



Cambridge International AS & A Level

MATHEMATICS

9709/41

Paper 4 Mechanics

October/November 2022

MARK SCHEME

Maximum Mark: 50

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

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This document consists of **16** printed pages.

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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).

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4	Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored (isw).
5	Where a candidate has misread a number in the question and used that value consistently throughout, provided that number does not alter the difficulty or the method required, award all marks earned and deduct just 1 mark for the misread.
6	Recovery within working is allowed, e.g. a notation error in the working where the following line of working makes the candidate's intent clear.

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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)
CAO	Correct Answer Only (emphasising that no ‘follow through’ from a previous error is allowed)
CWO	Correct Working Only
ISW	Ignore Subsequent Working
SOI	Seen Or Implied
SC	Special Case (detailing the mark to be given for a specific wrong solution, or a case where some standard marking practice is to be varied in the light of a particular circumstance)
WWW	Without Wrong Working
AWRT	Answer Which Rounds To

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

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

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

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

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

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

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

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

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

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

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



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

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

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

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

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

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

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Question	Answer	Marks	Guidance
4(a)	$P = D \times 15$	B1	For any D . OE including $\frac{P}{15}$.
	$D - 500 = 1200 \times 0.8 \ (\Rightarrow D = 1460)$	M1	Attempt at Newton's second law with three terms. Allow sign errors.
	Power = 21900 W	A1	Allow 21900 without units or 21.9 kW, but not simply 21.9 without units or with wrong units.
		3	
4(b)	$[\text{Change in KE} =] \frac{1}{2} \times 1200 \times 32^2 - \frac{1}{2} \times 1200 \times 15^2$ $[= 614400 - 135000 = 479400]$	B1	Sight of both KEs.
	Work done by engine = 21900×53 (= 1160700)	B1ft	OE e.g. $21900 = \frac{WD}{53}$ FT <i>their</i> 21900.
	Distance $AB = 1362.6$ m	B1	AG Must come from $1160700 - 500d = 479400$ OE e.g. $500d = 681300$.
		3	

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

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

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

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

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

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

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

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

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

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



Cambridge International AS & A Level

MATHEMATICS

9709/43

Paper 4 Mechanics

October/November 2022

MARK SCHEME

Maximum Mark: 50

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

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

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

This document consists of **12** printed pages.

PUBLISHED**Generic Marking Principles**

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

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

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

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

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

GENERIC MARKING PRINCIPLE 4:

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

GENERIC MARKING PRINCIPLE 5:

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

GENERIC MARKING PRINCIPLE 6:

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

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Mathematics Specific Marking Principles	
1	Unless a particular method has been specified in the question, full marks may be awarded for any correct method. However, if a calculation is required then no marks will be awarded for a scale drawing.
2	Unless specified in the question, answers may be given as fractions, decimals or in standard form. Ignore superfluous zeros, provided that the degree of accuracy is not affected.
3	Allow alternative conventions for notation if used consistently throughout the paper, e.g. commas being used as decimal points.
4	Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored (isw).
5	Where a candidate has misread a number in the question and used that value consistently throughout, provided that number does not alter the difficulty or the method required, award all marks earned and deduct just 1 mark for the misread.
6	Recovery within working is allowed, e.g. a notation error in the working where the following line of working makes the candidate's intent clear.

PUBLISHED**Mark Scheme Notes**

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

Types of mark

- M** Method mark, awarded for a valid method applied to the problem. Method marks are not lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. Correct application of a formula without the formula being quoted obviously earns the M mark and in some cases an M mark can be implied from a correct answer.
- A** Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated method mark is earned (or implied).
- B** Mark for a correct result or statement independent of method marks.
- DM or DB** When a part of a question has two or more ‘method’ steps, the M marks are generally independent unless the scheme specifically says otherwise; and similarly, when there are several B marks allocated. The notation DM or DB is used to indicate that a particular M or B mark is dependent on an earlier M or B (asterisked) mark in the scheme. When two or more steps are run together by the candidate, the earlier marks are implied and full credit is given.
- FT** Implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A or B marks are given for correct work only.
- A or B marks are given for correct work only (not for results obtained from incorrect working) unless follow through is allowed (see abbreviation FT above).
 - For a numerical answer, allow the A or B mark if the answer is correct to 3 significant figures or would be correct to 3 significant figures if rounded (1 decimal place for angles in degrees).
 - The total number of marks available for each question is shown at the bottom of the Marks column.
 - Wrong or missing units in an answer should not result in loss of marks unless the guidance indicates otherwise.
 - Square brackets [] around text or numbers show extra information not needed for the mark to be awarded.

Abbreviations

AEF/OE	Any Equivalent Form (of answer is equally acceptable) / Or Equivalent
AG	Answer Given on the question paper (so extra checking is needed to ensure that the detailed working leading to the result is valid)
CAO	Correct Answer Only (emphasising that no ‘follow through’ from a previous error is allowed)
CWO	Correct Working Only
ISW	Ignore Subsequent Working
SOI	Seen Or Implied
SC	Special Case (detailing the mark to be given for a specific wrong solution, or a case where some standard marking practice is to be varied in the light of a particular circumstance)
WWW	Without Wrong Working
AWRT	Answer Which Rounds To

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Question	Answer	Marks	Guidance
1(a)	$u = 30$	B1	From $v = u + at$ or equivalent.
		1	
1(b)	$0 = 30^2 - 2 \times 10 \times s$	M1	Use of <i>suvat</i> formulae.
	Greatest height = 45 m	A1 FT	FT $u^2/2g$ with <i>their</i> u from (a) .
		2	

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

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

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

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

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

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Question	Answer	Marks	Guidance
7(a)	$R = 3g \cos \alpha = 3 \times 10 \times 0.8$	B1	
	$F = 3g \sin \alpha = 3 \times 10 \times 0.6$	M1	Resolving parallel to plane.
	$\mu = \frac{18}{24} = 0.75$ or $\mu = \frac{3g \sin \alpha}{3g \cos \alpha} = \tan \alpha = 0.75$	A1	Uses $\mu = \frac{F}{R}$ AG.
		3	
7(b)	$a = g \sin \alpha$ or PE loss $= 1.5gx \sin \alpha$ for AB and $a = 0$ for BC $4.5g \times \sin \alpha - 0.75 \times 4.5g \cos \alpha = 4.5a$ leading to $a = 0$	B1	Accelerations for AB and BC.
	$v_1^2 = 2 \times g \sin \alpha \times x$] or $[1.5g \times x \sin \alpha = 0.5 \times 1.5 \times v_1^2$	M1	Uses 'suvat' or PE loss = KE gain for AB.
	$v_1^2 = 20x \sin \alpha = 12x$ leading to $v_1 = \sqrt{12x}$	A1	
	$1.5 \times \sqrt{12x} + 0 = 4.5 \times v_2$ leading to $v_2 = \frac{1}{3} \sqrt{12x}$	M1	Conservation of momentum.
	$4 = \frac{2}{3} \times \sqrt{12x}$	M1	Use of $s = vt$ on BC since $a = 0$.
	$x = 3$	A1	

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