

Cambridge International AS & A Level

MATHEMATICS**9709/41**

Paper 4 Mechanics

October/November 2024**MARK SCHEME**Maximum Mark: 50

Published

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

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

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This document consists of **13** 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 descriptions for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

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

GENERIC MARKING PRINCIPLE 2:

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

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

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

GENERIC MARKING PRINCIPLE 4:

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

GENERIC MARKING PRINCIPLE 5:

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

GENERIC MARKING PRINCIPLE 6:

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

PUBLISHED**Mathematics-Specific Marking Principles**

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- 2 Unless specified in the question, non-integer answers may be given as fractions, decimals or in standard form. Ignore superfluous zeros, provided that the degree of accuracy is not affected.
- 3 Allow alternative conventions for notation if used consistently throughout the paper, e.g. commas being used as decimal points.
- 4 Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored (isw).
- 5 Where a candidate has misread a number or sign in the question and used that value consistently throughout, provided that number does not alter the difficulty or the method required, award all marks earned and deduct just 1 A or B mark for the misread.
- 6 Recovery within working is allowed, e.g. a notation error in the working where the following line of working makes the candidate's intent clear.

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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	Use of Newton's second law for either particle or system	*M1	Correct number of terms; allow sign errors. Dimensionally correct.
	$T - 1.2g = 1.2a$ $1.8g - T = 1.8a$ $1.8g - 1.2g = (1.2 + 1.8)a$	A1	For any 2 correct equations.
	For attempt to solve for T	DM1	From equations with the correct number of relevant terms. If a found first, then substituting into an equation with the correct number of relevant terms and solving.
	$a = 2\text{ ms}^{-2}$ $T = 14.4\text{ N}$	A1	Both correct.
		4	

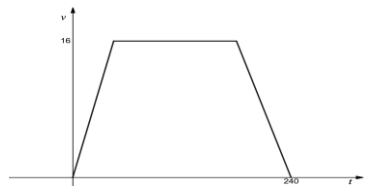
Question	Answer	Marks	Guidance
2(a)	$\text{KE} = \frac{1}{2} \times 7.5 \times v^2$ $\text{PE} = 7.5 \times g \times 12.5 \text{ [= 937.5]}$	*B1	Either correct.
	$v = 15.8\text{ ms}^{-1}$	DB1	$5\sqrt{10}$. SC B1 for $v^2 = 0^2 + 2(g \sin \theta) \left(\frac{12.5}{\sin \theta} \right) \Rightarrow v =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

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Question	Answer	Marks	Guidance
2(b)	$KE_B = 0.5 \times 7.5 \times 8^2 [= 240]$	B1	
	$7.5 \times g \times 12.5 = 0.5 \times 7.5 \times 8^2 + F \times 25$	M1	Attempt at work energy equation; 3 terms; dimensionally correct; allow sign errors.
	$F = 27.9$	A1	
	ALTERNATIVE FOR 2(b)		
	$8^2 = 0^2 + 2a \times 25 \Rightarrow a = 1.28$	B1	Finding the correct acceleration down the plane.
	$7.5g \times \frac{12.5}{25} - F = 7.5 \times a$	M1	Newton's second law parallel to the plane; allow sign errors and sin/cos mix on the weight component; dimensionally correct. Allow with their a , or just a .
	$F = 27.9$	A1	
		3	

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Question	Answer	Marks	Guidance
3	Resolving in any direction to get an equation	*M1	Allow sin/cos mix. only – or for $P^2 = 39^2 + 52^2$ or $\tan \theta = \frac{52}{39}$. (allow reciprocal for M mark).
	$P \cos \theta = 39$ $P \sin \theta = 52$	A1	Both correct – or for both $P^2 = 39^2 + 52^2$ and $\tan \theta = \frac{52}{39}$.
	$P = \sqrt{39^2 + 52^2}$ $\theta = \tan^{-1}\left(\frac{52}{39}\right)$	DM1	Attempt to solve for either P or θ from equations with the correct number of relevant terms. OE using sin/cos with P
	$P = 65$ $\theta = 53.1$	A1	Both correct; 53.13010...
		4	

Question	Answer	Marks	Guidance
4(a)		B1	Correct shape, starting at O and finishing on the t -axis.
		1	
4(b)	$t_1 = \frac{16}{a}$, $t_2 = \frac{64}{3a}$	*B1	Attempt at finding either the time for accelerating or for decelerating – must be in terms of a .
	$T = 240 - \left(\frac{16}{a} + \frac{64}{3a}\right)$	DB1	OE – allow un-simplified.
		2	

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Question	Answer	Marks	Guidance
4(c)	$3000 = \frac{1}{2} \times 16 \times (T + 240) \quad [T = 135]$	*M1	Use distance is area under the graph.
	$3000 = \frac{1}{2} \times 16 \times \left[240 + 240 - \left(\frac{16}{a} + \frac{64}{3a} \right) \right]$ $135 = 240 - \left(\frac{16}{a} + \frac{64}{3a} \right)$	DM1	Get an expression in terms of a ONLY using their T from part (b) and solve for a – their T must have come from an expression of the form $240 - \frac{k_1}{a} - \frac{k_2}{a}$ where k_1 and k_2 are positive constants. OE e.g. $3000 = 16 \times 240 - \frac{1}{2} \times 16 \times \frac{16}{a} - \frac{1}{2} \times 16 \times \frac{64}{3a}.$
	$a = \frac{16}{45}$	A1	Allow 0.356 or better.
		3	

Question	Answer	Marks	Guidance
5(a)	$s_A = 80T - \frac{1}{2}gT^2$ $s_B = 100(T - 1) - \frac{1}{2}g(T - 1)^2$	*M1	For use of $s = ut + \frac{1}{2}at^2$ at least once with $a = \pm g$ and $u = 80$ or 100 – allow t , T , $t \pm 1$, $T \pm 1$.
	Two correct expressions for the displacement of both particles at time T	A1	Allow t for T .
	$100(T - 1) - 5(T - 1)^2 = 80T - 5T^2$	DM1	Equate and attempt to solve for T or t – must not be using the same time for both expressions (so must be using the equivalent of T in one and $T \pm 1$ in the other).
	Leading to $T = 3.5$	A1	AG – no errors seen (but allow all working in terms of t).
		4	

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Question	Answer	Marks	Guidance
5(b)	$\left[s = 80 \times 3.5 - \frac{1}{2}g \times 3.5^2 \right] = 218.75\text{m}$	B1	OR $100 \times 2.5 - \frac{1}{2} \times 10 \times 2.5^2$.
		1	
5(c)	$v_A = 80 - g \times 3.5$ [= 45] $v_B = 100 - g \times 2.5$ [= 75]	*M1	For use of $v = u + at$ at least once to find the speed at collision with $a = \pm g$, $u = 80$ or 100 – with $t = 2.5$ or 3.5 only (but condone 2.5 with v_A and 3.5 with v_B).
	$45m + 75m = 2mv$	DM1	Use of conservation of momentum, 3 non-zero terms, allow sign errors. If total momentum before collision not correct then it must be clear where both terms came from.
	$v = 60$	A1	
	$-218.75 = 60t - \frac{1}{2}g \times t^2$	DM1	Complete method to find an equation in t using their v , their height from part (b) and $\pm g$ - dependent on both previous M marks.
	$t = 14.9 + 3.5 = 18.4\text{s}$	A1	
		5	

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Question	Answer	Marks	Guidance
6	Attempt at resolving perpendicular to the plane to get an equation	*M1	Correct number of relevant terms, allow sign errors, allow sin/cos mix, allow g missing. For reference $R = 1.2g \times \cos 16.26... + P \times \sin 16.26...$ - allow with an angle of 16 or better.
	$R = 1.2g \times \frac{24}{25} + P \times \frac{7}{25}$	A1	$R = 11.52 + 0.28P$ or $R = \frac{288}{25} + \frac{7}{25}P$.
	Attempt at resolving parallel to the plane to get an equation	*M1	Correct number of relevant terms, allow sign errors, allow sin/cos mix, allow g missing. For reference $F + P \times \cos 16.26... = 1.2g \times \sin 16.26...$ allow with an angle of 16 or better.
	$F + P \times \frac{24}{25} = 1.2g \times \frac{7}{25}$	A1	$F + 0.96P = 3.36$ or $F + \frac{24}{25}P = \frac{84}{25}$.
	Use of $F = 0.15R$ to get an equation in P only	DM1	Dependent on both previous M marks – where R is initially a linear combination of a P component and a weight component (or a mass component). $1.2g \times \frac{7}{25} - P \times \frac{24}{25} = 0.15 \times \left(1.2g \times \frac{24}{25} + P \times \frac{7}{25} \right)$.
	Solve to get $P = 1.63$	A1	Allow $\frac{272}{167}, 1.62874...$
		6	

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Question	Answer	Marks	Guidance
7(a)(i)	$\text{Power} = k \times 48^2 = 92160 \Rightarrow k = 40$	B1	AG
		1	
7(a)(ii)	$[DF =] \frac{92160}{45} [= 2048]$	B1	For any use of power = Fv e.g. $45 \times DF = 92160$.
	$2048 - 40 \times 45 = 1200a$	M1	Apply N2L using their $DF \neq 92160, 92.16, 1920$. 3 terms; allow sign errors. Dimensionally correct.
	$a = \frac{248}{1200} = \frac{31}{150} \text{ ms}^{-2}$	A1	Allow 0.207 or better.
		3	
7(b)	$DF = 40v + 1200g \times 0.15$	*M1	Two term expression for the driving force up the hill, allow sign errors and sin/cos mix – dimensionally correct.
	$\frac{92160}{v} = 40v + 1200g \times 0.15$	DM1	Set up an equation in v only – must be using $DF \times v = 92160$.
	$40v^2 + 1800v - 92160 [= 0]$	DM1	Attempt to solve their 3TQ in v – dependent on both previous M marks.
	$v = 30.5 \text{ ms}^{-1}$	A1	30.51179...
		4	

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Question	Answer	Marks	Guidance
8	$v = 0.3t^2 - 2.7t + c$ [$c = 4.2$]	*M1	Attempt to integrate a – increase power by 1 and a change in coefficient in at least one term (which must be the same term).
	$0.3t^2 - 2.7t + 4.2 [= 0]$	DM1	Set up 3TQ in t with correct constant term.
	$[(t - 2)(t - 7) = 0 \Rightarrow] t = 2, 7$	A1	Both correct values of t (method not required).
	Attempt to integrate v	DM1	Attempt to integrate v – increase power by 1 and a change in coefficient in at least one term (which must be the same term) – expression for v must be at least two terms (so may not include a constant term) so dependent on first M mark only.
	$s = 0.1t^3 - 1.35t^2 + 4.2t$ [$+c$]	A1	
	For use of their positive t limits in their cubic expression for s	M1	Dependent on all previous M marks. Using their two positive t values correctly in their three term cubic expressions for s (cubic must contain non-zero t^n terms where $n = 1, 2$ and 3).
	Total distance = 6.25 m	A1	For reference: $(0.1 \times 2^3 - 1.35 \times 2^2 + 4.2 \times 2)$ $- (0.1 \times 7^3 - 1.35 \times 7^2 + 4.2 \times 7)$ If integration of v not explicitly shown, then this can score max *M1 DM1 A1 then SC B1 for correct answer of 6.25 (so 4 marks max.).
		7	

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WWW	Without Wrong Working
AWRT	Answer Which Rounds To

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Question	Answer	Marks	Guidance
1(a)	Use of $v = u + at$ or use of acceleration is gradient of the line	M1	Use $v = 0$, $a = \pm \frac{5}{3}$ and $t = 10 - 4 [= 6]$. $0 = V - \frac{5}{3} \times (10 - 4)$ OR $\frac{0 - V}{10 - 4} = -\frac{5}{3}$ OR $\frac{V - 0}{4 - 0} = \frac{5}{2}$.
	$V = 10$	A1	Make sure that 10 comes from a correct initial equation or equivalent, if not then A0, e.g. $\frac{0 - V}{10 - 4} = \frac{5}{3}$ leading to $V = 10$ is M1A0.
		2	

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Question	Answer	Marks	Guidance
1(b)	Distance in first 10 seconds = $\frac{1}{2} \times 10 \times \text{their } V $	B1FT	SOI OE, e.g. $\frac{1}{2} \times 4 \times \text{their } V + \frac{1}{2} \times (10 - 4) \times \text{their } V $ If correct distance is 50 m.
	$\frac{1}{2} \times (T - 10) \times 3 + \frac{1}{2} \times 10 \times \text{their } V = 68$ OR $\frac{1}{2} \times (T - 10) \times 3 + \frac{1}{2} \times 4 \times \text{their } V + \frac{1}{2} \times (10 - 4) \times \text{their } V = 68$	M1	Use distance (68) is total area under graph. Their 50 must be from $5 \times \text{their } V $. Allow with -3. Allow $\frac{1}{2} \times X \times 3 + \frac{1}{2} \times 10 \times \text{their } V = 68$ and use of $T = X + 10$.
	$T = 22$	A1	WWW Be aware that $v = 10$ from wrong work in (a) can be awarded maximum of B1M1A0.
	Special Case for assumption of isosceles triangle for $t = 10$ to $t = T$:		
	Distance in first 10 seconds = $\frac{1}{2} \times 10 \times \text{their } V $	B1FT	SOI OE, e.g. $\frac{1}{2} \times 4 \times \text{their } V + \frac{1}{2} \times (10 - 4) \times \text{their } V $. If correct distance is 50 m.
	$\left[\frac{1}{2} \times \left(\frac{T - 10}{2} \right) \times 3 = \frac{1}{2} \times (68 - 50) \rightarrow \right] T = 22$	B1	WWW
	Special Case for assumption that particle returns to O:		
	$\left[\frac{1}{2} \times (T - 10) \times 3 = \frac{1}{2} \times 68 \rightarrow \right] T = \frac{98}{3}$ or 32.7	B1	32.66666. AWRT 32.7.
		3	

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Question	Answer	Marks	Guidance
2	Change in PE = $\pm 20g \sin 30 \times 2$ [= ± 200]	B1	
	$\pm \frac{1}{2} \times 20v^2$ [= $\pm 10v^2$] $\pm \frac{1}{2} \times 20 \times 5^2$ [= ± 250]	B1	For either expression. Do not allow $\frac{1}{2} \times 20(v-5)^2$.
	$\frac{1}{2} \times 20v^2 - \frac{1}{2} \times 20 \times 5^2 = 20g \sin 30 \times 2 - 50$ $[10v^2 - 250 = 200 - 50]$	M1	Attempt at work energy equation; 4 terms; dimensionally correct; allow sign errors; PE term must include a component (allow sin/cos mix). Do not allow with $\frac{1}{2} \times 20(v-5)^2$ for KE.
	Speed = 6.32 ms^{-1} OR $\sqrt{40} \text{ ms}^{-1}$	A1	OE, e.g. $2\sqrt{10}$. 6.324555.... AWRT 6.32.
	Special case for assumption of constant resistance force:		
	$20a = 20g \sin 30 - \frac{50}{2} \rightarrow a = 3.75$	B1	
	$v^2 = 5^2 + 2 \times 2 \times 3.75 \Rightarrow v = 6.32 \text{ ms}^{-1}$ OR $\sqrt{40} \text{ ms}^{-1}$	B1	OE, e.g. $2\sqrt{10}$. 6.324555... AWRT 6.32.
		4	

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Question	Answer	Marks	Guidance
3(a)	[Peddling force = $PF = \frac{250}{5}$	B1	For use of power = Fv e.g. $5 \times PF = 250$.
	<i>their</i> $PF - R = 90 \times 0.1$	M1	Using their $PF \neq 250$. 3 terms; allow sign errors. Dimensionally correct.
	Resistance = 41 N	A1	
		3	
3(b)	$\frac{250}{v} - \text{their } 41 - 90g \sin 2 = 0$	M1	For attempt at resolving up the hill; 3 terms; allow sign errors; Must be a component of weight (NOT mass) but allow sin/cos mix; allow use of <i>their</i> 41. Dimensionally correct. Oe eg $v = \frac{250}{\text{their } 41 + 90g \sin 2}$.
	Steady speed = 3.45 m s^{-1}	A1	3.45258... AWRT 3.45.
		2	

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Question	Answer	Marks	Guidance
4(a)	$T_{AB} \sin 45 = 0.2g \cos 45$ OR $\tan 45 = \frac{T_{AB}}{0.2g}$ OR $\tan 45 = \frac{0.2g}{T_{AB}}$ OR $T_{AB} = T_{AP} \cos 45$ and $T_{AP} \sin 45 = 0.2g$	*B1	BOD for using $\sin 45$ instead of $\cos 45$, particularly if using wrong components in (b) .
	$T_{AB} = 2 \text{ N}$	DB1	Condone $T_{AB} = 0.2g$ (with or without working) for full marks. WWW. DO NOT ISW.
	ALTERNATIVE for 4(a) using LAMI's THEOREM:		
	$\frac{T_{AB}}{\sin 135} = \frac{0.2g}{\sin 135}$	B1	
	$T_{AB} = 2 \text{ N}$	B1	Condone $T_{AB} = 0.2g$ (with or without working) for full marks. WWW. DO NOT ISW.
		2	

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Question	Answer	Marks	Guidance
4(b)	$T_{BQ} \cos \theta - \text{their } T_{AB} = 0$ $T_{BQ} \sin \theta - 0.1g = 0$	*M1	For resolving either horizontally OR vertically; 2 terms; allow sin/cos mix; allow their T_{AB} ; M0 for any use of $T_{AB} = T_{BQ} = T_{AP}$.
		A1FT	For both. FT their T_{AB} ONLY; $T_{AB} \neq T_{BQ}$. Sight of $(\text{their } T_{AB}) \tan \theta = 0.1g$ is M1 only without seeing an equation for T_{BQ} .
	$\theta = \tan^{-1} \left(\frac{0.1g}{\text{their } T_{AB}} \right)$ or $T_{BQ} = \sqrt{(0.1g)^2 + (\text{their } T_{AB})^2}$	DM1	Solve for θ or solve for T_{BQ} from equations with the correct number of relevant terms. Using their T_{AB} .
	$\theta = 26.6$ AND $T_{BQ} = \sqrt{5}$ or 2.24	A1	$\theta = 26.56505 \dots$ $T_{BQ} = 2.236067 \dots$ AWRT 26.6 and 2.24.
	FIRST ALTERNATIVE for 4(b):		
	$T_{BQ} = (\text{their } T_{AB}) \cos \theta + 0.1g \sin \theta$ $(\text{their } T_{AB}) \sin \theta = 0.1g \cos \theta$	M1	For resolving either parallel to BQ or perpendicular to BQ; 2 terms; allow sign errors on 3 term equation only; allow sin/cos mix; allow their T_{AB} . Sight of $(\text{their } T_{AB}) \tan \theta = 0.1g$ is M1 only without seeing an equation for T_{BQ} . M0 for any use of $T_{AB} = T_{BQ} = T_{AP}$.
		A1FT	For both. FT their T_{AB} ONLY; $T_{AB} \neq T_{BQ}$.
	$\theta = \tan^{-1} \left(\frac{0.1g}{(\text{their } T_{AB})} \right)$	DM1	Solve for θ (or solve for T_{BQ}) from equations with the correct number of relevant terms. Using their T_{AB} .

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Question	Answer	Marks	Guidance
4(b)	$\theta = 26.6$ AND $T_{BQ} = \sqrt{5}$ or 2.24	A1	$\theta = 26.56505\dots$ $T_{BQ} = 2.236067\dots$ AWRT 26.6 and 2.24.
	SECOND ALTERNATIVE for 4(b) using triangle of forces:		
	$T_{BQ}^2 = (0.1g)^2 + (their T_{AB})^2$ OR $0.1g = T_{BQ} \sin(\theta)$ OR $(their T_{AB}) = T_{BQ} \cos(\theta)$	M1	Using their T_{AB} ONLY; M0 for any use of $T_{AB} = T_{BQ} = T_{AP}$.
		A1FT	For any 2 equations. FT their T_{AB} ONLY; $T_{AB} \neq T_{BQ}$. Sight of $(their T_{AB}) \tan \theta = 0.1g$ is M1 only without seeing an equation for T_{BQ} .
	Solve for T_{BQ} or θ E.g. $T_{BQ} = \sqrt{(0.1g)^2 + (their T_{AB})^2}$ $\theta = \tan^{-1}\left(\frac{0.1g}{their T_{AB}}\right)$	DM1	Solve for θ or solve for T_{BQ} from equations with the correct number of relevant terms. Using their T_{AB} .
	$\theta = 26.6$ AND $T_{BQ} = \sqrt{5}$ or 2.24	A1	$\theta = 26.56505\dots$ $T_{BQ} = 2.236067\dots$ AWRT 26.6 and 2.24.
	THIRD ALTERNATIVE for 4(b) using LAMI's THEOREM:		
		*M1	For any 2 fractions correct; M0 for any use of $T_{AB} = T_{BQ} = T_{AP}$.

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Question	Answer	Marks	Guidance
	$\frac{T_{BQ}}{\sin 90} = \frac{0.1g}{\sin(180 - \theta)} = \frac{\text{their } T_{AB}}{\sin(90 + \theta)}$ OR $\frac{T_{BQ}}{\sin 90} = \frac{0.1g}{\sin \theta} = \frac{\text{their } T_{AB}}{\cos \theta}$	A1FT	For all 3 fractions correct. FT their T_{AB} ONLY. Sight of $(\text{their } T_{AB}) \tan \theta = 0.1g$ is M1 only without seeing an equation for T_{BQ} .
4(b)	$\theta = \tan^{-1} \left(\frac{0.1g}{\text{their } T_{AB}} \right)$	DM1	Solve for θ .
	$\theta = 26.6$ AND $T_{BQ} = \sqrt{5}$ or 2.24	A1	$\theta = 26.56505 \dots$ $T_{BQ} = 2.236067 \dots$ AWRT 26.6 and 2.24.
	FOURTH ALTERNATIVE for 4(b) for resolving on the whole system:		
	$T_{BQ} \sin \theta + (\text{their } T_{AP}) \sin 45 = 0.2g + 0.1g$ $T_{BQ} \cos \theta = (\text{their } T_{AP}) \cos 45$	M1 A1FT	For resolving either horizontally or vertically on the whole system; using $\text{their } T_{AP}$. M0 for any use of $T_{AB} = T_{BQ} = T_{AP}$. If T_{AP} not found in part (a), must have either $T_{AP} \sin 45 = 0.2g$ or $(\text{their } T_{AB}) = T_{AP} \cos 45$. Correct number of terms; allow sign errors on the 4 term equation ONLY; allow sin/cos mix. Both equations correct. May see $T_{BQ} \sin \theta = 1$ and $T_{BQ} \cos \theta = 2$. Sight of $(\text{their } T_{AB}) \tan \theta = 0.1g$ is M1 only without seeing an equation for T_{BQ} .

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Question	Answer	Marks	Guidance
	$\theta = \tan^{-1} \left(\frac{0.1g + 0.2g - (their\ T_{AP}) \sin 45}{(their\ T_{AP}) \cos 45} \right)$ or $T_{BQ} = \sqrt{(0.1g + 0.2g - (their\ T_{AP}) \sin 45)^2 + ((their\ T_{AP}) \cos 45)^2}$	DM1	Solve for θ or solve for T_{BQ} from equations with the correct number of relevant terms. Using their T_{AP} .
	$\theta = 26.6$ AND $T_{BQ} = \sqrt{5}$ or 2.24	A1	$\theta = 26.56505\dots$ $T_{BQ} = 2.236067\dots$ AWRT 26.6 and 2.24.
		4	

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Question	Answer	Marks	Guidance
5(a)	$[s_p \text{ up}] = \pm \left(2t - \frac{1}{2}gt^2 \right)$ OR $[s_Q \text{ down}] = \pm \frac{1}{2}gt^2$	M1	For use of $s = ut + \frac{1}{2}at^2$ at least once with $a = \pm g$ and $u = 0$ or $u = \pm 2$. Seen anywhere.
	$2t - \frac{1}{2}gt^2 + \frac{1}{2}gt^2 = 2 - 1 \left[\Rightarrow t = \frac{1}{2} \right]$	M1	Use $s_p + s_Q = \pm(2 - 1)$ OR ± 1 ONLY with s_p and s_Q of the correct form
	$v_p = 2 - \frac{1}{2}g = -3 \text{ ms}^{-1}$ so speed = 3 ms^{-1}	A1	Must be positive.
	$v_Q = -\frac{1}{2}g = -5 \text{ ms}^{-1}$ so speed = 5 ms^{-1}	A1	Must be positive. If A0A0 , allow SCB1 if both are negative
		4	

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Question	Answer	Marks	Guidance
5(b)	$2m \times (\text{their } 3[v_p]) + m \times (\text{their } 5[v_Q]) = 2mv + m \times 3.5$	*M1	Use of conservation of momentum; 4 non- zero terms; using <i>their</i> $\pm 3 \text{ ms}^{-1}$ and <i>their</i> $\pm 5 \text{ ms}^{-1}$; allow sign errors and m missing ONLY. Do not allow with $v_p = \pm 2$ or with $v_Q = 0$. Do not allow made up values for 3 and 5. Allow LHS of our equation to have only one term but only if getting $v_p = 0$ in (a) from $s_p = s_Q$.
	$v = 3.75$	A1	Allow $v = -3.75$ from correct work.
	$\left[At t = \frac{1}{2}, s_p = \right] \pm \left(2 \times \frac{1}{2} - \frac{1}{2} g \left(\frac{1}{2} \right)^2 \right) \left[= \mp \frac{1}{4} \right]$ $\text{OR } \left[s_p = \right] \pm \left(-3 \times \frac{1}{2} + \frac{1}{2} g \left(\frac{1}{2} \right)^2 \right) \left[= \mp \frac{1}{4} \right]$ $\text{OR } \left[s_p = \right] \pm \left(\frac{(-3)^2 - 2^2}{2g} \right) \left[= \pm \frac{1}{4} \right]$ $\text{OR } \left[At t = \frac{1}{2}, s_Q = \right] \pm \frac{1}{2} g \left(\frac{1}{2} \right)^2 \left[= \pm \frac{5}{4} \right]$ $\text{OR } \left[At t = \frac{1}{2}, s_Q = \right] \pm \left(5 \times \frac{1}{2} - \frac{1}{2} g \left(\frac{1}{2} \right)^2 \right) \left[= \pm \frac{5}{4} \right]$ $\text{OR } \left[s_Q = \right] \pm \left(\frac{5^2 - 0^2}{2g} \right) \left[= \pm \frac{5}{4} \right]$ $\left[\text{so height above ground} = \frac{3}{4} \right]$	*B1	This may be seen in part (a) , but do not award the mark until stated/used in part (b) .

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Question	Answer	Marks	Guidance
5(b)	$v^2 = (\text{their } 3.75)^2 + 2 \times (\pm g) \times \left(\pm \frac{3}{4} \right)$ OR $0^2 = (\text{their } 3.75)^2 - 2 \times (\pm g) \times s \Rightarrow s = \frac{45}{64}$ AND $v^2 = \left[0^2 + \right] 2 \times (\pm g) \times \left[\left(\frac{3}{4} \right) + \frac{45}{64} \right]$	DM1	Use of $v^2 = u^2 + 2as$ using their v and $a = \pm g$; <i>their</i> s is either $\pm \left[1 + \left(-\frac{1}{4} \right) \right]$ or $\pm \left[2 - \frac{5}{4} \right]$ OE. Dependent on the previous M mark and B mark being awarded.
	$v = 5.39 \text{ ms}^{-1}$	A1	Or $\frac{\sqrt{465}}{4}$; AWR 5.39; 5.390964...
		5	

Question	Answer	Marks	Guidance
6(a)	Attempt to integrate a for $0 \leq t \leq 1$	M1	Increase power by 1 and a change in coefficient in at least one term (which must be the same term); $v = at$ is M0. Expect $(v =) -t^{\frac{3}{2}} [+c]$.
	$(v =) -\frac{1.5}{1.5} t^{\frac{3}{2}} + 6 = -t^{\frac{3}{2}} + 6$	A1	Allow for $-t^{\frac{3}{2}} + c$ and $c = 6$ seen from CWO. Allow unsimplified.
	Velocity at $t = 1$ is 5 ms^{-1}	A1	CWO.
		3	

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Question	Answer	Marks	Guidance
6(b)	Attempt to integrate a for $t > 1$ $\left[(v =) \frac{1.5}{3/2} t^{\frac{3}{2}} - \frac{3}{1/2} t^{\frac{1}{2}} [+ c] = t^{\frac{3}{2}} - 6t^{\frac{1}{2}} [+ c] \right]$	*M1	Increase power by 1 and a change in coefficient in at least one term (which must be the same term); $v = at$ is M0.
	Use $v = \text{their } 5$ when $t = 1$ in attempt to find c $[5 = 1 - 6 + c]$	DM1	Must get a numerical expression for c ; if no substitution seen, c must be correct for their expression for v . Their 5 must not be a made up value.
	$(v =) t^{\frac{3}{2}} - 6t^{\frac{1}{2}} + 10$	A1	OE, but must be a complete (possibly unsimplified) expression.
		3	

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Question	Answer	Marks	Guidance
6(c)	For attempt at integration of <i>their</i> v for either section	*M1	Increase power by 1 and a change in coefficient in at least one term (which must be the same term); Their v 's have to come from integration. $s = vt$ is M0. Their v 's have to come from integration.
	$(s_1 =) -\frac{1}{5/2}t^{\frac{5}{2}} + 6t[+c] = -\frac{2}{5}t^{\frac{5}{2}} + 6t[+c]$ $(s_2 =) \frac{1}{5/2}t^{\frac{5}{2}} - \frac{6}{3/2}t^{\frac{3}{2}} + 10t[+c] = \frac{2}{5}t^{\frac{5}{2}} - 4t^{\frac{3}{2}} + 10t[+c]$	A1	For either correct. Allow unsimplified.
	For use of limits 0 and 1 for s_1 and 1 and 4 for s_2	DM1	Using correct limits correctly, in expressions that have come from integration (where all powers must have increased by 1 with a change in coefficient for non-linear terms) of a v that came from integration, and using the limits correctly would lead to 2 positive values when used in their expressions. s_1 and s_2 must have the correct number of non-constant terms and must include a linear term.
	Total distance = 20m	A1	$s_1 = \left(-\frac{2}{5} \times 1 + 6 \times 1 \right) - 0 \left[= \frac{28}{5} = 5.6 \right] .$ $s_2 = \left(\frac{2}{5} \times 4^{\frac{5}{2}} - 4 \times 4^{\frac{3}{2}} + 10 \times 4 \right) -$ $\left(\frac{2}{5} \times 1^{\frac{5}{2}} - 4 \times 1^{\frac{3}{2}} + 10 \times 1 \right) \left[= \frac{72}{5} = 14.4 \right] .$ If either displacement expression has a constant of integration and is given incorrectly, then award A0 even if 20 m seen. For reference the constant of integration for s_2 is -0.8.

Question	Answer	Marks	Guidance
6(c)	SC for integration not seen:		
	$s_1 = \frac{28}{5}$ or $s_2 = \frac{72}{5}$	B1	
	Total distance = 20m	B1	
		4	

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Question	Answer	Marks	Guidance
7(a)	$R = 0.2g \times 0.8 [=1.6]$	B1	Allow $\cos 37$ or better for 0.8.
	$F = 1.125R [=1.8]$	*M1	Where R is a component of weight. Must have $1.125 \times 0.2g \times 0.8$ or $1.125 \times 0.2g \times 0.6$ or with using $\cos 37$ or $\sin 37$ or better for 0.8 and 0.6 respectively. These 2 marks may be embedded in the N2L equation(s).
	Use of Newton's second law for A or B or system	*M1	Correct number of terms; allow sign errors; allow sin/cos mix. Dimensionally correct.
	$0.3g - T = 0.3a$ $T + 0.2g \times 0.6 - F = 0.2a$ $0.3g + 0.2g \times 0.6 - F = 0.5a$	A1	For any 2 correct equations. Allow $\sin 37$ or better for 0.6. Allow their possibly incorrect F .
	$a = 4.8 \text{ m s}^{-2}$	A1	Must be positive.
	For attempt to solve for T	DM1	From equations with the correct number of relevant terms. If a found first then substituting into an equation with the correct number of relevant terms and solving. If resolved equations incorrect and no working seen, then this mark is implied by the correct T value for their equations. Dependent on previous 2 M marks
	$T = 1.56 \text{ N}$	A1	
		7	

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Question	Answer	Marks	Guidance
7(b)	[For B or A] $v^2 = 0^2 + 2 \times 4.8 \times 0.25$ $\left[\Rightarrow v^2 = 2.4 \text{ or } v = \frac{2\sqrt{15}}{5} = 1.549\dots \right]$	*M1	Use of $v^2 = u^2 + 2as$ with $u = 0$ and using $s = 0.25$, $ their\ 4.8 $, $a \neq \pm g$. Must be a complete method to get an expression for v or v^2 .
	Attempt at Newton's 2nd Law on A when string becomes slack $[0.2g \times 0.6 - 1.125 \times 0.2g \times 0.8 = 0.2a]$	*M1	3 terms; allow sign errors; allow sin/cos mix; allow their non-zero F from part (a); Dimensionally correct; must be using 0.2 for the mass. Allow $\theta = 37$ or better. For reference $a = -3$ (or -2.99 if using $\theta = 36.9$).
	$0^2 = 2.4 + 2 \times (-3) \times s [\Rightarrow s = 0.4]$	DM1	Using constant acceleration formula(e) using a negative acceleration to get an expression in s only. Dependent on previous 2 M marks.
	Total distance = $0.25 + 0.4 = 0.65\text{ m}$	A1	AWRT 0.650. Allow 0.651 from use of $\theta = 36.9$.
	ALTERNATIVE for 7(b) using energy:		
	[For B or A] $v^2 = 0^2 + 2 \times 4.8 \times 0.25$ $\left[\Rightarrow v^2 = 2.4 \text{ or } v = \frac{2\sqrt{15}}{5} = 1.549\dots \right]$	*M1	Use of $v^2 = u^2 + 2as$ with $u = 0$. Using $s = 0.25$, $ their\ 4.8 $, $a \neq \pm g$. Must be a complete method to get an expression for v or v^2 .
	For attempt at work energy equation	DM1	3 terms; dimensionally correct; allow sin/cos mix in PE term and work done against Friction term; allow sign errors; allow their non-zero F from part (a).

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Question	Answer	Marks	Guidance
7(b)	$\frac{1}{2} \times 0.2 \times 2.4 + 0.2g \times 0.6 \times d - 1.125 \times 0.2g \times 0.8 \times d = 0$ $[\Rightarrow d = 0.4\text{m}]$	A1	For correct equation in d only; must be using 0.2 for the mass. Allow $\theta = 37$ or better.
	Total distance = $0.25 + 0.4 = 0.65\text{m}$	A1	AWRT 0.650. Allow 0.651 from use of $\theta = 36.9$.
		4	

Cambridge International AS & A Level

MATHEMATICS**9709/43**

Paper 4 Mechanics

October/November 2024**MARK SCHEME**Maximum Mark: 50

Published

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

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

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

Cambridge International is publishing the mark schemes for the October/November 2024 series for most Cambridge IGCSE, Cambridge International A and AS Level components, and some Cambridge O Level components.

This document consists of **19** 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 descriptions for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

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

GENERIC MARKING PRINCIPLE 2:

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

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

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

GENERIC MARKING PRINCIPLE 4:

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

GENERIC MARKING PRINCIPLE 5:

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

GENERIC MARKING PRINCIPLE 6:

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

PUBLISHED**Mathematics-Specific Marking Principles**

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

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	$\text{KE}_{\text{before}} = \frac{1}{2} \times m \times 5^2$ $\text{KE}_{\text{after}} = \frac{1}{2} \times m \times 6^2$	B1	For either correct. Do not allow $\frac{1}{2} \times m \times (6-5)^2$. Note: Difference = $\frac{1}{2} \times m \times 11$.
	WD against resistance $= 50 \times 24 \quad [=1200]$	B1	Do not allow if errors such as e.g. $(m-24) \times 50$.
	$\frac{1}{2} \times m \times (6^2 - 5^2) + 50 \times 24 = 1541$ $5.5m = 1541 - 1200$	M1	Attempt at work energy equation with 4 relevant terms; dimensionally correct. Allow sign errors. M0 for $\frac{1}{2} \times m \times (6-5)^2$.
	$m = \frac{341}{5.5} = 62$	A1	
	SC for constant acceleration method (question only gives total work done, and does not suggest constant force)		
	$a = 0.11$	SCB1	From $6^2 = 5^2 + 2 \times a \times 50$ SOI.
	$m = 62$	SCB1	From $\frac{1541}{50} - 24 = m \times 0.11$ or $30.82 - 24 = m \times 0.11$.
		4	

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Question	Answer	Marks	Guidance
2	Resolving either direction	M1	With correct number of relevant terms. Allow sin/cos mix. Allow sign errors. Do not allow ‘forces to the left = forces to the right’ e.g. $12\cos 30 - 8\sin 30 = 16\sin 30$ unless subsequently ‘corrected’.
	$\pm(12\sin 30 + 24 + 8\cos 30 - 16\cos 30)[= F_x \text{ or } F \cos \theta \text{ or } F \sin \alpha]$	A1	$F_x = \pm(30 - 4\sqrt{3}) \quad [= 23.07\dots]$
	$\pm(12\cos 30 - 8\sin 30 - 16\sin 30)[= F_y \text{ or } F \sin \theta \text{ or } F \cos \alpha]$	A1	$F_y = \pm(6\sqrt{3} - 12) \quad [= -1.607\dots]$
	$F = \sqrt{(6\sqrt{3} - 12)^2 + (30 - 4\sqrt{3})^2}$ $F = \frac{30 - 4\sqrt{3}}{\cos(\text{their } \theta)}$ $F = \frac{6\sqrt{3} - 12}{\sin(\text{their } \theta)}$	M1	Attempt to find F. Must have correct number of relevant terms. (Forces must have or not have components as required). All forces resolved/not resolved as appropriate, but allow consistent sin/cos muddle. Allow use of their θ provided correctly derived from equations with the correct number of relevant terms.
	$\theta = \tan^{-1}\left(\frac{6\sqrt{3} - 12}{30 - 4\sqrt{3}}\right)$ $\theta = \cos^{-1}\left(\frac{30 - 4\sqrt{3}}{\text{their } F}\right)$ Note: this will not give the correct answer unless F given to several significant figures $\theta = \sin^{-1}\left(\frac{6\sqrt{3} - 12}{\text{their } F}\right)$	M1	Attempt to find θ. Must have correct number of relevant terms. (Forces must have or not have components as required). All forces resolved/not resolved as appropriate, but allow consistent sin/cos muddle. Allow upside down so $\tan^{-1}\left(\frac{30 - 4\sqrt{3}}{6\sqrt{3} - 12}\right)$. Allow use of their F provided correctly derived from equations with the correct number of relevant terms. Note: watch for use of $\sin^{-1}\left(\frac{6\sqrt{3} - 12}{30 - 4\sqrt{3}}\right)$ or $\sin^{-1}\left(\frac{1.607}{23.07}\right)$ which leads to correct answer of angle 4.0° scores M0A0.

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Question	Answer	Marks	Guidance
2	$F = 23.1 \text{ N}$ $\theta = 3.99^\circ$ above the negative x-axis oe	A1	[23.1277...] Both correct Allow 4.0° but not simply 4° . [3.986...] Allow answers about the direction such as ‘Above the west’, ‘north of west’ etc, or clockwise 183.99 from x axis, or resultant sketch with angle indicated. If not specified in working please check original diagram to see if direction specified there instead. Allow a bearing of 274.0° . Allow explanation of direction that could be drawn uniquely. Or e.g. 86.0° to left of the y -axis or 176.0° from the positive x -axis.
		6	

Question	Answer	Marks	Guidance
3(a)	Resolving up slope. If correct should see $DF = 240 + 1600g \times 0.08 \quad [= 240 + 1280 = 1520]$	M1	Must have correct number of relevant terms (weight component and 240 N resistance). Allow sign errors. Allow $\cos 4.58$ or $\cos 4.6$. Do not allow g missing. Using $\sin^{-1} 0.08$ or $\sin 0.08$ scores M0B0A0. Must have either 0.08 or $\sin 4.58\dots$ or $\sin 4.6$, not just $\sin \theta$.
	$\text{Power} = \text{their}(1520) \times 32$	B1	OE. E.g. $\frac{\text{Power}}{32} = \text{their} 1520$. Allow any driving force provided it has a resistance and a weight component.
	$\text{Power} = 48640 \text{ W}$	A1	Allow $48\,600 \text{ W}$ or 48.64 kW or 48.6 kW . Must state units if given in kW.
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Question	Answer	Marks	Guidance
3(b)	$DF = \frac{0.95 \times \text{their } 48640}{24}$ or $\frac{46208}{24} = \frac{5776}{3}$ or 1925.3...	B1FT	$DF = \frac{\text{Power}}{v}$ oe e.g. $0.95 \times \text{their } 48640 = DF \times 24$ FT their power from part (a) Do not allow if not using power from part (a) Note: candidates who use $\sin 0.08$ in part (a) should get a DF of 332.3 N, which can score B1FT and use of $\sin^{-1} 0.08$ should get a DF of 93299 N, can score B1FT. If candidate uses 48600 $DF = \frac{46170}{24} = 1923.75$ Candidates who omit the weight component in part (a) should get a DF of 304 N, and can score B1FT
	$\text{their } DF - 240 - 1600g \times 0.08 = 1600a$	M1	N2L Must have correct number of relevant terms (weight component and 240 N resistance). Allow sign errors. Must be dimensionally correct. Allow without using 95% or with using 5%. Must have either 0.08 or $\sin 4.58...$ or $\sin 4.6$, not just $\sin \theta$ or $\sin^{-1} 0.08$ or $\sin 0.08$.
	$a = 0.253 \text{ ms}^{-2}$	A1	Allow $\frac{19}{75}$ Note: 0.25 scores A0. If candidate uses 48600 they <u>must</u> get 0.252(34...) rather than 0.253.
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Question	Answer	Marks	Guidance
4	For attempt at use of conservation of momentum.	*M1	Must have three non-zero terms. Allow sign errors. Must have correct masses with relevant velocities. Their v may be in the opposite direction. If g included with the masses: Allow M1A0A1 for first three marks. Can then score M1M0A0 for final three marks.
	$3 \times 8 = 3 \times 2 + 6v$ Or $3 \times 8 = -3 \times 2 + 6v$	A1	
	$v = 3$ [$v = 5$]	A1	Allow finding only $v = 3$, but if both speeds found they must both be correct
	KE_{after} $= 0.5 \times 3 \times 2^2 + 0.5 \times 6 \times \text{their } v_B^2$ [= 33] if correct	DM1	Allow use of any v_B even if < 0 Using speed of 5, $KE_{after} = 0.5 \times 3 \times 2^2 + 0.5 \times 6 \times \text{their } 5^2$ [= 81] Candidates may work out the loss for each particle separately which only scores DM1 when losses subsequently added together.
	$KE_{loss} = \pm (0.5 \times 3 \times 8^2 - (0.5 \times 3 \times 2^2 + 0.5 \times 6 \times \text{their } 3^2))$ [= 96 – 33] if correct	DM1	If two speeds found then FT their lower speed, even if later choose the wrong loss. If only one speed found then FT their speed. If the candidate thinks that the particles coalesce then score M0 here
	Loss = 63 [J]	A1	If both losses found, must state which is the greater. Only award this mark if no errors – e.g. the KE loss for $v = 5$ should be 15 J. If wrong then A0. Allow –63 [J]. Can score full marks even if only $v = 3$ is found.
		6	

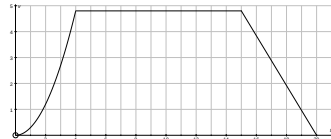
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Question	Answer	Marks	Guidance
5(a)	Attempt at resolving in at least one direction	*M1	Correct number of relevant terms with T resolved; allow sign errors; allow sin/cos mix. Can score M1 for any $F = T \cos 30^\circ$. Do not allow g missing in the equation for R . Must have 12, not just m . Could see R as part of an equation for F . E.g. $F = 0.5(12g - T \sin 30^\circ)$.
	$R + T \sin 30^\circ = 12g$ $F = T \cos 30^\circ$	A1	Both correct.
	Use of $F = 0.5R$ to form an equation in T or R only	*DM1	Allow sign errors in R ; allow consistent sin/cos mix in R but no other errors. Must be two term R as a linear combination of weight and a component of T , and F must be a single term which is a component of T . Do not allow g missing. If correct $T \cos 30^\circ = 0.5(12g - T \sin 30^\circ)$ or $\frac{\sqrt{3}}{2}T = 60 - 0.25T$. If no working shown to eliminate T or R , then DM2 for getting T value correct for their equations and A1 if fully correct. Could use $0.5R = T \cos 30^\circ$ and solve simultaneously.
	Attempt to solve for T	DM1	Allow consistent sin/cos mix and allow sign errors. Must get to ' $T =$ '. Dependent on both previous M1s.
	$T = 53.8 \text{ N}$	A1	[53.7622...] Note: For sign errors: $R - T \sin 30^\circ = 12g$ answer should be 97.3985... $R - T \sin 30^\circ = -12g$ answer should be -97.3985... $R + T \sin 30^\circ = -12g$ answer should be -53.7622..... Each of the above would usually get M1A0M1M1A0.
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Question	Answer	Marks	Guidance
5(b)	$T \cos 30 - F = 12 \times 0.2$	*M1	Attempt at N2L; correct number of relevant terms with T resolved; allow sign errors; allow sin/cos mix, but can be F or any reasonable attempt at friction.
	Use of $F = 0.5R$ to form an equation in T and solve	DM1	Must be a two term R as a linear combination of weight and a component of T . Allow sign errors and consistent sin/cos mix. Must get to ' $T =$ '. The equations if correct should be $T \cos 30 - 0.5(120 - T \sin 30) = 12 \times 0.2$ or $\frac{\sqrt{3}}{2}T - 60 + 0.25T = 2.4$ or $T \left(\frac{\sqrt{3}}{2} + 0.25 \right) = 62.4$ and these must be solved. Any use of T or R from part (a) scores DM0 here.
	$T = 55.9 \text{ N}$	A1	$T = 55.9127 \dots$ Note: For sign errors: $R - T \sin 30 = 12g$ answer should be 101.294... $R - T \sin 30 = -12g$ answer should be -93.5026... $R + T \sin 30 = -12g$ answer should be -51.6117... Each of the above would usually get M1M1A0.
		3	

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Question	Answer	Marks	Guidance
6(a)	$v = \int 0.6t \, dt = \frac{0.6}{2}t^2 [=0.3t^2] [+0]$ $[t = 4] \quad V = 0.3 \times 4^2 \text{ or } 0.3 \times 16 = 4.8$	B1	AG Must see $\frac{0.6}{2}t^2$ or $0.3t^2$ and 4 must be actually shown substituted. Merely stating $t = 4$ is not enough to score this mark. Do not allow use of $s = ut + \frac{1}{2}at^2$ which leads to 4.8 if $a = 0.6$ is used.
		1	
6(b)	Quadratic with correct curvature starting from (0, 0) to (4, 4.8).	B1	 Note: the grid is for reference – not shown in QP. Their graph does not need to be to scale.
	Horizontal line at from (4, 4.8) to (15, 4.8)	B1	The points should be specified somehow, but for an accurate sketch allow a line just below 5 without specifying 4.8.
	Line from (15, 4.8) to (20, 0)	B1	The points should be specified somehow, but for an accurate sketch allow a line just below 5 without specifying 4.8. Allow all 3 marks if using V instead of 4.8. ISW any extra out of the range for t of 0 to 20. If no marks scored then SC B1 for a correct shaped graph with no numbers. If using a value of $v \neq 4.8$, allow SC B1 for the first section correct and SC B1 for the second and third both correct.
		3	

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Question	Answer	Marks	Guidance
6(c)	Attempt to find acceleration	M1	For calculation $\frac{0-4.8}{20-15}$ oe $[-0.96]$ Allow $+0.96$.
	$[v=]19.2-0.96t$	A1	Oe e.g. Allow $[v=]4.8-0.96(t-15)$.
		2	
6(d)	$\left[\int_0^4 0.3t^2 dt\right] \frac{0.3}{3}t^3 [=0.1t^3]$	*M1	Attempt to integrate their v from part (a) provided this came from integration, but allow a restart here. The power of t must increase by 1 with a change of coefficient. Use of $s=vt$ scores M0. No need for limits. If no integration seen allow SCM1 for answer of 6.4 in place of M1M1.
	$0.1 \times 4^3 [-0.1 \times 0^3]$	DM1	Correct use of correct limit(s) (expect 6.4).
	$4.8 \times 11 + 0.5 \times 4.8 \times 5$ $[=52.8 + 12 = 64.8]$	B1	Both correct and added. May be done in one go using a trapezium $\frac{(11+16) \times 4.8}{2}$. Could do the last stage by integration. Maximum B1 for final answer 74.4 from thinking the first section is also straight.
	Distance = 71.2 m	A1	
		4	

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Question	Answer	Marks	Guidance
7(a)	$T - 3g = \pm 3a$ $5g - T = \pm 5a$ $5g - 3g = \pm(3+5)a$	*B1	For one correct equation.
		*B1	For any two correct consistent equations. If tensions T_A and T_B both stated must at some point state or imply that they are equal to score the second B1.
	Attempt to solve for T	DM1	May find a first [$a = 2.5$] Must get to ' $T =$ '. Dep on both B marks.
	$T = 37.5\text{ N}$ or $\frac{75}{2}\text{ N}$	A1	Allow without working.
	Correct use of suvat with <i>their</i> a and solve for t	DM1	E.g. $2 = 0.5 \times 2.5 \times t^2$ Must get to ' $t =$ '. Dep on both B marks or the B1 for the equation $5g - 3g = \pm(3+5)a$ if this used to find a , but not on first M1 mark. Could find $v = \sqrt{10}$ then use $2 = \frac{0 + \text{their} \sqrt{10}}{2} t$.
	$t = 1.26$ or $\frac{\sqrt{40}}{5}$ or $\frac{2\sqrt{10}}{5}$	A1	$t = 1.2649\dots$ If candidates do not try to find T but do attempt to find the time, they can score B1B1M0A0M1A1. Do not allow if also give negative answer and do not discard. Note: $t = \sqrt{1.6}$ only, scores A0.

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Question	Answer	Marks	Guidance
7(a)	Alternative for final 2 marks, even if nothing scored earlier		
	Use of energy to find velocity at plane and then suvat to find t	M1	PE loss = KE gain: $5g \times 2 - 3g \times 2 = \frac{1}{2} \times 5v^2 + \frac{1}{2} \times 3v^2$, Or PE loss – WD by tension = KE gain: $5g \times 2 - \text{their } 37.5 \times 2 = \frac{1}{2} \times 5v^2$, Or WD by tension – PE gain = KE gain: $\text{their } 37.5 \times 2 - 3g \times 2 = \frac{1}{2} \times 3v^2$, $v = \sqrt{10}$ or $v = 3.16$ then $2 = \frac{0+v}{2}t$, Dependent on both B marks only if candidate uses tension, but otherwise not dependent on either B mark.
	$t [= \sqrt{1.6}] = 1.26$ or $\frac{\sqrt{40}}{5}$ or $\frac{2\sqrt{10}}{5}$	A1	$t = 1.2649\dots$
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Question	Answer	Marks	Guidance
7(b)	Correct use of suvat before B hits the plane or when A has risen 2 m, to attempt to find velocity of A when string becomes slack Using <i>their a</i> and/or <i>their t</i> .	*M1	$v^2 = 0 + 2 \times 2.5 \times 2$. Must use $s = 2$ and $u = 0$, OR $v = 0 + 2.5 \times \sqrt{1.6}$ Must use $u = 0$, OR $2 = \frac{1}{2}(0 + v)\sqrt{1.6}$ Must use $s = 2$ and $u = 0$. Must be complete method to find v or v^2 $\left[v = \sqrt{10} \right]$. Could have found $v = \sqrt{10}$ in part (a) and give M1 if used in part (b).
	Correct use of suvat for motion of A (between height of 3m and 3.25 m), to form an equation in t , using $a = -g$	*DM1	$3.25 - 3 = (\text{their } \sqrt{10})t + 0.5 \times (-10) \times t^2$.
	Solving a 3 term quadratic for t to get at least one (unsimplified) value using their 2.5 (or using any other correct method)	DM1	If correct should get $t = 0.093, 0.540$ or $\frac{\sqrt{10} - \sqrt{5}}{10}, \frac{\sqrt{10} + \sqrt{5}}{10}$, 0.09262... or 0.53978... Could use formula and realise that the time for at least 3.25 m, $= 2 \frac{\sqrt{b^2 - 4ac}}{2a} = 2 \frac{\sqrt{10 - 4 \times 5 \times 0.25}}{2 \times 5}$ which gets DM1.
	Time = 0.447 s or $\frac{\sqrt{5}}{5}$ s or $\frac{1}{\sqrt{5}}$	A1	Time = 0.53978... – 0.09262... = 0.44721... $2 \left(\frac{\sqrt{10}}{10} - \frac{\sqrt{10} - \sqrt{5}}{10} \right) = 0.44721...$

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Question	Answer	Marks	Guidance
7(b)	Alternative for last 3 marks of Q7(b) finding max height		
	For attempt to find max height using correct suvat with $a = -g$	*DM1	$0^2 = (\text{their } \sqrt{10})^2 + 2 \times (-10)s$ Where s is distance above 3 metres. (which leads to a maximum height of 3.5 m).
	For attempt to find time from .25 m below top to top	DM1	$t = \pm 0.224$ or $\frac{\sqrt{5}}{10}$ [0.22360....] probably from $[3.5 - 3.25 = 0t + 0.5 \times 10t^2]$. Dep on both previous M1s.
	Time = 0.447 s or $\frac{\sqrt{5}}{5}$ s	A1	For doubling.
	Alternative for last 3 marks of Q7(b) by finding velocity at height of 3.25 m		
	Correct use of suvat for motion of A (between height of 3m and 3.25 m), to form an equation to find speed at height of 3.25 m	*DM1	$w^2 = \text{their } \sqrt{10}^2 + 2 \times (-g) \times 0.25$. $[w^2 = 5]$ or $[w = \sqrt{5}]$.
	For correct use of suvat to find time to max height	DM1	$0 = \sqrt{5} + (-g) \times t$ $\left[t = \frac{\sqrt{5}}{10} \right]$.
	Time = 0.447 s or $\frac{\sqrt{5}}{5}$ s	A1	For doubling.

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Question	Answer	Marks	Guidance
7(b)	Alternative using energy		
	Correct use of energy before B hits the plane or when A has risen 2 m, to attempt to find velocity of A when string becomes slack using <i>their</i> T if necessary.	*M1	PE loss = KE gain: $5g \times 2 - 3g \times 2 = \frac{1}{2} \times 5v^2 + \frac{1}{2} \times 3v^2$, Or PE loss – WD by tension = KE gain: $5g \times 2 - \text{their } 37.5 \times 2 = \frac{1}{2} \times 5v^2$, Or WD by tension – PE gain = KE gain: $\text{their } 37.5 \times 2 - 3g \times 2 = \frac{1}{2} \times 3v^2$. Must be complete method to find v or v^2 $\left[v = \sqrt{10} \text{ or } 3.162... \right]$. Do not allow sign errors.
	Correct use of energy to find velocity of A at height of 3.25 m	*DM1	PE gain = KE loss: $3g \times 0.25 = \frac{1}{2} \times 3 \times \sqrt{10}^2 - \frac{1}{2} \times 3w^2$. Must be complete method to find w or w^2 $w = \sqrt{5}$ or 2.236... Do not allow sign errors.
	For attempt to find time from .25 m below top to top	DM1	$t = \pm 0.224$ or $\frac{\sqrt{5}}{10}$ [0.22360....] probably from $0 = \sqrt{5} - 10t$. Dep on both previous M1s. Do not allow sign errors.
	Time = 0.447 s or $\frac{\sqrt{5}}{5}$ s	A1	For doubling.
		4	