

Cambridge International AS & A Level

MATHEMATICS**9709/41**

Paper 4 Mechanics

October/November 2025**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 **18** printed pages.

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GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
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GENERIC MARKING PRINCIPLE 2:

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

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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:

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- 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.

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We publish annotations in our mark schemes to help centres understand the annotations they may see on copies of scripts. Note that there may not be a direct correlation between the number of annotations on a script and the mark awarded. Similarly, the use of an annotation may not be an indication of the quality of the response.

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Annotations

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	More information required
	Accuracy mark awarded zero
	Accuracy mark awarded one
	Independent accuracy mark awarded zero
	Independent accuracy mark awarded one
	Independent accuracy mark awarded two
	Benefit of the doubt
	Blank Page
	Incorrect
Dep	Used to indicate DM0 or DM1

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Annotation	Meaning
DM1	Dependent on the previous M1 mark(s)
	Follow through
	Indicate working that is right or wrong
Highlighter	Highlight a key point in the working
	Ignore subsequent work
	Judgement
	Judgement
	Method mark awarded zero
	Method mark awarded one
	Method mark awarded two
	Misread
	Omission or Other solution
Off-page comment	Allows comments to be entered at the bottom of the RM marking window and then displayed when the associated question item is navigated to.
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	Judgment made by the PE
	Premature approximation
	Special case
	Indicates that work/page has been seen

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Annotation	Meaning
	Error in number of significant figures
	Correct
	Transcription error
	Correct answer from incorrect working

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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
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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)	$D - 350 = 900 \times 0.25$	M1	Attempt at N2L – correct number of terms. Allow sign errors but must be dimensionally correct.
	$D = 575 \text{ N}$	A1	
		2	
1(b)	$P = 575 \times 15$	M1	Use of $P = D \times v$ with their D from 1(a) and $v = 15$.
	$P = 8625 \text{ W}$ or 8.625 kW	A1	Allow 8625 without units, but 8.625 must have kW.
		2	

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Question	Answer	Marks	Guidance
2(a)	$3 \times 4 = 3 \times (-1) + 5 \times v$ or $3 \times 4 = 3 \times 1 + 5v$	M1	Attempt at conservation of linear momentum; three non-zero terms – allow sign errors. M1 only if using weight rather than mass.
	$v = 3 \text{ m s}^{-1}$	A1	
	$v = 1.8 \text{ m s}^{-1}$	A1	If A0 A0 SC B1 for both -3 and -1.8 .
		3	
2(b)	$\text{KE} = \frac{1}{2} \times 3 \times 4^2 (= 24)$ or $\text{KE} = \frac{1}{2} \times 3 \times 1^2 + \frac{1}{2} \times 5 \times 1.8^2 (= 9.6)$ or $\text{KE} = \frac{1}{2} \times 3 \times 1^2 + \frac{1}{2} \times 5 \times 3^2 (= 24)$	M1	Attempt at either the total kinetic energy before or after the collision. The total KE (before and after) could be embedded in a calculation for the KE loss. M1 be awarded just on sight of 24, 19.6 or 14.4.
	$\lambda = 14.4$ ONLY	A1	Allow -14.4 . Must have discarded $\lambda = 0$ if mentioned.
		2	

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Question	Answer	Marks	Guidance
NO MISREADS IN THIS QUESTION			
3	For attempt to resolve in any direction to form an equation or expression	*M1	Correct number of terms; allow sign errors and sin/cos mix ONLY.
	Vertically: $(Y =) \pm(45 + 28 \sin 35 - 72 \sin 50 - 35 \sin 60)$	A1	$\pm 24.405948 \dots$
	Horizontally: $(X =) \pm(28 \cos 35 + 72 \cos 50 - 35 \cos 60)$	A1	$\pm 51.716965 \dots$
	$R = \sqrt{(\text{their } 24.4059 \dots)^2 + (\text{their } 51.7169 \dots)^2}$	DM1	Attempt to solve for R from equations with the correct number of relevant terms (only sign errors and sin/cos mix allowed).
	$\theta = \tan^{-1} \left(\frac{\text{their } 24.4059 \dots}{\text{their } 51.7169 \dots} \right) [= \tan^{-1} 0.4719 \dots]$ OR $\alpha = \tan^{-1} \left(\frac{\text{their } 51.7169 \dots}{\text{their } 24.4059 \dots} \right) [= \tan^{-1} 2.1190 \dots]$	DM1	Attempt to solve for θ or α from equations with the correct number of relevant terms (only sign errors and sin/cos mix allowed).

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Question	Answer	Marks	Guidance
3	$R = 57.2 \text{ N}$ Direction is $25.^\circ$ below the positive x -direction or bearing 11°	A1	Both correct. Giving an angle only is insufficient. Direction may be seen on a diagram, with minimum of arrow on resultant OE. May give direction relative to one of the given forces e.g. $24.^\circ$ anticlockwise from the 72 N force. Arrows on both components only is A0 as it doesn't show the direction of the resultant. However the direction is stated, it must be able to be drawn uniquely.
		6	

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Question	Answer	Marks	Guidance
4	PE lost by A : $\pm mg \times 0.75$	B1	
	PE gained by B : $\pm 3g \times 0.75 \times 0.6 [= \pm 13.5]$	B1	Allow $\sin 37^\circ$ or better for 0.6. $\sin^{-1} 0.6 = 36.86989765^\circ$.
	KE gained by A and B : $\pm \left(\frac{1}{2} \times 3 \times 2^2 + \frac{1}{2} \times m \times 2^2 \right) [= \pm (6 + 2m)]$	B1	
	Work done against resistance = $\pm \frac{10}{3} \times 0.75 [= \pm 2.5]$	B1	
	$\frac{1}{2} \times 3 \times 2^2 + \frac{1}{2} \times m \times 2^2 = 0.75mg - 13.5 - 2.5$	M1	Attempt at work-energy equation. Equivalent of 5 terms, dimensionally correct, allow sign errors, PE gained by B must include a component of $3g$.
	$m = 4$	A1	
	Special case for use of N2L max 3 marks		
	$2^2 = 0^2 + 2 \times a \times 0.75 \Rightarrow a = \frac{8}{3}$	B1	
	$mg - T = ma$ and $T - 3g \times 0.6 - \frac{10}{3} = 3a$ OR $mg - 3g \times 0.6 - \frac{10}{3} = (m + 3)a$	M1	Correct number of dimensionally correct terms, allow sign errors, allow sin/cos mix. Allow $\sin 37^\circ$ or better for 0.6. $\sin^{-1} 0.6 = 36.86989765^\circ$.
	$m = 4$	A1	
		6	

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Question	Answer	Marks	Guidance
5	Attempt at resolving parallel or perpendicular to the plane to form an equation	*M1	Correct number of terms, allow sign errors, allow sin/cos mix, allow g missing on the weight term only (so not missing on the $8mg$ term). Forces that need resolving should be resolved, forces that do not need resolving should not be resolved.
	$8mg \cos \theta + mg \sin \theta = F$	A1	Allow with their possibly incorrect F .
	$R = mg \cos \theta + 8mg \sin \theta$	A1	
	Use of $F = 0.5R$ to get an equation in θ [m and g]	DM1	Where R is a linear combination of a weight (or mass) component and an $8mg$ component.
	$8mg \cos \theta + mg \sin \theta = 0.5(mg \cos \theta + 8mg \sin \theta)$ $\Rightarrow \tan \theta = 2.5$	DM1	Re-arranging to $\tan \theta = k$ where $k \neq 0$ (or equivalent method to reduce to a single trig. term). – dependent on both previous M1 marks.
	$\theta = 68.2$	A1	
		6	

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Question	Answer	Marks	Guidance
6	Acceleration of A down the plane is $g \times 0.2 [= 2]$	B1	Allow $-g \times 0.2$. Allow $\pm g \times \sin 12$ or better. Allow $2.5a = 2.5g \times 0.2$.
	Speed of A before collision is $g \times 0.2 \times 2 [= 4]$	*M1	Use of $v = u + at$ with $u = 0$, $t = 2$ and their a which must be equivalent to either $\pm g \times \sin 12$ or $\pm g \times \cos 12$ ONLY.
	$3 \times 3.5 + 2.5 \times (-4) = 3 \times (-0.5) + 2.5 \times u$	DM1	Attempt at conservation of linear momentum; four non-zero terms – allow sign errors. M1A0 only if using weight rather than mass.
	$u = 0.8$	A1	Correct speed (or velocity) of A after impact.
	$0 = 0.8^2 + 2 \times \left(-g \times \frac{1}{5}\right) \times s$	DM1	Use of $v^2 = u^2 + 2as$ (or other complete method to find s) with $v = 0$, their u and their $-a$ – condone sign errors. Dependent on both previous M1 marks.
	$s = 0.16 \text{ m}$	A1	CWO.
		6	

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Question	Answer	Marks	Guidance
7(a)	$v = \frac{1}{3}(2t^2 - 11t + 12) \Rightarrow \frac{dv}{dt} = \frac{1}{3}(4t - 11)$	M1	Expand to a 3-term quadratic equivalent and attempt to differentiate (oe e.g. product rule), decrease power by 1 and a change in coefficient in at least one term; allow un-simplified $a = \frac{v}{t}$ is M0 .
	$\frac{1}{3}(4 \times 2 - 11) = -1 \text{ m s}^{-2}$	A1	Must be negative.
		2	
7(b)	Attempt to integrate	*M1	Expand to a 3-term quadratic equivalent and attempt to integrate, increase power by 1 and a change in coefficient on the same term. $s = vt$ is M0 .
	$s = \frac{1}{3} \left(\frac{2t^3}{3} - \frac{11t^2}{2} + 12t \right) (+c)$	A1	Allow un-simplified.
	[P changes direction when] $t = 1.5$	*B1	$t = 1.5$ SOI.
	Attempt to evaluate their $\frac{1}{3} \left(\frac{2t^3}{3} - \frac{11t^2}{2} + 12t \right)$ for $t = 0$ to $t = 1.5$ and $t = 1.5$ to $t = 3$	DM1	Using the correct limits correctly.
	Total distance is $[2.625 + -1.125 =] 3.75 \text{ m}$	A1	If no integration seen, then B1 for 3.75 (so 2 marks max.).
		5	

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Question	Answer	Marks	Guidance
7(c)	Attempt to evaluate their s for $t = 0$ to $t = 4$	M1	OE e.g. compare $\int_0^{1.5} v \, dt$ with $\int_{1.5}^4 v \, dt$ or setting their three-term cubic expression in t (with no constant term) equal to zero and attempting to solve or attempt discriminant.
	$\int_0^4 v \, dt = \frac{8}{9} > 0$ so, no P does not return to O	A1	OE e.g. obtaining $4t^2 - 33t + 72 = 0$ and showing that this has no real roots (and hence P does not return to O). $4t^2 - 33t + 72 = 0$ gives $b^2 - 4ac = (-33)^2 - 4 \times 4 \times 72 = -63$. $\frac{2}{9}t^2 - \frac{11}{6}t + 4 = 0$ gives $b^2 - 4ac = \left(-\frac{11}{6}\right)^2 - 4 \times \frac{2}{9} \times 4 = -\frac{7}{36}$.
		2	

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Question	Answer	Marks	Guidance
8(a)	$T \cos 15 = 0.5 \times 1.2$	M1	N2L for B – correct number of terms, allow sin/cos mix ONLY.
	$T = 0.621 \text{ N}$	A1	Allow $\frac{3\sqrt{6} - 3\sqrt{2}}{5}$.
		2	
8(b)	Attempt to resolve vertically for A to form an equation	*M1	Correct number of terms, allow sign errors and sin/cos mix, allow their (possibly incorrect) T from 8(a) .
	$6 \sin 20 + R_A = 2g + T \sin 15$	A1	$R_A = 18.10864\dots$
	Attempt at N2L for A	*M1	Correct number of terms, allow sign errors and sin/cos mix, allow their (possibly incorrect) T from 8(a) .
	$6 \cos 20 - T \cos 15 - F = 2 \times 1.2$	A1	$F = 2.63815\dots$
	Use of $F = \mu R$ to get an equation in μ only	DM1	Dependent on both previous M1 marks.
	$\mu = 0.146$	A1	$\mu = 0.1456848\dots$
		6	

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	$x = 80$	A1	CWO. Must be $x = \dots$ M1A0 for those who have $\frac{x-0}{4-6} = 40$ and have $x = -80$ followed by $x = 80$ without any explanation.
	$a = 10$	A1	CWO.
		3	

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Question	Answer	Marks	Guidance
2	Attempt at Newton's second law at least once	*M1	Correct number of terms, allow sign errors, allow sin/cos mix, allow g missing.
	$450000 + 240000g \times 0.04 - 120000 - T = 240000a$ $\left[\begin{array}{l} 450000 + 96000 - 120000 - T = 240000a \\ 426000 - T = 240000a \end{array} \right]$ $T + 36000g \times 0.04 - 15000 = 36000a$ $\left[\begin{array}{l} T + 14400 - 15000 = 36000a \\ T - 600 = 36000a \end{array} \right]$ $450000 + (240000 + 36000)g \times 0.04 - 120000 - 15000 = (240000 + 36000)a$ $\left[\begin{array}{l} 450000 + 110400 - 120000 - 15000 = 276000a \\ 425400 = 276000a \end{array} \right]$	A2	A1 for any equation correct. A2 for any 2 equations correct. Allow sin 2.3 or better for 0.04. A candidate may be using <i>their</i> a in the either of the first 2 equations if they have used the 3 rd equation to find a .
	Solving for a or T , from equation(s) with the correct number of relevant terms	DM1	Allow g missing, terms should be components where necessary. Must get to $a = \dots$ or $T = \dots$
	Acceleration = 1.54ms^{-2} and Tension = 56100 N	A1	Allow $a = \frac{709}{460}$, $a = 1.54130\dots$, $T = 56086.9\dots$ Allow with use of sin 2.3. If using $a = 1.54$, then $T = 56400$ from locomotive equation or $T = 56040$ from coach equation. If using $a = 1.541$, then $T = 56160$ from locomotive equation or $T = 56076$ from coach equation.
		5	

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Question	Answer	Marks	Guidance
3(a)	$175 = \frac{1}{2}(15 + 20)t$	M1	For complete method to get an equation in time only using $s = 175$, $u = 15$ and $v = 20$. May see $a = 0.5$.
	Time = 10 s	A1	
		2	

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Question	Answer	Marks	Guidance
3(b)(i)	$\text{Change in KE} = \pm \left(\frac{1}{2} \times 1400 \times 20^2 - \frac{1}{2} \times 1400 \times 15^2 \right)$ $[= \pm (280000 - 157500) = \pm 122500]$ OR Work done against resistance $= \pm 800 \times 175 [= \pm 140000]$	B1	
	$\text{Work done by engine} = \frac{1}{2} \times 1400 \times 20^2 - \frac{1}{2} \times 1400 \times 15^2 + 800 \times 175$	*M1	Attempt at work energy equation. Correct number of relevant terms; dimensionally correct; allow sign errors. May see : Work done by engine = $DF \times 175$. Using $\frac{1}{2} \times 1400 \times (20 - 15)^2$ is M0 . For reference if correct $WD = 262500$, $DF = 1500$.
	$\text{Av power} \times (\text{their } 10) = \frac{1}{2} \times 1400 \times 20^2 - \frac{1}{2} \times 1400 \times 15^2 + 800 \times 175$	DM1	FT <i>their</i> 10 from 3(a) or if recalculated t in 3(b)(i)
	Average power = 26250 W	A1FT	FT their value of t only so $\frac{262500}{\text{their } 10}$ or $\frac{1500 \times 175}{\text{their } 10}$. Allow 26300 from correct working. Allow 26.25 kW or 26.3 kW with units.
	Special case for using N2L Maximum 2 marks		
	$20^2 = 15^2 + 2 \times a \times 175 \Rightarrow a = 0.5 ;$ $DF - 800 = 1400 \times 0.5 \Rightarrow DF = 1500$	B1	This is for getting $DF = 1500$.
	$DF \times 175 = \text{Average power} \times (\text{their } 10) \Rightarrow \text{Average power} = 26250 \text{ W}$ OR $P = 1500 \times 15 = 22500$ and $P = 1500 \times 20 = 30000$ so $\text{Average power} = \frac{1}{2} (22500 + 30000) = 26250 \text{ W}$	B1FT	FT their value of t so $\frac{1500 \times 175}{\text{their } 10}$ Allow 26.25 kW with units
		4	

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Question	Answer	Marks	Guidance
3(b)(ii)	$their\ 26250 = 800v$	M1	For use of $P = Fv$.
	Speed = 32.8125 or $\frac{525}{16} \text{ m s}^{-1}$	A1	OE. Allow 32.875 or 32.9 or better from use of 26300.
		2	

Question	Answer	Marks	Guidance
4(a)	$[Height\ gained\ by\ P\ (s_P) =]30t - \frac{1}{2}gt^2$ $[Height\ lost\ by\ Q\ (s_Q) =]10t - \frac{1}{2}gt^2$	*M1	For use of $s = ut + \frac{1}{2}at^2$ at least once with $a = \pm g$ and $u = \pm 30$ or $u = \pm 10$. Allow this M1 only if using a found value of t .
	Meet when $30t - \frac{1}{2}gt^2 = 10t - \frac{1}{2}gt^2 + 15$	DM1	For use of $s_P = s_Q \pm 15$ with s_P and s_Q of the correct form which would lead to a linear equation in t (so in the expressions for s_P and s_Q the signs of the $\frac{1}{2}gt^2$ terms must be the same).
	$t = \frac{3}{4}$ or 0.75	A1	OE. CWO.
	Height = 19.6875 m or $\frac{315}{16} \text{ m}$	A1	Allow 19.7 or better. CWO. DO NOT ISW.
		4	

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Question	Answer	Marks	Guidance
4(b)	$[v_P =] \pm \left(30 - \frac{3}{4}g\right) [= \pm 22.5]$ $[v_Q =] \pm \left(10 - \frac{3}{4}g\right) [= \pm 2.5]$ OR $[v_P =] \pm \sqrt{30^2 - 2g \times 19.6875} [= \pm 22.5]$ $[v_Q =] \pm \sqrt{10^2 - 2g \times (19.6875 - 15)} [= \pm 2.5]$	*B1FT	For either expression for the speed of P or Q before impact FT <i>their</i> $t = \frac{3}{4}$ and/or FT their height. $= \frac{315}{16} = 19.6875$. The 2 M marks in 4(a) must have been awarded.
	$0.1 \times 22.5 + 0.4 \times 2.5 = (0.1 + 0.4) \times v_{PQ}$	DM1	Use of conservation of momentum; correct number of non-zero terms, allow sign errors. 22.5 and 2.5 coming from a correct method. Do not allow with $v_P = \pm 30$ or with $v_Q = \pm 10$. If using mg rather than m , then do not allow subsequent A marks.
	$v_{PQ} = 6.5$	A1	SOI, allow to 2sf.
	$v^2 = \text{their } 6.5^2 + 2g \times \text{their } 19.6875$ OR $0 = \text{their } 6.5^2 + 2(-g)s \Rightarrow s = 2.1125,$ height above ground $= 2.1125 + 19.6875 = 21.8$ hence $v^2 = 0^2 + 2g \times 21.8$	DM1	Dependent on previous M1 and B1 . Complete method to get an equation in speed or (speed) ² . May see $t = 2.738061302$.
	Speed $= 20.9 \text{ ms}^{-1}$ or $2\sqrt{109} \text{ ms}^{-1}$	A1	20.88061303... Use of g in momentum equation can be awarded B1M1A0M1A0 , 3 marks max.
		5	

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Question	Answer	Marks	Guidance
5	For resolving in any direction to form an equation	*M1	Correct number of relevant dimensionally correct terms; allow sin/cos mix; allow sign errors.
	$R = 5g \cos 10 - 20 \sin 35$ [= 37.76885892]	A1	OE. For reference $F = 15.10754357$
	$20 \cos 35 + 5g \sin 10 - F = 5a$ [25.06544977 – $F = 5a$]	A1	OE, allow with <i>their</i> possibly incorrect F . Allow $F - 20 \cos 35 - 5g \sin 10 = 5a$.
	For use of $F = 0.4R$ to get an equation in a only	DM1	From both dimensionally correct equations with the correct number of relevant terms. For reference $a = 1.99$ [1.99158124...].
	$v^2 = 2^2 + 2 \times (\text{their } 1.99) \times 3$	DM1	Dependent on both previous M marks. M0 if their calculated a is negative from using N2L down the plane. M0 if their calculated a is positive from using N2L up the plane. <i>Their</i> calculated 1.99 and 3 must be same sign. For use of $v^2 = u^2 + 2as$ or any complete method to get an equation in v or v^2 , where $v^2 > 0$.
	Speed = 3.99 ms^{-1}	A1	3.993680939...

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Question	Answer	Marks	Guidance
5	Alternative for Q5 using energy		
	For resolving perpendicular to the plane to form an equation for normal reaction	*M1	Correct number of relevant dimensionally correct terms; allow sin/cos mix; allow sign errors.
	$R = 5g \cos 10 - 20 \sin 35$ [= 37.76885892]	A1	OE.
	$20 \cos 35 \times 3 + 5g \sin 10 \times 3 + \frac{1}{2} \times 5 \times 2^2 - F \times 3 = \frac{1}{2} \times 5 \times v^2$ $[49.1491... + 26.0472... + 10 - 3F = 2.5v^2]$	*M1	Attempt at Work-energy equation. Correct number of relevant terms, dimensionally correct, allow sin/cos mix, allow sign errors, allow their F .
		A1	Allow their possibly incorrect F . Note: $60 \cos 10$ comes from $3 \times 0.4(5g \cos 10)$.
	For use of $F = 0.4R$ to get an equation in v only	DM1	Dependent on both previous M marks. Attempt at Work-energy equation. Correct number of relevant terms, dimensionally correct.
	Speed = 3.99 ms^{-1}	A1	3.993680939...
		6	

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Question	Answer	Marks	Guidance
6	Acceleration = 0 when $\left[2(t+1)^{-\frac{1}{2}} - 1 = 0 \Rightarrow (t+1)^{\frac{1}{2}} = 2 \right] t = 3$	B1	CWO. Those who use $2(t+1)^{-\frac{1}{2}}$ or claim that $2(t+1)^{-\frac{1}{2}} - 1$ is $(2t+2)^{-\frac{1}{2}} - 1$ score 0 marks.
	For attempt at integration of $(a=)2(t+1)^{-\frac{1}{2}} - 1$	*M1	$v = at$ is M0 . Of the form $a(t+1)^{\frac{1}{2}} - t[+c]$, where $a \neq 2$.
	$[v =] \frac{2}{-\frac{1}{2}+1} (t+1)^{-\frac{1}{2}+1} - t[+c] = 4(t+1)^{\frac{1}{2}} - t[+c]$	A1	Allow un-simplified.
	$v = 0 \text{ at } t = 0 \Rightarrow c = -4 \left[\Rightarrow v = 4(t+1)^{\frac{1}{2}} - t - 4 \right]$	DM1	For attempt to find c using $v = 0$ at $t = 0$. Must get a value for c . M0 for stating $v = 0$ at $t = 0 \Rightarrow c = 0$ with no working.
	Attempt to integrate <i>their</i> v , which has come from integration	DM1	Increase power by 1 and change of coefficient on the same term from a 3 term expression in t to get an expression of the form $p(t+1)^{\frac{3}{2}} + qt^2 + rt$, where $p \neq 0$, $q \neq 0$ and $r \neq 0$. $s = vt$ is M0 . Dependent on previous 2 M marks.
	$[s =] \frac{4}{\frac{1}{2}+1} (t+1)^{\frac{1}{2}+1} - \frac{1}{1+1} t^{1+1} - 4t[+k] = \frac{8}{3} (t+1)^{\frac{3}{2}} - \frac{1}{2} t^2 - 4t[+k]$	A1	Allow un-simplified. Condone using $+c$ again.
	$= \left(\frac{8}{3} \times 4^{\frac{3}{2}} - \frac{1}{2} \times 3^2 - 4 \times 3 \right) - \left(\frac{8}{3} - 0 - 0 \right)$ OR evaluate k from using $s = 0$ when $t = 0$ AND substitute $t = \text{their } 3$	DM1	Use of limits 0 and <i>their</i> positive 3 correctly, <i>their</i> 3 must have come from considering given $a = 0$. Dependent on all 3 previous M marks. If evaluating k , then $k = -\frac{8}{3}$ if correct.

Question	Answer	Marks	Guidance
6	Distance = $\frac{13}{6}$ m or 2.17m	A1	SC, If no integrating v seen then SCB1 for 2.17 so B1M1A1M1SCB1 5 marks max
		8	

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Question	Answer	Marks	Guidance
NO MISREADS IN THIS QUESTION			
7(a)	For attempt to resolve in any direction to form an expression or equation	*M1	Correct number of terms; allow sign errors and sin/cos mix ONLY.
	$[X =] \pm (30 \cos 30 + 15 \cos 45 - 20 \cos 20)$ OR $[S \cos \alpha =] \pm (30 \cos 30 + 15 \cos 45 - 20 \cos 20)$	A1	OE. $\pm 17.79351142\dots$
	$[Y =] \pm (25 + 15 \sin 45 - 20 \sin 20 - 30 \sin 30)$ OR $[S \sin \alpha =] \pm (25 + 15 \sin 45 - 20 \sin 20 - 30 \sin 30)$	A1	OE. $\pm 13.76619885\dots$
	$S = \sqrt{(their 17.7935\dots)^2 + (their 13.76661\dots)^2}$ OR $S = \frac{their 17.7935\dots}{\cos(their 37.7278\dots)}$ OR $S = \frac{their 13.76661\dots}{\sin(their 37.7278\dots)}$	DM1	For attempt to find force from equations with the correct number of relevant terms (only sign errors and sin/cos mix allowed).
	$\alpha = \tan^{-1}\left(\frac{their 13.7661\dots}{their 17.7935\dots}\right)$ OR $\alpha = \cos^{-1}\left(\frac{their 17.7935\dots}{their 22.4970\dots}\right)$ OR $\alpha = \sin^{-1}\left(\frac{their 13.7661\dots}{their 22.4970\dots}\right)$	DM1	Allow reciprocal in $\tan^{-1}$ only. For attempt to find angle from equations with the correct number of relevant terms (only sign errors and sin/cos mix allowed).
	$[S =] 22.5$ $[\alpha =] 37.7$	A1	$S = 22.497050406\dots$ $\alpha = 37.72782933\dots$ Condone $\alpha = 37.8$. Allow $S = -22.5$ becoming 22.5 with no explanation. Allow $\alpha = -37.7$ becoming 37.7 with no explanation. A0 for $\alpha = -37.7$ ONLY, A0 for $S = -22.5$ ONLY
		6	

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Question	Answer	Marks	Guidance
7(b)	$(\text{their } 17.7935 \dots) - F = 0.6a$ OR $30\cos 30 + 15\cos 45 - 20\cos 20 - F = 0.6a$ OR $(\text{their } S)\cos(\text{their } \alpha) - F = 0.6a$ [$17.8025 - F = 0.6a$]	*M1	Using N2L with correct number of dimensionally correct terms, allow sign errors, allow sin/cos mix. <i>their</i> 17.7935 must have come from horizontal component from 7(a) with only sign errors and sin/cos mix allowed. May be using <i>their</i> F and/or <i>their</i> a which may be incorrect. OR $(\text{their } S)\cos(\text{their } \alpha) - F = 0.6 \times a$ so in this case dependent on all 3 M marks in part (a) and must be using cosine.
	$2 = 0 + \frac{1}{2}a \times 3^2 \left[a = \frac{4}{9} \right]$	*M1	Use of $s = ut + \frac{1}{2}at^2$ or other complete method to get an equation in a , using $s = 2, u = 0$ and $t = 3$.
	$R = \text{their}(13.7661 \dots) + 0.6g$ [= 19.7661...] OR $R = 25 + 15\sin 45 - 20\sin 20 - 30\sin 30 + 0.6g$ OR $R = (\text{their } S)\sin(\text{their } \alpha) + 0.6g$ [$R = 13.759 + 0.6g$]	*B1FT	<i>their</i> 13.7661 must have come from vertical component from 7(a) with only sign errors and sin/cos mix allowed. OR $R = (\text{their } S)\sin(\text{their } \alpha) + 0.6g$ so in this case dependent on all 3 M marks in 7(a) and must be using sine
	$(\text{their } 17.7935) \dots - \mu \times 19.7661 = 0.6 \times \left(\text{their } \frac{4}{9} \right)$	DM1	Dependent on all previous marks. Use of $F = \mu R$ to get an equation in μ only.
	$\mu = 0.887$	A1	0.886711... Condone 0.886. Condone 0.888.

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Question	Answer	Marks	Guidance
7(b)	Alternative scheme for using energy		
	$\frac{1}{2} \times 0.6 \times v^2 = (\text{their } 17.7935) \times 2 - F \times 2$ OR $\frac{1}{2} \times 0.6 \times v^2 = (30 \cos 30 + 15 \cos 45 - 20 \cos 20) \times 2 - F \times 2$ OR $\frac{1}{2} \times 0.6 \times v^2 = (\text{their } S) \cos(\text{their } \alpha) \times 2 - F \times 2$	*M1	Work energy equation with correct number of dimensionally correct terms, allow sign errors, allow sin/cos mix. <i>their</i> 17.7935 must have come from horizontal component from 7(a) with only sign errors and sin/cos mix allowed. May be using <i>their</i> F and/or <i>their</i> v which may be incorrect. $\frac{1}{2} \times 0.6 \times v^2 = (\text{their } S) \cos(\text{their } \alpha) \times 2 - F \times 2$, so in this case dependent on all 3 M marks in 7(a) and must be using cosine.
	$2 = \frac{1}{2}(0 + v) \times 3 \quad \left[v = \frac{4}{3} \right]$	*M1	Use of $s = \frac{1}{2}(u + v)t$ or other complete method to get an equation in v , using $s = 2$, $u = 0$ and $t = 3$.
	$R = \text{their}(13.7661...) + 0.6g \quad [= 19.7661...]$ OR $R = 25 + 15 \sin 45 - 20 \sin 20 - 30 \sin 30 + 0.6g$ OR $R = (\text{their } S) \sin(\text{their } \alpha) + 0.6g \quad [R = 13.759 + 0.6g]$	*B1FT	<i>their</i> 13.7661 must have come from vertical component from 7(a) with only sign errors and sin/cos mix allowed. Or $R = (\text{their } S) \sin(\text{their } \alpha) + 0.6g$ so in this case dependent on all M marks in 7(a) and must be using sine.
	$\frac{1}{2} \times 0.6 \times \left(\text{their } \frac{4}{3} \right)^2 = (\text{their } 17.7935) \times 2 - 19.7661 \times \mu \times 2$	DM1	Dependent on all previous marks. Use of $F = \mu R$ to get an equation in μ only.
	$\mu = 0.887$	A1	0.886711... Condone 0.886. Condone 0.888.
		5	

Cambridge International AS & A Level

MATHEMATICS**9709/43**

Paper 4 Mechanics

October/November 2025**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 2025 series for most Cambridge IGCSE, Cambridge International A and AS Level components, and some Cambridge O Level components.

This document consists of **21** 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**Annotations guidance for centres**

Examiners use a system of annotations as a shorthand for communicating their marking decisions to one another. Examiners are trained during the standardisation process on how and when to use annotations. The purpose of annotations is to inform the standardisation and monitoring processes and guide the supervising examiners when they are checking the work of examiners within their team. The meaning of annotations and how they are used is specific to each component and is understood by all examiners who mark the component.

We publish annotations in our mark schemes to help centres understand the annotations they may see on copies of scripts. Note that there may not be a direct correlation between the number of annotations on a script and the mark awarded. Similarly, the use of an annotation may not be an indication of the quality of the response.

The annotations listed below were available to examiners marking this component in this series.

Annotations

Annotation	Meaning
	More information required
	Accuracy mark awarded zero
	Accuracy mark awarded one
	Independent accuracy mark awarded zero
	Independent accuracy mark awarded one
	Independent accuracy mark awarded two
	Benefit of the doubt
	Blank Page
	Incorrect
Dep	Used to indicate DM0 or DM1

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Annotation	Meaning
DM1	Dependent on the previous M1 mark(s)
	Follow through
	Indicate working that is right or wrong
Highlighter	Highlight a key point in the working
	Ignore subsequent work
	Judgement
	Judgement
	Method mark awarded zero
	Method mark awarded one
	Method mark awarded two
	Misread
	Omission or Other solution
Off-page comment	Allows comments to be entered at the bottom of the RM marking window and then displayed when the associated question item is navigated to.
On-page comment	Allows comments to be entered in speech bubbles on the candidate response.
	Judgment made by the PE
	Premature approximation
	Special case
	Indicates that work/page has been seen

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Annotation	Meaning
	Error in number of significant figures
	Correct
	Transcription error
	Correct answer from incorrect working

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)	1.6 ms^{-2}	B1	oe e.g. $\frac{8}{5}$ etc. Condone -1.6 .
		1	
1(b)	$[3 \times] \frac{1}{2} \times 10 \times 8$ or $[6 \times] \frac{1}{2} \times 5 \times 8$	M1	Correct expression for the area of either one of the right-angled triangles with base length 5 or one of the isosceles triangles of base length 10. Sight of 40 or 20 as part of a total distance calculation can score this mark.
	120 m	A1	
		2	

Question	Answer	Marks	Guidance
2(a)	Driving force $F = \frac{105000}{35}$ [=3000]	B1	OE e.g. $F \times 35 = 105000$.
	$F - 35 \times c = 400 \times 0.5$	M1	Use of N2L; allow sign errors but must be 3 terms. Allow F or any non-zero value for the driving force (but not 105000). If assuming $a = 0$ then e.g. $105000 = c \times 35^2$ ($\Rightarrow c = 85.714...$) scores B1 M0 .
	$\frac{105000}{35} - 35 \times c = 400 \times 0.5 \Rightarrow c = 80$ ($2800 = 35c \Rightarrow c = 80$)	A1	AG – a correct equation for c e.g. $3000 - 35 \times c = 400 \times 0.5$ followed by $c = 80$ scores A1 .
		3	

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Question	Answer	Marks	Guidance
2(b)	$\frac{105000}{v} - 80 \times v - 400g \times \frac{3}{20} [= 0]$ $\Rightarrow 80v^2 + 600v - 105000 [= 0]$	B1	B1 for correct weight component: $\pm 400g \times \frac{3}{20}$ or $\pm 400g \times \sin\left(\sin^{-1}\left(\frac{3}{20}\right)\right)$. $[= \pm 600]$.
	OR $80v^2 + 600v = 105000$	M1	OE. M1 for applying N2L with the correct number of dimensionally correct terms (with $a = 0$) leading to a three term quadratic equation/expression in v . Allow sign errors and sin/cos mix on the weight component. Must be using $c = 80$ for this mark.
	Speed = 32.7 m s^{-1} ONLY	A1	CWO. Allow exact $\frac{-15 + 5\sqrt{849}}{4}$ or AWRT 32.7. (For reference: 32.6720057...). If negative value ($-40.172\dots$) stated, then must be rejected for this mark.
		3	

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Question	Answer	Marks	Guidance
3(a)	$R + 25\sin 36 = 4g \quad [\Rightarrow R = 25.30536\dots]$	*M1	Attempt to resolve vertically to form an equation for the normal contact force for the block; correct number of dimensionally correct terms, condone sign errors, and sin/cos mix on the 25 N force term. Use of $R = 4g$ scores no marks in this part.
	Work done against friction $= 120 \times \frac{2}{5} \times (40 - 25\sin 36)$	DM1	Use of Work done $= 0.4R \times 120$ ONLY so M0 if subtracting/adding the Work done by the pulling force to this value e.g. a final answer of 1212 (or 1210) coming from $120 \times (25\cos 36 - 0.4 \times (40 - 25\sin 36))$ scores M1 M0 A0 .
	1210 or 1215 J	A1	CWO 1210 or final AWRT 1215 or 1214 (usually coming from using $R = 25.3$). For reference: 1214.6576...
		3	

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Question	Answer	Marks	Guidance
3(b)	KE change = $\pm \left(\frac{1}{2} \times 4 \times v_B^2 - \frac{1}{2} \times 4 \times 7^2 \right)$	B1	SOI, by KE terms on opposite sides of an equation with the same sign so must imply a change in KE (e.g. $2v^2$ on one side and 98 on the other).
	Work Done by pulling force = $\pm 25 \cos 36 \times 120$ [= $\pm 2427.050...$]	B1	
	$\frac{1}{2} \times 4 \times v_B^2 - \frac{1}{2} \times 4 \times 7^2 = 25 \cos 36 \times 120 - '1214.65...'$ [$2v_B^2 - 98 = 2427.050... - '1214.65...'$]	M1	Attempt at work-energy equation using their work done against friction from 3(a) with four dimensionally correct terms but allow sign errors and sin/cos mix on the pulling force term. Dependent on both M1 marks in 3(a) unless the total work done is recovered in this part e.g. a candidate might, in 3(a) , find the total work done by the block (which if correct is 1212.39...) rather than the required work done against friction. Therefore, an answer of 1212.39... 3(a) would score M1 M0 A0 but then seeing $2v^2 - 98 = 1212.39...$ (or even 1210 but only if coming from 1212.39...) followed by 25.6 would score full marks in this part. M0 if using 25×120 for the pulling force.
	$v_B = 25.6 \text{ m s}^{-1}$	A1	AWRT 25.6. (For reference: 25.59680...).
	Special case for using N2L Maximum 2 marks		
	$25 \cos 36 - 0.4(40 - 25 \sin 36) = 4a \Rightarrow a = 2.53$	B1	This is for getting $a = 2.53$. (For reference: $a = 2.525819...$).
	$v^2 = 7^2 + 2 \times 2.5258... \times 120 \Rightarrow v = 25.6 \text{ m s}^{-1}$	B1	AWRT 25.6. (For reference: 25.59680...).
		4	

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Question	Answer	Marks	Guidance
4(a)	Attempt to differentiate $s = 0.01t^3 - 0.3t^2 - 2.07t$	*M1	Decrease power by 1 and change of coefficient on the same term; $a = \frac{v}{t}$ is M0 .
	$[v =] 0.03t^2 - 0.6t - 2.07$	A1	Allow un-simplified.
	$[a =] 0.06t - 0.6$ OR $[v] = 0.03(t - 10)^2 - 5.07$	A1	Allow un-simplified. Must follow from the correct 3 term quadratic in t for v so A0 if coming from $v = 0.03t^2 - 0.6t$. Or the correct completing the square form for the correct expression for v .
	$0.06t - 0.6 = 0 \ (\Rightarrow t = 10)$	DM1	Setting their $a = 0$ where a is a two-term linear expression (of the form $k_1t + k_2$ where $k_1, k_2 \neq 0$) in t . Or setting their $t - 10$ (from completing the square on a three term quadratic in t) equal to 0.
	$s = -40.7$	A1	CWO (so first four marks must have been awarded). Must be negative so do not allow $s = -40.7 \Rightarrow s = 40.7$ so no ISW. Saying that $s = -40.7$ or 40.7 is A0 .
	$v = -5.07 \Rightarrow$ speed is 5.07 m s^{-1}	A1	CWO (so first four marks must have been awarded or first three marks if completing the square). Must be positive – allow A1 if negative sign is dropped without justification but saying speed is either -5.07 or 5.07 is A0 .
		6	

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Question	Answer	Marks	Guidance
4(b)	$0.03t^2 - 0.6t - 2.07 = 0$	*M1	Set their 3 term quadratic expression in t for v equal to zero – dependent on first M1 mark in 4(a) . This mark can be implied by a correct value of $t = 23$ appearing in this part.
	$t = 23$	A1	CWO Ignore mention of $t = -3$. Working might appear in 4(a) , but this value must be stated in 4(b) to earn this mark.
	$a = 0.06 \times 23 - 0.6$	DM1	Their positive t substituted into their two-term linear expression for a – this mark can be implied by a correct answer.
	$a = 0.78 \text{ m s}^{-2}$ ONLY	A1	OE e.g. $\frac{39}{50}$, etc. if -0.78 found then must be explicitly rejected.
		4	

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Question	Answer	Marks	Guidance
5(a)	Attempt at N2L for either A or B or the system	*M1	Correct number of dimensionally correct terms, allow sign errors. Condone using $a = \pm 10$ (or another incorrect value of a) in either the equation for A or B for this mark only .
	$A: T - 2g = 2a$ $B: 6g - T = 6a$ System: $6g - 2g = (2 + 6)a$	A1	For any two correct equations in a and T (or implied by correct answers) – note that T must be positive in one equation and negative in the other. Note that the three equations: $2g - T = 2a$, $T - 6g = 6a$ and $2g - 6g = 8a$ score M1 A1 and lead to $T = 3g$ and $a = -0.5g$.
	Solving for T	DM1	From two N2L equations (both containing a) with the correct number of dimensionally correct terms OE.
	$a = 0.5g$ or 5 m s^{-2} and $T = 3g$ or 30 N	A1	a must be positive – allow those who say $a = -0.5g \Rightarrow a = 0.5g$ (or $a = -5 \Rightarrow a = 5$) without justification (but must be from correct working).
		4	

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Question	Answer	Marks	Guidance
5(b)	$-3.2 = 1.2t + \frac{1}{2} \times (-5) \times t^2$ OR $3.2 = -1.2t + \frac{1}{2} \times 5 \times t^2$	M1	Using $s = ut + \frac{1}{2}at^2$ with $s = \pm 3.2$, $u = \pm 1.2$ and their a from 5(a) (not $\pm g$ but allow ± 10 if come from wrong working in 5(a)) – dependent on either a system equation with the correct number of dimensionally correct terms from 5(a) or from equations for A and B that both contain the correct number of dimensionally correct terms – or other complete method to find t .
	1.4(0) s	A1	AWRT 1.4 or $\frac{6 + 2\sqrt{209}}{25}$. (For reference: 1.39654...).
		2	
5(c)	Distance A travels from initial position to first time at rest: $0 = 1.2^2 + 2 \times (-5) \times s_1 \quad (\Rightarrow s_1 = 0.144)$ OR $0 = (-1.2)^2 + 2 \times (5) \times s_1 \quad (\Rightarrow s_1 = -0.144)$ OR $s_1 = 1.2 \times 0.24 + \frac{1}{2} \times (-5) \times 0.24^2 \quad (\Rightarrow s_1 = 0.144)$	M1	Attempt at finding the distance of A below its starting position when it first comes to instantaneous rest. Using 1.2 and their 5 from 5(a) – same dependency as in 5(b) for the value of a from 5(a) . If using $s = 1.2 \times t_1 + 0.5at_1^2$ then their t_1 must have come from $0 = 1.2 + a \times t_1$ with their value of a from 5(a) . Energy for A : $0 - \frac{1}{2} \times 2 \times 1.2^2 = 2 \times 10 \times s_1 - 30 \times s_1$. Energy for B : $0 - \frac{1}{2} \times 6 \times 1.2^2 = -6 \times 10 \times s_1 + 30 \times s_1$. Energy for system: . $0 - \left(\frac{1}{2} \times 2 \times 1.2^2 + \frac{1}{2} \times 6 \times 1.2^2 \right) = 2 \times 10 \times s_1 - 6 \times 10 \times s_1$. If using energy – must have the correct number of dimensionally correct terms but allow sign errors. If considering either A or B then their value of $T (= 30)$ is dependent on both M1 marks in 5(a) .

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Question	Answer	Marks	Guidance
	$w^2 = 1.2^2 + 2 \times 5 \times 3.2$ or $w^2 = 0^2 + 2 \times 5 \times (3.2 + 0.144)$ $(\Rightarrow w^2 = 33.44, w = 5.7827\dots)$ OR $w = 1.2 + 5(1.1565\dots - 0.24)$	*M1	Correct method to find the speed or speed ² of <i>A/B</i> after travelling 3.2 metres (oe) – using 1.2 and their <i>a</i> from 5(a) – same dependency as in part (b) for the value of <i>a</i> from 5(a) . If using $v = u + at$ then <i>t</i> must come from considering $t_2 - t_1$ (see reference on previous page).
	Distance <i>A</i> travels from a point 6.4 metres above the ground to rest: $0 = 33.44 + 2 \times (-10) \times s_2$ ($\Rightarrow s_2 = 1.672$)	DM1	Attempt to find the distance travelled by <i>A</i> after <i>B</i> hits the ground, using their <i>w</i> , $a = -g$ and $v = 0$.
	Difference in distances is $s_1 + 3.2 + s_2 = 5.016$ m	A1	AWRT 5.02 or 5.01 CWO.
		4	

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Question	Answer	Marks	Guidance
6(a)	$m \times u + 2 \times (-3u) = m \times \left(-\frac{1}{3}u\right) + 2 \times v$	M1	Attempt at conservation of momentum with correct number of terms. Allow sign errors ONLY so no misreads in this part. However, if using g with either (or both) masses, then allow this mark but do not allow subsequent A marks.
	$v = \frac{2}{3}mu - 3u$	A1	A correct (un-simplified) expression for the velocity of Q after the collision e.g. $\frac{(2m-9)u}{3}$, $\frac{4}{6}mu - 3u$, $\frac{mu - 6u + \frac{1}{3}mu}{2}$, etc.
	$v > 0 \Rightarrow \frac{2}{3}mu - 3u > 0 \therefore m > 4.5$	A1	AG CWO – accept a correct expression for v put > 0 followed by $m > 4.5$. Note that $\frac{2}{3}mu - 3u = 0 \Rightarrow m = 4.5 \therefore m > 4.5$ is A0 . Using trial and improvement to show that v is negative with value(s) of m that are less than 4.5 is A0 unless they also show that $v = 0$ when $m = 4.5$. Similarly, if attempting to show that v is positive with value(s) of m that are greater than 4.5 they must also show that $v = 0$ when $m = 4.5$ for A1 . This A1 mark is dependent on the previous A1 mark.
		3	

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Question	Answer	Marks	Guidance
6(b)	$[Q\text{'s speed is reduced by 75\% by its impact with the wall } \Rightarrow] \text{ speed after impact is } \frac{1}{4}\left(\frac{2}{3}mu - 3u\right) \left[= \frac{1}{6}mu - \frac{3}{4}u \right]$	*B1FT	Follow through their v of the form $k_1mu + k_2u$ (if simplified) for $k_1, k_2 \neq 0$ from 6(a) OE e.g. $\frac{(2m-9)u}{12}$ or possibly implied by later working e.g. $-\frac{1}{3}u \leq \frac{(9-2m)u}{12}$. Allow $\pm$ e.g. $-\frac{1}{4}\left(\frac{2}{3}mu - 3u\right)$. Look out for this expression embedded in later (possibly incorrect) working.
	No further collisions therefore $\frac{1}{3}u \geq \frac{1}{6}mu - \frac{3}{4}u$	DM1	For $\frac{1}{3}u \geq \frac{1}{4}v$ with v of the form $k_1mu + k_2u$ for $k_1, k_2 \neq 0$ from 6(a) – allow $>$ or $=$ for this mark Note that $\frac{4}{3}u = \frac{2}{3}mu - 3u$ (which leads to $m = 6.5$) scores B1 M1 ONLY.
	Solve inequality to obtain $m \leq 6.5$	DM1	Solve to obtain an inequality of the form '$m <$' or '$m \leq$'. Dependent on both previous marks - M0 if an equation for m found rather than an inequality for a range of values of m.
	$(4.5 <)m \leq 6.5 \Rightarrow m = 6$	A1	CWO – condone $m = 6$ from $m < 6.5$.
		4	

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Question	Answer	Marks	Guidance
7(a)	For resolving in any direction to form an equation	*M1	Correct number of relevant dimensionally correct terms; allow sin/cos mix; allow sign errors. Forces that need resolving should be resolved, forces that do not need resolving should not be resolved.
	Perpendicular to plane: $R = 6g \cos \theta + 12 \sin \theta$	A1	Or $12 + F \cos \theta = R \sin \theta$ (resolving horizontally).
	Parallel to plane: $F + 12 \cos \theta = 6g \sin \theta$ or $6g \sin \theta - 12 \cos \theta = \mu(\dots)$	A1	Or $R \cos \theta + F \sin \theta = 6g$ (resolving vertically).
	For use of $F = \mu R$ to get an equation in μ and θ only	DM1	From dimensionally correct equations with the correct number of relevant terms (forces that need resolving should be resolved, forces that do not need resolving should not).
	$6g \sin \theta - 12 \cos \theta = \mu(6g \cos \theta + 12 \sin \theta)$ leading to $\mu = \frac{5 \tan \theta - 1}{5 + \tan \theta}$ With some evidence of intermediate step e.g. $\frac{12 \cos \theta \left(\frac{5 \sin \theta}{\cos \theta} - 1 \right)}{12 \cos \theta \left(5 + \frac{\sin \theta}{\cos \theta} \right)}$ OR $\frac{12 \cos \theta (5 \tan \theta - 1)}{12 \cos \theta (5 + \tan \theta)}$ OR ‘divide by cosine’ OR use/mention of $\tan \theta = \frac{\sin \theta}{\cos \theta}$ OR $\sin \theta = \tan \theta \cos \theta$, etc.	A1	AG – CWO must give some indication of how the equation in sin/cos leads to the given answer e.g. $\mu = \frac{6g \sin \theta - 12 \cos \theta}{6g \cos \theta + 12 \sin \theta}$ then ‘divide through by cos’ gives $\mu = \frac{5 \tan \theta - 1}{5 + \tan \theta}$ scores A1 (so therefore mentioning ‘dividing by cos’). Seeing $\mu = \frac{6g \sin \theta - 12 \cos \theta}{6g \cos \theta + 12 \sin \theta} = \frac{5 \tan \theta - 1}{5 + \tan \theta}$ only is A0 .
		5	

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Question	Answer	Marks	Guidance
7(b)	$\mu > 0 \Rightarrow \tan \theta > \frac{1}{5}$	M1	Set the numerator of μ either =, > or $\geq$ to 0 and obtain $\tan \square k$ where $\square$ is =, > or $\geq$ and $k \neq 0$ - ignore any consideration of an upper bound (e.g. saying that $\mu < 1$).
	$11.3 < \theta (< 90)$	A1	AWRT 11.3 (11.30993...). Must be strict inequality. Allow $\theta > 0.197(39\dots)$ - if anything other than < 90 then A0 .
		2	

Cambridge International AS & A Level

MATHEMATICS**9709/45**

Paper 4 Mechanics

October/November 2025**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 2025 series for most Cambridge IGCSE, Cambridge International A and AS Level components, and some Cambridge O Level components.

This document consists of **26** printed pages.

PUBLISHED**Generic Marking Principles**

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied along side 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**Annotations guidance for centres**

Examiners use a system of annotations as a shorthand for communicating their marking decisions to one another. Examiners are trained during the standardisation process on how and when to use annotations. The purpose of annotations is to inform the standardisation and monitoring processes and guide the supervising examiners when they are checking the work of examiners within their team. The meaning of annotations and how they are used is specific to each component and is understood by all examiners who mark the component.

We publish annotations in our mark schemes to help centres understand the annotations they may see on copies of scripts. Note that there may not be a direct correlation between the number of annotations on a script and the mark awarded. Similarly, the use of an annotation may not be an indication of the quality of the response.

The annotations listed below were available to examiners marking this component in this series.

Annotations

Annotation	Meaning
	More information required
	Accuracy mark awarded zero
	Accuracy mark awarded one
	Independent accuracy mark awarded zero
	Independent accuracy mark awarded one
	Independent accuracy mark awarded two
	Benefit of the doubt
	Blank Page
	Incorrect
Dep	Used to indicate DM0 or DM1

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Annotation	Meaning
DM1	Dependent on the previous M1 mark(s)
	Follow through
	Indicate working that is right or wrong
Highlighter	Highlight a key point in the working
	Ignore subsequent work
	Judgement
	Judgement
	Method mark awarded zero
	Method mark awarded one
	Method mark awarded two
	Misread
	Omission or Other solution
Off-page comment	Allows comments to be entered at the bottom of the RM marking window and then displayed when the associated question item is navigated to.
On-page comment	Allows comments to be entered in speech bubbles on the candidate response.
	Judgment made by the PE
	Premature approximation
	Special case
	Indicates that work/page has been seen

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Annotation	Meaning
	Error in number of significant figures
	Correct
	Transcription error
	Correct answer from incorrect working

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	Resolving in any direction to get an equation	*M1	Correct number of relevant terms; allow sign errors; allow consistent or inconsistent sin/cos mix.
	$P + 21\cos 47 - Q\cos 65 - 32\cos 35 = 0$ $P + 14.321\dots - Q\cos 65 - 26.212\dots = 0$	A1	This could be with their Q .
	$21\sin 47 + 32\sin 35 - Q\sin 65 = 0$ $15.358\dots + 18.354\dots - Q\sin 65 = 0$ $33.712\dots - Q\sin 65 = 0$	A1	
	Attempt to solve for $P = -21\cos 47 + (37.198\dots)\cos 65 + 32\cos 35$	DM1	From equation(s) with correct number of relevant terms. Using their Q . Must be a numerical expression for P . All forces resolved as appropriate but allow consistent or inconsistent sin/cos mix. If no intermediate working to solve their two original equations, can still earn DM1 if answers correct for their equations but DM0 if answers wrong for their equations.
	$P = 27.6$ AND $Q = 37.2$	A1	27.61147... and 37.19804... DM1 may be earned here.
		5	

Question	Answer	Marks	Guidance
2(a)	Correct velocity-time graph	B1	Trapezium starting and finishing on the horizontal axis. V and 246 labelled but ignore gradients. Ignore any other labelling. Condone label o6 rather than V .
		1	

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Question	Answer	Marks	Guidance
2(b)	Method using total time first		
	Time accelerating is $\frac{V}{0.5}$ [= 2V] or time decelerating is $\frac{V}{0.2}$ [= 5V]	*B1	For one correct time in terms of V .
	$[T =] 246 - \frac{V}{0.5} - \frac{V}{0.2} [= 246 - 7V]$	B1	OE Allow correct un-simplified expression.
	$\frac{1}{2} \left(\frac{V}{0.5} \times V \right) + V(246 - 7V) + \frac{1}{2} \left(\frac{V}{0.2} \times V \right) = 1350$ or $\frac{1}{2}(246 + 246 - 7V)(V) = 1350$ or $0 + \frac{1}{2} \times 0.5 \times (2V)^2 + V(246 - 7V) + V \times 5V - \frac{1}{2} \times 0.2 \times (5V)^2 = 1350$ or $\frac{V^2}{2(0.5)} + V(246 - 7V) + \frac{V^2}{2(0.2)} = 1350$ or $0 = V - 0.2 \left(246 - 246 + 7V - \frac{V}{0.5} \right)$ or e.g. $246 - 7V = \frac{2700 - 246V}{V}$	DM1	Set up an equation in V only with the correct number of relevant terms to find total distance. Dependent on $\frac{V}{0.5}$ and $\frac{V}{0.2}$ seen, possibly embedded. e.g. triangle/rectangle/triangle to get first equation or trapezium to get second equation or use $s = ut + \frac{1}{2}at^2$ to get the third equation or use $v^2 = u^2 + 2as$ to get the fourth equation or use $v = u + at$ to get the fifth equation or two expressions for T can be equated to form an equation for V to get the sixth equation OE.

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Question	Answer	Marks	Guidance
2(b)	$7V^2 - 492V + 2700 = 0$	A1	AG. No need to see intermediate steps after a correct equation seen but must check that any intermediate steps seen are correct. If any errors seen anywhere then A0 .
	Alternative using total displacement first (trapezium OE)		
	Distance accelerating is $\frac{V^2}{2 \times 0.5} [= V^2]$ or distance decelerating is $\frac{V^2}{2 \times 0.2} [= 2.5V^2]$ $\frac{1}{2}(246 + T)V = 1350$ or $\frac{246 - T}{2}V + VT = 1350$ or alternatively $\frac{1}{2}\left(\frac{V}{0.5} \times V\right) + VT + \frac{1}{2}\left(\frac{V}{0.2} \times V\right) = 1350$	*B1	For distance accelerating/decelerating. or for trapezium area or could use 2 triangles and rectangle.
	$[T =] \frac{2700}{V} - 246 \left[= \frac{2700 - 246V}{V} \right]$ or alternatively (from above alternative) $[T =] \frac{1350 - \frac{7}{2}V^2}{V}$	B1	OE. Allow correct un-simplified expression.
	$t_1 + T + t_2 = 246 \Rightarrow \frac{V}{0.5} + \frac{2700}{V} - 246 + \frac{V}{0.2} = 246$ or $2V + \frac{2700}{V} - 246 + 5V = 246$ oe or alternatively (from above alternative) $7v + \frac{1350 - \frac{7}{2}V^2}{V} = 246$	DM1	Set up an equation in V only with the correct number of relevant terms but all terms present. Some candidates are getting to the correct equation for T and then substituting this back into the trapezium equation which simply gets $1350 = 1350$, so does not show the required equation and gets B1B1M0A0 .

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Question	Answer	Marks	Guidance
2(b)	$7V^2 - 492V + 2700 = 0$	A1	AG. No need to see intermediate steps after a correct equation seen but must check that any intermediate steps seen are correct. If any errors seen anywhere then A0 .
	Alternative where T is not found		
	Time accelerating is $\frac{V}{0.5}$ [= 2V] or time decelerating is $\frac{V}{0.2}$ [= 5V] or Distance accelerating is $\frac{V^2}{2 \times 0.5}$ [= V^2] or distance decelerating is $\frac{V^2}{2 \times 0.2}$ [= $2.5V^2$]	*B1	For one correct time or distance in terms of V .
	Total distance = $246V - \frac{V^2}{2 \times 0.5} - \frac{V^2}{2 \times 0.2}$	B1	OE.
	$246V - \frac{V^2}{2 \times 0.5} - \frac{V^2}{2 \times 0.2} = 1350$	DM1	Set up an equation in V only with the correct number of relevant terms but all terms present.
	$7V^2 - 492V + 2700 = 0$	A1	AG. No need to see intermediate steps after a correct equation seen, but must check that any intermediate steps seen are correct. If any errors seen anywhere then A0 .
		4	

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Question	Answer	Marks	Guidance
2(c)	$V = 6$ ONLY	*B1	B0B0 if both solutions stated and do not discard $\frac{450}{7}$
	$V \neq \frac{450}{7}$ as e.g. this would lead to the athlete running at a constant speed for a negative time $\left[\frac{2700 - 246\left(\frac{450}{7}\right)}{\left(\frac{450}{7}\right)} \text{ or } 246 - 7\left(\frac{450}{7}\right) = -204 \right]$ OR the athlete would take longer than 246 seconds to decelerate $\left[t_{\text{decelerate}} = \frac{450}{7} \div 0.2 = \frac{2250}{7} = 321.4 > 246 \right]$ OR $\left[t_{\text{acc+dec}} = \frac{450}{7} \times 7 = 450 > 246 \right]$	DB1	Any acceptable reason for rejecting greater root e.g. not feasible for an athlete to be running at 64.3 metres per second. Other root must be seen, not e.g. just state $T > 0$ without mention of other root but if they state $\frac{450}{7}$, then say $T > 0$, so not suitable then award B1 . Calculations not necessary but if calculations are shown they must be correct.
		2	

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Question	Answer	Marks	Guidance
3(a)	Either driving force: $\frac{P}{12}$ or $\frac{P}{20}$	*B1	OE. $P=12F$ or $P=20F$ but B0 if erroneous value of F .
	$\frac{P}{20} - R = 0$ or $20F_1 = 12F_2$	*B1	OE. $P=20R$ or $F_1 = \frac{3}{5}F_2$.
	$\frac{P}{12} - R - 800g \times 0.15 = 0$ or $F_2 - R - 800g \times 0.15 = 0$ where F_2 is the larger of the two forces or $\frac{P}{12} - R - 800g \times \sin 8.6 = 0$ or $P = 12(R + 800g \times 0.15)$ or $P = 12(R + 800g \times \sin 8.6)$	*M1	Attempt at N2L on inclined section of the road; correct number of relevant terms, allow sign errors and sin/cos mix with components only where needed. Must have more than simply $\sin \alpha$ or $\cos \alpha$. g must be present. Resistance term here must be same as that in second B1 .
	$\frac{P}{12} - \frac{P}{20} - 800g \times 0.15 = 0 \Rightarrow P =$ or $F_2 - F_1 - 800g \times 0.15 = 0 \Rightarrow P =$ or $\frac{P}{12} - \frac{P}{20} - 800g \times \sin 8.6 = 0 \Rightarrow P =$ or $20R - 12(R + 800g \times 0.15) = 0 \Rightarrow R =$ or $20R - 12(R + 800g \times \sin 8.6) = 0 \Rightarrow R =$	DM1	Eliminate and solve for either P or R . Correct number of relevant terms, allow sign errors and sin/cos mix. Must have more than simply $\sin \alpha$ or $\cos \alpha$. If no solving seen, answer must be correct for their equations to be awarded DM1 . Dependent on B1B1M1
	$P=36000$ and $R=1800$	A1	Using angle of 8.63 gives $P=36012(36000)$ and $R=1800.6(1800)$ which scores A1 . Using an angle of 8.6 does not give answers correct to 3sf so gets A0 .
		5	

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Question	Answer	Marks	Guidance
3(b)	Attempt at N2L to form an equation on inclined section of the road	M1	Correct number of relevant terms, allow sign errors and sin/cos mix with components only where needed. Must have more than simply $\sin \alpha$ or $\cos \alpha$. Allow D for driving force. g must be present.
	$\frac{32000}{10} - 800g \times 0.15 - 1800 = 800a$ or $\frac{32000}{10} - 800g \times \sin 8.6 - 1800 = 800a$	A1FT	Correct equation following through their R .
	0.25 [m s ⁻²]	A1	Condone answer of 0.249 from using an angle of 8.63. Using an angle of 8.6 does not give answer correct to 3sf so gets A0 .
		3	

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Question	Answer	Marks	Guidance
4(a)	$a = kt - 3 \Rightarrow v = \frac{1}{2}kt^2 - 3t \Rightarrow [+c]$	*M1	Increase power by 1 and a change in coefficient in at least one term (which must be the same term). Use of $v = at$ scores M0 .
	$t = 0, v = 1 \Rightarrow v = \frac{1}{2}kt^2 - 3t + 1$	A1	Correct expression for v . $v = \frac{1}{2}kt^2 - 3t [+c]$ followed by $c = 1$ scores A1 .
	Discriminant $9 - 4 \times \frac{1}{2}k < 0$ or Discriminant $36 - 4(k)(2) < 0$	DM1	Set the discriminant of their 3-term quadratic in t to less than zero (or other complete method). NB: attempt at quadratic formula to find roots can score M1 only if they find $b^2 - 4ac$ and consider its sign OE.
	$[9 - 2k < 0 \text{ or } 36 - 8k < 0 \Rightarrow] k > 4.5$	A1	AG. If any errors seen anywhere then A0 .
	Alternative for final 2 marks using completing the square		
	$\left[k \left(t - \frac{3}{k} \right)^2 - \frac{9}{k} + 2 > 0 \Rightarrow \right] -\frac{9}{k} + 2 > 0$	DM1	Attempt to complete the square and then use fact that the last two terms > 0 . Must get to $-\frac{\text{their } 3^2}{k} + 2 \times \text{their } 1 > 0$. Must be from 3 term quadratic.
	$k > 4.5$	A1	AG If any errors seen anywhere then A0 .

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Question	Answer	Marks	Guidance
4(a)	Alternative for final 2 marks using fact that $a=0$ gives minimum velocity		
	$\left[\text{When } a=0 \right] \left[\text{or } t = \frac{-b}{2a} \right], t = \frac{3}{k} \Rightarrow v = \frac{1}{2}k \left(\frac{3}{k} \right)^2 - 3 \times \frac{3}{k} + 1 = -\frac{9}{2k} + 1$ so minimum value of v is $v = -\frac{9}{2k} + 1 \Rightarrow -\frac{9}{2k} + 1 > 0$	DM1	Complete method to find minimum velocity and set greater than zero. If state maximum rather than minimum, then M1A0 . Allow their 3 and their 1.
	$k > 4.5$	A1	AG. If any errors seen anywhere then A0 .
		4	

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Question	Answer	Marks	Guidance
4(b)	$\frac{1}{2} \times 2.5t^2 - 3t + 1 = 0$ or $5t^2 - 12t + 4 = 0$ oe $\Rightarrow t = \dots$	*M1	Substitute $k = 2.5$ and attempt to solve 3-term quadratic in t to get at least one t -value. If working shown must be using correct formula or if factorising two terms must be correct for their three-term quadratic when expanding brackets. If no working shown they must have at least one answer for their 3-term quadratic and if two answers, both must be correct. Dep on first M1 in 4(a) .
	$t = 2$ (and 0.4)	A1	If 2 used below as the middle limit without any working allow M1A1 .
	Attempt at integration of a 3-term quadratic for v	*M1	Increase power of their v by 1 and a change in coefficient in at least one term (which must be the same term) Use of $s = vt$ scores M0 . Allow with value of k not substituted Dep on first M1 in 4(a) .
	$s = \frac{5}{12}t^3 - \frac{3}{2}t^2 + t [+c]$	A1	Allow un-simplified. Must have k substituted.
	$\left[\frac{5}{12}t^3 - \frac{3}{2}t^2 + t \right]_1^2 = \left(\frac{5}{12}(2)^3 - \frac{3}{2}(2)^2 + 2 \right) - \left(\frac{5}{12}(1)^3 - \frac{3}{2}(1)^2 + 1 \right)$ $\left[-\frac{2}{3} - \left(-\frac{1}{12} \right) = -\frac{7}{12} \right]$ $\left[\frac{5}{12}t^3 - \frac{3}{2}t^2 + t \right]_2^3 = \left(\frac{5}{12}(3)^3 - \frac{3}{2}(3)^2 + 3 \right) - \left(\frac{5}{12}(2)^3 - \frac{3}{2}(2)^2 + 2 \right)$ $\left[\frac{3}{4} - \left(-\frac{2}{3} \right) = \frac{17}{12} \right]$	DM1	Use both limits correctly between 1 and their 2 and between their 2 and 3 provided $1 < \text{their } 2 < 3$. No other phases should be included e.g. 0 to 0.4 Dependent on M1M1 .

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Question	Answer	Marks	Guidance
4(b)	Total distance is 2 m	A1	SCB1 for correct answer with no attempt at integration seen following on from first M1A1. NB answer of $\frac{5}{6}$ from not finding t when $v = 0$ usually gets max M0A0M1A1M0A0. However if they find t when $v = 0$ and make an error in the sign e.g. $\frac{7}{12}$ rather than $-\frac{7}{12}$ can score max M1A1M1A1M1A0. Do not ISW. Accept AWRT 2.00 to 3sf.
		6	

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Question	Answer	Marks	Guidance
5(a)	Attempt N2L for Q and R to form two equations	*M1	Correct number of relevant terms in each, allow sign errors and T for both tensions. Masses must be correct. Condone different accelerations. Ignore anything relating to P . For first 4 marks condone substituted value of g .
	$5g - T_{PQ} = 5a$ or $5g - 2T_{[PR]} = 5a$ $T_{PR} - 2g = 2a$ or $T_{[PR]} - 2g = 2a$ or $\frac{5g - T_{PQ}}{5} = \frac{T_{PR} - 2g}{2} [= a]$	A1	Must be using different T 's – possibly with the result that $T_{PQ} = 2T_{PR}$. Condone use of $2T_{PQ} = T_{PR}$ for this A1 . Accelerations must be the same. Allow $T_{PQ} - 5g = 5a$ and $2g - T_{PR} = 2a$.
	$5g - 4g = 5a + 4a$ or $5g - 2(2a + 2g) = 5a$ oe Or $\frac{5g - 2T_{PR}}{5} = \frac{T_{PR} - 2g}{2}$ oe	DM1	Use $T_{PQ} = 2T_{PR}$ to obtain an equation in a only or in T only. Can be implied by correct value of a or T_{PQ} or T_{PR} if no solving seen.
	$a = \frac{1}{9}g$ Condone $\frac{10}{9}$ or $\frac{9.8}{9}$ or $\frac{9.81}{9}$ or 1.11. $T_{PR} = \frac{20}{9}g$, $T_{PQ} = \frac{40}{9}g$ Allow $T_{PR} = 2.22g$ and $T_{PQ} = 4.44g$	A1	A1 for any one of the three answers. Second A1 for all three.
		A1	You may see $a = -\frac{1}{9}g$ if equations ‘backwards’ but must get to $a = \frac{1}{9}g$ OE for A1 . Tensions must be in terms of g but ISW. Do not allow e.g. $T_{PQ} = 5g - \frac{5}{9}g$ as final answer. Allow A1 if tensions not labelled.
		5	

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Question	Answer	Marks	Guidance
5(b)	$[R_p =] 6g \cos 30$	B1	Seen or implied by $\frac{60\sqrt{3}}{2}$ or $30\sqrt{3}$ or $3g\sqrt{3}$ but must be the normal reaction.
	Attempt N2L for P or whole system to form an equation	*M1	Correct number of relevant terms (5) (or 4 terms if tensions combined), allow sign errors, allow F for friction but must be using two different expressions for tensions. Must be component of weight (and weights, not masses, if using whole system). Must substitute their tension and acceleration. Must use correct mass(es). You may see an equation such as $5g - F = 4a$, which comes from combining equations for P and N2L for Q or R , and this may be shown in 5(a) rather than 5(b) , so in this case link the two parts.
	For P: $6g \sin 30 + \text{their } \frac{40}{9}g - \text{their } \frac{20}{9}g - F = 6 \times \text{their } \frac{1}{9}g$ For system: $5g + 6g \sin 30 - 2g - F = 13 \times \text{their } \frac{1}{9}g$	A1FT	Correct equation following through their two different values of T and their a . Do not need a value for F and allow with wrong F . Note: $\text{their } \frac{40}{9}g - \text{their } \frac{20}{9}g$ may be combined into $\text{their } \frac{20}{9}g$ Note: $F = \frac{410}{9} = 45.5555\dots$ Check very carefully for FT of their a, T_{PR}, T_{PQ} .
	$6g \sin 30 + \text{their } \frac{40}{9}g - \text{their } \frac{20}{9}g - \mu \times 6g \cos 30 = 6 \times \text{their } \frac{1}{9}g$	DM1	Use of $F = \mu R$ to obtain an equation in μ only where R is a component of $6g$.

Question	Answer	Marks	Guidance
5(b)	$\mu = 0.877$	A1	0.876717...; $\frac{41\sqrt{3}}{81}$.
		5	

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Question	Answer	Marks	Guidance
5(c)	$d = \frac{1}{2} \times \frac{1}{9} g \times 1.5^2 \quad [\Rightarrow d = 1.25]$	M1	OE. Use of $s = ut + \frac{1}{2}at^2$ with $u = 0$, $t = 1.5$ and their a from part (a) or other complete method to get an equation in d only. May use $\frac{1}{2}x$ rather than d . Must not use $a = 10$ unless this is their a from 5(a).
	2.5 [m]	A1FT	FT 2.25a.
	Alternative using work-energy		
	For 6kg particle $\frac{1}{2} \times 6 \times \left(\text{their } \frac{g}{9} \times 1.5 \right)^2 - 6g \sin 30 \times d = \text{their } \frac{40g}{9} \times d - \text{their } \frac{20g}{9} \times d - \text{their } \mu \times 6g \cos 30 \times d$ $[\Rightarrow d = 1.25]$ for whole system $\frac{1}{2} \times 13 \times \left(\text{their } \frac{g}{9} \times 1.5 \right)^2 - 6g \sin 30 \times d = 5gd - 2gd - \text{their } \mu \times 6g \cos 30 \times d$ $[\Rightarrow d = 1.25]$	M1	Use of work-energy with all dimensionally correct terms present. Terms should have components as required and allow consistent sin/cos mix May use $\frac{1}{2}x$ rather than d .
	2.5 [m]	A1FT	
		2	

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Question	Answer	Marks	Guidance
6	$km \times 2u - m \times u = km \times u + m \times v_B$	*M1	Attempt at CLM; correct number of terms and correct masses with relevant velocities but allow sign errors. v_B is the speed of B after impact. If g included with the masses then M1A0 .
	$v_B = (k-1)u$ or $ku = v_B + u$ or $k = \frac{v_B + u}{u}$ or $k = \frac{v_B}{u} + 1$	A1	Any correct equation linking v_B, k and u but with m eliminated.
	$KE_{\text{before}} = \frac{1}{2} \times km \times (2u)^2 + \frac{1}{2} \times m \times (\pm u)^2 \left[= 2kmu^2 + \frac{1}{2}mu^2 \right]$	*B1	KE before impact.
	$KE_{\text{after}} = \frac{1}{2} \times km \times u^2 + \frac{1}{2} \times mv_B^2$ Or $KE_{\text{after}} = \frac{1}{2} \times km \times u^2 + \frac{1}{2} \times mu^2 (k-1)^2$	*B1FT	KE after impact. Allow if their expression for v_B is wrong. Allow B1B1 for the change in KE = $\pm \left(\frac{3}{2}kmu^2 + \frac{1}{2}mu^2 - \frac{1}{2}mv_B^2 \right)$
	$0.65 \times \left(2kmu^2 + \frac{1}{2}mu^2 \right) = \frac{1}{2}mu^2 (k + (k-1)^2)$ Or $\left(2kmu^2 + \frac{1}{2}mu^2 \right) - \frac{1}{2}mu^2 (k + (k-1)^2) = 0.35 \times \left(2kmu^2 + \frac{1}{2}mu^2 \right)$ Or $0.8ku^2 + 0.325u^2 = \frac{1}{2}(k-1)^2 u^2$	*DM1	Setting up the equation $0.65 \times KE_{\text{before}} = KE_{\text{after}}$ OE with their expression for v_B in terms of k substituted. Must be correct way around and must use 0.65 OE. Dependent on M1B1B1 . May see $1.6ku^2 + 0.65u^2 = v_B^2$ leading to $1.6ku^2 + 0.65u^2 = (k-1)^2 u^2$.
	$2.6k + 0.65 = k + k^2 - 2k + 1 \Rightarrow k^2 - 3.6k + 0.35 = 0$ or $20k^2 - 72k + 7 = 0$	DM1	Re-arrange to a 3-term quadratic in k only – Dependent on M1B1B1M1 .

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Question	Answer	Marks	Guidance
6	$k = 3.5$ only	A1	If $k = 0.1$ seen must be rejected. Reason not required but if a reason given it must be valid e.g. as $k - 1 > 0$ or reject later e.g. if $k = 0.1 \Rightarrow v_B = -0.9u$ but not possible as $v_B > 0$.
	$v_B = 2.5u$ Ignore the other solution if shown ($v_B = -0.9u$)	A1	Not dependent on previous A mark. If g included in momentum equation then max M1A0B1B1M1M1A1A0 .
	ALTERNATIVE (eliminating k)		
	$km \times 2u - m \times u = km \times u + m \times v_B$	*M1	Attempt at CLM; correct number of terms and correct masses with relevant velocities but allow sign errors - v_B is the speed of B after impact. If g included with the masses then M1A0 .
	$v_B = (k - 1)u$ or $ku = v_B + u$ or $k = \frac{v_B + u}{u}$ or $k = \frac{v_B}{u} + 1$	A1	Any correct equation linking v_B, k and u but with m eliminated.
	$KE_{\text{before}} = \frac{1}{2} \times km \times (2u)^2 + \frac{1}{2} \times m(\pm u)^2 \left[= 2kmu^2 + \frac{1}{2}mu^2 \right]$ Or $KE_{\text{before}} = \frac{1}{2} \times \left(\frac{v_B + u}{u} \right) m \times (2u)^2 + \frac{1}{2} \times mu^2$	*B1FT	KE before impact. Allow if their expression for k is wrong.
	$KE_{\text{after}} = \frac{1}{2} \times km \times u^2 + \frac{1}{2} \times mv_B^2$ or $KE_{\text{after}} = \frac{1}{2} \times \left(\frac{v_B + u}{u} \right) m \times u^2 + \frac{1}{2} \times mv_B^2$	*B1FT	KE after impact. Allow if their expression for k is wrong. Allow B1B1 for the change in KE $\pm \left(\frac{3}{2}kmu^2 + \frac{1}{2}mu^2 - \frac{1}{2} \times mv_B^2 \right)$.

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Question	Answer	Marks	Guidance
6	$0.65 \times \left(\frac{1}{2} \times \left(\frac{v_B + u}{u} \right) m \times (2u)^2 + \frac{1}{2} \times mu^2 \right) = \frac{1}{2} \times \left(\frac{v_B + u}{u} \right) m \times u^2 + \frac{1}{2} \times mv_B^2 \text{ or}$ $\left(\frac{1}{2} \times \left(\frac{v_B + u}{u} \right) m \times (2u)^2 + \frac{1}{2} \times mu^2 \right) - \left(\frac{1}{2} \times \left(\frac{v_B + u}{u} \right) m \times u^2 + \frac{1}{2} \times mv_B^2 \right) =$ $0.35 \left(\frac{1}{2} \times \left(\frac{v_B + u}{u} \right) m \times (2u)^2 + \frac{1}{2} \times mu^2 \right)$ $\text{or } 0.65 \times \left(2mu(v_B + u) + \frac{1}{2} mu^2 \right) = \frac{1}{2} mu(v_B + u) + \frac{1}{2} mv_B^2$	*DM1	Setting up the equation $0.65 \times KE_{\text{before}} = KE_{\text{after}}$. OE with expression for k in terms of v_B substituted. Must be correct way around and must use 0.65 OE. Dependent on M1B1B1. May see $1.6ku^2 + 0.65u^2 = v_B^2$ oe leading to $1.6 \left(\frac{v_B + u}{u} \right) u^2 + 0.65u^2 = v_B^2.$
	$1.3uv_B + 1.625u^2 = 0.5u^2 + 0.5uv_B + 0.5v_B^2$ $\Rightarrow v_B^2 - 1.6uv_B - 2.25u^2 = 0$ $\Rightarrow 20v_B^2 - 32uv_B - 45u^2 = 0$	DM1	Re-arrange to a 3-term quadratic in terms of v_B and u only. Dependent on M1B1B1M1.
	$v_B \neq -0.9u$	A1	Explicitly seen and rejected.
	$v_B = 2.5u$ Ignore the other solution if shown ($v_B = -0.9u$)	A1	Not dependent on previous A mark. If g included in momentum equation, then max M1A0B1B1M1M1A1A0.
		8	