v_C) \times 2 = 9 + 2a$
	$[2 \times 4.5 - ½a \times 2^2 = \frac{4}{5}\ (2 \times 4.5 + ½a \times 2^2)]$	M1	Use the given information to find a valid equation for a
	$a = 0.5\ \text{ms}^{-2}$	A1	
	Alternative method for question 4(a)		
	$[4.5 = u + 2a,\ s_{AC} = 4u + 8a,\ s_{AB} = 2u + 2a]$	M1	Any two relevant equations in u, a, s_{AB} and s_{AC} where u is the velocity at A
	Two correct equations	A1	
	Three correct equations	A1	
	$[2(4.5 - 2a) + 6a = \frac{5}{4}\ \{2(4.5 - 2a) + 2a\}]$	M1	Use the given information that $BC = {}^5/_4 AB$ to find a valid equation such as the one shown OE involving a only
	$a = 0.5\ \text{ms}^{-2}$	A1	
	Alternative method for question 4(a)		
	$[AC = 4.5 \times 4]$	M1	Using $AC = v_B \times 4$ since v_B is the average velocity over AC
	$BC = 5/9 \times AC$ **or** $AB = 4/9 \times AC$	M1	
	$BC = 10$ or $AB = 8$	A1	
	$[10 = 4.5 \times 2 + 2a$ **or** $8 = 4.5 \times 2 - 2a]$	M1	Using $s = ut + ½\ at^2$ for BC **or** $s = vt - ½\ at^2$ for AB
	$a = 0.5\ \text{ms}^{-2}$	A1	

Question	Answer	Marks	Guidance
		5	
4(b)	$s_{AB} = 2 \times 4.5 - ½ \times 0.5 \times 2^2 = 8$ **OR** $s_{BC} = 2 \times 4.5 + ½ \times 0.5 \times 2^2 = 10$	**M1**	Attempt to find the value of s_{AB} or s_{BC} **OR** attempt to find s_{AB} directly as $s_{AC} = 3.5 \times 4 + ½ \times a \times 4^2$ or ½ $(4.5 - 2a + 4.5 + 2a) \times 4$ **or** add the 2 expressions found in **4(a)** for s_{AB} and s_{BC}
	$s_{AC} = 8 + {}^5/_4 \times 8 = 18$ m **OR** $s_{AC} = 10 + {}^4/_5 \times 10 = 18$ m	**A1**	
		2	

Question	Answer	Mark	Guidance
5(a)	[4 sin 30 + F sin 60 – 6 = 0]	**M1**	Resolve forces vertically and equate to zero
	Correct equation	**A1**	
	$F = 4.62$	**A1**	Allow $F = \dfrac{8}{\sqrt{3}}$ or $F = \dfrac{8}{3}\sqrt{3}$
		3	

Question	Answer	Marks	Guidance
5(b)	Resolve forces either vertically or horizontally	**M1**	
	$F \sin \alpha + 4 \sin 30 - 6 = 0$ and $F \cos \alpha + 3 - 4 \cos 30 = 0$	**A1**	Both equations correct $[F \sin \alpha = 4]$ $[F \cos \alpha = 0.464102...]$
	$[F^2 = 4^2 + 0.464^2]$ or $\left[F = \dfrac{4}{\sin 83.4} = \dfrac{0.464}{\cos 83.4}\right]$	**M1**	Attempt to solve for F using Pythagoras or from a value found for α
	$\left[\alpha = \tan^{-1}\left(\dfrac{4}{0.464}\right)\right]$ or $\left[\alpha = \sin^{-1}\left(\dfrac{4}{4.03}\right) = \cos^{-1}\left(\dfrac{0.464}{4.03}\right)\right]$	**M1**	Attempt to solve for α using trigonometry or from a value found for F
	$F = 4.03$ and $\alpha = 83.4$	**A1**	Both correct as shown [$F = 4.0268…$, α = 83.382…]
		5	

Question	Answer	Marks	Guidance
6(a)	$[T - 200 = 700 \times -12]$ Car: $-T - 600 - F = 1600 \times -12$ System: $-600 - 200 - F = 2300 \times -12$	**M1**	Apply Newton's 2nd law to the trailer or apply Newton's 2nd law to the car and to the system and eliminate the braking force, *F*.
	Magnitude of $T = 8200$ N	**A1**	
		2	
6(b)	Car $[T - F - 600 = 1600 \times -12]$ or System $[-600 - 200 - F = 2300 \times -12]$	**M1**	Apply Newton's second law either to the car or to the system with braking force = *F* and use of *their T* from **6(a)**
	Braking force $F = 26800$ N	**A1**	
		2	
6(c)	$[v^2 = 22^2 + 2 \times -12 \times 17.5]$	**M1**	A complete method using constant acceleration equations which would lead to an equation for finding v, using $u = 22$, $s = 17.5$ and $a = -12$
	$v = 8 \text{ ms}^{-1}$	**A1**	AG
		2	
6(d)	$[2300 \times 8 + m \times 0 = 2300 \times 2 + m \times 5]$	**M1**	For applying the conservation of momentum equation to the system of car, trailer and van, where m = mass of the van
		A1	Correct equation
	$m = 2760$ kg	**A1**	
		3	

Question	Answer	Marks	Guidance
7(a)	[$v = 2t - 3$]	**M1**	For differentiation of s for $0 \leqslant t \leqslant 6$
	$t = 1.5$	**A1**	
		2	
7(b)	Velocity at arrival = 9 ms^{-1}	**B1**	$t = 6$ used in v
	$v = -\dfrac{24}{t^2} - 0.5t$	**M1**	For differentiation of s for $t \geqslant 6$
	Velocity when leaves = –3.67 ms^{-1}	**A1**	Allow $v = -11/3$
		3	
7(c)	At $t = 0$, $s = 2$ **or** at $t = 6$, $s = 20$	**B1**	SOI
	At $t = 1.5$, $s = -0.25$	**B1**	SOI
	At $t = 10$, $s = 2.4$	**B1**	SOI
	[Total distance = 2 + 0.25 + 0.25 + 20 + (20 – 2.4)]	**M1**	Evidence of distance rather than displacement involving all three sections, (0, 1.5), (1.5, 6) and (6, 10)
	So total distance travelled = 40.1 m	**A1**	
		5	

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1	Resultant $= 100 - 2 \times 50\cos\alpha$	**M1**
	20 N	**A1**
	Direction is to the left (or equivalent)	**B1**
		3

Question	Answer	Marks
2(a)	$[T - 100 = 400 \times 1.5]$	**M1**
	$T = 700$ N	**A1**
		2
2(b)	$F - 250 - 100 = 2200 \times 1.5$ ($F = 3650$ N) (**M1** for using Newton's second law for the system or for the car using the result from **2(a)**)	**M1**
	For use of power $= Fv$	**M1**
	73 000 W or 73 kW	**A1**
		3

Question	Answer	Marks
3(a)	$0 = 5^2 - 2gs$	**M1**
	$s = 1.25$	**A1**
	[Height above ground =] 4.05 m	**A1**
		3
3(b)	Use of $s = ut + ½ at^2$	**M1**
	$0.8 = 5t - 5t^2$	**A1**
	$t = 0.2$ or 0.8	**M1**
	Length of time = 0.6 s	**A1**
		4

Question	Answer	Marks
4(a)	Resolving forces in either direction	**M1**
	$R = T\sin30 + 0.1g,\ F = T\cos30$	**A1**
	$T\cos30 = 0.8\ (T\sin30 + 0.1g)$	**M1**
	$T = 1.72\ (1.7166...)$	**A1**
		4
4(b)	$R = 3\sin30 + 0.1g$	**B1**
	$3\cos30 - 0.8(3\sin30 + 0.1g) = 0.1a$	**M1**
	$a = 5.98\ \text{ms}^{-2}\ (5.9807...)$	**A1**
		3

Question	Answer	Marks
5(a)	Attempt at finding PE lost	**M1**
	PE lost = $35g\,(4\cos 22.5 - 4\cos 45)$	**A1**
	$\frac{1}{2} \times 35v^2 = 35g\,(4\cos 22.5 - 4\cos 45)$	**M1**
	Speed = 4.16 ms^{-1} (4.1643...)	**A1**
		4
5(b)	Use of the work-energy equation in the form: PE lost = KE gain + WD against resistance	**M1**
	$\frac{1}{2} \times 35 \times 4^2 = 35g\,(4 - 4\cos 45) - X$	**A1**
	$X = 130$ (130.05...)	**A1**
		3

Question	Answer	Marks
6(a)	$\int k\left(t^2 - 10t + 21\right)\mathrm{d}t$	**M1**
	$s = k\left(\frac{1}{3}t^3 + 5t^2 + 21t\right) + \mathrm{C}$	**A1**
	$2.85 = k\left(\frac{1}{3}\times 3^3 - 5\times 3^2 + 21\times 3\right) + \mathrm{C}$ or $2.4 = k\left(\frac{1}{3}\times 6^3 - 5\times 6^2 + 21\times 6\right) + \mathrm{C}$	**M1**
	$2.85 = 27k + \mathrm{C}$, $2.4 = 18k + \mathrm{C}$ (**A1** for both)	**A1**
	Solving for k	**M1**
	$k = 0.05$	**A1**
	$s = 0.05\left(\frac{1}{3}t^3 - 5t^2 + 21t\right) + 1.5$	**A1**
		7
6(b)	Differentiating v or completing the square for v	**M1**
	$a = 0.05(2t - 10)$	**A1**
	Min value of v is at $t = 5$.	**M1**
	Displacement at $t = 5$ is 2.58 m (2.5833...)	**A1**
		4

Question	Answer	Marks
7(a)	$0.3g\sin 30 = 0.3a$ ($a = 5$) (**M1** for applying Newton's second law parallel to the plane)	**M1**
	$v^2 = 0 + 2 \times 2.5 \times a$	**M1**
	$v = 5$	**A1**
	$0.3 \times 5 + 0 = 0.3 \times 2 + 0.2\,w$	**M1**
	Velocity of $Q = 4.5$ ms^{-1}	**A1**
		5

Question	Answer	Marks
7(b)	$0.3 \times z + 0 = 0.5 \times 1.2$	**M1**
	Velocity of P before collision $z = 2$	**A1**
	Friction force on P after reaches horizontal plane $F = \mu \times 0.3\,g$	**B1**
	$\mu \times 0.3g \times 1.5 = \frac{1}{2} \times 0.3 \times 5^2 - \frac{1}{2} \times 0.3 \times 2^2$	**M1**
	Coefficient $\mu = 0.7$	**A1**
	Alternative method for question 7(b)	
	$0.3 \times z + 0 = 0.5 \times 1.2$	**M1**
	Velocity of P before collision $z = 2$	**A1**
	Friction force on P after reaches horizontal plane $F = \mu \times 0.3\,g$	**B1**
	$a = (5^2 - 2^2)\,/\,(2 \times 1.5) = 7,\ F = 0.3 \times 7$	**M1**
	Coefficient $\mu = 0.7$	**A1**
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Mark Scheme Notes

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AWRT	Answer Which Rounds To

Question	Answer	Marks
1(a)	Trapezium, deceleration steeper than acceleration	**B1**
	Time from 0 to 200	**B1**
		2
1(b)	$0.5(170+200)v = 2775$	**M1**
	$v = 15$	**A1**
		2
1(c)	$a = 15 \div 20$	**M1**
	$a = 0.75$	**A1**
		2

Question	Answer	Marks
2	Resolving forces in either direction	**M1**
	$20\cos\theta = 4P\cos 30$	**A1**
	$4P + 2P\sin 30 = 20\sin\theta$	**A1**
	$\cos\theta = \frac{\sqrt{3}}{10}P$ $\sin\theta = \frac{P}{4}$ $\frac{3}{100}P^2 + \frac{1}{16}P^2 = 1$	**M1**
	$P = 3.29$	**A1**
	$\theta = 55.3$	**A1**
		6

Question	Answer	Marks
3	$T\sin 60 + R = 25\cos 20$	**B1**
	Attempt at resolving in any direction	**M1**
	$T\cos 60 = F + 25\sin 20$	**A1**
	$T\cos 60 + F = 25\sin 20$	**A1**
	Use of $F = \mu R$	**M1**
	$T\cos 60 = 25\sin 20 \pm 0.3(25\cos 20 - T\sin 60)$ $T = \dfrac{25\sin 20 \pm 0.3 \times 25\cos 20}{\cos 60 \pm 0.3\sin 60}$	**M1**
	$T = 6.26$	**A1**
	$T = 20.5$	**A1**
		8

Question	Answer	Marks
4(a)	$4\times10\,[+0]=4\times0.5v+2v$	**M1**
	$v_A=5$ and $v_B=10$	**A1**
		2
4(b)	Conservation of momentum *B, C* $2\times10\,[+0]=2\times v+3v$	**M1**
	$v=4$	**A1**
	$v_A>v_B$, hence another collision	**A1**
		3
4(c)	Conservation of momentum *A, B*	**M1**
	$4\times their 5+2\times their 4=4v+2v \qquad v=\frac{14}{3}\ (\text{m s}^{-1})$	**A1**
	KE initial $=\frac{1}{2}\times4\times10^2$	**M1**
	KE final $=\frac{1}{2}\times6\times their\,(\frac{14}{3})^2+\frac{1}{2}\times1\times their\,12^2$	**A1**
	Loss of KE $=200-\frac{412}{3}=\frac{188}{3}$	**A1**
		5

Question	Answer	Marks
5(a)(i)	$DF = 750$	B1
	Power $= their(750) \times 32$ $= 24\text{kW}$	B1 FT
		2
5(a)(ii)	$16000 = DF \times 32$ $DF = 500$	M1
	$500 - 750 = 1250 \times a$	M1
	$a = [-]0.2$	A1
		3
5(b)	$DF = 1000 + 8v + 1250 \times 10 \times 0.096$	M1
	$2200 + 8v$	A1
	$60000 = (2200 + 8v)v$	M1
	$8v^2 + 2200v - 60000 = 0$	A1
	$v = 25$	A1
		5

Question	Answer	Marks
6(a)	Correct for $0 \le t \le 5$	B1
	Correct for $5 \le t \le 7$	B1
	Correct for $7 \le t \le 13.5$	B1
		3
6(b)	$a = -2t$ by differentiating	M1
	$a = -12$	A1
		2
6(c)	$s = \int_0^5 (2t+1)\,dt + \int_5^6 (36-t^2)\,dt + \left\| \int_6^7 (36-t^2)\,dt + \int_7^{13.5} (2t-27)\,dt \right\|$	M1
	$s = \int_0^5 (2t+1)\,dt + \int_5^6 (36-t^2)\,dt + \left\| \int_6^7 (36-t^2)\,dt + \int_7^{13.5} (2t-27)\,dt \right\|$	A1
	$s = [t^2 + t] + [36t - \frac{t^3}{3}] + t^2 - 27t$	M1
	All correct	A1
	$s = 84.25$	A1
		5

Cambridge Assessment International Education

Cambridge International AS & A Level

MATHEMATICS	**9709/43**
Paper 4 Mechanics	**May/June 2020**
MARK SCHEME	
Maximum Mark: 50	

Published

Students did not sit exam papers in the June 2020 series due to the Covid-19 global pandemic.

This mark scheme is published to support teachers and students and should be read together with the question paper. It shows the requirements of the exam. The answer column of the mark scheme shows the proposed basis on which Examiners would award marks for this exam. Where appropriate, this column also provides the most likely acceptable alternative responses expected from students. Examiners usually review the mark scheme after they have seen student responses and update the mark scheme if appropriate. In the June series, Examiners were unable to consider the acceptability of alternative responses, as there were no student responses to consider.

Mark schemes should usually be read together with the Principal Examiner Report for Teachers. However, because students did not sit exam papers, there is no Principal Examiner Report for Teachers for the June 2020 series.

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

Cambridge International is publishing the mark schemes for the June 2020 series for most Cambridge IGCSE™ and Cambridge International A & AS Level components, and some Cambridge O Level components.

Generic Marking Principles

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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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Question	Answer	Marks
1	Use of conservation of momentum	**M1**
	$m \times 2 + 0 = m \times (-0.5) + 0.2 \times 1$	**A1**
	$m = 0.08$	**A1**
		3

Question	Answer	Marks
2(a)	$F - 900 = 4000 \times 0.5$ (**M1** for use of Newton's second law, 3 terms)	**M1**
	$F = 2900$ N	**A1**
2(b)	900×25 (**M1** for use of $P = Fv$ with F = resistance only)	**M1**
	22 500 W or 22.5 kW	**A1**

Question	Answer	Marks
3	Attempt to resolve, either direction with correct number of terms	M1
	$F\cos\alpha = 40\sin30 + 20\sin60 - 50\sin45$ (= 1.965...)	A1
	$F\sin\alpha = 50\cos45 + 20\cos60 - 40\cos30$ (= 10.714...)	A1
	Method for either F or α	M1
	$F = \sqrt{\left((1.965...)^2 + (10.714...)^2\right)} = 10.9(10.893)$	A1
	$\alpha = \tan^{-1}(10.714... / 1.965...) = 79.6\ (79.606...)$	A1
		6

Question	Answer	Marks
4(a)	Trapezium shape with gradient of right-hand side approximately 2 times left side	B1
		1
4(b)	Constant velocity = 500/25 = 20 ms^{-1}	B1
	$20^2 = 0 + 2a \times 50$	M1
	$a = 4$	A1
		3
4(c)	Time to accelerate = 20/4 = 5 s	B1
	Deceleration time = 2.5 s	B1
	So total time = 5 + 25 + 2.5 = 32.5 s	B1
		3

Question	Answer	Marks
5(a)	Decrease in KE = $\frac{1}{2} \times 4 \times (12^2 - 8^2)$	**M1**
	160 J	**A1**
		2
5(b)	PE gained = 4g × 10sin30 (= 200)	**B1**
	Total work done = 200 – 160	**M1**
	Total work done = 40 J	**A1 FT**
		3
5(c)	$-4g\sin 30 = 4a$	**M1**
	$a = -5$	**A1**
	$-10 = 8t - \frac{1}{2} \times 5t^2$	**M1**
	$t = 4.16$ s	**A1**
		4

Question	Answer	Marks
6(a)	$a = 4 - t$ (**M1** for differentiation)	**M1**
	When $a = 0$, $t = 4$	**A1**
	At $t = 4$, $v = 12.5$	**A1**
		3
6(b)	Velocity = 0 when $4.5 + 4t - 0.5t^2 = 0$	**M1**
	$t = 9$ (reject $t = -1$)	**A1**
	$\int (4.5 + 4t - 0.5t^2)dt$	**M1**
	$4.5t + 2t^2 - \frac{1}{6}t^3\ [+c]$	**A1**
	Apply limits (0 and 9)	**M1**
	Distance = 81 m	**A1**
		6

Question	Answer	Marks
7(a)	$T - 2mg = 0$	**B1**
	$3mg\sin\theta - T = 0$ (**M1** for resolving forces parallel to the plane and solving for θ)	**M1**
	$\theta = 41.8\ (41.810...)$	**A1**
		3
7(b)	$R = 3mg\cos 30$	**B1**
	Use of $F = \mu R$	**M1**
	$2mg - T = 0.1 \times 2m$ OR $T - 3mg\sin 30 - \mu \times 3mg\cos 30 = 0.1 \times 3m$	**M1**
	$2mg - 0.2m - 3mg\sin 30 - \mu \times 3mg\cos 30 = 0.1 \times 3m$	**M1**
	$\mu = \frac{\sqrt{3}}{10}$	**A1**
		5
7(c)	$v^2 = 0 + 2 \times 0.1 \times 0.8 \quad (v = 0.4)$	**M1**
	$-3mg\sin 30 - \mu \times 3mg\cos 30 = 3ma\ (a = -6.5)$	**M1**
	$0 = -0.4 - 6.5t$	**M1**
	$t = 0.4/6.5 = 0.0615$ s	**A1**
		4

Cambridge International AS & A Level

MATHEMATICS **9709/41**

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.

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- 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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AWRT	Answer Which Rounds To

Question	Answer	Marks	Guidance
1(a)	$6 \times 2.5 = 2.5v + 5v$	**M1**	Apply conservation of momentum, 3 terms implied
	$v = 2\ \text{ms}^{-1}$	**A1**	
		2	
1(b)	Use KE = ½ mv^2 either before or after collision	**M1**	Allow this for either particle
	KE(before) = $0.5 \times 2.5 \times 6^2$ KE(after) = $0.5 \times 7.5 \times 2^2$	**A1 FT**	Both correct FT on v
	Loss of KE = 30 J	**A1**	
		3	

Question	Answer	Marks	Guidance
2(a)	$P = 350 \times 20$	**M1**	Using $P = Fv$
	$P = 7$ kW	**A1**	
		2	
2(b)	$15\,000 = \text{DF} \times 20$ [DF = 750]	**B1**	Using $P = Fv$
	$\text{DF} - 350 = 1400a$	**M1**	Use Newton's 2nd law, 3 terms
	$a = \frac{2}{7}\ \text{ms}^{-2}$	**A1**	$a = 0.286$
		3	

Question	Answer	Marks	Guidance
3	Resolve forces either horizontally or vertically	**M1**	Correct number of relevant terms
	$P \cos \theta = 12 + 8 \cos 30 - 10 \cos 45$ [= 11.857]	**A1**	
	$P \sin \theta = 10 \sin 45 - 8 \sin 30$ [= 3.071]	**A1**	
	$P = \sqrt{(11.857^2 + 3.071^2)}$	**M1**	OE. Use of correct method for finding P
	$\theta = \tan^{-1}\left(\frac{3.071}{11.857}\right)$	**M1**	OE. Use of correct method for finding θ
	$P = 12.2$ and $\theta = 14.5$	**A1**	Both correct
		6	

Question	Answer	Marks	Guidance
4	[$v = 3t^2 - 18t$ (+ C)]	***M1**	Attempt to integrate a
	[$s = t^3 - 9t^2$ (+ C)]	**#M1**	Attempt to integrate v
	$v = 3t^2 - 18t$ $s = t^3 - 9t^2$	**A1**	Both integrals correct
	$v = 0$, $3t^2 - 18t = 0$ [$t = 6$]	***DM1**	Attempt to find t when $v = 0$
	$s = 6^3 - 9 \times 6^2 - [0]$	**#DM1**	Substitute limits correctly into s
	$s = 108$ m	**A1**	Answer must be positive
		6	

Question	Answer	Marks	Guidance
5(a)	$0.8g - T = 0.8a$, $T - 0.2g = 0.2a$, For system: $0.8g - 0.2g = (0.8 + 0.2)a$	**M1**	Apply Newton's 2nd law to either particle or to the system
		A1	Any 2 correct equations
	Attempt to solve for either a or T	**M1**	
	$a = 6 \text{ ms}^{-2}$ and $T = 3.2$ N	**A1**	AG. Both correct
		4	
5(b)	$v^2 = 2 \times 6 \times 0.5$	**M1**	Attempt to find v or v^2 as 0.8 kg particle reaches the ground using a from **5(a)**
	$0 = 6 - 20s$	**M1**	Attempt to find the extra height reached by 0.2 kg particle using v^2 from previous M1 mark
	Greatest height = 0.5 + 0.5 + 0.3 = 1.3 m	**A1**	
		3	

Question	Answer	Marks	Guidance
6(a)	KE (final) = $\frac{1}{2} \times 1500 \times 20^2 + \frac{1}{2} \times 750 \times 20^2$ KE (initial) = $\frac{1}{2} \times 1500 \times 30^2 + \frac{1}{2} \times 750 \times 30^2$	**B1**	Use KE = $\frac{1}{2}mv^2$ for any two of the four elements
	PE gain = $2250 \times 10 \times 800 \times 0.08$	**B1**	
	WD against friction = 600×800	**B1**	
	$\frac{1}{2} \times 2250 \times 30^2 + \text{DF} \times 800 = 600 \times 800 + \frac{1}{2} \times 2250 \times 20^2 + 2250 \times 10 \times 800 \times 0.08$	**M1**	Use energy equation.
	DF = 1700 N	**A1**	DF = 1696.875 N
		5	

Question	Answer	Marks	Guidance
6(b)	$2400 - 600 = 2250a$ or $T - 200 = 750a$ **and** $2400 - 400 - T = 1500a$	**M1**	Apply Newton's second law to the system or to each of the car and trailer separately
		A1	Two correct equations
	Attempting to solve for a or for T	**M1**	
	$T = 800$ N and $a = 0.8$ ms^{-2}	**A1**	
		4	

Question	Answer	Mark	Guidance
7(a)	$0.2\times10\times0.5=\frac{1}{2}\times0.2\times v_B^2$	**M1**	Attempt PE or KE for motion from A to B
		M1	Attempt PE loss = KE gain from A to B
	$v_B^2=10$	**A1**	
	Alternative method for the first 3 marks		
	$0.2 \times 10 \times \sin 30 = 0.2a$, $a = 5$	**(M1)**	Attempt to find acceleration a for motion from A to B
	$v_B^2=0^2+2\times5\times1$	**(M1)**	Use $v^2 = u^2 + 2as$ in attempt to find speed at B
	$v_B^2=10$	**(A1)**	

Question	Answer	Marks	Guidance
7(a)	**THEN, either this method for the next 5 marks**		
	$R = 0.2 \times 10 \times \cos 30 = \sqrt{3}$	**B1**	
	$F = \frac{\sqrt{3}}{2} \times 0.2 \times \frac{\sqrt{3}}{2} \times 10 = 1.5$	**M1**	For using $F = \mu R$ where R must be a component of $0.2g$
	PE loss = $0.2 \times 10 \times 0.5 = 1$ WD against $F = 1.5 \times 1$	**M1**	Attempt to find either PE loss or WD against F from B to C
	$\frac{1}{2}0.2\times10+0.2\times10\times0.5=1.5\times1+\frac{1}{2}0.2v_C^2$	**M1**	Apply work-energy equation for motion from B to C as KE at B + PE at B = WD against F + KE at C with $v_B \neq 0$
	$v_c = \sqrt{5} = 2.24\ \text{ms}^{-1}$	**A1**	
	OR, this method for the next 5 marks		
	$R = 0.2 \times 10 \times \cos 30 = \sqrt{3}$	**(B1)**	
	$F = \frac{\sqrt{3}}{2} \times 0.2 \times \frac{\sqrt{3}}{2} \times 10 = 1.5$	**(M1)**	For using $F = \mu R$ where R must be a component of $0.2g$
	$0.2 \times 10 \sin 30 - 1.5 = 0.2a \quad a = -2.5$	**(M1)**	Attempt to find acceleration a for motion from B to C
	$v_c^2 = 10 + 2\times -2.5\times1$	**(M1)**	Use $v^2 = u^2 + 2as$ in attempt to find v_c using $v_B \neq 0$
	$v_c = \sqrt{5} = 2.24\ \text{ms}^{-1}$	**(A1)**	
		8	

Question	Answer	Marks	Guidance
7(a)	**Alternative method for question 7(a)**		
	PE loss = $0.2 \times 10 \times 2 \sin 30 = 2$	**M1**	Attempt PE loss for motion from *A* to *C*
	KE gain $= \frac{1}{2} \times 0.2 \times v_C^2$	**M1**	Attempt KE gain for motion from *A* to *C*
	Both PE loss and KE gain correct	**A1**	
	$R = 0.2 \times 10 \times \cos 30 = \sqrt{3}$	**B1**	
	$F = \frac{\sqrt{3}}{2} \times 0.2 \times \frac{\sqrt{3}}{2} \times 10 = 1.5$	**M1**	For using $F = \mu R$ where R must be a component of $0.2g$
	WD against $F = 1.5 \times 1$	**M1**	Attempt WD against F
	$0.2 \times 10 \times 1 = 1.5 \times 1 + \frac{1}{2} \times 0.2 \times v_C^2$	**M1**	Attempt work-energy equation for motion from *A* to *C*
	$v_c = \sqrt{5} = 2.24 \text{ ms}^{-1}$	**A1**	
		8	

Question	Answer	Marks	Guidance
7(b)	$0 = 10 + 2a \quad [a = -5]$	**M1**	Attempt to find a for motion from B to C, using $v_B^2 = 10$, $v_C = 0$
	$0.2 \times 10 \times \sin 30 - F = 0.2 \times -5$	**M1**	Attempt Newton's 2nd law for motion from B to C
	$2 = \mu\sqrt{3}$	**M1**	Use $F = \mu R$ where R is a component of $0.2g$ but $R = 0.2g$ is M0
	$\mu = \frac{2}{\sqrt{3}}$	**A1**	Any correct exact form such as $\frac{2}{3}\sqrt{3}$
	Alternative method for question 7(b)		
	PE loss $= 0.2 \times 10 \times 1 \sin 30 = 1$	**M1**	Attempt PE loss for motion from B to C
	$1 + \frac{1}{2} \times 0.2 \times 10 = F \times 1$	**M1**	Work-Energy equation for motion from B to C in the form PE at B + KE at B = WD against F using $v_B^2 = 10$, $v_C = 0$
	$F = \mu\sqrt{3}$	**M1**	Use $F = \mu R$ leading to an equation in μ where R is a component of $0.2g$
	$\mu = \frac{2}{\sqrt{3}}$	**A1**	Any correct exact form such as $\frac{2}{3}\sqrt{3}$

Question	Answer	Marks	Guidance
7(b)	**Alternative method for question 7(b)**		
	PE loss = $0.2 \times 10 \times 2 \sin 30 = 2$	**M1**	Attempt PE loss for motion from *A* to *C*
	$2 = F \times 1$	**M1**	Work-Energy equation for motion from *B* to *C*
	$F = \mu\sqrt{3}$	**M1**	Use $F = \mu R$ leading to an equation in μ where R is a component of $0.2g$
	$\mu = \frac{2}{\sqrt{3}}$	**A1**	Any correct exact form such as ${}^{2}/_{3}\sqrt{3}$
		4	

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.

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This document consists of **14** printed pages.

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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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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)
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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	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	

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		
	$\left[\dfrac{T}{\sin 150} = \dfrac{mg \text{ or } W}{\sin 75} = \dfrac{20}{\sin 135}\right]$	**M1**	Attempt at one pair of terms using Lami's Method
	$\dfrac{T}{\sin 150} = \dfrac{mg}{\sin 75} = \dfrac{20}{\sin 135}$	**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)	$\left[2 = \frac{20}{T}\right] \to T = 10$	**B1**	
		1	
4(b)	Distance travelled before constant speed = $\frac{1}{2} \times 10 \times 20 + \frac{1}{2} \times (20 + V) \times 5$ $\frac{1}{2} \times 10 \times 20 + \frac{1}{2} \times (20 - V) \times 5 + 5V$ $[= 150 + 2.5V]$	**B1 FT**	May be implied if seen within total distance FT on T value from **4(a)**
	Distance travelled after constant speed $= 27.5V + \frac{1}{2} \times 5V\ [= 30V]$	**B1**	May be implied if seen within total distance
	$\frac{1}{2} \times 10 \times 20 + \frac{1}{2} \times (20 + V) \times 5$ $= \frac{1}{3}\left[\frac{1}{2} \times 10 \times 20 + \frac{1}{2} \times (20 + V) \times 5 + 27.5V + \frac{1}{2} \times 5V\right]$	**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 $\frac{1}{2} \times 10 \times 20 + \frac{1}{2} \times (20 + V) \times 5 = \frac{1}{2}\left[27.5V + \frac{1}{2} \times 5V\right]$
	$V = 12$	**A1**	
		4	

Question	Answer	Mark	Guidance
5(a)	$40 - gt = 0$ $[t = 4]$	**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 = $4 - ½(4) = 2$	**A1**	May see $t = 4 + 2 = 6$ for A1
	$h = 40 \times 2 - ½ \times 10 \times 2^2$ $h = 40 \times 6 - ½ \times 10 \times 6^2$	**M1**	Using $s = ut + ½\, at^2$ 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**	
	$s = ½ \times 10 \times 2^2$	**M1**	Use either $s = vt - ½\, at^2$ with $v = 0$, $a = -g$, $t = 2$ or use $s = ut + ½\, at^2$ 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 $= 40t - \frac{1}{2} \times 10t^2$	B1	
	Height of second particle above top of building $= 20(t-1) - \frac{1}{2} \times 10 \times (t-1)^2$	B1	
	$60 + 20(t-1) - \frac{1}{2} \times 10 \times (t-1)^2 = 40t - \frac{1}{2} \times 10t^2$	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)	$\int\left(0.04t^{5/2}+1.72\right)dt$ [$s=\dfrac{2}{175}t^{7/2}+1.72t\left(+C'\right)$]	*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	
	$a = 7.5\ \text{ms}^{-2}$	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	
	$v = 2.5\ \text{ms}^{-1}$	A1	
		4	

Cambridge International AS & A Level

MATHEMATICS	**9709/43**
Paper 4 Mechanics	**October/November 2020**
MARK SCHEME	
Maximum Mark: 50	

Published

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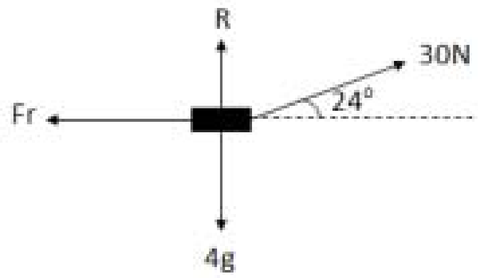
WWW	Without Wrong Working
AWRT	Answer Which Rounds To

Question	Answer	Marks	Guidance
1(a)	$v = 30$	**B1**	Use $v = u + at$ (or equivalent *suvat)* with $v = 0$, $a = -g$ and $t = 3$
		1	
1(b)	$[0 = 30^2 + 2(-10)s]$	**M1**	Using $v^2 = u^2 + 2as$ with $a = -g$, $v = 0$ and u = value from **1(a)**, or equivalent *suvat* method
	Greatest height is 45 m	**A1**	
		2	

Question	Answer	Marks	Guidance
2(a)	$WD = 40 \times 15 = 600$ J	**B1**	
		1	
2(b)	$[PE = 5 \times 10 \times 15 \sin 20]$	**M1**	Attempt PE gain
	257 J (256.5151... J)	**A1**	
		2	
2(c)	$WD = 40 \times 15 + 5 \times 10 \times 15 \sin 20 = 857$ J	**B1 FT**	FT 600 + 'PE'(> 0) from **2(b)**
		1	

Question	Answer	Marks	Guidance
3(a)		**B1**	4 forces, labelled
		1	
3(b)	For resolving horizontally or vertically	**M1**	
	$30 \cos 24 = F$ ($F = 27.406…$)	**A1**	
	$R + 30 \cos 24 = 40$ ($R = 27.797…$)	**A1**	
	$\mu = \dfrac{30\cos 24}{40 - 30\sin 24}$	**M1**	Using $\mu = F/R$
	$\mu = 0.986$ ($0.9859…$)	**A1**	
		5	

Question	Answer	Marks	Guidance
4	For using conservation of momentum (either case)	**M1**	
	$6 \times 4 = 3m + 4 \times 1.5$ **or** $6 \times 4 = 3m - 4 \times 1.5$	**A1**	
	$m = 6$ **and** $m = 10$	**A1**	
	KE_A initial $= ½ \times 4 \times 6^2$ (72 J) or KE_A after $= ½ \times 4 \times 1.5^2$ (4.5 J) or KE_B after $= ½ \times 6 \times 3^2$ (27 J) or KE_B after $= ½ \times 10 \times 3^2$ (45 J)	**B1 FT**	$KE = ½ \times m \times v^2$ FT $4.5m$ for KE_B
	KE loss $= [½ \times 4 \times 6^2 - ½ \times 4 \times 1.5^2 - ½ \times 6 \times 3^2]$ or $[½ \times 4 \times 6^2 - ½ \times 4 \times 1.5^2 - ½ \times 10 \times 3^2]$	**M1**	Uses KE loss = KE before – KE after
	Loss of KE = 40.5 J or 22.5 J	**A1**	
		6	

Question	Answer	Marks	Guidance
5(a)	$4t^2 - 20t + 21 = (2t - 3)(2t - 7) = 0 \rightarrow t = \ldots$	**M1**	For setting $v = 0$ and attempting to solve $v = 0$
	$t = 1.5$ and $t = 3.5$	**A1**	
		2	
5(b)	$a = 8t - 20$, $a(0) = \ldots$	**M1**	For using $a = dv/dt$ and evaluating for $t = 0$
	$a = -20$	**A1**	
		2	

Question	Answer	Marks	Guidance
5(c)	$8t - 20 = 0$, $t = 2.5 \rightarrow v = \ldots$ or $v = (2t - 5)^2 - 4$, $v_{\min} = \ldots$	**M1**	For setting $a = 0$, attempting to solve for t and substituting to obtain v, or for attempting to complete the square on the expression for v
	$v_{\min} = -4\ \text{ms}^{-1}$	**A1**	
		2	
5(d)	$s = \int(4t^2 - 20t + 21)\ \mathrm{d}t$	**M1**	For using $s = \int v\ \mathrm{d}t$ and attempting integration
	$s = \frac{4}{3}t^3 - 10t^2 + 21t(+c)$	**A1**	Correct integration
	$\frac{49}{6} - \frac{27}{2}$	**M1**	Substitute their limits (1.5 and 3.5) into *their* integral
	Distance = $\frac{16}{3} = 5.33$ m	**A1**	
		4	

Question	Answer	Marks	Guidance
6(a)(i)	$P = 650 \times 25$	**M1**	Use $P = Fv$ with F = total resistance
	$P = 16\,250$ W = 16.25 kW	**A1**	Accept 16 300 W or 16.3 kW (3sf)
		2	

Question	Answer	Marks	Guidance
6(a)(ii)	$DF = \frac{39000}{25}$ (= 1560)	**B1**	For using DF = P/v
	For applying Newton's 2nd law to the system to form an equation in a, or to the caravan or the car to form an equation in T and a	**M1**	[$1560 - 650 = 2400 \times a$]
	$1560 - 650 = 2400a$ $T - 250 = 800a$ $1560 - 400 - T = 1600a$	**A1**	Two correct equations
	$\left[a = \frac{(1560 - 650)}{2400}\right]$	**M1**	For solving for a or for T
	$a = 0.379\ \text{ms}^{-2}$ (0.37916…) $T = 553$ N (553.33…)	**A1**	
		5	
6(b)	[$DF = 650 + 2400 \times 10 \times 0.05$]	**M1**	Newton's 2nd law
	$32\,500 = (650 + 24\,000 \times 0.05)v$	**M1**	For using $P = Fv$
	$v = 17.6$	**A1**	Allow $v = \frac{650}{37}$
		3	

Question	Answer	Marks	Guidance
7(a)	$[T = 2g \sin 10]$ or $[3g \sin 20 = F + T]$	**M1**	Resolve forces parallel to plane *P* for particle *A* or parallel to plane *Q* for Particle *B*
	$T = 2g \sin 10$ **and** $3g \sin 20 = F + T$	**A1**	
	$R = 30 \cos 20$ (= 28.19...)	**B1**	Resolving forces perpendicular to plane *Q* for particle *B*
	$\mu = \dfrac{3g\sin 20 - 2g\sin 10}{30\cos 20}$	**M1**	Using $\mu = F/R$
	$\mu = 0.241$ (=0.2407…)	**A1**	
		5	
7(b)	$3g \sin 20 - T = 3a$ or $T - 2g \sin 10 = 2a$ or System: $3g \sin 20 - 2g \sin 10 = 5a$	**M1**	For applying Newton's second law to either *A* or to *B* or to the system
	$a = \dfrac{(3g\sin 20 - 2g\sin 10)}{5}$	**M1**	For applying Newton's second law to the second particle and/or solving for *a*
	$a = 1.3575…$	**A1**	
	$h_1 = x \sin 20$ $h_2 = x \sin 10$ $x \sin 20 + x \sin 10 = 1$	**B1**	Using expressions for height change of each particle after each moves a distance *x* along the plane, to obtain equation in *x*
	$\dfrac{1}{\sin 10 + \sin 20} = 0 + \dfrac{1}{2} \times 1.3575 \times t^2$	**M1**	For using $s = ut + ½at^2$ for either particle with $s = x$, $u = 0$ and using *their a* (= 1.3575)
	$t = 1.69$	**A1**	
		6	

Cambridge International AS & A Level

MATHEMATICS	**9709/42**
Paper 4 Mechanics	**March 2021**
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.

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This document consists of **14** printed pages.

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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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- 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	$\pm 0.2 \times 0.5$ or $\pm 0.3 \times 1$	**B1**	For initial momentum for either particle. Allow kg or g.
	$0.2 \times 0.5 + 0.3 \times (-1) = 0.2 \times v + 0$	**M1**	For conservation of momentum. Dimensions correct. Allow if 3 relevant momentum terms are seen regardless of sign.
	Speed = 1 m s^{-1}	**A1**	Allow if final answer given as $v = 1$ or speed = 1 from an equation whose solution is $v = -1$
		3	

Question	Answer	Marks	Guidance
2(a)	Driving force = DF $= \dfrac{22500}{v}$	**B1**	
	$\text{DF} - 1400g \times 0.1 - 600 = 0$	**M1**	Apply Newton's 2nd law to the car with $a = 0$, three relevant terms. May see term $1400g \sin 5.7°$.
	$v = 11.25 \text{ m s}^{-1}$	**A1**	**AG** From exact working only, may be implied if using 5.7°.
		3	

Question	Answer	Marks	Guidance
2(b)	DF – 1400g sin 2 – 600 = 1400a	**M1**	Use of Newton's second law for the car, 4 relevant terms.
	$\frac{22500}{11.25} - 1400g \sin 2 - 600 = 1400a$	**A1**	
	$a = 0.651 \text{ m s}^{-2}$ (3sf)	**A1**	
		3	

Question	Answer	Marks	Guidance
3	For attempting to resolve forces in either direction.	**M1**	Correct number of relevant terms.
	$T_P \cos 60 = T_R \cos 30$	**A1**	
	$T_P \sin 60 = T_R \sin 30 + 0.2g$	**A1**	
	Attempt to solve simultaneously for either tension.	**M1**	From 2 equations, with correct number of relevant terms.
	$T_P = 3.46$ N and $T_R = 2$ N	**A1**	Both correct. Allow $T_P = 2\sqrt{3}$ N.
	Alternative method for question 3		
	$\frac{T_P}{\sin 60} = \frac{T_R}{\sin 150} = \frac{0.2g}{\sin 150}$	**M1**	Attempt one pair of Lami's equations. Correct angles.
	One pair correct	**A1**	
	Equations all correct	**A1**	
	Solve for T_P or T_R	**M1**	From equations of the correct form.
	$T_P = 3.46$ N and $T_R = 2$ N	**A1**	Both correct. Allow $T_P = 2\sqrt{3}$ N
		5	

Question	Answer	Marks	Guidance
4(a)	Acceleration = $\frac{4}{3}$ m s^{-2}	**B1**	Allow = 1.33 m s^{-2}.
		1	
4(b)	$\frac{1}{2}(7+4.5)\times 2=\frac{1}{2}(8.5+5)\times V$	**M1**	Equate expressions for the two areas (distances) leading to an equation in V.
	V = 1.7[0] (3sf)	**A1**	Allow $V = \frac{46}{27}$.
		2	
4(c)	Acceleration = −2 m s^{-2}	**B1**	Or Deceleration = 2.
	$T - 1500g = 1500\times(-2)$	**M1**	Apply Newton's second law to the lift, using an acceleration $(\neq \frac{4}{3}$ or *their* **4(a)**). Correct dimensions and number of relevant terms.
	T = 12 000 N	**A1**	
		3	

Question	Answer	Marks	Guidance
5(a)	$[2 = \frac{1}{2} \times a \times 25]$	**M1**	Use of $s = ut + \frac{1}{2}at^2$ OE using $u = 0$, $s = 2$ and $t = 5$.
	$a = 0.16\ \text{m s}^{-2}$	**A1**	Allow $a = \frac{4}{25}$.
		2	
5(b)	$R = 5g - X\sin 30$	**B1**	
	$X\cos 30 - F = 5a$	**M1**	Apply Newton's 2nd law to the block, using their a.
	$X\cos 30 - 0.4(5g - X\sin 30) = 5 \times 0.16$	**M1**	Use $F = 0.4R$ to obtain an equation in X only, using their R which must involve $5g$ and a component of X only.
	$X = 19.5$ (3sf)	**A1**	
		4	
5(c)	$R = (5g - 25\sin 30)$ $[R = 37.5]$	**B1**	
	$F = 25\cos 30$ $\left[F = \frac{25\sqrt{3}}{2}\right]$	**B1**	
	$\mu = \frac{F}{R} = 0.577$ (3sf)	**B1**	Allow $\mu = \frac{\sqrt{3}}{3}$ or $\mu = \frac{1}{\sqrt{3}}$.
		3	

Question	Answer	Marks	Guidance
6(a)	$[s =]\int\left(t^2 - 8t^{\frac{3}{2}} + 10t\right)\mathrm{d}t$	*M1	For attempting to integrate *v*.
	$[s =]\frac{1}{3}t^3 - \frac{16}{5}t^{\frac{5}{2}} + 5t^2\,[+C]$	A1	Allow unsimplified.
	For correct use of correct limits.	DM1	Use of limit at $t = 0$ may be implied.
	Displacement = 2.13 m (3sf)	A1	Allow displacement = $\frac{32}{15}$.
		4	

Question	Answer	Marks	Guidance
6(b)	For attempting to differentiate v.	*M1	
	$[a=]2t-12t^{\frac{1}{2}}+10$	A1	Allow unsimplified.
	$a=0 \Rightarrow 2t-12t^{\frac{1}{2}}+10=0$	DM1	Dependent on *M1. Set $a = 0$ and attempt to solve their 3 term equation in $\sqrt{t}$ or t or $p\left(=\sqrt{t}\right)$ by treating it as a quadratic equation.
	$2\left(t^{\frac{1}{2}}-5\right)\left(t^{\frac{1}{2}}-1\right)=0$ leading to $t = 1$ or $t = 25$	A1	Both correct.
	$\frac{da}{dt}=2-6t^{-\frac{1}{2}}$	*DM1	Dependent on *M1. Determine the nature of the stationary point by: Either differentiating a and testing the sign of $\frac{da}{dt}$ or by substituting values either side of their t value(s) and attempt to determine the nature of the stationary point(s). If using $\frac{da}{dt}$ then must evaluate it at a t value for M1. Allow use with any t value from *their* 'quadratic'.
	Use $t = 25$ in $\frac{da}{dt}=2-6\times 25^{-\frac{1}{2}}$ Evaluating $\frac{da}{dt}$ correctly, hence a minimum.	A1	Or by using a convincing argument to show that $t = 25$ gives a minimum value of v. If evaluated then $\frac{da}{dt}$ must be 0.8.
	Minimum velocity $= 25^2-8\times 25^{\frac{3}{2}}+10\times 25 = -125 \text{ m s}^{-1}$	B1	**AG** This mark is awarded only if the previous 6 marks are awarded.
		7	

Question	Answer	Marks	Guidance
7(a)	Attempt Newton's 2nd law for either P, Q or the system.	**M1**	Correct number of relevant terms, dimensionally correct.
	For P: $0.8 + 0.5g \sin 30 - T = 0.5a$ For Q: $T - 0.3g \sin 45 = 0.3a$ System: $0.8 + 0.5g \sin 30 - 0.3g \sin 45 = 0.8a$	**A1**	For any one correct equation.
		A1	For two correct equations.
	Attempt to solve for T.	**M1**	Using two equations, each with the correct number of relevant terms. [$a = 1.4733$ may be seen].
	$T = 2.56$ N (3sf)	**A1**	Allow $T = \dfrac{99 + 75\sqrt{2}}{80}$.
		5	

Question	Answer	Marks	Guidance
7(b)	KE and PE for m kg particle: $\frac{1}{2}m\times0.36=0.18m$ and $mg\sin45=5\sqrt{2}m$	B1	Any 2 correct PE or KE terms.
	KE and PE for 0.5 kg particle: $\frac{1}{2}\times0.5\times0.36=0.09$ and $0.5g\sin30=2.5$	B1	All 4 correct PE and KE terms.
	Apply the work-energy equation to the system as: PE loss + WD by 0.8 N = KE gain + 0.5	M1	Must include at least 5 relevant terms only and no extra terms. All terms dimensionally correct.
	$0.5g\times1\times\sin30-mg\times1\times\sin45+0.8\times1$ $=\frac{1}{2}\times(0.5+m)\times0.36+0.5$	A1	May be seen as: $2.5-5\sqrt{2}m+0.8=0.09+0.18m+0.5$
	$m=0.374$	A1	
	Alternative method for question 7(b)		
	KE and PE for m kg particle: $\frac{1}{2}m\times0.36=0.18m$ and $mg\sin45=5\sqrt{2}m$	B1	Correct KE and PE for m kg particle.
	$a=0.18$ and $3.3-T=0.5(0.18)$ leading to $T=3.21$	B1	Evaluate the tension in the string using Newton's second law applied to the 0.5 kg particle.
	For m kg particle: WD by T = KE gain + PE gain + 0.5	M1	At least 3 relevant terms including tension. All terms dimensionally correct.
	$3.21\times1=\frac{1}{2}m\times0.36+mg\sin45+0.5$	A1	
	$m=0.374$	A1	

Question	Answer	Marks	Guidance
7(b)	**Alternative method for question 7(b)**		
	KE and PE for *m* kg particle: $\frac{1}{2}m\times 0.36 = 0.18m$ and $mg\sin 45 = 5\sqrt{2}m$	B1	Any 2 correct PE or KE terms.
	KE and PE for 0.5 kg particle $\frac{1}{2}\times 0.5\times 0.36 = 0.09$ and $0.5g\sin 30 = 2.5$	B1	All 4 correct PE and KE terms.
	Apply the work-energy equation to both particles as: $0.8\times 1 + 0.5g\sin 30 = \frac{1}{2}\times 0.5\times 0.36 + T\times 1$ and $T\times 1 = \frac{1}{2}m\times 0.36 + mg\sin 45 + 0.5$	M1	Must include at least 5 relevant terms only and tension terms in both. $[T = 3.21]$ All terms dimensionally correct.
	$0.8\times 1 + 0.5g\sin 30 - \frac{1}{2}\times 0.5\times 0.36 = \frac{1}{2}m\times 0.36 + mg\sin 45 + 0.5$	A1	
	$m = 0.374$	A1	
		5	

Cambridge Assessment International Education

Cambridge International A Level

MATHEMATICS **9709/41**

Paper 4 Mechanics **May/June 2021**

MARK SCHEME

Maximum Mark: 50

Published

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Abbreviations

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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	Force exerted by winch $= 50g\sin 60 + 100[= 433.0 + 100 = 533.0]$	**M1**	For resolving forces along the plane
	Work done $= 5\times(50g\sin 60 + 100)$	**M1**	Use of WD = Force × distance
	Work done = 2670 J	**A1**	
	Alternative method for Question 1		
	PE increase $= 50g\times 5\sin 60$	**M1**	Correct dimensions
	Work done $= 50g\times 5\sin 60 + 100\times 5$	**M1**	Apply the work-energy equation, 3 terms
	Work done = 2670 J	**A1**	
		3	

Question	Answer	Marks	Guidance
2(a)	0.1 kg particle $T - 0.1g = 0.1a$ m kg particle $mg - T = ma$ System $mg - 0.1g = (m + 0.1)a$	**M1**	Apply Newton's 2nd law to either the 0.1 kg particle, the *m* kg particle or to the system, correct number of terms
		A1	Two correct equations
	Solve for m $[a = 5]$	**M1**	From 2 equations with the correct number of relevant terms
	$m = 0.3$	**A1**	
		4	

Question	Answer	Marks	Guidance
2(b)	$v^2 = 0 + 2 \times 5 \times 0.9$	**M1**	Use of $v^2 = u^2 + 2as$ with $u = 0$, $s = 0.9$ and *their* $a \neq \pm g$
	$v = 3 \text{ m s}^{-1}$	**A1 FT**	FT on $\sqrt{1.8a}$
		2	

Question	Answer	Marks	Guidance
3(a)	Use of conservation of momentum, 3 terms	**M1**	Correct dimensions
	$0.1 \times 5 + 0 = 0.1 \times (-1) + 0.2 \times (\pm v)$	**A1**	
	$v = 3 \text{ m s}^{-1}$	**A1**	A0 for $v = -3$
		3	
3(b)	$0.2 \times \textit{their}\, 3 + 0 = 0.2 \times u + 0.5V$	**M1**	Use of conservation of momentum, 3 terms, correct dimensions. Allow $u = 0$ used or if Q and R coalesce
	$u \geqslant -1$	**B1**	Allow $u = -1$. Allow equality for finding greatest value of V. Condition for no collision with P, may be a statement.
	Greatest $V = 1.6$	**A1 FT**	FT on *their* 3 from **3(a)** if $u = -1$ used.
		3	

Question	Answer	Marks	Guidance
4(a)	Isabella $v = 5 \times 1.1$ $[= 5.5]$	**B1**	Isabella's constant speed for 10 seconds
	Use of $s = ut + ½at^2$ or use of v–t graph to find total distance	**M1**	For either Isabella or Maria, all sections included but allow one error in use of formulae
	$s_I = \frac{1}{2} \times 1.1 \times 5^2 + 10 \times 5.5 + \frac{1}{2} \times 1.1 \times 5^2$ $[= 82.5]$ or $s_I = \frac{1}{2} \times (20 + 10) \times 5.5$ $[= 82.5]$	**A1**	For correct expression for Isabella, accept unsimplified
	$s_M = 27.5 + 5 \times 10 + \frac{1}{2} \times 5 \times 5$ $[= 90]$	**A1**	For correct expression for Maria, accept unsimplified
	Distances for Isabella = 82.5 and Maria = 90, so Maria goes further	**B1**	
		5	
4(b)	$\frac{1}{2} a \times 5^2 + 10 \times 5a + \frac{1}{2} a \times 5^2 = 90$ or $\frac{1}{2} \times (20 + 10) \times 5a = 90$	**M1**	Attempt total distance travelled by Isabella and set up an equation for a, using their value of $s_M = 90$. All parts included, allow one error.
	$a = 1.2$	**A1**	
		2	

Question	Answer	Marks	Guidance
5(a)	$v = \int \left(6t^{\frac{1}{2}} - 2t\right)\mathrm{d}t$	**M1**	For integration. $v = at$ is M0.
	$v = 4t^{\frac{3}{2}} - t^2\ (+c)$	**A1**	Allow unsimplified coefficients.
	$v = 0$ leading to $t = 0$ or $t^{\frac{1}{2}} = 4$ leading to $t = 16$	**A1**	
		3	
5(b)	$6t^{\frac{1}{2}} - 2t = 0$	**M1**	Attempt to solve $a = 0$, using valid algebra, reaching $t = \ldots$
	$t = 9$	**A1**	
	$s = \int \left(4t^{\frac{3}{2}} - t^2\right)\mathrm{d}t$ $\left[s = \frac{8}{5}t^{\frac{5}{2}} - \frac{1}{3}t^3\ (+c)\right]$	**M1**	For integration of their expression for v which includes a term with a fractional power. Allow unsimplified coefficients. $v = at$ is M0
	$s = \frac{8}{5}t^{\frac{5}{2}} - \frac{1}{3}t^3$	**A1**	For correct integral
	Distance = 145.8 m	**B1**	Allow $\frac{729}{5}$ or 146 to 3s.f.
		5	

Question	Answer	Marks	Guidance
6(a)	$20\cos 30 = 25\cos 60 + 10\cos\alpha$ $[17.32 = 12.5 + 10\cos\alpha, \ \to \cos\alpha = 0.4821]$	**M1**	For resolving forces horizontally, all relevant terms included
	$\alpha = 61.2$	**A1**	From $\alpha = 61.18$
	Resultant $= 20\sin 30 + 10\sin 61.2 - 25\sin 60$ $[= 10 + 8.761 - 21.651]$	**M1**	For resolving forces vertically, all relevant terms included
	Magnitude of resultant force = 2.89 N	**A1**	A0 for –2.89 N or for ±2.89 N. Allow 2.89 N downwards
		4	
6(b)	$X = 25\cos 60 + 10\cos 45 - 20\cos 30$ $= 12.5 + 7.07107 - 17.32051 = 2.25056$ $Y = 20\sin 30 + 10\sin 45 - 25\sin 60$ $= 10 + 7.07107 - 21.65064 = -4.57957$	**M1**	For either horizontal or vertical component, correct number of relevant terms. Allow $\pm X$ and/or $\pm Y$
		A1	For both correct, allow unsimplified
	$R = \sqrt{X^2 + Y^2}$	**M1**	OE. Using a method to find the resultant force, using expressions for X and Y with at least 5 relevant terms.
	$\alpha = \tan^{-1}\dfrac{Y}{X}$	**M1**	OE. A method to find the direction, using expressions for X and Y with at least 5 relevant terms.
	Resultant = 5.10 N, Direction = 63.8° below positive x-axis	**A1**	For both correct, angle clearly explained. May use a diagram with a correct arrow and arc for angle. Allow angle 296° (measured anticlockwise from +ve x-axis)
		5	

Question	Answer	Marks	Guidance
7(a)(i)	PE $= 35g \times 2.5 \sin 30$	**M1**	
	$\frac{1}{2} \times 35v^2 = 35g \times 2.5 \sin 30$	**M1**	Use of conservation of energy, 2 terms, correct dimensions
	$v = 5 \text{ m s}^{-1}$	**A1**	
	Alternative method for Question 7(a)(i)		
	$mg \sin 30 = ma$ leading to $a = 5$	**M1**	For applying Newton's 2nd law down the plane, 2 terms, correct dimensions
	$v^2 = 0 + 2 \times 5 \times 2.5$	**M1**	For using $v^2 = u^2 + 2as$, using *their* $a \neq \pm g$
	$v = 5 \text{ m s}^{-1}$	**A1**	
		3	

Question	Answer	Marks	Guidance
7(a)(ii)	$\frac{1}{2}\times 35\times 5^2 = 250d$	**M1**	Use of work-energy from the bottom of the slide until motion stops, 2 terms, correct dimensions, using *their* v
	$d = 1.75$ m	**A1**	
	Alternative method for Question 7(a)(ii)		
	$35g\times 2.5\sin 30 = 250d$	**M1**	Use of work-energy from the start until motion stops, 2 terms, correct dimensions.
	$d = 1.75$ m	**A1**	
	Alternative method for Question 7(a)(ii)		
	$-250 = 35a$ leading to $a = -\frac{50}{7} = -7.14$ $0 = 5^2 + 2(a)d$	**M1**	Newton's 2nd law on the horizontal section with resistance = 250 N to find a and use $v^2 = u^2 + 2as$ with $v = 0$, $u = 5$ and $s = d$.
	$d = 1.75$m	**A1**	
		2	

Question	Answer	Marks	Guidance
7(b)	$\frac{1}{2}\times 35v^2 = 250\times 1.05\ \left[v^2 = 15\right]$ or $-250 = 35a$ leading to $a = -\frac{50}{7}$ $0 = v^2 + 2\times -\frac{50}{7}\times 1.05\qquad \left[v^2 = 15\right]$	**B1**	Either use the correct work energy equation for motion on the horizontal section or use the fact that the frictional force on the horizontal section is 250 N in order to set up an equation that would lead to finding the speed at the bottom of the slide.
	$R = 35g\cos 30\left[= 303.11\right]$	**B1**	
	$v^2 = 0 + 2\times a\times 2.5 = 15$ leading to $a = 3$ or PE change $= 35g\times 2.5\sin 30\left[= 437.5\right]$	**M1**	For using $v^2 = u^2 + 2as$, with their v^2 to set up an equation that would lead to finding a.
	$35g\sin 30 - F = 35a$ or $\left[175 - F = 35a\right]$ or $35g\times 2.5\sin 30 = F\times 2.5 + \frac{1}{2}\times 35\times 15\ \left[437.5 = F\times 2.5 + 262.5\right]$	**M1**	For using Newton's 2nd law down the slope with correct dimensions. or For using energy equation, 3 relevant terms with correct dimensions.
	$F = \mu\times R$	**M1**	For using $F = \mu R$, where R is a component of $35g$.
	$\mu = 0.231$	**A1**	Allow $\mu = \frac{2\sqrt{3}}{15}$ OE

Question	Answer	Marks	Guidance
7(b)	**Alternative method for Question 7(b)**		
	$R = 35g\cos 30$	**B1**	
	PE change $= 35g \times 2.5\sin 30[= 437.5]$	**B1**	
	WD against friction on the flat $= 250 \times 1.05$	**B1**	WD = 262.5
	$35g \times 2.5\sin 30 = F \times 2.5 + 250 \times 1.05$ $[437.5 = F \times 2.5 + 262.5]$	**M1**	For using energy equation, 3 relevant terms with correct dimensions.
	$F = \mu \times R$	**M1**	For using $F = \mu R$ at any stage, where R is a component of $35g$.
	$\mu = 0.231$	**A1**	Allow $\mu = \frac{2\sqrt{3}}{15}$ OE
		6	

Cambridge International AS & A Level

MATHEMATICS **9709/42**

Paper 4 Mechanics **May/June 2021**

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 2021 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

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AG	Answer Given on the question paper (so extra checking is needed to ensure that the detailed working leading to the result is valid)
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WWW	Without Wrong Working
AWRT	Answer Which Rounds To

Question	Answer	Marks	Guidance
1	Initial KE $=\frac{1}{2}\times 0.6\times 4^2 \quad [=4.8]$ Final KE $=\frac{1}{2}\times 0.6\times v^2$ PE loss $=0.6\times g\times 15\sin 10 \quad [=15.628]$	**B1**	Any one of the three expressions correct
	$0.6\times g\times 15\sin 10+\frac{1}{2}\times 0.6\times 4^2 = \frac{1}{2}\times 0.6\times v^2$	**M1**	Apply energy equation, 3 terms, dimensions correct
	$v=8.25\ \text{ms}^{-1}$	**A1**	
		3	

Question	Answer	Marks	Guidance
2	Resolve either horizontally or vertically with correct number of terms.	**M1**	Allow θ and α as in the question for this mark
	$[X=]30-34\times\frac{8}{17}-26\times\frac{5}{13}[=4]$	**A1**	Allow $\pm X$ as they may resolve forces left or right Allow $[X=]30-34\sin 28-26\sin 23$ angle 2s.f. or better
	$[Y=]34\times\frac{15}{17}-26\times\frac{12}{13}[=6]$	**A1**	Allow $\pm Y$ as they may resolve forces up or down Allow $[Y=]\ 34\cos 28-26\cos 23$ angle 2s.f. or better
	$[R=]\sqrt{X^2+Y^2}$	**M1**	Attempt to solve for the magnitude of the force
	$[\beta=]\tan^{-1}\left(\frac{Y}{X}\right)$ or $[\beta=]\tan^{-1}\left(\frac{X}{Y}\right)$	**M1**	Attempt to solve for the direction of the resultant force

Question	Answer	Marks	Guidance
2 cont'd	$R=\sqrt{52}=2\sqrt{13}=7.21$ N **and** $\beta=56.3$ above 30N force or anticlockwise from 30N force	A1	Both correct with correct explanation of the direction. Must be a correct and clear explanation.
		6	

Question	Answer	Marks	Guidance
3	Resolving along or perpendicular to the rod	M1	3 terms in either direction
	$8\sin 10+R=0.3g$	A1	
	$8\cos 10-F=0.3a$	A1	
	$F=0.8R$ $\quad[R=1.61081\ldots, F=1.28865\ldots]$	M1	Using $F = \mu R$, where R is 2 terms involving weight and a component of 8 N.
	$[a=21.966\ldots]$ $0.6=\frac{1}{2}\times 21.966\times t^2$	M1	Complete method leading to an equation in t such as $s = ut + \frac{1}{2}at^2$ with $s = 0.6$, $u = 0$ and using *their* value of a found from a Newton's second law with 3 terms, namely, component of 8 N, any friction and $0.3a$.
	$t=0.234$ seconds	A1	Allow use of $a=22$ for M1 and A1
	Alternative method for Question 3		
	Resolving perpendicular to the rod	M1	
	$8\sin 10+R=0.3g$	A1	
	$F=0.8R$ $\quad[R=1.61081\ldots, F=1.28865\ldots]$	M1	Using $F = \mu R$, where R must involve $0.3g$ and a component of 8 N.

Question	Answer	Marks	Guidance
3	$8\cos 10 \times 0.6 = F \times 0.6 + \frac{1}{2} \times 0.3v^2 \quad [v = 5.134]$	**B1**	Work energy equation to find v after 0.6 metres.
	$0.6 = \frac{1}{2}(0 + 5.134) \times t$	**M1**	Using $s = \frac{1}{2}(u+v)t$ to find t.
	$t = 0.234$ seconds	**A1**	
		6	

Question	Answer	Marks	Guidance
4	For resolving either parallel to or perpendicular to the plane	**M1**	Three relevant terms in either equation.
	$P\cos 8 = F + 12g\sin 25$	**A1**	
	$12g\cos 25 = R + P\sin 8$	**A1**	
	$F = 0.3R$	**M1**	Use $F = 0.3R$, where R must involve components of both $12g$ and P.
	$P\cos 8 = 0.3(12g\cos 25 - P\sin 8) + 12g\sin 25$	**M1**	For attempting to solve for P, using equations with the correct number of relevant terms in both.
	$P = 80.8$	**A1**	From $P = 80.755\ldots$ Allow $P \leqslant 80.8$ If more than one case is considered for direction of friction then a choice must be made for final answer.
	Alternative mark scheme for Question 4		
	For resolving forces either vertically or horizontally	**M1**	Correct number of terms in either equation.
	$R\cos 25 + P\sin 33 = 12g + F\sin 25$	**A1**	

Question	Answer	Marks	Guidance
4	$P\cos 33 = F\cos 25 + R\sin 25$	**A1**	
	$F = 0.3R$	**M1**	Use $F = 0.3R$
	Solve a pair of simultaneous equations in P and R May see $R = 97.5$	**M1**	For attempting to solve for P, using equations with the correct number of relevant terms.
	$P = 80.8$	**A1**	From $P = 80.755\ldots$ Allow $P \leqslant 80.8$ If more than one case is considered for direction of friction then a choice must be made for final answer.
		6	

Question	Answer	Marks	Guidance
5(a)(i)	$P = (440 + 280) \times 30$	**M1**	Using $P = Fv$ with F as total resistance
	$P = 720 \times 30 = 21.6$ kW	**A1**	Answer must be in kW
		2	

Question	Answer	Marks	Guidance
5(a)(ii)	$P = 21600 - 8000$ W $\text{DF} = \frac{21600 - 8000}{30} \quad \left[= \frac{13600}{30} = 453.333.. \right]$	B1 FT	Follow through on *their* power from **5(a)(i)** Allow Driving Force $(\text{DF}) = \frac{8000}{30} = 266.7$ as the force due to solely to the change in power provided correct equation(s) used.
	Car: $\text{DF} - 440 - T = 1250a$ Caravan: $T - 280 = 800a$ System: $\text{DF} - (440 + 280) = 2050a$	M1	Apply Newton's 2nd law to either the car or to the caravan or to the system. Must be correct number of relevant terms. If $\text{DF} = \frac{8000}{30}$ is used then the equations must be either $-\text{DF} = 2050a$ or $T - 280 = 800a$
	Solve for either a or T	M1	Using equation(s) with no missing/extra terms, $\text{DF} \neq 720$. Solving for a either from the system equation or from the car AND caravan equation. OR solving for T from the car AND caravan equation.
	$a = -0.13 \text{ ms}^{-2}$ and $T = 176$ N	A1	
		4	

Question	Answer	Marks	Guidance
5(b)(i)	System: $\text{DF} = 720 + 2050g \times 0.06 \quad [= 1950]$ Car: $\text{DF} - 440 - T - 1250g \times 0.06 = 0$ Caravan: $T - 280 - 800g \times 0.06 = 0$	M1	Apply Newton's 2nd law with $a = 0$, either to the system OR by eliminating T between the equations for the car and the caravan, no extra or missing relevant terms, dimensionally correct, to find DF
	$1950v = 28000$	B1	$P = \text{DF} \times v$. $\frac{28000}{v}$ SOI.
	$v = 14.4 \text{ ms}^{-1}$	A1	
		3	

Question	Answer	Marks	Guidance
5(b)(ii)	$\text{PE} = 800g \times d \times 0.06 = 800g \times 14.4 \times 60 \times 0.06$	**M1**	Using PE = *mgh* with *h* being height gained in 60 s, using *their* v
	$\text{PE} = 414\,000$ (J) or $\text{PE} = 414$ kJ	**A1**	Using $v = 560/39 = 14.359$
	Alternative method for Question 5(b)(ii)		
	$28\,000 \times 60 = \text{PE of Caravan} + 1250g \times d \times 0.06 + 720 \times d$ **and** $d = 60 \times 14.359 = 861.54$	**M1**	For use of $\text{WD} = P \times t$ to find an expression for PE of caravan and the distance travelled up the incline in 1 minute.
	$[\text{PE} = 28\,000 \times 60 - 1250g \times 861.54 \times 0.06 - 720 \times 861.54]$ $\text{PE} = 414\,000$ (J) or $\text{PE} = 414$ kJ	**A1**	
		2	

Question	Answer	Marks	Guidance
6	$s_A = \pm(30t - 5t^2)$ or $s_B = \pm 5t^2$	**B1**	Use of constant acceleration equations to find expressions for displacements of *A* or *B*.
	$s_A + s_B = 15$ leading to $15 = 30t$ leading to $t = 0.5$	**B1**	Use $s_A + s_B = 15$ to find time at which particles collide.
	$t = 0.5$ leading to $v_A = \pm 25$ and $v_B = \pm 5$	**B1**	Find speed of particles at $t = 0.5$ before collision.
	$t = 0.5$ leading to $h_A = \pm\left(30 \times 0.5 - \frac{1}{2}g \times 0.5^2\right) = \pm 13.75$	**B1**	Find position of *A* or *B* at which collision occurs at $t = 0.5$ Alternatively allow $h_B = \pm 1.25$ as displacement of *B*
	$25 \times (2m) - 5(m) = (3m)v \rightarrow v_1 = 15$ $25(m) - 5 \times (2m) = (3m)v \rightarrow v_2 = 5$	**M1**	Use of conservation of momentum, either case, using *their* v_A and $v_B \neq 0$ or 30, with 3 terms.
		A1	Both values of v correct

Question	Answer	Marks	Guidance
6	Particle C_1 $-13.75 = 15t - 5t^2$ Particle C_2 $-13.75 = 5t - 5t^2$	**M1**	Use of $s = ut + \frac{1}{2}at^2$ OE to find t, using either *their* numerical v_1 or numerical v_2 from a relevant conservation of momentum equation.
	$t_{C_1}, t_{C_2} = 3.74, 2.23$ leading to $T = 1 + \sqrt{5} - \sqrt{3} = 1.50$	**A1**	Find $T = t_{C_1} - t_{C_2}$ from $t_{C_1} = 3.736$ and $t_{C_2} = 2.232$
		8	Subscripts 1 and 2 refer to the two cases.
	Alternative method for the final two marks		
	$0 = 15 - gt_1$, $0 = 5 - gt_2$ $\rightarrow$ $t_1 = 1.5$, $t_2 = 0.5$ Total heights $h_1 = 13.75 + 11.25 = 25$ Or $h_2 = 13.75 + 1.25 = 15$ $25 = 5T_1^2$ and $15 = 5T_2^2$ $\rightarrow$ $T_1 = \sqrt{5}$, $T_2 = \sqrt{3}$	**M1**	Use of $v = u - gt$ to find time to highest point for either case and use of $v^2 = u^2 - 2gs$ to find total height reached for either case, using either *their* numerical v_1 or numerical v_2 from a relevant conservation of momentum equation. Use $s = 0 + \frac{1}{2}gT^2$ to find time to reach ground (either case).
	$T = 1.5 + \sqrt{5} - \left(0.5 + \sqrt{3}\right) = 1 + \sqrt{5} - \sqrt{3} = 1.50$	**A1**	Find difference in total times $T = \left(t_1 + T_1\right) - \left(t_2 + T_2\right)$

Question	Answer	Marks	Guidance
7(a)	$v = 6t + 2t^2\,[+c]$ or $v = 14t\,[+c]$	M1	Attempt to integrate a in Stage 1 or Stage 2 or in Stage 2 for use of $v = u + at$
	$v = 6t + 2t^2$ and $v = 14t - 8$ or $v(t = 2) = 20$ $v(t = 4) = 20 + 14 \times 2 = 48$	A1	Velocity in Stage 1 and Stage 2 correct including correct constant Find v at $t = 2$ and use $v = u + 14t$ to find v at $t = 4$
	$v = 16t - t^2\,[+c]$	*M1	Attempt to integrate a in Stage 3.
	$55 = 16t - t^2$	DM1	Attempt to solve a relevant 3-term quadratic equation which comes from their 2 term v from Stage 3 equated to 55 and finding two values of t
	$t = 5$ and $t = 11$ only	A1	Allow only if $c = 0$ has been shown correctly.
	Alternative method for Question 7(a)		
	State or imply that only possible range is $4 \leqslant t \leqslant 16$	B1	Allow this method if candidates only consider Stage 3
	$v = 16t - t^2 + c$	M1	For attempt at integration.
	$c = 0$ shown	A1	Using $v = 0$ at $t = 16$
	Solve $55 = 16t - t^2$	M1	Must find 2 values of t and must be from equating *their* 2 term v to 55
	$t = 5$ and $t = 11$ only	A1	Allow only if $c = 0$ has been shown correctly.
		5	

Question	Answer	Marks	Guidance
7(b)	Positive quadratic for $0 \leqslant t < 2$ through (0,0) joining to the bottom of the given line or Negative quadratic for $4 \leqslant t \leqslant 16$ going through the point (16,0) and joining the top of the given line	**B1**	
	All correct with correct gradients (approx)	**B1**	Negative quadratic must have a maximum. There must be no point of inflexion particularly near $t = 16$. Ignore any curve drawn outside $0 \leqslant t \leqslant 16$.
		2	
7(c)	$s = \int \left(16t - t^2\right) \mathrm{d}t \quad \left[= 8t^2 - \frac{1}{3}t^3 \left(+c\right)\right]$	**M1**	Attempt to integrate *their v*.
	$s = \left[8t^2 - \frac{1}{3}t^3\right]_8^{16}$ $s = \left[2048 - 1365\frac{1}{3}\right] - \left[512 - 170\frac{2}{3}\right]$	**A1**	Correct integral and the correct limits used correctly to find an unsimplified expression for the distance from $t = 8$ to $t = 16$ only.
	$s = 341\frac{1}{3}$	**B1**	Allow $s = 341$ to 3s.f. If no integration seen (calculator used) allow B1 (max 1 out of 3 marks)
		3	

Cambridge Assessment International Education

Cambridge International A Level

MATHEMATICS **9709/43**

Paper 4 Mechanics **May/June 2021**

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 2021 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	$0.4 \times 2.5 - 0.5 \times 1.5$	**M1**	Attempt momentum before impact.
	$0.4 \times 2.5 - 0.5 \times 1.5 = 0.4v + 0.5 \times 2v$	**M1**	Use of conservation of momentum, either case.
	$0.4 \times 2.5 - 0.5 \times 1.5 = 0.4v + 0.5 \times 2v$ or $0.4 \times 2.5 - 0.5 \times 1.5 = -0.4v + 0.5 \times 2v$	**A1**	One correct equation
	Speed is $0.179\ \mathrm{m\,s^{-1}}$ or $0.417\ \mathrm{m\,s^{-1}}$	**A1**	Both values
		4	

Question	Answer	Marks	Guidance
2(a)	Forward force exerted by cyclist = $\frac{150}{4}$ N [= 37.5 N]	**B1**	OE. $P = Fv$ used correctly.
	$\frac{150}{4} - 20 = m \times 0.25$	**M1**	Use of Newton's second law
	$m = 70$ kg	**A1**	
		3	
2(b)	$150/3 - 20 - 70g\sin\theta = 0$	**M1**	For resolving up the plane
	$\theta = 2.5°$ to 1d.p.	**A1 FT**	From 2.456…. FT $\theta = \sin^{-1}\left(\frac{3}{m}\right)$ from **(a)**
		2	

Question	Answer	Marks	Guidance
3	$F\sin\theta + 20\sin 60 - 30\sin\alpha - 40\sin\beta = 0$	**M1**	For resolving in either direction
	Vertical: $F\sin\theta + 20\sin 60 - 30\times 0.28 - 40\times 0.6 = 0$ [$F\sin\theta = 15.07949\ldots$]	**A1**	
	Horizontal: $F\cos\theta + 40\times 0.8 - 30\times 0.96 - 20\cos 60 = 0$ [$F\cos\theta = 6.8$]	**A1**	
	$\theta = \tan^{-1}\dfrac{15.0794\ldots}{6.8}$	**M1**	For method for finding θ
	$F = \sqrt{15.07949\ldots^2 + 6.8^2}$	**M1**	For method for finding F
	$\theta = 65.7$, $F = 16.5$	**A1**	
		6	

Question	Answer	Marks	Guidance
4(a)	$24 = u\times 2 - \dfrac{1}{2}g \times 2^2$	**M1**	Use of $s = ut + \frac{1}{2}at^2$
	$u = 22$	**A1**	AG
		2	

Question	Answer	Marks	Guidance
4(b)	At maximum height $0 = 22^2 - 2gs$	**M1**	Use of $v^2 = u^2 + 2as$ to find maximum height.
	Maximum height $s = 24.2$ m	**A1**	
	Height down $= 0.5g \times 1.8^2$ (=16.2)	**M1**	Find distance travelled down in 1.8 s.
	$h = 8$	**A1**	
	Alternative method for Question 4(b)		
	$0 = 22 - 10t$	**M1**	Use of $v = u - gt$ with $u = 22$ and $v = 0$ to find time to reach maximum height
	$t = 2.2$	**A1**	
	$h = 22 \times (2.2 - 1.8) - \frac{1}{2}g \times (2.2 - 1.8)^2$	**M1**	Use of $s = ut + \frac{1}{2}at^2$ to find value of h
	$h = 8$	**A1**	
	Alternative method for Question 4(b)		
	$22t - \frac{1}{2}gt^2 = 22 \times (t + 3.6) - \frac{1}{2}g \times (t + 3.6)^2$	**M1**	Use of $s = ut + \frac{1}{2}at^2$ for times t and $t + 3.6$ to find time taken to reach height h.
	$t = 0.4$ (or $t + 3.6 = 4$)	**A1**	
	$h = 22 \times 0.4 - \frac{1}{2}g \times 0.4^2$	**M1**	Use $s = ut + \frac{1}{2}at^2$ to find value of h.
	$h = 8$	**A1**	
		4	

Question	Answer	Marks	Guidance
5(a)	Increase in KE = ½ × 1900 × 30^2 – ½ × 1900 × 20^2 [= 475000 J]	**B1**	May be implied by energy equation.
	Loss of PE = 1900 × g × s sin 5 [= 1655.95s J]	**B1**	May be implied by energy equation.
	1900 × g × s sin 5 + 150 000 = ½ × 1900×30^2 – ½ × 1900 × 20^2	**M1**	For attempt at work/energy equation
		A1	Correct
	s = [Length of hill =] 196 m	**A1**	
		5	
5(b)	$30^2 = 20^2 + 2a \times 200$	**M1**	Use of $v^2 = u^2 + 2as$
	a = 1.25 m s^{-2}	**A1**	
	T – 100 + 500g sin 5 = 500a	**M1**	For applying Newton's second law to the trailer.
	T = 289 N	**A1**	
		4	

Question	Answer	Marks	Guidance
6(a)	$(2t-3)(t-1)=0$ leading to $t=$ …..	**M1**	Attempt to solve $v=0$
	$t=1$ or $t=1.5$	**A1**	
	Minimum velocity when $t=1.25$ leading to $v=$ ….. or $\frac{dv}{dt}=4t-5=0$ $t=1.25$ leading to $v=$ ….. or $v=2\left[\left(t-\frac{5}{4}\right)^2-\frac{25}{16}\right]+3$ leading to $v=$ …..	**M1**	Uses roots or $dv/dt=0$ to find t for v_{min} and attempts substitution to obtain v_{min}. Alternatively completes square.
	Minimum velocity is -0.125 m s^{-1}	**A1**	Allow $v=-\frac{1}{8}$
		4	
6(b)	Quadratic curve (two roots and $v(3)>v(0)$)	**B1**	
	Goes through (1.25, –0.125), (0, 3), (1, 0), (1.5, 0), (3,6)	**B1**	3 of the 5 key points shown on axes or as coordinates
	All five points shown on a totally correct graph	**B1**	
		3	
6(c)	$s=\frac{2}{3}t^3-\frac{5}{2}t^2+3t$	**M1**	For use of $s=\int v\,dt$
	$\left[\frac{2}{3}(1.5)^3-\frac{5}{2}(1.5)^2+3(1.5)\right]-\left[\frac{2}{3}(1)^3-\frac{5}{2}(1)^2+3(1)\right]$	**M1**	Correct use of limits (*their* 1 and 1.5)
	Distance = 0.0417 m	**A1**	A0 for –0.0417
		3	

Question	Answer	Marks	Guidance
7(a)	$R = 0.3g\cos\theta + 4\sin\theta = 3\times\frac{24}{25} + 4\times\frac{7}{25}$ [=4]	M1	Resolving forces perpendicular to the plane or parallel to the plane. Allow use of θ = 16.3°
	$F = 4\cos\theta - 0.3g\sin\theta = 4\times\frac{24}{25} - 3\times\frac{7}{25}$ [=3]	A1	Two correct equations
	$3 = \mu \times 4$	M1	For use of $F = \mu R$
	$\mu = \frac{3}{4}$	A1	AG Must be from correct and exact working, not using 16.3
		4	
7(b)	$F = \mu \times 0.3g\cos\theta = \frac{3}{4} \times 3 \times \frac{24}{25}$ $\left[= \frac{54}{25} = 2.16\right]$	B1	
	$4 - \frac{3}{4} \times 0.3g \times \frac{24}{25} - 0.3g \times \frac{7}{25} = 0.3a$	M1	Use of Newton's second law
	$a = \frac{10}{3}$ m s^{-2}	A1	
		3	

Question	Answer	Marks	Guidance
7(c)	$s_1 = \frac{1}{2} \times \frac{10}{3} \times 3^2 = 15$ and $v = \frac{10}{3} \times 3 = 10$	B1 FT	Distance s_1 in 3s and v after 3s; FT a from **(b)**
	$-0.3g \times \sin\theta - \mu \times 0.3g\cos\theta = 0.3a$ leading to $a = -10$ $0 = 10^2 + 2 \times (-10) \times s_2$	M1	Apply Newton's 2nd law after 4 N removed, find a and use $v^2 = u^2 + 2as$ to find extra distance s_2
	[$s_2 = 5$ leading to total distance $= s_1 + s_2 = 15 + 5 =$] 20 m	A1	
	Alternative method for Question 7(c)		
	Work done $= 4 \times 0.5 \times \frac{10}{3} \times 3^2$ [= 60 J]	B1 FT	WD = Fs and $s = ½ at^2$ for 4 N force; FT a from **(b)**
	$60 = \mu \times 0.3g\cos\theta \times d + 0.3g \times d\sin\theta$	M1	WD by 4 N force = WD against F + PE gain
	$d = 20$ m	A1	
		3	