



Cambridge International AS & A Level

MATHEMATICS

9709/41

Paper 4 Mechanics

May/June 2023

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 May/June 2023 series for most Cambridge IGCSE, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

PUBLISHED**Generic Marking Principles**

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

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

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

GENERIC MARKING PRINCIPLE 2:

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

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

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

GENERIC MARKING PRINCIPLE 4:

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

GENERIC MARKING PRINCIPLE 5:

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

GENERIC MARKING PRINCIPLE 6:

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

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

PUBLISHED**Mark Scheme Notes**

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

Types of mark

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

Abbreviations

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

PUBLISHED

Question	Answer	Marks	Guidance
1(a)	$m \times 5 + 0 = m \times 2 + 0.3v$	M1	Attempt at conservation of momentum; 3 non-zero terms (with m appearing in two terms); allow sign errors.
	Speed = $10m \text{ (ms}^{-1}\text{)}$	A1	M1A0 if using g in momentum terms. $v = -10m$ is A0.
		2	
1(b)	$0.3 \times 10m + 0 = 0 + 0.6 \times 1.5$ [$3m = 0.9$]	M1	Attempt at conservation of momentum between Q and R (so must be using correct masses of 0.3 and 0.6) to form a linear equation in m using their answer from (a); 2 non-zero terms; allow sign errors.
	$m = 0.3$	A1FT	FT $\frac{3}{\text{their +ve coefficient of } m \text{ from (a)}}$ Condone including kg in answer.
		2	

Question	Answer	Marks	Guidance
2(a)	$0 = 10^2 + 2(-g)s \Rightarrow s = \dots$	M1	For use of $v^2 = u^2 + 2as$ with $v = 0$, $u = \pm 10$ and $a = \pm g$ or ± 10 and solve for s (or any other complete SUVAT method). Or using an energy method: $0.4gh = \frac{1}{2}(0.4)(10)^2$ and solve for h (with two terms using correct given values – condone lack of masses in conservation of energy equation).
	Max. height = 5(m)	A1	
		2	

PUBLISHED

Question	Answer	Marks	Guidance
2(b)	KE before impact $= \frac{1}{2} \times 0.4 \times 10^2 [= 20]$	B1FT	Or loss of PE $= \pm 0.4 \times g \times 5$ using their maximum height from (a) .
	$\frac{1}{2} \times 0.4 \times v^2 = 20 - 7.2 [v = 8]$ or $0.4gh = 20 - 7.2 [h = 3.2]$	*M1	M1 for $\frac{1}{2} \times 0.4v^2 = \text{KE/PE before impact} - 7.2$ (must be correct method of subtracting 7.2 (OE)). Or, for finding the maximum height after first impact. Need not solve for v (or h) for this mark.
	$-8 = 8 + (-g)t \Rightarrow t = \dots$ or $0 = 8t + \frac{1}{2} \times -g \times t^2 \Rightarrow t = \dots$	DM1	For use of a complete method to find t . Condone sign errors but $a = \pm g$. If calculating the time to the maximum height between the first and second impacts, then candidates must double this answer (OE). E.g., $0 = 8 + (-g)T, t = 2T = \dots$ or $3.2 = 0 - 0.5 \times -g \times T^2 \Rightarrow t = 2T = \dots$
	Time = 1.6(s)	A1	
		4	

PUBLISHED

Question	Answer	Marks	Guidance
3	For an attempt at differentiation.	*M1	Decrease power by 1 and a change in coefficient in at least one term. $v = \frac{s}{t}$ is M0.
	$(v =) \frac{5}{2}t^{\frac{3}{2}} - \frac{45}{8}t^{\frac{1}{2}}$	A1	Allow unsimplified, including indices (including a +c is A0).
	$v = 0 \Rightarrow \frac{1}{8}t^{\frac{1}{2}}(20t - 25) = 0 \Rightarrow t = \dots$	DM1	Attempting to find t by equating v to 0 and attempt to solve a linear equation for t (if correct $t = 2.25$). Must be of the form $t = \dots$.
	$s = \frac{15}{16} [= 0.9375]$	A1	Condone 0.938 .
		4	

Question	Answer	Marks	Guidance
4(a)	Distance = $\frac{1}{2}(6+10) \times 0.9$	M1	Completely correct method for finding the total area underneath the velocity-time graph from $t = 0$ to 10 only. Can be done as two triangles and a rectangle e.g., $\frac{1}{2} \times 3 \times 0.9 + (9-3) \times 0.9 + \frac{1}{2} \times 1 \times 0.9$ (allow a slip in one value); need not see all three components added together.
	Distance = 7.2(m)	A1	
		2	

PUBLISHED

Question	Answer	Marks	Guidance
4(b)	$\frac{1}{2}(12-10)v_{\min} = -7.2$	M1	Setting $\frac{1}{2}(12-10)v_{\min}$ equal to $\pm$ their (a) .
	Minimum velocity = $-7.2 \text{ (ms}^{-1}\text{)}$	A1	Must be negative – allow those who solve $\frac{1}{2}(12-10)v_{\min} = 7.2$ and obtain $v_{\min} = 7.2$ and then change to -7.2 without justification. SC B1 for assuming the triangle is isosceles.
		2	
4(c)	$\frac{1}{2} \times (T-10) \times 3 = 7.2$ or $\frac{1}{2} \times t \times 3 = 7.2$	*M1	Correct method for finding T or t . Condone sign errors but must equate to their answer to (a) .
	$T = 14.8$	A1	OE (e.g. from $t + 10 = 4.8 + 10 = 14.8$).
	$\frac{14.4}{14.8}$	DM1	M1 for $\frac{2(\text{their (a)})}{\text{their } T}$ or $\frac{2(\text{their (a)})}{10 + \text{their } T}$.
	Average speed = $\frac{36}{37} \text{ (ms}^{-1}\text{)}$	A1	OE 0.973 [For reference: 0.97297...]. SC *B1 (for $T = 14.8$). DM1A1 for assuming the triangle is isosceles.
		4	

PUBLISHED

Question	Answer	Marks	Guidance
5(a)	Resolving either direction.	M1	3 terms; allow sign errors and allow sin/cos mix. Must be an equation with either = 0 or with an attempt to balance forces.
	Vertical: $F \sin \theta + 40 \sin 60 - 50 = 0$	A1	$[F \sin \theta = 50 - 20\sqrt{3} = 15.358...]$
	Horizontal: $F \cos \theta + 10 - 40 \cos 60 = 0$	A1	$[F \cos \theta = 10]$
	$\theta = \tan^{-1}(5 - 2\sqrt{3})$	M1	Attempt to solve for θ ; one missing term in total $\theta = \tan^{-1} 1.535898...$
	$F = \sqrt{15.358...^2 + 10^2}$	M1	Attempt to solve for F : one missing term in total.
	$\theta = 56.9, F = 18.3$	A1	Both correct (18.327530..., 56.932462...).
		6	
5(b)	$(Y =) \pm (10\sqrt{2} \sin 45 + 40 \sin 60 - 50) [= \pm(20\sqrt{3} - 40)]$	B1	Allow non-exact values for $\sqrt{2}$ etc. in correct expression.
	$(X =) \pm (10\sqrt{2} \cos 45 + 10 - 40 \cos 60) [= 0]$	B1	Allow non-exact values for $\sqrt{2}$ etc. in correct expression. Could be implied by correct answer.
	Resultant force is $40 - 20\sqrt{3}$ (N) in the same direction as the 50(N) force.	B1	Allow vertically downwards, south, 180° , negative y -direction. Resultant force must be exact and positive (so $20\sqrt{3} - 40$ is B0).
		3	

PUBLISHED

Question	Answer	Marks	Guidance
6(a)	$R = 0.1g \cos 60 [= 0.5]$	B1	Correctly resolving perpendicular to the plane for Q .
	$F = 0.7 \times 0.1g \cos 60 [= 0.35]$	M1	Use of $F = \mu R$ for Q where R is a component of weight but not mass; allow sin/cos mix.
	For whole system: LHS of Newton's second law: $0.2g \sin 60 - 0.1g \sin 60 - F [= 0.866... - F]$ Or separately for P and Q : $0.2g \sin 60 - T (= 0.2a)$ and $T - 0.1g \sin 60 - F (= 0.1a)$, and eliminate T to get $0.2g \sin 60 - 0.1g \sin 60 - F (= 0.3a)$	M1	Complete method to determine the resultant force for the whole system. Allow sign errors and sin/cos mix, but must include all required terms and be dimensionally correct. If considering either the whole system or P and Q separately then ignore the RHS of their Newton's second law equations.
	As $\frac{\sqrt{3}}{2} - 0.35 > 0$ the particles do move.	A1	Correct indication (with no incorrect working) that the resultant force is positive (e.g. $0.8660... - 0.35 > 0$ or $0.516...$ (to at least 1 sf) which is positive) together with a correct conclusion. Candidates may calculate the acceleration which is $\frac{10\sqrt{3} - 7}{6} = 1.72008...$ and then say that the particles are moving.
		4	

PUBLISHED

Question	Answer	Marks	Guidance
6(b)	Attempt to use Newton's second law for P : $0.2g \sin 60 - (\sqrt{3} - 1) = 0.2a$	M1	Allow sign errors, sin/cos mix. but must be dimensionally consistent.
	$a = 5 \text{ (ms}^{-2}\text{)}$	A1	
	Newton's second law for system: $0.2g \sin 60 - 0.1g \sin \theta = 0.3(5)$ or Newton's second law for Q : $(\sqrt{3} - 1) - 0.1g \sin \theta = 0.1(5)$	M1	Attempt Newton's second law for Q , or for the whole system. Allow sign errors, sin/cos mix, but must be dimensionally consistent.
	$\theta = 13.4$	A1	13.41784...
		4	

Question	Answer	Marks	Guidance
7(a)	Driving force $F = \frac{16000}{20} [= 800]$	B1	OE e.g. $16000 = 20 \times F$
	$F - 500 = 1200a$	M1	Use of Newton's second law; allow sign errors but must be 3 terms. Allow F or any non-zero value for the driving force (allow 0.8 from using 16 rather than 16000) but not 16000, 16, 20 or 500 for F .
	$a = 0.25 \text{ (ms}^{-2}\text{)}$	A1	
		3	

PUBLISHED

Question	Answer	Marks	Guidance
7(b)	$\frac{16000}{v} - 500 = 0$	M1	Allow sign errors but must be 2 terms. Condone $\frac{16}{v} - 500 = 0$ for M1.
	$v = 32 \text{ (ms}^{-1}\text{)}$	A1	
		2	
7(c)	Work done by engine = $16000 \times 15 [= 240000]$	B1	Or $16000 = \frac{\text{WD}}{15}$.
	KE change = $\pm \left(\frac{1}{2} \times 1200 \times v^2 - \frac{1}{2} \times 1200 \times 20^2 \right)$	B1	$\pm(600v^2 - 240000)$
	PE change = $\pm \left(1200 \times g \times 316 \times \frac{1}{60} \right) [= \pm 63200]$	B1	Allow $1200 \times g \times 316 \times \sin 0.955$ or $1200 \times g \times 316 \times \sin 0.95$ or $1200 \times g \times \frac{79}{15}$ or $1200 \times g \times 5.266\dots$
	Attempt at work-energy equation.	M1	Use of work-energy principle with 5 terms; dimensionally correct. Allow sign errors and sin/cos mix on PE term
	$16000 \times 15 - 128400 = \frac{1}{2} \times 1200 \times v^2 - \frac{1}{2} \times 1200 \times 20^2 + 1200g \times 316 \times \frac{1}{60}$ ($240000 - 128400 = 600v^2 - 240000 + 63200$)	A1	Allow a value in the interval [62870,63600] for the PE term from using non-exact values for the given angle (but not if from incorrect working).
	$v = 21.9 \text{ (ms}^{-1}\text{)}$	A1	21.924111...
		6	



Cambridge International AS & A Level

MATHEMATICS

9709/42

Paper 4 Mechanics

May/June 2023

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 May/June 2023 series for most Cambridge IGCSE, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

PUBLISHED**Generic Marking Principles**

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

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

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

GENERIC MARKING PRINCIPLE 2:

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

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

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

GENERIC MARKING PRINCIPLE 4:

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

GENERIC MARKING PRINCIPLE 5:

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

GENERIC MARKING PRINCIPLE 6:

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

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

PUBLISHED**Mark Scheme Notes**

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

Types of mark

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

Abbreviations

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

PUBLISHED

Question	Answer	Marks	Guidance
1	$12^2 = 2 \times 9 \times a$. OR $a = 8$.	M1	Use of suvat to get an equation in a .
	$1.6g - R = 1.6a$. [may see $R = 3.2$]	M1	Use Newton's second law with 3 terms, allow sign errors. Allow <i>their</i> $a \neq g$. Allow a if it isn't subsequently replaced with g .
	WD $[= 3.2 \times 9] = 28.8$ J	A1	
	Alternative method for Question 1		
	(KE $\Rightarrow$) $\frac{1}{2} \times 1.6 \times 12^2$ OR 115.2	B1	Allow for the expression for KE.
	(Loss of PE $\Rightarrow$) $\pm 1.6g \times 9$ OR ± 144	B1	Allow for the expression for PE.
	WD = 28.8 J	B1	Allow if get -28.8 and then say 28.8 without explanation. Do not allow -28.8 as final answer to working, so if get 28.8 and state -28.8 then ISW.
		3	

Question	Answer	Marks	Guidance
2(a)	$\pm[3.2v + 2.4 \times (-6)] = 0$	M1	Attempt at conservation of momentum; 2 non-zero terms; allow sign errors.
	$v = 4.5$	A1	M1A0 for use of mgv . $v = -4.5$ is A0.
		2	

PUBLISHED

Question	Answer	Marks	Guidance
2(b)	$\text{KE} = \pm \frac{1}{2} \times 3.2 \times (\text{their } 4.5)^2 \text{ OR } \pm \frac{1}{2} \times 2.4 \times 6^2$	M1	Attempt at either KE term, using <i>their</i> v. Do not allow $\frac{1}{2} \times 3.2 \times (\text{their } 4.5 \pm 6)^2$, or $\frac{1}{2} \times 2.4 \times (\text{their } 4.5 \pm 6)^2$, or $\frac{1}{2} \times (3.2 + 2.4) \times (\text{their } 4.5 \pm 6)^2$, or $\frac{1}{2} \times 3.2 \times (\text{their } 4.5 - 0)^2$, or $\frac{1}{2} \times 2.4 \times (6 - 0)^2$.
	$\text{KE}_{\text{loss}} = 75.6 \text{ J}$	A1	Allow -75.6 . Note $\frac{1}{2} \times (3.2 + 2.4) \times 6^2$ or $\frac{1}{2} \times (3.2 + 2.4) \times (\text{their } 4.5)^2$ is M1A0.
		2	

PUBLISHED

Question	Answer	Marks	Guidance
3(a)	Resolving either direction.	M1	Correct number of terms, allow sign errors, allow sin/cos mix. Do not allow with just $\sin \alpha$ and $\cos \alpha$.
	$(33+15) \times \frac{3}{5} = P \cos \theta + 30 \cos \theta$ OR $(33+15) \cos \left(\tan^{-1} \frac{4}{3} \right) = P \cos \theta + 30 \cos \theta$ OR $19.8 + 9 = P \cos \theta + 30 \cos \theta$	A1	OE, but see note for final A1. Allow: $28.8 = (P + 30) \cos \theta$ $(33+15) \cos 53(.1) = P \cos \theta + 30 \cos \theta$ $19.81 + 9.01 = P \cos \theta + 30 \cos \theta$ $19.86 + 9.03 = P \cos \theta + 30 \cos \theta.$
	$15 \times \frac{4}{5} + 30 \sin \theta = 33 \times \frac{4}{5} + P \sin \theta$ OR $15 \sin \left(\tan^{-1} \frac{4}{3} \right) + 30 \sin \theta = 33 \sin \left(\tan^{-1} \frac{4}{3} \right) + P \sin \theta$ OR $12 + 30 \sin \theta = 26.4 + P \sin \theta$	A1	OE, but see note for final A1. Allow: $14.4 = (30 - P) \sin \theta$ $15 \sin 53(.1) + 30 \sin \theta = 33 \sin 53(.1) + P \sin \theta$ $12.00 + 30 \sin \theta = 26.39 + P \sin \theta$ $11.98 + 30 \sin \theta = 26.35 + P \sin \theta.$
	[Use $\cos^2 \theta + \sin^2 \theta = 1$ with] $\cos \theta = \frac{28.8}{P+30}$ and $\sin \theta = \frac{14.4}{30-P}$ to get $\left(\frac{14.4}{30-P} \right)^2 + \left(\frac{28.8}{P+30} \right)^2 = 1$	A1	AG. Must have evidence of where 28.8 and 14.4 come from. A0 for any error seen. A0 if use of inexact angles seen. Any inexact decimals seen for force components, i.e. if 14.4 and/or 28.8 have come from rounding to 3sf, scores M1A1A1A0 max 3/4. If exact values of $\sin \alpha$ and $\cos \alpha$ not shown (e.g. $28.8 = (P+30) \cos \theta$ or $14.4 = (30-P) \sin \theta$ from no working), this scores M1A1A1A0 max 3/4 marks.
		4	

PUBLISHED

Question	Answer	Marks	Guidance
3(b)	Sub $P = 6$ into $\left(\frac{14.4}{30-P}\right)^2 + \left(\frac{28.8}{P+30}\right)^2$ to get $\left[\left(\frac{14.4}{24}\right)^2 + \left(\frac{28.8}{36}\right)^2\right] = \left(\frac{3}{5}\right)^2 + \left(\frac{4}{5}\right)^2 = 0.36 + 0.64 = 1$	B1	Must see either $\left(\frac{3}{5}\right)^2 + \left(\frac{4}{5}\right)^2 = 1$ or $0.36 + 0.64 = 1$ as minimum working.
	$\theta = 36.9$	B1	AWRT 36.9 .
		2	

Question	Answer	Marks	Guidance
4(a)	$\left(\text{Resistive force} = DF = \frac{60}{3} = \right) 20 \text{ N}$	B1	
		1	

PUBLISHED

Question	Answer	Marks	Guidance
4(b)	$PE = \pm 84g \times 150 \sin 0.8$	B1	$\pm 1759.23\dots$
	$KE \text{ change} = \pm \left(\frac{1}{2} \times 84v^2 - \frac{1}{2} \times 84 \times 3^2 \right)$	B1	$\pm \left(\frac{1}{2} \times 84v^2 - 378 \right)$
	$Work \text{ Done} = \pm (24 \times 150 - 13 \times 150)$	B1	$\pm (3600 - 1950) = \pm 1650$
	Attempt at work-energy equation.	M1	5 terms, dimensionally correct, allow sign errors, sin/cos mix on PE term, PE must include $\sin 0.8$ or $\cos 0.8$.
	$84g \times 150 \sin 0.8 + \frac{1}{2} \times 84v^2 - \frac{1}{2} \times 84 \times 3^2 = 24 \times 150 - 13 \times 150$ $[1759.23\dots + 42v^2 - 378 = 3600 - 1950 \rightarrow 42v^2 = 268.765\dots]$	A1	
	$[v =] 2.53 \text{ ms}^{-1}$	A1	AWRT 2.53; 2.5296...
		6	
	Special case for use of constant acceleration: Maximum 4 marks		
	Resolve parallel to slope and use Newton's second law	*M1	Four terms, allow sign errors, allow sin/cos mix.
	$24 - 13 - 84g \sin 0.8 = \pm 84a$	A1	For reference $a = \pm 0.008669\dots$
	Use constant acceleration formula to get an equation in v or v^2	DM1	E.g. $v^2 = 3^2 + 2 \times (\text{their } a) \times 150$.
	$[v =] 2.53 \text{ ms}^{-1}$	A1	AWRT 2.53; 2.5296...
		4	

PUBLISHED

Question	Answer	Marks	Guidance
5	Attempt at resolving parallel or perpendicular to the plane.	*M1	3 terms, allow sign errors, allow sin/cos mix, allow g missing. Forces that need resolving should be resolved, forces that do not need resolving should not be resolved.
	$R = P \sin 35 + 0.6g \cos 35$ [$R = (0.573...)P + 4.914...$]	A1	
	$F + P \cos 35 = 0.6g \sin 35$ [$F + (0.819...)P = 3.441...$]	A1	Their F .
	Use of $F = 0.4R$	*M1	Where R is initially a linear combination of a P component and a weight component (or a mass component).
	Solve for P .	DM1	From equations with the correct number of relevant resolved terms. $R = \frac{0.6g}{\cos 35 + 0.4 \sin 35} = 5.7222$ Must get to $P = \dots$, e.g. $P = \frac{0.6g \sin 35 - 0.4 \times 0.6g \cos 35}{\cos 35 + 0.4 \sin 35}$ If no working seen, allow this mark if correct solution for their equations. If $F \leq 0.4R$ used, it should be used correctly. e.g. $0.6g \sin 35 - P \cos 35 \leq 0.4(P \sin 35 + 0.6g \cos 35)$.
	$P = 1.41$	A1	AWRT 1.41 . If $P \geq 1.41$ seen, must then state the least value explicitly for A1.

PUBLISHED

Question	Answer	Marks	Guidance
5	Alternative for Question 5: Resolving vertically and horizontally		
	Attempt at resolving vertically or horizontally.	*M1	3 terms, allow sign errors, allow sin/cos mix, allow g missing. Forces that need resolving should be resolved, forces that do not need resolving should not be resolved.
	$R \cos 35 + F \sin 35 = 0.6g$	A1	<i>Their</i> F or R .
	$P + F \cos 35 = R \sin 35$	A1	<i>Their</i> F or R .
	Use of $F = 0.4R$	*M1	To get 2 equations, one in R (or F) and the other in P and R (or P and F) from resolved equations with correct number of relevant terms. Allow g missing.
	Solve for P	DM1	From equations with the correct number of relevant resolved terms. May see $R = \frac{0.6g}{\cos 35 + 0.4 \sin 35} = 5.7222$; Must get to $P = \dots$, e.g. $P = \frac{0.6g \sin 35 - 0.4 \times 0.6g \cos 35}{\cos 35 + 0.4 \sin 35}$. If no working seen, allow this mark if correct solution for <i>their</i> equations.
	$P = 1.41$	A1	AWRT 1.41 .
		6	

PUBLISHED

Question	Answer	Marks	Guidance
6(a)	$4b + 4^{\frac{3}{2}}c = 8 [\rightarrow 4b + 8c = 8]$ and $9b + 9^{\frac{3}{2}}c = 13.5 [\rightarrow 9b + 27c = 13.5]$ State $b = 3$ and $c = -0.5$ OR $3 \times 4 + (-0.5) \times 4^{\frac{3}{2}} = 8$ AND $3 \times 9 + (-0.5) \times 9^{\frac{3}{2}} = 13.5$	B1	Must have 2 correct equations, which do not have to be simplified. Allow to just state the values of b and c . Allow substitution of $b = 3$ and $c = -0.5$ in both equations to verify. No further calculation required. B0 if any incorrect work seen.
		1	
6(b)	$\left(a = \frac{dv}{dt} = \right) 3 - 0.5 \times \frac{3}{2} \times t^{\frac{1}{2}}$ OR $b + c \times \frac{3}{2} \times t^{\frac{1}{2}}$	M1	Attempt to differentiate, decrease power by 1 and a change in coefficient in at least one term (which must be the same term); allow unsimplified; $a = \frac{v}{t}$ is M0.
	acceleration = 2.25 ms^{-2}	A1	OE, e.g. $\frac{9}{4}$ or $2\frac{1}{4}$. SC B1 for 2.25 if no differentiation seen.
		2	

PUBLISHED

Question	Answer	Marks	Guidance
6(c)	Equate v to 0 and attempt to solve for t	M1	Must get to $t = \dots$ and must be positive.
	$t = 36$ ONLY	A1	WWW. Allow if $t = 0$ seen and not rejected.
	Attempt to integrate	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.
	$s = \frac{3}{2}t^2 - 0.5 \times \frac{2}{5} \times t^{\frac{5}{2}} (+D) = \frac{3}{2}t^2 - \frac{1}{5}t^{\frac{5}{2}} (+D)$ OR $s = \frac{b}{2}t^2 + c \times \frac{2}{5} \times t^{\frac{5}{2}} (+D)$	A1	Allow unsimplified (including indices).
	Sub $t = 36$ (or use limits 36 and 0) to get distance = 388.8 m ONLY	A1	Allow 389 m. If no integration seen for the last 3 marks, allow SC B1 for 388.8 m. Max M1A1B1 for 3/5 marks.
		5	
6(d)	$\frac{3}{2}t^2 - 0.5 \times \frac{2}{5} \times t^{\frac{5}{2}} = 0$	M1	Equate <i>their</i> s (that has come from an integration attempt) to 0 and attempt to solve for t . Must get to $t = \dots$
	$t = 56.25$	A1	WWW. OE, e.g. $\frac{225}{4}$. Allow 2sf or better. Allow any correct unsimplified expression equivalent to 56.25 e.g. $\frac{15^2}{2^2}$ or 7.5^2 .
	Speed = 42.2 ms^{-1} ONLY	A1	AWRT 42.2. Speed = -42.2 is A0. Allow A1 if negative sign dropped without justification.
		3	

PUBLISHED

Question	Answer	Marks	Guidance
7(a)(i)	Particle P : $2g \sin 30 - F - T = 2a$ [$10 - F - T = 2a$] Particle Q : $T - 0.25g = 0.25a$ System: $2g \sin 30 - F - 0.25g = (2 + 0.25)a$	M1	Newton's second law on either particle or for the system with correct masses; correct number of terms, allow sin/cos mix, allow sign errors. Allow with <i>their</i> F .
		A1	Both particle equations correct (with the same T) or system equation correct. Allow with <i>their</i> F . If <i>their</i> a direction is different to ours, allow if <i>their</i> a is consistently used e.g. $-2g \sin 30 + F + T = 2a'$ and $0.25g - T = 0.25a'$.
	$F = 0.3R = 0.3 \times 2g \cos 30 [= 3\sqrt{3} = 5.1961\ldots]$	M1	Use of $F = 0.3R$, where R is a component of weight.
	Acceleration from A to $B = 1.02 \text{ m s}^{-2}$	A1	Solving for the acceleration from A to B . Allow $\frac{10 - 4\sqrt{3}}{3}$; AWR 1.02 . May see $T = \frac{10 - \sqrt{3}}{3} = 2.7559\ldots$
		4	

PUBLISHED

Question	Answer	Marks	Guidance
7(a)(ii)	Use of suvat from A to B to get an equation in v^2 or v .	*M1	Using $u = 0$ and <i>their</i> $ a $ from (a)(i) to get a positive v^2 . E.g. $v^2 = 2 \times 0.8 \times (\text{their } 1.02)$ or $v^2 = 2 \times (-0.8) \times (-\text{their } 1.02)$.
	$v^2 = \left[\frac{80 - 32\sqrt{3}}{15} \right] = 1.64$ OR $v = 1.28$	A1	Not $v = 1.29$. Allow 2sf or better without wrong work, i.e. $v^2 = 1.6$ or $v = 1.3$.
	Find the acceleration from B to C : $2g \sin 30 - 0.25g = (2 + 0.25)a$	*M1	Resolving on both particles and eliminate T (if <i>their</i> a direction is different to ours, allow if <i>their</i> a is consistently used) OR for the system to get an equation in a only. Correct number of relevant terms, allow sin/cos mix, allow sign errors. For reference $a = \frac{10}{3}$ or 3.33. May see $T = \frac{10}{3}$.
	$v^2 = (\text{their } 1.28)^2 + 2 \times \left(\text{their } \frac{10}{3} \right) \times 1.2$	DM1	Use of suvat from B to C , allow <i>their</i> positive $a \neq g$ from (a)(ii) not <i>their</i> a from (a)(i) and <i>their</i> 1.28. Dependent on previous two marks.
	Velocity = $3.1(0) \text{ ms}^{-1}$	A1	AWRT 3.1(0) to 3sf.

PUBLISHED

Question	Answer	Marks	Guidance
7(a)(ii)	Alternative Method for Question 7(a)(ii): using suvat in first stage and energy in second stage		
	Use of suvat from <i>A</i> to <i>B</i> to get an equation in v^2 or v .	*M1	Using <i>their</i> positive <i>a</i> from (a)(i) E.g. $v^2 = 2 \times 0.8 \times (\text{their } 1.02)$.
	$v^2 = \left[\frac{80 - 32\sqrt{3}}{15} \right] = 1.64$ OR $v = 1.28$	A1	Allow 2sf or better, i.e. $v^2 = 1.6$ or $v = 1.3$.
	Change in PE = $\pm(2g \times 1.2 \sin 30 - 0.25g \times 1.2)$ OR Change in KE = $\pm \left[\frac{1}{2}(2 + 0.25)v^2 - \frac{1}{2}(2 + 0.25)(\text{their } 1.28)^2 \right]$	B1	
	$\frac{1}{2}(2 + 0.25)v^2 - \frac{1}{2}(2 + 0.25)(\text{their } 1.28)^2 = 2g \times 1.2 \sin 30 - 0.25g \times 1.2$	DM1	Use of work-energy 6 terms; dimensionally correct. Allow sign errors. Allow sin/cos mix on PE. Dependent on previous M.
	Velocity = $3.1(0) \text{ m s}^{-1}$	A1	AWRT 3.1(0) to 3sf.

PUBLISHED

Question	Answer	Marks	Guidance
7(a)(ii)	Alternative Method for Question 7(a)(ii): using energy for complete motion		
	Change in PE = $\pm(2g \times 2 \sin 30 - 0.25g \times 2)$	B1	
	Work done against friction = $0.3 \times 2g \cos 30 \times 0.8$	B1	
	Change in KE = $\frac{1}{2}(2 + 0.25)v^2$	B1	
	$\frac{1}{2}(2 + 0.25)v^2 + 0.3 \times 2g \cos 30 \times 0.8 = (2g \times 2 \sin 30 - 0.25g \times 2)$	M1	Use of work-energy 5 terms; dimensionally correct. Must be considering both particles. Allow sign errors. Allow sin/cos mix on PE and/or WD against friction.
	Velocity = $3.1(0) \text{ ms}^{-1}$	A1	AWRT 3.1(0) to 3sf.

PUBLISHED

Question	Answer	Marks	Guidance
7(a)(ii)	Alternative Method for Question 7(a)(ii): using energy in two stages		
	$\frac{1}{2}(2 + 0.25)v^2 + 0.3 \times 2g \cos 30 \times 0.8 = 2g \times 0.8 \sin 30 - 0.25g \times 0.8$ OR $\frac{1}{2} \times 2 \times v^2 + (their\ 2.7559...) \times 0.8 + 0.3 \times 2g \cos 30 \times 0.8 = 2g \times 0.8 \sin 30$ OR $\frac{1}{2} \times 0.25 \times v^2 + 0.25g \times 0.8 = (their\ 2.7559...) \times 0.8$	*M1	Use of work-energy 5 terms; dimensionally correct. Allow sign errors. Allow sin/cos mix on PE. OR Use of work-energy 4 terms; dimensionally correct. Allow sign errors. Allow sin/cos mix on PE. OR Use of work-energy 3 terms; dimensionally correct. Allow sign errors.
	$v^2 = \left[\frac{80 - 32\sqrt{3}}{15} \right] = 1.64 \text{ OR } v = 1.28$	A1	Allow 2sf or better, i.e. $v^2 = 1.6$ or $v = 1.3$.
	Change in PE = $\pm(2g \times 1.2 \sin 30 - 0.25g \times 1.2)$ OR Change in KE = $\pm \left[\frac{1}{2}(2 + 0.25)v^2 - \frac{1}{2}(2 + 0.25)1.28^2 \right]$	B1	
	$\frac{1}{2}(2 + 0.25)v^2 - \frac{1}{2}(2 + 0.25)1.28^2 = 2g \times 1.2 \sin 30 - 0.25g \times 1.2$	DM1	Use of work-energy 6 terms; dimensionally correct. Allow sign errors. Allow sin/cos mix on PE. Dependent on previous 2 marks.
	Velocity = $3.1(0) \text{ m s}^{-1}$	A1	AWRT 3.1(0) to 3sf.
		5	

PUBLISHED

Question	Answer	Marks	Guidance
7(b)	$0.8 = 0 + \frac{1}{2} \times (\text{their positive answer to (a)(i)}) \times t_1^2$ and solve for t_1 OR $0.8 = \frac{1}{2} (0 + \text{their positive 1.28 from (a)(ii)}) t_1$ and solve for t_1 OR $(\text{their positive 1.28 from (a)(ii)}) = (\text{their positive answer to (a)(i)}) t_1$ and solve for t_1	M1	Use of suvat from A to B to find t_1 , using $s = 0.8$ and <i>their</i> positive $a \neq g$ from (a)(i) . Must get to $t_1 = \dots$ OR using their positive 1.28 . OR using their positive $a \neq g$ from (a)(i) and positive 1.28 .
	$1.2 = (\text{their 1.28 from (a)(ii)}) t_2 + \frac{1}{2} \times \left(\text{their } \frac{10}{3} \right) \times t_2^2$ and solve for t_2 OR $1.2 = \frac{1}{2} ((\text{their 1.28 from (a)(ii)}) + (\text{their answer to (a)(ii)})) t_2$ and solve for t_2 OR $(\text{their answer to (a)(ii)}) = (\text{their 1.28 from (a)(ii)}) + \left(\text{their } \frac{10}{3} \right) t_2$ and solve for t_2	M1	Use of suvat from B to C to find t_2 , using $s = 1.2$ and <i>their</i> positive $a \neq g$ from (a)(ii) (not <i>their a</i> from (a)(i)) and <i>their</i> 1.28 which would lead to a positive t_2 value. Must get to $t_2 = \dots$ OR using <i>their</i> 1.28 and/or <i>their</i> answer to (a)(ii) which would lead to a positive t_2 value. OR using <i>their</i> 1.28 and/or <i>their</i> answer to (a)(ii) and <i>their a</i> $\neq g$ from (a)(ii) (not <i>their a</i> from (a)(i)) which would lead to a positive t_2 value.
	$t_1 = 1.25$ or $t_2 = 0.547$	A1	These can be seen as an expression. Allow $t_1 = \frac{0.8}{0.64}$ $t_2 = \frac{1.2}{2.19}$ OE. Allow 2sf or better, e.g. $t_1 = 1.3$ or $t_1 = 0.55$.
	Total time = 1.8(0) s	A1	WWW. AWRT 1.8(0) to 3sf.
		4	



Cambridge International AS & A Level

MATHEMATICS

9709/43

Paper 4 Mechanics

May/June 2023

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 May/June 2023 series for most Cambridge IGCSE, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

PUBLISHED**Generic Marking Principles**

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

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

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

GENERIC MARKING PRINCIPLE 2:

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

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

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

GENERIC MARKING PRINCIPLE 4:

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

GENERIC MARKING PRINCIPLE 5:

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

GENERIC MARKING PRINCIPLE 6:

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

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

PUBLISHED**Mark Scheme Notes**

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

Types of mark

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

Abbreviations

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

PUBLISHED

Question	Answer	Marks	Guidance
1	For attempt at use of conservation of momentum in one case	M1	$0.1 \times 4 + 0 = 0.4v + 0.1v$ or $0.1 \times 4 + 0 = 0.4v + 0.1(-v)$ OE. Must have correct number of terms. Allow sign errors.
	Speed = $0.8[\text{ms}^{-1}]$ or $\frac{4}{5}$	A1	Must be positive. Allow Max M1A1A0 if g included with the masses.
	Speed = $\frac{4}{3}[\text{ms}^{-1}]$ Allow 1.33	A1	Must be positive.
		3	

Question	Answer	Marks	Guidance
2	Attempt to use Newton's second law	M1	Must have correct number of terms. Allow sign errors. Must use 300 and 1.25, not T and a .
	Trailer $300 - 200 = m \times 1.25$ or Car $3200 - F - 300 = 1500 \times 1.25$ System $3200 - F - 200 = (1500 + m) \times 1.25$	A1	Any 2 equations. Third equation could be with <i>their</i> m substituted if found already.
	Solve for m or F	M1	Must get to ' $m =$ ' or ' $F =$ '. Must have correct number of terms. Allow sign errors. Can be implied by correct answers.
	$m = 80$ and $F = 1025$	A1	
		4	

PUBLISHED

Question	Answer	Marks	Guidance
3	For attempt to resolve in one direction	M1	Must use 0.2 substituted for m if just awarding M1 for vertical equation. Must have correct number of relevant terms (forces must have components as required). Allow sin/cos mix. Allow sign errors. Allow g missing.
	$X \sin 60 + T \sin 30 - 0.2g = 0$	A1	OE. Correct vertical.
	$X \cos 60 - T - T \cos 30 = 0$	A1	OE. Correct horizontal. If the two T s are different, they can get max M1A1A0M0A0, unless they subsequently state that the two T s are equal.
	For attempt to solve for tension or X	M1	Must have correct number of relevant terms in both equations. Must get to ' $T =$ ' or ' $X =$ '. Allow g missing. Can be implied by correct answers. If no working shown their values must follow from their equations.
	$X = 2$, tension in string = 0.536[N]	A1	Allow exact value of tension = $4 - 2\sqrt{3}$. Allow awrt 2.00 for X .

PUBLISHED

Question	Answer	Marks	Guidance
3	Alternative method for Question 3: Resolving parallel and perpendicular to the XN force		
	For attempt to resolve in one direction, with 0.2 substituted for m	M1	Must have correct number of relevant terms (forces must have components as required). Allow sin/cos mix. Allow sign errors. Allow g missing.
	$X - 0.2g \cos 30 - T \cos 60 = 0$	A1	OE. Correct parallel to X .
	$T + T \cos 30 - 0.2g \cos 60 = 0$	A1	OE. Correct perp to X . If the two T s are different, they can get max M1A1A0M0A0 unless they subsequently state that the two T s are equal.
	For attempt to solve for the tension or for X	M1	Must have correct number of relevant terms in both equations. Must get to ' $T =$ ' or ' $X =$ '. Allow g missing. Can be implied by correct answers. If no working shown their values must follow from their equations.
	$X = 2$, Tension in string = 0.536[N] [0.53589...]	A1	Allow exact value of tension = $4 - 2\sqrt{3}$. Allow awrt 2.00 for X .
		5	

PUBLISHED

Question	Answer	Marks	Guidance
4(a)	For use of $P = Fv$	B1	$P = 20F$ or $P = 25F$ OE (e.g. $F = \frac{P}{20}$ or $F = \frac{P}{25}$). But not with wrong F substituted (e.g. 6000).
	Attempt to use Newton's second law in at least one case	M1	Must have 3 terms. Allow sign errors. Allow F .
	$\frac{P}{20} - 6000 = 15000a$ and $\frac{P}{25} - 6000 = 15000\left(\frac{1}{2}a\right)$	A1	OE for both. Allow $2a'$ and a' . Must be the same P for both.
	For solving simultaneously	M1	Dependent on 2 equations of the correct form with the correct number of relevant terms. Must get to ' $P =$ ' or ' $a =$ ', but $P = 200\text{kW}$ or $200\,000\text{W}$ with no attempt at a gets M0. Must be the same P for both.
	Power [= 200 000W] = 200kW, $a = \frac{4}{15} [\text{ms}^{-2}]$	A1	AG. OE awrt 0.267. Do not allow 200 000 [W] as final answer. Must show some working when they find P .
	Alternative Method for Question 4(a): Using two expressions for P		
	For use of $P = Fv$	B1	$P = 20F$ or $P = 25F$ OE (e.g. $F = \frac{P}{20}$ or $F = \frac{P}{25}$). But not with wrong F substituted (e.g. 6000).
	For one expression for P in terms of a only	M1	Allow sign errors. Need 2 term expression.
	$(15000a + 6000) \times 20 = (15000 \times 0.5a + 6000) \times 25$	A1	Correct equation.
	For solving for a	M1	Must get to ' $a =$ '.
	Power [= 200 000W] = 200kW, $a = \frac{4}{15} [\text{ms}^{-2}]$	A1	AG. OE awrt 0.267. Do not allow 200 000 [W] as final answer. Must show some working when they find P .

PUBLISHED

Question	Answer	Marks	Guidance
4(a)	Alternative Method for Question 4(a): Using the given value of $P = 200 \text{ kW}$		
	For use of $P = Fv$	B1	e.g. $200\,000 = 20F$ or $200\,000 = 25F$ OE. e.g. $F = \frac{200000}{20} [= 10000]$ or $F = \frac{200000}{25} [= 8000]$.
	Attempt to use Newton's second law in at least one case	M1	Must have 3 terms. Allow sign errors. Allow with F . Allow 200 in place of 200 000.
	$\frac{200000}{20} - 6000 = 15000a$ and $\frac{200000}{25} - 6000 = 15000\left(\frac{1}{2}a\right)$	A1	For both. Allow $2a'$ and a' here.
	For solving for a in both cases.	M1	
	For showing that both equations lead to $a = \frac{4}{15} [\text{ms}^{-2}]$	A1	awrt 0.267.
		5	
4(b)	For attempt at resolving up hill $\frac{200000}{v} - 6000 - 15000g \sin 1 = 0$	M1	Or $\frac{200000}{v} - 6000 - 2618 = 0$. May see $\frac{200000}{8618}$. Must have correct number of terms. Allow sin/cos mix. Allow sign errors. Allow g missing, but not a different acceleration. Do not allow F .
	Steady speed = $23.2 [\text{m s}^{-1}]$	A1	
		2	

PUBLISHED

Question	Answer	Marks	Guidance
5(a)	For attempt at integration	M1	The power of t must increase by 1 with a change of coefficient. Do not penalise missing c . Use of $v = at$ scores M0.
	$v = \frac{2}{3}kt^{\frac{3}{2}}[+c]$	A1	Allow unsimplified e.g. $v = \frac{1}{1.5}kt^{\frac{1}{2}+1}[+c]$.
	$1.8 = \frac{2}{3}k \times 9^{\frac{3}{2}} \Rightarrow k = \left[\frac{3}{2} \times 1.8 \div 27 = \right] 0.1$	B1	AG. Must show values substituted OE (e.g. $1.8 = 18k$).
		3	

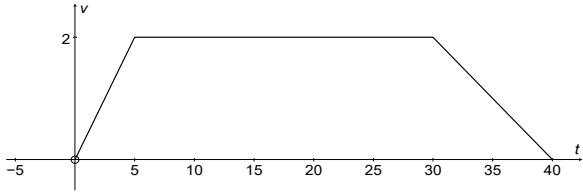
PUBLISHED

Question	Answer	Marks	Guidance
5(b)	For attempt at integration of either $\int \left(\frac{2}{3}kt^{\frac{3}{2}} \right) dt$ or $\int (0.2(t-9)^2 + 1.8) dt$ or $\int (0.2t^2 - 3.6t + 18) dt$	M1	The power of t or $(t-9)$ must increase by 1 with a change of coefficient in at least one term. Use of $s = vt$ is M0.
	$\left[\frac{4}{150}t^{\frac{5}{2}} \right]_0^9$ and $\left[\left(\frac{0.2}{3}(t-9)^3 + 1.8t \right) \right]_9^{18}$ or $\left[\left(\frac{0.2}{3}t^3 - \frac{3.6}{2}t^2 + 18t \right) \right]_9^{18}$	A1	Allow unsimplified. No need for limits. Could include '+c' with either or both.
	$= \frac{4}{150} \times 9^{\frac{5}{2}} \left[= 6.48 \text{ or } \frac{162}{25} \right]$ or $= \frac{0.2}{3}(18-9)^3 + 1.8 \times 18 - 1.8 \times 9 = \left[64.8 \text{ or } \frac{324}{5} \right]$ $\left(\frac{0.2}{3} \times 18^3 - \frac{3.6}{2} \times 18^2 + 18 \times 18 \right) - \left(\frac{0.2}{3} \times 9^3 - \frac{3.6}{2} \times 9^2 + 18 \times 9 \right)$ or $\left[= \frac{648}{5} - \frac{324}{5} = \frac{324}{5} \right]$	M1	Correct use of limits 0, 9 or limits 9, 18. Can be implied by either answer following integration “+c” method is as follows: $s = \frac{0.2}{3}(t-9)^3 + 1.8t - \frac{243}{25}$, or $s = \frac{0.2}{3}t^3 - \frac{3.6}{2}t^2 + 18t - \frac{1458}{25}$, then substitute $t = 18$ to get $\frac{1782}{25}$, subtract $\frac{162}{25}$, so distance = $\frac{324}{5}$.
	$6.48 = \frac{1}{10} \times 64.8$ or $64.8 = 10 \times 6.48$ or $\frac{324}{5} = 10 \times \frac{162}{25}$	A1	AG OE. Check working as can get answer from wrong working NFWW (not from wrong working).

PUBLISHED

Question	Answer	Marks	Guidance
5(b)	Alternative Method for Question 5(b): Special Case for those who use a calculator to integrate. Award max 2/4		
	Either $\int_0^9 \left(\frac{2}{3} kt^{\frac{3}{2}} \right) dt = 6.48$ or $\frac{162}{25}$ Or $\int_9^{18} (0.2(t-9)^2 + 1.8) dt = 64.8$ or $\frac{324}{5}$	SC B1	
	$6.48 = \frac{1}{10} \times 64.8$ or $64.8 = 10 \times 6.48$ or $\frac{324}{5} = 10 \times \frac{162}{25}$	SC B1	OE.
		4	
5(c)	For differentiation Should get $a = 0.4(t-9)$ or $a = 0.4t - 3.6$	M1	The power of t or $(t-9)$ must decrease by 1 with a change of coefficient. M0 for $a = \frac{v}{t}$.
	$0.4[\text{ms}^{-2}]$ [at $t = 10$]	A1	SC B1 for 0.4 with no differentiation seen.
	0.3 seen (from the first phase) and state that 0.4 is final answer	B1	No working needed. If M1A0 or M0A0 scored, then SC B1 for 0.3 without mention of the maximum acceleration.
		3	

PUBLISHED

Question	Answer	Marks	Guidance
6(a)	Greatest speed = $2 \text{ [m s}^{-1}]$ $[0.4 \times 5]$	B1	This can be seen on the graph and not stated explicitly.
	Trapezium shape	B1	Sitting on t -axis, starting at origin.
		B1	All correct including height of 2 and t -values of 5, 30, 40 on the horizontal axis. Labels not needed. Does not need to be to scale.
		3	
6(b)	Distance = $\frac{1}{2}(25+5+25+their\ 10) \times their\ 2$ or $\frac{1}{2} \times 5 \times their\ 2 + 25 \times their\ 2 + \frac{1}{2} \times their\ 10 \times their\ 2$	M1	Allow M1 for finding total area under their trapezium or appropriate 'suvat' in each phase. If presented as 3 areas, they do not need to be added for M1. Allow one wrong value but must represent all 3 phases of motion.
	Distance = 65 [m]	A1	
		2	
6(c)	Attempt at Newton's second law	M1	Must have correct number of terms (5). Allow sign errors. Allow g missing. Use of $a = g$ is M0A0A0 but condone use of $a = 0.4$ (from wrong phase).
	$12250 - 1200g - mg = (1200 + m) \times (-0.2)$ Or $1200g + mg - 12250 = (1200 + m) \times 0.2$	A1	Correct equation. Note that taking $a = 0.2$ and omitting mg gets M0A0A0.
	$m = 50$	A1	
		3	

PUBLISHED

Question	Answer	Marks	Guidance
6(d)	Realise that this is when accelerating and attempt Newton's second law for the crate only	M1	Must have correct number of terms (3). Allow sign errors. Allow g missing. Must use $a = \pm 0.4$, M0A0A0 otherwise.
	$R - 50g = 50 \times 0.4$ or $50g - R = 50 \times (-0.4)$	A1FT	Correct equation using their 50.
	Force $R = 520$ [N], upwards	A1	Must include 'upwards' OE.
		3	

Question	Answer	Marks	Guidance
7(a)	PE lost = $mgh = 25g \times 1.8 [= 450]$	B1	
	For work energy equation	M1	Must have correct number of terms. Allow sign errors. Dimensionally correct. Must use 25, not m . Candidates who try to use constant acceleration can only score B1.
	$25g \times 1.8 - 50 = \frac{1}{2} \times 25v^2$	A1	OE. Must be correct.
	$v = 4\sqrt{2}$ [ms ⁻¹] or 5.66 [5.6568...]	A1	Allow $\sqrt{32}$.
		4	

PUBLISHED

Question	Answer	Marks	Guidance
7(b)	PE gained/lost = $\pm 25g \times 2 \times 0.28 [= \pm 140]$ or KE gained/lost = $\pm \frac{1}{2} \times 25 \left(\text{their } 4\sqrt{2} \right)^2$ [KE = ± 400]	B1FT	For either. FT from <i>their</i> v for KE. Must have α substituted for PE. Allow $25g \times 2 \sin 16.26^\circ$ or $25g \times 2 \sin 16.3^\circ$.
	For work energy equation	*M1	Must have correct number of terms. Allow sign errors. Dimensionally correct. Allow sin/cos mix Do not allow with WD instead of $F \times 2$. Must have substituted α and v .
	$F \times 2 = 25g \times 2 \times 0.28 + \frac{1}{2} \times 25 \left(4\sqrt{2} \right)^2 [\Rightarrow F = 270]$	A1FT	FT <i>their</i> v^2 or v .
	$R = 25g \times 0.96 [= 240]$	B1	Allow $25g \cos 16.26^\circ$ or $25g \cos 16.3^\circ$.
	Use of $F = \mu R$ to form an equation in μ only	DM1	Must be from 3 term F , dimensionally correct and single term R . Allow sin/cos mix but must be different components of weight. F and R must be numerical expressions.
	$\mu = \frac{9}{8}$	A1	CAO. Allow $1\frac{1}{8}$, but no other answer.
	Alternative method 1 for first 3 marks: Using energy from the initial position (use existing scheme for final 3 marks).		
	PE lost = $\pm 25g \times (1.8 + 2 \times 0.28) [= \pm 590]$	B1	Allow $25g \times (1.8 + 2 \sin 16.26^\circ)$ or $25g \times (1.8 + 2 \sin 16.3^\circ)$.
	For work energy equation	*M1	Must have correct number of terms. Allow sign errors. Dimensionally correct. Allow sin/cos mix. Do not allow with WD instead of $F \times 2$. Must have substituted α .
	$F \times 2 = 25g \times (1.8 + 2 \times 0.28) - 50 [\Rightarrow F = 270]$	A1	

PUBLISHED

Question	Answer	Marks	Guidance
7(b)	Special Case: Use of constant acceleration. Award max 4/6		
	$0 = (4\sqrt{2})^2 + 2(\pm a) \times 2$		Use of $v^2 = u^2 + 2as$.
	$a = \pm 8$	SC B1FT	FT <i>their</i> v^2 or v . Note: 8.01 or 8.0089 from use of 5.66.
	$R = 25g \times 0.96$	SC B1	Allow $25g \cos 16.26^\circ$ or $25g \cos 16.3^\circ$.
	Use of $F = \mu R$ and attempt at N2L If correct should get $25g \sin 16.3^\circ - \mu \times 25g \cos 16.3^\circ = 25 \times (-8) [\Rightarrow 70 - 240\mu = -200]$	SC M1	To form an equation in μ only. Using <i>their</i> a . Allow sign errors. Allow sin/cos mix but must be different components of weight. F and R must be numerical expressions. Must have substituted a .
	$\mu = \frac{9}{8}$	SC A1	CAO. Allow $1\frac{1}{8}$, but no other answer.
		6	