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MATHEMATICS **9709/42**

Paper 4 Mechanics **February/March 2024**

MARK SCHEME

Maximum Mark: 50

Published

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

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

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

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

Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level 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.

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.

Mark Scheme Notes

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

Types of mark

M Method mark, awarded for a valid method applied to the problem. Method marks are not lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. Correct application of a formula without the formula being quoted obviously earns the M mark and in some cases an M mark can be implied from a correct answer.

A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated method mark is earned (or implied).

B Mark for a correct result or statement independent of method marks.

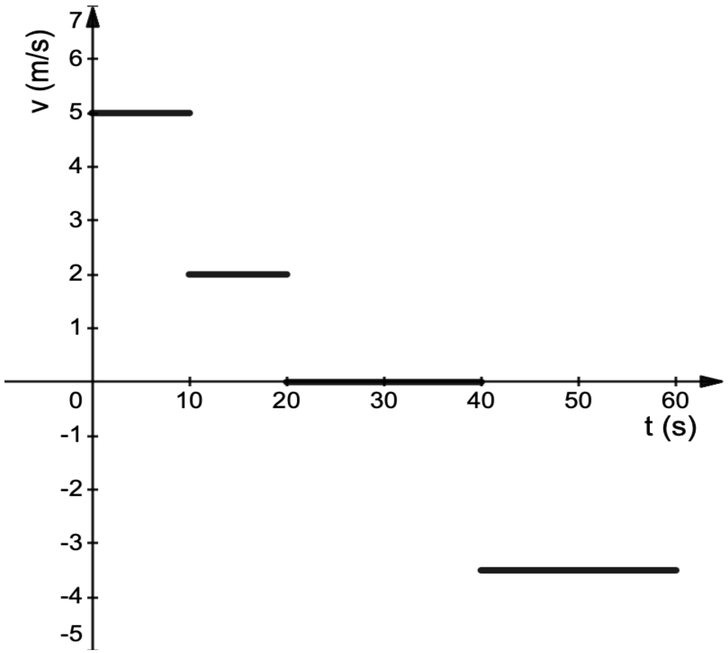
DM or **DB** When a part of a question has two or more 'method' steps, the M marks are generally independent unless the scheme specifically says otherwise; and similarly, when there are several B marks allocated. The notation DM or DB is used to indicate that a particular M or B mark is dependent on an earlier M or B (asterisked) mark in the scheme. When two or more steps are run together by the candidate, the earlier marks are implied and full credit is given.

FT Implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A or B marks are given for correct work only.

- A or B marks are given for correct work only (not for results obtained from incorrect working) unless follow through is allowed (see abbreviation FT above).
- For a numerical answer, allow the A or B mark if the answer is correct to 3 significant figures or would be correct to 3 significant figures if rounded (1 decimal place for angles in degrees).
- The total number of marks available for each question is shown at the bottom of the Marks column.
- Wrong or missing units in an answer should not result in loss of marks unless the guidance indicates otherwise.
- Square brackets [ ] around text or numbers show extra information not needed for the mark to be awarded.

Abbreviations

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

Question	Answer	Marks	Guidance
1(a)	Total distance travelled = $50+2\times10\ [=70]$	B1	Any explicit expression for the distance, e.g. $\frac{x-50}{20-10}=2\to x=2(20-10)+50$.
	Velocity $=-\frac{70}{20}=-3.5\ \mathrm{m\,s^{-1}}$	B1FT	Oe. Ft *their* distance $\neq 50$. Must be negative. Do not ISW if (e.g.) velocity = 3.5. Do allow "$3.5\ \mathrm{m\,s^{-1}}$, directed towards *O*."
		2	
1(b)	Velocity $5\ \mathrm{m\,s^{-1}}$ for $0\leqslant t\leqslant 10$	B1	May be seen on diagram.
		B1	Stepped diagram with four horizontal lines segments. Ignore vertical line segments.
		B1FT	All correct. 10, 20, 40 and 60 indicated on the *t*-axis. *Their* 5, 2 and *their* –3.5 (allow –3 and –4 is acceptable too with line segment halfway between them) indicated on the *v*-axis, corresponding to the position of the horizontal line segments. FT *their* $-3.5\ \mathrm{m\,s^{-1}}$ and/or FT their $5\ \mathrm{m\,s^{-1}}$. If their answer to **(a)** is positive, allow use of negative their answer for this mark.
		3	

Question	Answer	Marks	Guidance
2(a)	$-5 = u - g \times 2$ or $5 = u + g \times 2$ or $5 = 0 + gt \Rightarrow t = 0.5$, so time to greatest height is $T = 2 - 0.5 = 1.5$. Hence $0 = u + (-g) \times 1.5$	M1	For use of constant acceleration to get an equation in u only. Using $v = -5$, $t = 2$ and $a = \pm g$.
	Speed = 15 m s^{-1}	A1	Must be positive.
		2	
2(b)	$0^2 = 10^2 - 2gs$ $[\Rightarrow s = 5]$ or $10^2 = [0^2 +] 2gs$ $[\Rightarrow s = 5]$ or $10 = 0 + gt \Rightarrow t = 1$, so $s = 10 \times 1 - \frac{1}{2} g \times 1^2$ $[\Rightarrow s = 5]$ or $\frac{1}{2}(m) \times 10^2 = (m)gh$ $[\Rightarrow h = 5]$	M1	For use of constant acceleration formula(e) to find distance travelled from height with speed 10 m s^{-1} to maximum height with speed 0 m s^{-1}, $a = \pm g$. Must be a complete method, e.g. $0^2 = (\textit{their}\,15)^2 - 2gs_1$ $[\Rightarrow s_1 = 11.25]$ and $10^2 = (\textit{their}\,15)^2 - 2gs_2$ $[\Rightarrow s_2 = 6.25]$ or $10 = (\textit{their}\,15) - gt$ $[\Rightarrow t = 0.5]$, $s_2 = \frac{1}{2}(\textit{their}\,15 + 10) \times (\textit{their}\,0.5)$ and with an attempt at $s_1 - s_2 [= 5]$. Energy method with 2 terms, dimensionally correct.
	Total distance = 10 m	A1FT	FT *their* 15 m s^{-1} if used.
		2	

Question	Answer	Marks	Guidance
3	Driving force = $\frac{8000}{2}$ or 4000	**B1**	Use of $F=\frac{P}{v}$, oe. E.g. $DF\times 2=8000$.
	$R=600g\cos 30\left[=3000\sqrt{3}=5196.152423\right]$	**B1**	
	their Driving force $-600g\sin 30-F=0$ $\left[F=4000-3000=1000\right]$	***M1**	For attempt to resolve parallel to the plane; 3 terms; allow sign errors; allow sin/cos mix; allow g missing; F not resolved. Allow with just DF.
	Use of $F=\mu R$	**DM1**	To form an equation in μ only where R is a component of weight or mass.
	$\mu=0.192$ or $\frac{\sqrt{3}}{9}$	**A1**	Awrt 0.192 [0.1924500897]. Oe, e.g. $\frac{1}{3\sqrt{3}}$. Allow 2sf.
		5	

Question	Answer	Marks	Guidance
4	For resolving in either direction	*M1	Correct number of terms allow sign errors; allow sin/cos mix on θ. Forces that need resolving should be resolved.
	$F + 2F\cos 45 = 30\sin\theta$	A1	
	$2F\sin 45 + 3F = 30\cos\theta$	A1	
	$\theta = \tan^{-1}\left(\frac{1+2\cos 45}{2\sin 45+3}\right)$ or $\theta = \sin^{-1}\left(\frac{F+2F\cos 45}{30}\right)$ or $\theta = \cos^{-1}\left(\frac{2F\sin 45+3F}{30}\right)$	DM1	For attempt to find θ. Using their F which can be solved for θ. From equations with correct number of relevant terms, forces that need resolving should be resolved. If $\tan\theta = \frac{\cos\theta}{\sin\theta}$, so have $\theta = \tan^{-1}\left(\frac{2\sin 45+3}{1+2\cos 45}\right)$, then allow M1.
	$\left[F^2(3+2\sin 45)^2 + F^2(1+2\cos 45)^2 = 30^2 \Rightarrow\right]$ $F = \sqrt{\frac{30^2}{(3+2\sin 45)^2+(1+2\cos 45)^2}}$ or $F = \frac{30\sin\theta}{1+2\cos 45}$ or $F = \frac{30\cos\theta}{3+2\sin 45}$	DM1	For attempt to find F. From equations with the correct number of relevant terms, forces that need resolving should be resolved. Using *their* θ.
	$F = 5.96$ [5.96270…] and $\theta = 28.7$ [28.6750…]	A1	Awrt to 5.96 and 28.7. Allow 5.97.
		6	

Question	Answer	Marks	Guidance
5(a)	For attempt at integration	*M1	Increase power by 1 and a change in coefficient in at least one term (which must be the same term). $s = vt$ is M0.
	$(s =)\frac{1}{(3+1)}t^{3+1} - \frac{9}{2\times(2+1)}t^{2+1} + t[+c] = \frac{1}{4}t^4 - \frac{3}{2}t^3 + t[+c]$	A1	May be unsimplified.
	Distance = $\left(\frac{1}{4}\times\left(\frac{1}{2}\right)^4 - \frac{3}{2}\left(\frac{1}{2}\right)^3 + \left(\frac{1}{2}\right)\right)[-(0)]$	DM1	Use limits 0 and $\frac{1}{2}$ correctly, or substitute $t = \frac{1}{2}$. M0 if including other regions.
	$= \frac{21}{64}$ m	A1	Oe, e.g. 0.328125. Condone 0.328.
	Special Case if no integration seen. Maximum 1/4		
	$\frac{21}{64}$ m	B1	Oe, e.g. 0.328125. Condone 0.328.
		4	

Question	Answer	Marks	Guidance
5(b)	Attempt to differentiate $\left[(a=)3t^2-9t\right]$	*M1	Decrease power by 1 and a change in coefficient in at least one term (which must be the same term). $a=\frac{v}{t}$ is M0.
	Solve $a=0$ to get $t=3$	A1	Ignore $t=0$ if not rejected.
	Distance from $t=\frac{1}{2}$ to $t=3$ = $\pm\left(\left(\frac{1}{4}\times3^4-\frac{3}{2}\times3^3+3\right)-\left(\frac{1}{4}\times\left(\frac{1}{2}\right)^4-\frac{3}{2}\left(\frac{1}{2}\right)^3+\left(\frac{1}{2}\right)\right)\right)=$ $\pm\left(\left(\frac{1}{4}\times3^4-\frac{3}{2}\times3^3+3\right)-\frac{21}{64}\right)\left[=\mp17\frac{37}{64}=\mp\frac{1125}{64}=\mp17.578125\right]$	DM1	Must be using an expression for s from integration. Allow missing minus sign at start; use limits $\frac{1}{2}$ and their 3 correctly, where $\frac{1}{2}<\textit{their}\,3\le4$. Or use limit 3 and find difference from *their* $\frac{21}{64}$ from part **(a)**. May see $2\times\left(\frac{1}{4}\times\left(\frac{1}{2}\right)^4-\frac{3}{2}\left(\frac{1}{2}\right)^3+\left(\frac{1}{2}\right)\right)-\left(\frac{1}{4}\times3^4-\frac{3}{2}\times3^3+3\right)$
	So total $\left[=\frac{21}{64}+17\frac{37}{64}\right]=17\frac{29}{32}$ m	A1FT	Oe, e.g. $\frac{573}{32}$, 17.90625. Condone 17.9. FT *their* positive integration value in part **(a)**, e.g. $17\frac{37}{64}+\textit{their}$ **(a)** or $\frac{69}{4}+2\times\textit{their}$ **(a)**.

Question	Answer	Marks	Guidance
5(b)	**Special Case if no integration seen. Maximum M1A1B1 for 3 marks**		
	Attempt to differentiate $\left[(a=)3t^2-9t\right]$	**M1**	Decrease power by 1 and a change in coefficient in at least one term (which must be the same term). $a=\frac{v}{t}$ is M0.
	Solve $a=0$ to get $t=3$	**A1**	
	$17\frac{29}{32}$ m	**B1**	Oe, e.g. $\frac{573}{32}$, 17.90625. Condone 17.9.
		4	

Question	Answer	Marks	Guidance
6(a)	Attempt at Newton's second law on car or trailer or system	*M1	Correct number of terms; allow sign errors; allow sin/cos mix; $\sin\alpha$ or $\alpha = 2.865\ldots$ needs to be substituted; allow with $\alpha = 2.87 \text{ or } 2.9$ or better; allow g missing.
	Car: $3000 - 1800g \times 0.05 - 800 - T = 1800a$ $[3000 - 900 - 800 - T = 1800a \rightarrow 1300 - T = 1800a]$ Trailer: $T - 300g \times 0.05 - 100 = 300a$ $[T - 150 - 100 = 300a \rightarrow T - 250 = 300a]$ System: $3000 - 1800g \times 0.05 - 300g \times 0.05 - 800 - 100 = (1800 + 300)a$ $[3000 - 900 - 150 - 800 - 100 = 2100a \rightarrow 1050 = 2100a]$	A1	Any two equations correct.
	Solving for a or T	DM1	From equations with correct number of relevant terms, allow g missing. If no working seen, must be correct for their equations.
	Acceleration $= 0.5\text{ m s}^{-2}$	A1	Oe. Allow 0.499 from $\alpha = 2.87$.
	Tension $= 400\text{ N}$	A1	Allow awrt 400 to 3sf, www. Condone using car equation with 0.499 to get $T = 400.5$. Using exact a from an inexact angle gives $T = 400$.
		5	

Question	Answer	Marks	Guidance
6(b)	Work done against resistance on car = $800 \times 50 [= 40000]$ or Work done by driving force = $3000 \times 50 [= 150000]$	**B1**	
	PE change $= (1800 + 300) g \times 50 \times 0.05 [= 52500]$	**B1**	Allow $2100g \times 50 \times \sin 2.9$. Or $2100g \times 50 \times \sin 2.87$.
	Initial KE = $\frac{1}{2} \times (1800 + 300) \times 20^2 [420000]$	**B1**	
	$\frac{1}{2} \times (1800+300) v^2 = 3000 \times 50 - 800 \times 50 - 6000 - (1800+300) g \times 50 \times 0.05 + \frac{1}{2} \times (1800+300) \times 20^2$ $[1050v^2 = 150000 - 40000 - 6000 - 52500 + 420000]$ $[1050v^2 = 471500]$	**M1**	Attempt at work-energy equation; correct number of relevant terms; dimensionally correct; allow sign errors; allow sin/cos mix in relevant resolved terms. Only PE must be from a component. Allow $2100g \times 50 \times \sin 2.9$ or $2100g \times 50 \times \sin 2.87$.
	Speed = 21.2 m s^{-1} [21.1907…]	**A1**	Awrt 21.2 to 3sf. $\alpha = 2.87$ gives 21.18909187. $\alpha = 2.9$ gives 21.17674855.

Question	Answer	Marks	Guidance
6(b)	**Alternative Method for Question 6(b): Using energy on Car or Trailer only (Must be finding Tension for this method)**		
	Car: $3000 - 1800g \times 0.05 - 800 - T = 1800a$ Trailer: $T - 300g \times 0.05 - \frac{6000}{50} = 300a$ Solve to get $T = \frac{2920}{7} = 417.1428571$	**B1**	
	Work done against resistance on car = $800 \times 50[= 40000]$ or Work done by driving force = $3000 \times 50[= 150000]$ or Work done against tension = $\frac{2920}{7} \times 50\left[= \frac{146000}{7}\right]$	**B1**	
	PE change $= 1800g \times 50 \times 0.05[= 45000]$ or Initial KE = $\frac{1}{2} \times 1800 \times 20^2\,[360000]$	**B1**	Or $300g \times 50 \times 0.05[= 7500]$. Allow $1800g \times 50 \times \sin 2.9$ or $1800g \times 50 \times \sin 2.87$. Or $\frac{1}{2} \times 300 \times 20^2\,[60000]$.
	$\frac{1}{2} \times 1800v^2 = 3000 \times 50 - 800 \times 50 - \frac{2920}{7} \times 50 - 1800g \times 50 \times 0.05 + \frac{1}{2} \times 1800 \times 20^2$	**M1**	Attempt at work-energy equation; correct number of relevant terms; dimensionally correct; allow sign errors; allow sin/cos mix in relevant resolved terms. Only PE must be from a component. M0 if using T from part **(a)**.
	Speed = 21.2 m s^{-1} [21.1907…]	**A1**	Awrt 21.2 to 3sf.

Question	Answer	Marks	Guidance
6(b)	**Special case: use of constant acceleration. Maximum 2 marks**		
	$F=\frac{6000}{50}=120,\ 2100a=3000-\frac{6000}{50}-800-2100g\times 0.05\ \left[a=\frac{103}{210}\right]$	**B1**	Oe. Allow $2100a=3000-\frac{6000}{50}-800-2100g\times\sin 2.9$. Allow $2100a=3000-\frac{6000}{50}-800-2100g\times\sin 2.87$.
	$\left[v^2=20^2+2\times 50\times\frac{103}{210}\rightarrow\right]v=21.2\ \text{m s}^{-1}$	**B1**	
		5	

Question	Answer	Marks	Guidance
7(a)	$(m)a = (m)g\sin\theta = (m)g \times 0.6\ [\Rightarrow a = 6]$	**M1**	For attempt at Newton's second law; 2 terms; allow sign errors; allow sin/cos mix, allow $\theta = 36.9$ or better. Allow $\theta = 37$. Allow for $a = 6$ seen/used.
	$v^2 = [0^2] + 2 \times 6 \times 0.75 \Rightarrow v = 3$	**A1**	AG.
	$3 = [0] + 6t \Rightarrow t = 0.5$	**A1**	AG. Allow A2 for use of $a = 6$ with any 2 of $v = 3$, $t = 0.5$ and $s = 0.75$ to get the third value.
	Alternative Method 1 for Question 7(a)		
	$(m)a = (m)g\sin\theta = (m)g \times 0.6\ [\Rightarrow a = 6]$	**M1**	For attempt at Newton's second law; 2 terms; allow sign errors; allow sin/cos mix, allow $\theta = 36.9$ or better. Allow $\theta = 37$. Allow for $a = 6$ seen/used.
	$0 + 6 \times 0.5 = 3$	**A1**	AG.
	$0 \times 0.5 + \frac{1}{2} \times 6 \times 0.5^2 = 0.75$ or $3 \times 0.5 - \frac{1}{2} \times 6 \times 0.5^2 = 0.75$	**A1**	AG. Allow A2 for $3 \times 0.5 - \frac{1}{2} \times 6 \times 0.5^2 = 0.75$.
	Alternative Method 2 for Question 7(a)		
	$\frac{1}{2}(m)v^2 = (m)g \times 0.75 \times 0.6$	**M1**	Attempt at conservation of energy, 2 terms, dimensionally correct, allow sin/cos mix, allow $\theta = 36.9$ or better. Allow $\theta = 37$.
	$v = 3$	**A1**	AG.
	Use constant acceleration to get $t = 0.5$	**A1**	AG. Must show $a = 6$.

Question	Answer	Marks	Guidance
7(a)	**Alternative Method 3 for Question 7(a)**		
	$(s=)\frac{1}{2}(0+3)\times 0.5$ or $0.75=\frac{1}{2}(0+v)\times 0.5$ or $0.75=\frac{1}{2}(0+3)t$	**M1**	Use $s=\frac{1}{2}(u+v)t$ with $u=0$ with any 2 of $v=3$, $t=0.5$ and $s=0.75$.
	Correctly identifies one value.	**A1**	
	$(s=)0.75$ or $v=3$ or $t=0.5$	**A1**	AG.

Question	Answer	Marks	Guidance
7(a)	**Alternative Method 4 for Question 7(a)**		
	$3^2 = (0^2 +)2a \times 0.75 \rightarrow a = 6$ or $3 = (0+)0.5a \rightarrow a = 6$ or $0.75 = (0 \times 0.5 +)\frac{1}{2}a \times 0.5^2 \rightarrow a = 6$ or $0.75 = 3 \times 0.5 - \frac{1}{2}a \times 0.5^2 \rightarrow a = 6$	**B1**	Use constant acceleration to get an equation in a only, using $u = 0$ and any 2 of $v = 3$, $t = 0.5$ and $s = 0.75$. Or using $v = 3$, $t = 0.5$ and $s = 0.75$.
	$3 = (0+)6t$, $0.75 = (0 \times t +)\frac{1}{2} \times 6 \times t^2$, $0.75 = 3t - \frac{1}{2} \times 6 \times t^2$ or $s = (0 \times 0.5 +)\frac{1}{2} \times 6 \times 0.5^2$, $s = 3 \times 0.5 - \frac{1}{2} \times 6 \times 0.5^2$ or $v = (0+)0.5 \times 6$; $v^2 = (0^2 +)2 \times 6 \times 0.75$; $0.75 = 0.5v - \frac{1}{2} \times 6 \times 0.5^2$ or $3 = u + 6 \times 0.5$, $3^2 = u^2 + 2 \times 6 \times 0.75$, $0.75 = 0.5u + \frac{1}{2} \times 6 \times 0.5^2$	**M1**	Use constant acceleration formula in an attempt to find the third unused value using $a = 6$. Or use constant acceleration formula in an attempt to find u using $a = 6$.
	Get correct unused value	**A1**	Or $u = 0$ if using all 3 values to find $a = 6$. AG.
		3	

Question	Answer	Marks	Guidance
7(b)	For BC $(m)a=(m)g\sin\theta-(m)g\times0.8\times0.25=(m)g\times0.6-(m)g\times0.8\times0.25$ $[\Rightarrow a=4]$	*M1	For attempt at Newton's second law; 3 terms; allow sign errors; allow g missing; allow sin/cos mix, allow $\theta=36.9$ or better.
	For P, $s_P=3t+\frac{1}{2}\times4t^2$ For Q, $s_Q=\frac{1}{2}\times4(t+0.5)^2$ Or for P, $s_P=3(T-0.5)+\frac{1}{2}\times4(T-0.5)^2$ For Q, $s_Q=\frac{1}{2}\times4T^2$	A1	For either s_P or s_Q. t is the time after P arrives at B. T is the time from when both particles released.
	$3t+\frac{1}{2}\times4t^2=\frac{1}{2}\times4(t+0.5)^2\left[\Rightarrow3t+2t^2=2t^2+2t+0.5\right]$ Or $3(T-0.5)+\frac{1}{2}\times4(T-0.5)^2=\frac{1}{2}\times4T^2$ $\left[\Rightarrow3T-1.5+2(T^2-T+0.25)=2T^2\right]$	DM1	For use of $s_P=s_Q$; s_P and s_Q of correct form. Using their $a\neq$ *their* (from part **(a)**, $a\neq\pm g$. Using same a in both s_P and s_Q.
	t = 0.5, so total time = 1 s or time $T=1$ s	A1	

Question	Answer	Marks	Guidance
7(b)	**Alternative Method for Question 7(b)**		
	For BC $(m)a=(m)g\sin\theta-(m)g\times0.8\times0.25=(m)g\times0.6-(m)g\times0.8\times0.25[\Rightarrow a=4]$	*M1	For attempt at Newton's second law; 3 terms; allow sign errors; allow g missing; allow sin/cos mix, allow $\theta=36.9$ or better.
	For P $s_P=3t+\frac{1}{2}\times4t^2$ Or Q has speed $2\,\text{m s}^{-1}$ after 0.5 s, so $s_Q=2t+\frac{1}{2}\times4t^2$	A1	For either. t is the time after P arrives at B.
	$3t+\frac{1}{2}\times4t^2=2t+\frac{1}{2}\times4t^2+\frac{1}{2}\times4\times0.5^2$	DM1	For use of $s_P=s_Q\pm their\frac{1}{2}\times4\times0.5^2$; s_P or s_Q of correct form. Using their $a\neq their\,\epsilon$ from part **(a)**, $a\neq\pm g$. Using same a in both s_P or s_Q.
	t = 0.5 so total time = 1 s	A1	
	Alternative Method 2 for Question 7(b): Using relative velocity		
	For BC $(m)a=(m)g\sin\theta-(m)g\times0.8\times0.25=(m)g\times0.6-(m)g\times0.8\times0.25$ $[\Rightarrow a=4]$	*M1	For attempt at Newton's second law; 3 terms; allow g missing; allow sign errors; allow sin/cos mix.
	[In 0.5 s] Q has speed $2\,\text{m s}^{-1}$ and has moved 0.5 m	A1	For both.
	$t=\frac{0.5}{3-2}$	DM1	Attempt at time from relative velocity using their 0.5 m and their $2\,\text{m s}^{-1}$.
	t = 0.5 so total time = 1 s	A1	
		4	

Question	Answer	Marks	Guidance
7(c)	Immediately before the collision speed of P $\left[=3+4\times\frac{1}{2}\right]=5\text{ ms}^{-1}$ Speed of Q $[=0+4\times1]=4\text{ m s}^{-1}$	B1	For either.
	$5(m)+4(m)=[(m)+(m)]\times v$ $[\Rightarrow v=4.5]$	*M1	Use of conservation of momentum; 4 non-zero terms; allow sign errors; allow their 4ms^{-1} $(\neq 0\text{ or }2)$ and 5ms^{-1} $(\neq 3)$. Use of mg then withhold final A mark.
	Distance from B at collision $=\frac{1}{2}\times4\times1^2=2$ m OR $=3\times0.5+\frac{1}{2}\times4\times0.5^2=2$ m	B1	May be implied by 1.25 m.
	$1.25=4.5t+\frac{1}{2}\times4t^2$	DM1	Use of constant acceleration with $u=\textit{their}\ 4.5$, $a=\textit{their}\ 4(\neq\pm g)$ and $s=3.25-\textit{their}\ 2$, $s\neq3.25$, $s\neq0.75$, $s\neq4$, $s\neq2.75$, $s\neq0.5$. If using two formulae, must be a complete method to get an equation in t only.
	$t=0.25$s only	A1	A0 if from use of mg in conservation of momentum.
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