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MATHEMATICS **9709/42**

Paper 4 Mechanics **May/June 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.

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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.

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Mathematics-Specific Marking Principles

1 Unless a particular method has been specified in the question, full marks may be awarded for any correct method. However, if a calculation is required then no marks will be awarded for a scale drawing.

2 Unless specified in the question, 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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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.

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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	Initial KE $= \frac{1}{2} \times 72 \times 8^2 \left[= 2304\right]$ OR Final KE $= \frac{1}{2} \times 72 \times 16^2 \left[= 9216\right]$ OR Work done against resistance $= 28 \times 100 \left[= 2800\right]$	**B1**	Correct expression for either KE or correct expression for work done against resistance. For reference, $\frac{1}{2} \times 72 \times \left(16^2 - 8^2\right) = 6912$.
	Attempt at work-energy equation $\left[\frac{1}{2} \times 72 \times 8^2 + \text{WD} = \frac{1}{2} \times 72 \times 16^2 + 28 \times 100\right]$	**M1**	4 terms; allow sign errors; dimensionally correct.
	$\text{WD} = 9712\,\text{J}$	**A1**	OE. Condone 9710 J. Do not ISW.
	Alternative method for Question 1:		
	$\left[16^2 = 8^2 + 2 \times 100 \times a \Rightarrow\right] \; a = \frac{16^2 - 8^2}{2 \times 100} = 0.96$	**(B1)**	OE, e.g. $a = \frac{192}{200}$. Use of suvat in a complete method to find an expression for a. Must be of the form '$a = \ldots$'.
	Attempt at Newton's second law $\left[\text{DF} - 28 = 72 \times \left(\textit{their}\, 0.96\right)\right]$	**(M1)**	Three terms; dimensionally correct; allow sign errors; must be using *their* value of a.
	$\text{WD}\left[= 97.12 \times 100\right] = 9712\,\text{J}$	**(A1)**	OE. Condone 9710 J. Do not ISW.
		3	

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Question	Answer	Marks	Guidance
2(a)	Attempt to differentiate given v	**M1**	Decrease power by 1 and a change in coefficient in at least one term (which must be the same term); allow unsimplified. Use of $a = \frac{v}{t}$ scores M0.
	$\left[44 - 12t > 0 \Rightarrow\right] \; t < \frac{11}{3}$	**A1**	OE, e.g. $\frac{44}{12}$, $3\frac{2}{3}$, 3.67 or better. Do not allow $t \leqslant \frac{11}{3}$. May solve $44 - 12t = 0$, but final answer must be $t < \frac{11}{3}$. If a lower limit included it must be 0. Allow $t > 0$ or $t \geqslant 0$. Allow $\left[0, \frac{11}{3}\right)$ or $\left(0, \frac{11}{3}\right)$.
	Alternative Method for Question 2(a):		
	Use completing the square to get $-6\left[\left(t - \frac{11}{3}\right)^2 + \ldots\right] + \ldots$	**(M1)**	OE
	$t < \frac{11}{3}$	**(A1)**	CWO If a lower limit included it must be 0. Allow $t > 0$ or $t \geqslant 0$. Allow $\left[0, \frac{11}{3}\right)$ or $\left(0, \frac{11}{3}\right)$.

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Question	Answer	Marks	Guidance
2(a)	**Alternative Method 2 for Question 2(a):**		
	Solving $44t - 6t^2 - 36 = 0$ and find $\frac{t_1 + t_2}{2}$, or equivalent.	**(M1)**	Complete method for finding the value of t at maximum, or use $-\frac{b}{2a}$ with correct a and b. For reference, $t = \frac{11 \pm \sqrt{67}}{3}$.
	$t < \frac{11}{3}$	**(A1)**	If a lower limit included it must be 0. Allow $t > 0$ or $t \geqslant 0$. Allow $\left[0, \frac{11}{3}\right)$ or $\left(0, \frac{11}{3}\right)$.
		2	
2(b)	Attempt to integrate given v	**M1**	Increase power by 1 and a change in coefficient in at least one term (which must be the same term). Use of $s = vt$ is M0.
	$(s =)\frac{44}{1+1}t^{1+1} - \frac{6}{2+1}t^{2+1} - 36t(+c) = 22t^2 - 2t^3 - 36t(+c)$	**A1**	Allow unsimplified.
	$\left[22t^2 - 2t^3 - 36t = 0 \Rightarrow\right]$ $t = 2,\ 9(\text{and}\,0)$ ONLY	**A1**	CWO Ignore $t = 0$ if not rejected.
		3	

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Question	Answer	Marks	Guidance
3	Resolving either direction to get an equation	***M1**	Correct number of relevant terms; allow sign errors; allow sin/cos mix.
	$10\cos 25 = 2\cos 40 + 16\sin\theta$ $\begin{bmatrix} 9.06307787 = 1.532088886 + 16\sin\theta \\ 7.530988984 = 16\sin\theta \\ \sin\theta = 0.4706868115 \end{bmatrix}$	**A1**	
	$P = 10\sin 25 + 16\cos\theta + 2\sin 40$ $\begin{bmatrix} P = 4.226182617 + 16\cos\theta + 1.285575219 \\ P = 5.511757837 + 16\cos\theta \end{bmatrix}$	**A1**	This may be with *their* θ.
	Attempt to solve for $\theta = \sin^{-1}\left(\frac{10\cos 25 - 2\cos 40}{16}\right)$	**DM1**	From equation(s) with correct number of relevant terms. Must be a numerical expression for θ.
	Attempt to solve for $P = 10\sin 25 + 16\cos(\textit{their}\,\theta) + 2\sin 40$	**DM1**	From equation(s) with correct number of relevant terms. Using *their* θ. Must be a numerical expression for P.
	$\theta = 28.1$ AND $P = 19.6$	**A1**	28.07888819 and 19.6285636. AWRT 28.1 and AWRT 19.6 from correct work.
		6	

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Question	Answer	Marks	Guidance
4(a)(i)	$\left[k \times 24^2 = 480 \Rightarrow\right] \; k = \frac{5}{6}$	**B1**	OE, e.g. $\frac{480}{576}$, 0.833 or better.
		1	
4(a)(ii)	Attempt at Newton's second law $\left[DF = 480 + 1400g \times 0.12 \Rightarrow DF = 2160\right]$	***M1**	3 terms; allow sign errors; allow sin/cos mix. Allow $DF = 480 + 1400g \times \sin 6.9$ or better. May see $DF = \left(their \frac{5}{6}\right) 24^2 + 1400g \times 0.12$.
	Power $= \left(their\, 2160\right) \times 24$	**DB1**	For using $P = DF$ x v, where DF is numerical.
	51840 W	**A1**	Allow W missing, but if given in kW units must be present. Allow 51.84 kW. Allow 51800, 51.8 kW.
		3	
4(b)	$DF = \frac{54000}{v}$ and $DF = \left(their \frac{5}{6}\right) v^2$	***B1FT**	FT $their \frac{5}{6} > 0$.
	Get an equation of the form $av^3 = b$ and attempt to solve for v to get a positive value	**DM1**	a and b must both be positive or both negative. Must get to a value for v; if cubic not seen, the cubic may be implied by the correct answer for their equation.
	Speed = $40.2\,\text{m s}^{-1}$	**A1**	40.165977. AWRT 40.2 from correct work.
		3	

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Question	Answer	Marks	Guidance
5	Attempt at resolving perpendicular to plane to get an equation	***M1**	3 relevant terms; allow sign errors; allow sin/cos mix; allow *g* missing; $m = 0.8$ must be used; correct angles must be used.
	$R + T\sin 35 = 0.8g\cos 28$ $\left[R + (0.57357\ldots)\ T = 7.06358\right]$	**A1**	
	Attempt to resolve parallel to plane for one of the possible cases to get an equation	***M1**	3 relevant terms; allow sign errors; allow sin/cos mix; allow *g* missing; $m = 0.8$ must be used; correct angles must be used.
	$T\cos 35 = 0.8g\sin 28 + F$ $\left[(0.81915\ldots)T = 3.75577\ldots + F\right]$	**A1**	May use *their F*.
	$T\cos 35 = 0.8g\sin 28 - F$ $\left[(0.81915\ldots)T = 3.75577\ldots - F\right]$	**A1**	May use *their F*.
	Use of $F = 0.2R$ to get an equation in *T* only	**DM1**	Dependent on previous 2 M marks. May be implied by correct *T* value. Allow *g* missing. If resolved equations incorrect and no working seen, then this mark is implied by the correct *T* value for their equations.
	Solve to get $T = 5.53$	**A1**	5.534499898 AWRT 5.53 from correct work. Allow 5.54 from correct work.
	Solve to get $T = 3.33$	**A1**	3.326141531 AWRT 3.33 from correct work. Allow 3.32 from correct work.
		8	

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Question	Answer	Marks	Guidance
6(a)	Attempt at conservation of momentum for the 1st collision $\left[5\times 6=(5+1)v_D\right]$	***M1**	3 non-zero terms; allow sign errors; using correct masses. For reference $v_D=5$. If *mgv* used, allow M1 M1 A0 max.
	Attempt at conservation of momentum for the 2nd collision $\left[(5+1)(\textit{their}\, v_D)-2v=(5+1+2)v_E\right]$	**DM1**	6 non-zero terms; allow sign errors; using correct masses; allow their numerical v_D. Allow $v=v_E$ for this mark. Note: $5\times 6-2v=(5+1+2)v_E$ is M2. If *mgv* used, allow M1 M1 A0 max.
	$(v_E=)\ \dfrac{15-v}{4}$	**A1**	AG Must in terms of *v*, as *v* is given in the question or explicitly defined their letter used as *v.* Do not allow $v=v_E$ for this mark. Any error seen is A0 but condone saying 'divide by 2' or equivalent. If *mgv* used, allow M1 M1 A0 max.
		3	

Question	Answer	Marks	Guidance
6(b)	$\text{KE}_{initial} = \frac{1}{2}\times 5\times 6^2 + \frac{1}{2}\times 2\times v^2 \left[= 90 + v^2\right]$ $\text{KE}_{final} = \frac{1}{2}(5+1+2)\left(\frac{15-v}{4}\right)^2$	**B1**	For either $\text{KE}_{initial}$ or KE_{final} correct.
	Attempt difference in KE is 63 to get an equation $\left[\frac{1}{2}\times 5\times 6^2 + \frac{1}{2}\times 2\times v^2 - \frac{1}{2}(5+1+2)\left(\frac{15-v}{4}\right)^2 = 63\right]$	**M1**	Using $(\text{sum of two initial } KEs) - \text{KE}_{final} = \pm 63$. Correct number of relevant terms – correct masses, must be adding 2 KE terms for $\text{KE}_{initial}$. $(\text{sum of two initial } KEs)$ and KE_{final} coming from use of correct formula and of the correct form.
	Solve algebraically $3v^2 + 30v - 117 = 0$ OE to get $v = 3$ ONLY	**A1**	AG Any error seen is A0. Allow solving correct quadratic expression, rather than correct quadratic equation, for full marks. If $v = -13$ seen it must be discarded. Must see solving for this mark. A quadratic equation followed by the answer is insufficient.

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Question	Answer	Marks	Guidance
6(b)	**Alternative Method for Question 6(b): Using loss of KE in second collision**		
	$\text{KE}_{\textit{after 1st collision}} = \frac{1}{2}\times 6\times 5^2 + \frac{1}{2}\times 2\times v^2 \left[= 75 + v^2\right]$ $\text{KE}_{\textit{final}} = \frac{1}{2}(5+1+2)\left(\frac{15-v}{4}\right)^2$	**(B1)**	For either $\text{KE}_{\textit{after 1st collision}}$ or $\text{KE}_{\textit{final}}$ correct.
	Attempt difference in KE is $63 - \left(\frac{1}{2}\times 5\times 6^2 - \frac{1}{2}\times 6\times 5^2\right)\left[= 63-15 = 48\right]$ to get an equation $\left[\frac{1}{2}\times 6\times 5^2 + \frac{1}{2}\times 2\times v^2 - \frac{1}{2}(5+1+2)\left(\frac{15-v}{4}\right)^2 = 63-15\right]$	**(M1)**	Using $\text{KE}_{\textit{after 1st collision}} - \text{KE}_{\textit{final}} = \pm(63 - \textit{their}\,15)$. Correct number of relevant terms. $\text{KE}_{\textit{after 1st collision}}$, $\text{KE}_{\textit{final}}$ and *their* 15 coming from use of correct formula and of the correct form.
	Solve algebraically $3v^2 + 30v - 117 = 0$ OE to get $v = 3$ ONLY	**(A1)**	AG Any error seen is A0. If $v = -13$ seen it must be discarded. Must see solving for this mark. A quadratic equation followed by the answer is insufficient.
	Alternative Method 2 for Question 6(b): Verifying that $v = 3$		
	$\text{KE}_{\textit{initial}} = \frac{1}{2}\times 5\times 6^2 + \frac{1}{2}\times 2\times 3^2 = 99$	**(B1)**	
	$\text{KE}_{\textit{final}} = \frac{1}{2}(5+1+2)\left(\frac{15-3}{4}\right)^2 = 36$	**(B1)**	
	$\text{KE}_{\textit{initial}} - \text{KE}_{\textit{final}} = 63$, hence loss in KE is 63 J	**(B1)**	Must have a conclusion for this mark.
		3	

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Question	Answer	Marks	Guidance
6(c)(i)	Time A to $B = 6\,\text{s}$	**B1**	
	Distance $BC = 98 - 3\times(their\,6)$ $[=80]$	***B1FT**	FT *their* 6 which MUST come from $6t = 36$.
	Use sum of distance moved by D and distance moved by C is 80 m $[(their\,5)t + 3t = their\,80]$ OR use distance moved by C divided by relative velocity $\left[\dfrac{80}{(their\,5)+3}\right]$	**DM1**	Using $their\,v_D$ from part **(a)**. $v_D \neq 6$ or 3 and $their\,80 \neq 98$.
	Time = 10 s	**A1**	Do not ISW.
		4	
6(c)(ii)	$\left[6 + 10 + \dfrac{3\times10 + 3\times6}{3} =\right] 32\,\text{s}$	**B1**	
		1	

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Question	Answer	Marks	Guidance
7(a)	$R = 2.5g\cos 30\left[= \frac{25\sqrt{3}}{2} = 21.65063509\right]$	**B1**	Note: $F = 0.5g\cos 30 = \frac{5\sqrt{3}}{2} = 4.330127019$.
	Attempt at Newton's second law	***M1**	Correct number of dimensionally correct/relevant terms; allow sign errors; allow sin/cos mix. Using this twice to get equations for P and Q; allow different T's (equations with 0.5 and 2.5). Using once to get a system equation (equation with $0.5 + 2.5$).
	EITHER: $T - 0.5g = 0.5a$ AND $2.5g\sin 30 - F - T = 2.5a$ OR: $2.5g\sin 30 - F - 0.5g = (2.5 + 0.5)a$	**A1**	EITHER: Both correct; allow their F; must be the same T. OR: correct system equation; allow their F.
	Use $F = 0.2R$ to get an equation in a only $\left[2.5g\sin 30 - 0.2 \times 2.5g\cos 30 - 0.5g = (2.5 + 0.5)a\right]$	**DM1**	Where R is a component of weight of P only; from equation(s) with the correct number of dimensionally correct/relevant terms.
	$a = 1.06\ \text{m s}^{-2}$	**A1**	Allow $\frac{15 - 5\sqrt{3}}{6}$. 1.05662433. AWRT 1.06 from correct work.
		5	

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Question	Answer	Marks	Guidance
7(b)	$\left[x\sin 30 = 2 - x \Rightarrow\right]\ x = \frac{4}{3}$ OR $\left[(2-y)\sin 30 = y \Rightarrow\right]\ y = \frac{2}{3}$ OR $\left[\frac{1}{2}\times 1.056\ldots \times t^2 + \frac{1}{2}\times 1.056\ldots \times t^2 \times \sin 30 = 2 \Rightarrow t = 1.5886\ldots\right]$ $\Rightarrow x\left[= \frac{1}{2}\times 1.056\ldots \times (1.5886..)^2 \sin 30\right] = \frac{2}{3}$ OR $\Rightarrow y\left[= \frac{1}{2}\times 1.056\ldots \times (1.5886..)^2\right] = \frac{4}{3}$	***B1**	Where x is the distance P moves down the plane or Q moves vertically upwards, or where y is the vertical distance of Q below P's starting point. Allow $x = 1.3$ or better; allow $y = 0.67$ or better.
	Change in PE $= \pm\left(2.5g\left(their\ x\right)\sin 30 - 0.5g\left(their\ x\right)\right)\ \left[= \pm\frac{3}{4}g\left(their\ x\right)\right]$ OR $= \pm\left(2.5g\left(2 - their\ y\right)\sin 30 - 0.5g\left(2 - their\ y\right)\right)$ $\left[= \pm\left(3\left(their\ y\right) - 1\right)g\right]$	**B1**	Using *their* $x\left(\neq 2 \text{or } 1 \text{ or } 0\right),\ 0 < x < 2$; or *their* $y\left(\neq 2 \text{or } 1 \text{ or } 0\right),\ 0 < y < 2$.
	WD against friction $= 0.2\times 2.5g\cos 30\times\left(their\ x\right)\ \left[= 4.33\left(their\ x\right)\right]$ OR WD against friction $= 0.2\times 2.5g\cos 30\times\left(2 - \left(their\ y\right)\right)$	**B1**	Using *their* $x\left(\neq 2 \text{or } 1 \text{ or } 0\right),\ 0 < x < 2$; or *their* $y\left(\neq 2 \text{or } 1 \text{ or } 0\right),\ 0 < y < 2$.
	$\frac{1}{2}\times 2.5\times v^2 + \frac{1}{2}\times 0.5\times v^2 =$ $2.5g\left(\frac{4}{3}\right)\sin 30 - 0.5g\left(\frac{4}{3}\right) - 0.2\times 2.5g\cos 30\times\left(\frac{4}{3}\right)$ OR $\frac{1}{2}\times 2.5\times v^2 + \frac{1}{2}\times 0.5\times v^2 =$ $2.5g\left(2 - \frac{2}{3}\right)\sin 30 - 0.5g\left(2 - \frac{2}{3}\right) - 0.2\times 2.5g\cos 30\times\left(2 - \frac{2}{3}\right)$	**DM1**	Attempt at work energy equation; dimensionally correct; 5 relevant terms; allow sign errors; allow sin/cos mix. Must be using correct values of x or y.

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Question	Answer	Marks	Guidance
	$v = 1.68$	**A1**	1.67859014 AWRT 1.68 from correct work.

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Question	Answer	Marks	Guidance
7(b)	**Alternative Method for Question 7(b): Considering energy on *Q* only** **Must be using tension and mass 0.5 kg only to be awarded the last 4 marks**		
	$\left[x\sin 30 = 2 - x \Rightarrow\right]\ x = \frac{4}{3}$ OR $\left[(2-y)\sin 30 = y \Rightarrow\right]\ y = \frac{2}{3}$ OR $\left[\frac{1}{2}\times 1.056\ldots \times t^2 + \frac{1}{2}\times 1.056\ldots \times t^2 \times \sin 30 = 2 \Rightarrow t = 1.5886\ldots.\right]$ $\Rightarrow x\left[= \frac{1}{2}\times 1.056\ldots \times (1.5886..)^2 \sin 30\right] = \frac{2}{3}$ OR $\Rightarrow y\left[= \frac{1}{2}\times 1.056\ldots \times (1.5886..)^2\right] = \frac{4}{3}$	**(*B1)**	Where x is the distance P moves down the plane or Q moves vertically upwards, or where y is the vertical distance of Q below P's starting point. Allow $x = 1.3$ or better; allow $y = 0.67$ or better.
	Change in PE $= \pm 0.5g \times (their\ x)$ OR Change in PE $= \pm 0.5g \times (2 - (their\ y))$	**(B1)**	Using *their* $x\ (\neq 2 \text{ or } 1 \text{ or } 0),\ 0 < x < 2$; or *their* $y\ (\neq 2 \text{ or } 1 \text{ or } 0),\ 0 < y < 2$.
	WD by tension $= (their\ 5.528312164) \times (their\ x)$ OR WD by tension $= (their\ 5.528312164) \times (2 - (their\ y))$	**(B1)**	Using *their* tension from **7(a)** from equation(s) with the correct number of dimensionally correct/relevant terms. Using *their* $x\ (\neq 2 \text{ or } 1 \text{ or } 0),\ 0 < x < 2$; or *their* $y\ (\neq 2 \text{ or } 1 \text{ or } 0),\ 0 < y < 2$.
	$0.5g\left(\frac{4}{3}\right) + \frac{1}{2}\times 0.5 \times v^2 = (their\ 5.528312164) \times \left(\frac{4}{3}\right)$ OR $0.5g\left(2 - \frac{2}{3}\right) + \frac{1}{2}\times 0.5 \times v^2 = (their\ 5.528312164) \times \left(2 - \frac{2}{3}\right)$	**(DM1)**	Using *their* tension from **7(a)** from equation(s) with the correct number of dimensionally correct/relevant terms. Attempt at work energy equation; dimensionally correct; 3 relevant terms; allow sign errors. Must be using correct values of x or y.
	$v = 1.68$	**(A1)**	1.67859014 AWRT 1.68 from correct work.

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Question	Answer	Marks	Guidance
7(b)	**Alternative Method 2 for Question 7(b): Considering energy on *P* only** **Note: must be using tension and mass 2.5 kg only to be awarded the last 4 marks**		
	$\left[x\sin 30 = 2 - x \Rightarrow\right]\ x = \frac{4}{3}$ OR $\left[(2-y)\sin 30 = y \Rightarrow\right]\ y = \frac{2}{3}$ OR $\left[\frac{1}{2}\times 1.056\ldots \times t^2 + \frac{1}{2}\times 1.056\ldots \times t^2 \times \sin 30 = 2 \Rightarrow t = 1.5886\ldots.\right]$ $\Rightarrow x\left[= \frac{1}{2}\times 1.056\ldots \times (1.5886..)^2 \sin 30\right] = \frac{2}{3}$ OR $\Rightarrow y\left[= \frac{1}{2}\times 1.056\ldots \times (1.5886..)^2\right] = \frac{4}{3}$	**(*B1)**	Where x is the distance P moves down the plane or Q moves vertically upwards, or where y is the vertical distance of Q below P's starting point. Allow $x = 1.3$ or better; allow $y = 0.67$ or better.
	Change in PE $= \pm 2.5g(\textit{their}\ x)\sin 30$ OR $= \pm 2.5g(\textit{their}\ y)$	**(B1)**	Using *their* $x(\neq 2 \text{ or } 1 \text{ or } 0),\ 0 < x < 2$; or *their* $y(\neq 2 \text{ or } 1 \text{ or } 0),\ 0 < y < 2$.
	WD by tension $= (\textit{their}\ 5.528312164) \times (\textit{their}\ x)$ OR WD against friction $= 0.2 \times 2.5g\cos 30 \times (\textit{their}\ x)$	**(B1)**	Using *their* tension from **7(a)** from equation(s) with the correct number of dimensionally correct/relevant terms. Using *their* $x(\neq 2 \text{ or } 1 \text{ or } 0),\ 0 < x < 2$; or *their* $y(\neq 2 \text{ or } 1 \text{ or } 0),\ 0 < y < 2$.
	$2.5g\left(\frac{4}{3}\right)\sin 30 = \frac{1}{2}\times 2.5\times v^2 +$ $0.2\times 2.5g\cos 30\times\left(\frac{4}{3}\right) + (\textit{their}\ 5.528312164)\times\left(\frac{4}{3}\right)$	**(DM1)**	Using *their* tension from **7(a)** from equation(s) with the correct number of dimensionally correct/relevant terms. Attempt at work energy equation; dimensionally correct; 4 relevant terms; allow sign errors; allow sin/cos mix. Must be using correct values of x or y.
	$v = 1.68$	**(A1)**	1.67859014 AWRT 1.68 from correct work.

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Question	Answer	Marks	Guidance
7(b)	**Special Case for using constant acceleration: Maximum 2 marks**		
	$\left[x\sin 30 = 2 - x \Rightarrow\right]\ x = \frac{4}{3}$ OR $\left[(2-y)\sin 30 = y \Rightarrow\right]\ y = \frac{2}{3}$ OR $\left[\frac{1}{2}\times 1.056\ldots \times t^2 + \frac{1}{2}\times 1.056\ldots \times t^2 \times \sin 30 = 2 \Rightarrow t = 1.5886\ldots.\right]$ $\Rightarrow x\left[= \frac{1}{2}\times 1.056\ldots \times (1.5886..)^2 \sin 30\right] = \frac{2}{3}$ OR $\Rightarrow y\left[= \frac{1}{2}\times 1.056\ldots \times (1.5886..)^2\right] = \frac{4}{3}$	**(B1)**	Where x is the distance P moves down the plane or Q moves vertically upwards, or where y is the vertical distance of Q below P's starting point. Allow $x = 1.3$ or better; allow $y = 0.67$ or better.
	$\left[v^2 = 2\times 1.06\times \frac{4}{3}\Rightarrow\right]\quad v = 1.68$	**(B1)**	1.67859014 AWRT 1.68 from correct work.
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