Cambridge Assessment International Education

Cambridge International AS & A Level

MATHEMATICS **9709/41**

Paper 4 Mechanics **October/November 2021**

MARK SCHEME

Maximum Mark: 50

Published

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

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

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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.

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.

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.

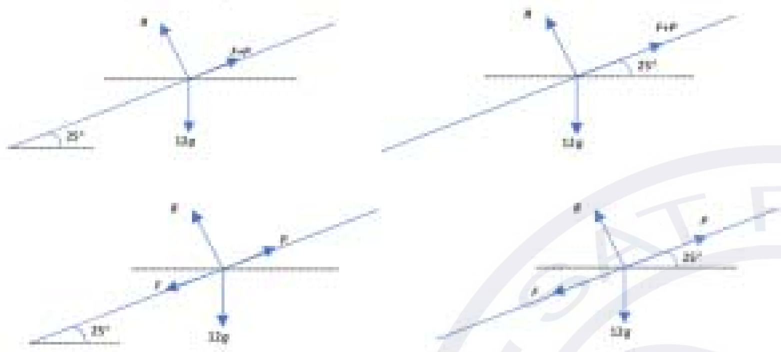
Abbreviations

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)	$6V + 30V + 3V = 585$ $0.5(30+48)V = 585$	M1	Use of constant acceleration equations or a *v*-*t* graph. Complete method to set up an equation in V using constant acceleration equations or correct area formula in *v*-*t* graph.
	Speed of the bus = 15 ms^{-1}	A1	Must be positive.
		2	
1(b)	Magnitude of deceleration = 2.5	B1 FT	OE. Do not allow $a = -2.5$.
		1	

Question	Answer	Marks	Guidance
2(a)	Attempt at use of conservation of momentum	**M1**	4 terms implied, i.e. *m* and *km* included before and after collision. Velocity after collision is the same for *m* and *km*.
	$km \times 6 - m \times 2 = (km + m) \times 4$	**A1**	
	$k = 3$	**A1**	
		3	
2(b)	KE initial = $\frac{1}{2} \times km \times 6^2 + \frac{1}{2} \times m \times (-2)^2$ KE after = $\frac{1}{2} \times (km + m) \times 4^2$	**M1**	Attempt at any of the three possible KE terms, unsimplified. *k* need not be substituted here.
	Loss of KE = $24m$ J	**A1 FT**	KE loss = $56m - 32m$ FT on *their* k, KE loss $= (10k - 6)m$, $k > 0.6$.
		2	

Question	Answer	Marks	Guidance
3	Attempt at resolving in any direction	M1	Correct number of terms. No substitution for α required.
	$P\cos\theta = (36-24)\cos 36.9$ or $P\cos\theta = (36-24)\times 0.8$	A1	
	$P\sin\theta + 20 = (24+36)\sin 36.9 = 14.4 + 21.6$ or $P\sin\theta + 20 = 60\times 0.6 = 36$	A1	
	$P\cos\theta = 9.6, P\sin\theta = 16 \quad P = \sqrt{16^2 + 9.6^2}$	M1	Correct method for solving equations for *P*. OE
	$\theta = \tan^{-1}\left(\frac{16}{9.6}\right)$	M1	Correct method for solving equations for θ. OE e.g. $\theta = \tan^{-1}\left(\frac{5}{3}\right)$
	$P = 18.7$ $\theta = 59[.0]$	A1	Allow $P = \frac{16\sqrt{34}}{5}$. Allow $P = 18.6$.
		6	

Question	Answer	Marks	Guidance
4(a)	Correct 4 force diagram 	B1	Angles shown. F either up/down slope. 
		1	
4(b)	Attempt to resolve forces parallel to the plane	M1	Three terms, allow sign errors.
	$P + F = 12g\sin 25$ $[= 50.7]$	A1	Must have correct direction of F here.
	$R = 12g\cos 25$ [= 108.8]	B1	
	$F = 120\cos 25 \times 0.35$ $[= 38.1]$ $P + 38.1 = 120\sin 25$	M1	Attempt to solve for P using equations with the correct number of terms. R must be a single-term component of $12g$.
	$P = 12.6$	A1	P = 12.64926… Allow $P = 12.7$
		5	

Question	Answer	Marks	Guidance
5(a)	$s = 30 \times 20$	B1	
	$\text{PE change} = 1600 \times g \times s \times 0.12$ $[\text{PE change} = 1600 \times g \times 20 \times 30 \times 0.12]$	M1	Attempt change in PE. May use angle = 6.9º. Allow sin/cos error only.
	Change in PE $= 1152000$ J	A1	
		3	
5(b)	$1\,960\,000 = WD_{res} + \textit{their}\text{PE}$ $[1\,960\,000 = WD_{res} + 1152\,000]$ $[WD_{res} = 808\,000\text{ J}]$	M1	Using work-energy, allow sign error.
	$R = WD_{res} \div 600$	B1	Using $WD_{res} = R \times 600$.
	Force resisting motion = $R = 1350\text{ N}$ to 3sf	A1	Allow $R = \frac{4040}{3}$ N. Allow R negative.
	Alternative method for question 5(b)		
	$DF - R - 1600g \times 0.12 = 0$	M1	R is the resisting force.
	$DF = \frac{196000}{20 \times 30}\left[= \frac{9800}{3}\right]$	B1	
	Force resisting motion = $R = \frac{4040}{3} = 1350\text{ N}$ to 3sf	A1	Allow R negative.
		3	

Question	Answer	Marks	Guidance
5(c)	$P = \left(\frac{4040}{3} + 1600 \times g \times 0.12\right) \times 20$ $\left[= \frac{196\,000}{3}\right]$	M1	For using $P = DF \times v$. Allow use of *their R*.
	$P = 65.3$ kW	A1	
	Alternative method for question 5(c)		
	$P = \frac{1960\,000}{30}$	M1	For using $P = \text{Work done} \div \text{Time}$.
	$P = 65.3$ kW	A1	
	Alternative method for question 5(c)		
	$P = \frac{9800}{3} \times 20$	M1	For using $P = DF \times v$. Allow use of *their DF*.
	$P = 65.3$ kW	A1	
		2	

Question	Answer	Marks	Guidance
5(d)	$0.85 \times \frac{196\,000}{3} = DF \times 20$	B1 FT	$P = DF \times v$ $\left[DF = \frac{8330}{3}\right]$ FT on *their P*.
	$DF - R - 1600g \times 0.12 = 1600a$ $\left[\frac{8330}{3} - \frac{4040}{3} - 1920 = 1600a\right]$	M1	Newton's 2nd law, four terms, allow sin/cos error, *their R* and *their DF*.
	$a = [-]0.306\,\text{ms}^{-2}$	A1	$a = [-]\frac{490}{1600} = [-]\frac{49}{160}$
	Alternative method for question 5(d)		
	$9800 = DF \times 20$	B1 FT	Using the reduction in power as the cause of the deceleration. $9800 = 0.15 \times$ *their* $P = DF \times v$
	$DF = 1600d$ $\left[\frac{9800}{20} = 1600d\right]$	M1	
	$a = [-]0.306\,\text{ms}^{-2}$	A1	$a = [-]\frac{490}{1600} = [-]\frac{49}{160}$
		3	

Question	Answer	Marks	Guidance
6(a)	$a = 2pt - q$	*M1	Attempt to differentiate *v*.
	$36p - 6q = 36$ $4p - q = 0$	DM1	For attempting to set up 2 equations using $a = 0$ at $t = 2$ and matching the velocities at $t = 6$ and solve for p or q.
	$p = 3, q = 12$	A1	Both correct.
		3	
6(b)	Correct quadratic from $t = 0$ to $t = 6$ **or** Correct straight line from 6 to 14	B1	No labelling necessary for this mark.
	Both quadratic and straight line correct	B1	Must join and no labelling needed.
	All correct and key points shown	B1	All correct, labelled at (4, 0), (6, 36) and (14, 0).
		3	
6(c)	Attempt to integrate *v*	*M1	Allow in terms of *p* and *q*.
	$s = t^3 - 6t^2$	A1 FT	FT on *their* *p* and *q* values.
	$s(\text{quadratic}) = \left[\left\|t^3 - 6t^2\right\|\right]_0^4 + \left[t^3 - 6t^2\right]_4^6$	DM1	$[= 32 + 32]$ Using limits correctly for $t = 0$ to $t = 6$. Allow in terms of *p* and *q*.
	$s(\text{triangle}) = \left[63t - 2.25t^2\right]_6^{14} = 144$ or area of triangle $= 144$	B1	
	Total distance travelled in 14 s = 208 m	A1	
		5	

Question	Answer	Marks	Guidance
7	Particle A: $2g - T = 2a$ Particle B: $T - 3g\sin 18 = T - 9.27 = 3a$ System: $2g - 3g\sin 18 = 2g - 9.27 = (2+3)a$	M1	Apply Newton's 2nd law to either particle A, or to particle B or the system. Correct number of terms.
		A1	A and B correct or system correct.
	$a = 2.145898034$ $[5a = 10.72949017]$	M1	Attempt to find a using equations with correct number of terms.
	$v^2 = 2 \times a \times 0.45$	M1	Use of constant acceleration equations with *their* $a \neq \pm g$ to find v^2 when A reaches the ground.
	$v^2 = 2 \times 2.145898034 \times 0.45 = 1.931308\cdots$ $[v = 1.389715162]$	A1	Allow unsimplified.
	$T = 0,\ \pm 3g\sin 18 = 3a$ $[a = \pm 3.0901699]$	M1	Attempt to find a for the motion of B when string becomes slack. Allow sin/cos error, no extra terms.
	$[0 = 1.93 - 2 \times 3.09 \times s]$ $[s = 0.312]$	M1	Use constant acceleration equations, using a new $a \neq \pm g$, to find the further distance, s, travelled by B before coming to rest.
	Total distance moved by B = 0.45 + 0.312 = 0.762 m	A1	
	Alternative method for question 7		
	Attempt PE loss as A reaches the ground	M1	Allow sin/cos error.
	PE loss = $2g \times 0.45 - 3g \times 0.45\sin 18$ $[= 4.82827]$	A1	Correct unsimplified.
	$2g \times 0.45 - 3g \times 0.45\sin 18 = \frac{1}{2} \times (2+3)v^2$	*M1	Apply work-energy equation as PE loss = KE gain, allow sign error, sin/cos error, 4 terms implied.

Question	Answer	Marks	Guidance
7	Solve for v^2	**DM1**	
	$v^2 = 1.931308\ldots \quad [v = 1.389715162]$	**A1**	
	PE gain = $3g \times s \sin 18$	**M1**	Attempt PE gain for *B* after string breaks, allow sign error, sin/cos mix, *s* = extra distance travelled by *B* along the plane.
	$3g \times s \sin 18 = \frac{1}{2} \times 3 \times 1.931308 \quad [s = 0.312]$	**M1**	Work energy equation for *B* as PE gain = KE loss, 2 terms.
	Total distance moved by *B* = 0.45 + 0.312 = 0.762 m	**A1**	
		8	

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Question	Answer	Marks	Guidance
1(a)	$\frac{20-6}{50-T}=\frac{20}{5}$ or $20=6+\frac{20}{5(50-T)}$	**M1**	Equate the accelerations and set up an equation in *T*. Allow correct use of *their* incorrect $\frac{20}{5}$.
	$T = 46.5$	**A1**	
		2	
1(b)	Distance = $\frac{1}{2}\times 5\times 20 + 20\times 20 + \frac{1}{2}\times 5\times(20+6) +$ $+ 6\times(T-30) + \frac{1}{2}\times(50-T)\times(20+6) + \frac{1}{2}\times 10\times 20$ [= 50 + 400 + 65 + 99 + 45.5 + 100] OR Distance = $\frac{1}{2}\times 20\times(60+45) - \frac{1}{2}\times 14\times(25+T-30)$ [= 1050 – 290.5]	**M1**	Attempt to find the total distance travelled using areas. Allow with *T* not yet substituted. Allow one error in use of area formulae or omission of only one of the areas: 0–5, 5–25, 25–30, 30–*T*, *T*–50, 50–-60.
	Total distance travelled = 759.5 m	**A1 FT**	FT *their T* value: Provided $30 < T < 50$ and distance $= 1085 - 7T$
		2	

Question	Answer	Marks	Guidance
2(a)	For van: $2500 - 700 - T = 3600a$ For trailer: $T - 300 = 1200a$ For system: $2500 - 700 - 300 = (3600 + 1200)a$	M1	Apply Newton's 2nd law to the van or to the trailer or to the system of van and trailer. Correct number of terms.
		A1	For any two correct.
	Obtain an equation in T only $\left[a = \frac{5}{16} = 0.3125\right]$	M1	
	Tension in the rope = $T = 675$ N	A1	
		4	
2(b)	For van: $-F - 700 = 3600a$ For trailer: $-300 = 1200a$ System: $-F - 700 - 300 = (3600 + 1200)a$	M1	Apply Newton's 2nd law to any two of the van, the trailer and the system with braking force F and with $T = 0$.
	Least possible value of braking force = $F = 200$ N	A1	Allow $F = -200$
		2	

Question	Answer	Marks	Guidance
3(a)	$mg \times 1.8 = \frac{1}{2}mv^2$	M1	Use of conservation of energy, 2 terms. Must NOT use constant acceleration equations. Use of equations such as $v^2 = u^2 + 2as$ scores **M0 A0.**
	Speed of block at $B = v = 6\ \text{ms}^{-1}$	A1	**AG**
		2	
3(b)	Attempt the work-energy equation	M1	In the form: ± KE lost = ± PE gain ± WD against Resistance
	$\frac{1}{2} \times m \times 6^2 = 4.5 + mg \times 1.2$	A1	If using motion from A to final point $mg \times 1.8 = mg \times 1.2 + 4.5$
	Mass of the block $= m = 0.75$ kg	A1	
		3	

Question	Answer	Marks	Guidance
4(a)	For differentiation of s	*M1	
	$v = 0.004(150t - 3t^2)$ [$= 0.6t - 0.012t^2$]	A1	
	$v = 0$ when $t = 50$. At $t = 50$, $s = 0.004(75 \times 50^2 - 50^3) = 0.3 \times 50^2 - 0.004 \times 50^3$	DM1	Solve $v = 0$ for t and substitute this value into s.
	Distance $AB = 250$ m	A1	**AG**
		4	

Question	Answer	Marks	Guidance
4(b)	Attempt to determine stationary points for v by differentiation or by use of symmetry [$a = 0.004(150 - 6t) = 0.6 - 0.024t$] or using symmetry attempt to find the mid-point between $t = 0$ and *their* t value at $v = 0$	***M1**	If symmetry used then an attempt to find the required mid-point must be seen.
	Maximum v when $a = 0$ so $t = 25$ Or finding the mid-point if symmetry is used e.g. $v = 0.004(150 \times 25 - 3 \times 25^2) = 0.6 \times 25 - 0.012 \times 25^2$ [$= 7.5 \text{ ms}^{-1}$]	**DM1**	Attempt to solve $a = 0$ or use symmetry to find the relevant t value.
	Maximum velocity = 7.5 ms^{-1}	**A1**	
	Alternative method for question 4(b)		
	Attempt to velocity as $v = -0.012\left[(t-25)^2 - 25^2\right]$	**M1***	Attempt to complete the square for *their* velocity as far as $k\left[(t-a)^2 - a^2\right]$
	$v = -0.012(t-25)^2 + 0.012 \times 25^2$ and select $t = 25$ as the maximum point.	**DM1**	Or select the 0.012×25^2 term as the maximum velocity.
	Maximum $= [0.012 \times 625 =] 7.5 \text{ ms}^{-1}$	**A1**	
		3	

Question	Answer	Marks	Guidance
5(a)	Driving force = $DF = \frac{960\,000}{30}$	B1	Allow for 960 000 = $DF \times 30$
	$DF - 75000g \times \sin\alpha - R = 0$	M1	Resolve forces along the slope. Must use a value for either $\sin\alpha$ or α.
	Resistance force = R = 24 500 N	A1	Allow correct work with 24500 to 3 sf.
		3	
5(b)	WD by engine in 60 s = 900 000 × 60 [= 54000000]	B1	
	$KE_{init} = \frac{1}{2} \times 75000 \times 30^2$ $KE_{final} = \frac{1}{2} \times 75000 \times v^2$	B1	For either correct expression for KE.
	$900000 \times 60 + \frac{1}{2} \times 75000 \times 30^2 = 46500000 + \frac{1}{2} \times 75000 \times v^2$	M1	For use of the work-energy equation with 4 terms, correct dimensions.
	Speed of engine after 60 s = v = 33.2 ms^{-1}	A1	Allow $v = \sqrt{1100} = 10\sqrt{11}$
		4	

Question	Answer	Marks	Guidance
6(a)	Horizontal: $100 - T_U \sin 60 - T_L \sin 60 = 0$ Vertical: $T_U \cos 60 - T_L \cos 60 - 5g = 0$ Perp to T_U $T_L \cos 30 + 5g \cos 30 = 100 \cos 60$	**M1**	Resolve horizontally or vertically or perpendicular to the upper string to reach an equation. Correct number of terms, Allow X for 100 in horizontal equation.
		A1	Either horizontal and vertical equations correct or perpendicular correct. Must see $X = 100$ used for A1.
	Solve for either T_L or T_U using equation(s) with no missing term.	**M1**	May see $T_U = 107.74$
	$T_L = 7.74$ N	**A1**	Allow 7.73
		4	
6(b)	Horizontal: $X - T_{up} \sin 60 = 0$ Vertical: $T_{up} \cos 60 - 5g = 0$ Perp to T_{up} $5g \cos 30 = X \cos 60$	**M1**	Resolve either horizontally or vertically or perpendicular to the upper string. Must be using the tension $T_{low} = 0$. Equivalent to Lami as: $\frac{5g}{\sin 150} = \frac{X}{\sin 120} \left(= \frac{T_{up}}{\sin 90} \right)$
		A1	Either horizontal and vertical equations correct or perpendicular correct.
	Eliminate T_{up} and/or solve for X	**M1**	$T_{up} = 100$
	Least value of $X = 86.6$	**A1**	Allow $X = 50\sqrt{3}$
		4	

Question	Answer	Marks	Guidance
7(a)	For *Q*: $-2mg\sin\alpha - F = 2ma$ $[-16m - 7.2m = 2ma]$ $R = 2mg\cos\alpha$ $[= 12m]$	M1	Apply Newton's 2nd law along or perpendicular to the plane to particle *Q*. Must use values for α or sin α or cos α.
		A1	Both correct.
	$F = 0.6 \times 2mg\cos\alpha = 0.6 \times 0.6 \times 20m$ $[= 7.2m]$ $[2(m)a = -2(m)g\,(0.8) - 0.6 \times 2(m)g\,(0.6)]$	M1	Using $F = 0.6R$ where R is a component of $2mg$ only
	Acceleration of *Q* up the plane while moving up the plane is $a = -11.6$ ms^{-2}	A1	**AG**
		4	
7(b)	For *P*: $mg\sin\alpha - 0.6R = ma$, leading to $8m - 3.6m = ma$ $[R = mg\cos\alpha = 6m,\ a = 4.4 \text{ ms}^{-2}]$	M1	Apply Newton's 2nd law to attempt to find the acceleration of particle *P*. Must use values for α or sin α.
	Q comes to rest when $10 - 11.6T_1 = 0$, $\left[T_1 = \frac{25}{29} = 0.862\right]$	M1	For using constant acceleration equations to attempt to determine when $v_Q = 0$.
	For *P* $s_{P(\text{down})} = \frac{1}{2} \times 4.4 \times T_1^2$ $[= 1.635]$ For *Q* $s_{Q(\text{up})} = 10T_1 + \frac{1}{2} \times (-11.6) \times T_1^2$ $[= 4.31]$	M1	Use constant acceleration equations to attempt to find either $s_{P(\text{down})}$ or $s_{Q(\text{up})}$ at time T_1.
	$d = 6.4 - s_{P(down)} - s_{Q(up)}$ $[= 0.455]$ and to find T_2 $[= 0.12]$ by using $d = s_{P2} - s_{Q2} = (4.4T_1) \times T_2$ [s_{P2} and s_{Q2} are distances travelled by *P* and *Q* in time T_2]	M1	For attempting to find the extra distance $d[= 0.455]$ needed to reach 6.4 m and using $u_P = 4.4T_1$ at T_1 to find T_2 as $d = (4.4T_1)T_2 + \frac{1}{2} \times 4.4T_2^2 - \frac{1}{2} \times 4.4T_2^2$.
	Time before collision = $[t = T_1 + T_2 = 0.862 + 0.12 =]\,0.982$	A1	$t = 0.98194357\ldots$

Question	Answer	Marks	Guidance
7(b)	**Alternative method for Question 7(b)**		
	For P: $mg\sin\alpha - 0.6R = ma$, leading to $8m - 3.6m = ma$ $[R = mg\cos\alpha = 6m, a = 4.4\ \text{ms}^{-2}]$	**M1**	Apply Newton's 2nd law to attempt to find the acceleration of particle P. Must use values for α or $\sin\alpha$
	Q comes to rest when $10 - 11.6T_1 = 0$, $\left[T_1 = \frac{25}{29} = 0.862\right]$	**M1**	For using constant acceleration equations to attempt to determine when $v_Q = 0$
	For P $s_{P(\text{down})} = \frac{1}{2} \times 4.4 \times t^2$ For Q $s_{Q(\text{up})} = 10T_1 + \frac{1}{2} \times (-11.6)T_1^2 - \frac{1}{2} \times 4.4(t - T_1)^2$	**M1**	Use constant acceleration equations to attempt to find either $s_{P(\text{down})}$ or $s_{Q(\text{up})}$ at time t where t is the total time before collision.
	$\frac{1}{2} \times 4.4t^2 + 10T_1 + \frac{1}{2} \times (-11.6)T_1^2 - \frac{1}{2} \times 4.4(t - T_1)^2 = 6.4$	**M1**	For using $s_{P(\text{down})} + s_{Q(\text{up})} = 6.4$ and solving for t
	Time before collision is $t = 0.982$ s	**A1**	$t = 0.98194357\ldots$
		5	
	Special case for those who do not take into account the fact that Q comes to rest and then changes its direction		
	For P: $mg\sin\alpha - 0.6R = ma$, leading to $8m - 3.6m = ma$ $[R = mg\cos\alpha = 6m, a = 4.4\ \text{ms}^{-2}]$	**M1**	Apply Newton's 2nd law to attempt to find the acceleration of particle P. Must use values for α or $\sin\alpha$.
	For P $s_{p(\text{down})} = (\pm)\frac{1}{2} \times 4.4t^2$ For Q $s_{q(\text{up})} = (\pm)\ 10t + \frac{1}{2} \times (-11.6)t^2$	**M1**	For using constant acceleration equations to attempt to find either $s_{p(\text{down})}$ or $s_{q(\text{up})}$.
	$s_p + s_q = 6.4$ leading to $\frac{1}{2} \times 4.4t^2 + 10t + \frac{1}{2} \times (-11.6)t^2 = 6.4$	**M1**	For applying $(\pm)\ s_p + (\pm)\ s_q = 6.4$ using their expressions for s_p and s_q to set up and solve a 3-term quadratic equation in t to obtain at least 1 solution.

Question	Answer	Marks	Guidance
7(b)	Time that particles are in motion before collision = $t = 1$ s	A1	Must reject $t = 16/9$ **Maximum mark 4 out of 5**
		4	
7(c)	$u_{p(\text{down})} = 0 + 4.4 \times 0.982$ [= 4.3208]	B1 FT	Allow ±4.4. FT on *their* 4.4 and *their* 0.982
	$u_{q(\text{down})} = 4.4 \times 0.12$ [= 0.528]	B1 FT	Allow ±4.4. FT on *their* 4.4 and *their* 0.12
	$\pm m \times 4.3208 \pm 2m \times 0.528 = \pm (m + 2m)v$ [Correct equation is $m \times 4.3208 + 2m \times 0.528 = \pm (m + 2m)v$]	M1	Apply conservation of momentum, 4 terms, using *their* u_p and u_q values with m and $2m$ respectively. Velocity of P and Q after impact must be equal.
	Speed of combined particle immediately after impact = $v = 1.79$ ms^{-1}	A1	Must be positive
	Special case for those who do not take into account the fact that *Q* comes to rest and then changes its direction		
	$u_{p(\text{down})} = 0 + 4.4 \times 1$ [= 4.4]	B1 FT	Allow ±4.4, FT on *their* 1 and *their* 4.4
	$u_{q(\text{up})} = 10 - 11.6 \times 1$ [= –1.6] so $u_{q(\text{down})} = 1.6$	B1 FT	Allow ± (10 – 11.6 × 1), FT on *their* 1
	$\pm m \times 4.4 \pm 2m \times 1.6 = \pm (m + 2m)v$	M1	Apply conservation of momentum, 4 terms, using their u_p and u_q values with m and $2m$ respectively. Velocity of P and Q after impact must be equal.
	Speed of combined particle immediately after impact = $v = 2.53$ ms^{-1}	A1	Allow $v = \frac{38}{15}$. Must be positive.
		4	

Cambridge Assessment International Education

Cambridge International AS & A Level

MATHEMATICS **9709/43**

Paper 4 Mechanics **October/November 2021**

MARK SCHEME

Maximum Mark: 50

Published

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- 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.

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GENERIC MARKING PRINCIPLE 3:
Marks must be awarded **positively**:
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- 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.

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GENERIC MARKING PRINCIPLE 5:
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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	
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Mark Scheme Notes

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Types of mark

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

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

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

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

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

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

Abbreviations

AEF/OE	Any Equivalent Form (of answer is equally acceptable) / Or Equivalent
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)	$120\times8=120v+40v$	M1	Applying conservation of momentum.
	$v=6\ \text{ms}^{-1}$	A1	
		2	
1(b)	$1600-4800=160a$ leading to $a=-20$	M1	Applying Newton's 2nd law to the system.
	$0 = 6^2 + 2 \times (-20) \times s$	M1	Use of constant acceleration equations such as $v^2 = u^2 + 2as$.
	Distance travelled by post = 0.9 m	A1	
	Alternative method for question 1(b)		
	Initial KE = $\frac{1}{2} \times 160 \times 6^2$	M1	Use of KE = $\frac{1}{2}mv^2$ for combined mass.
	$\frac{1}{2} \times 160 \times 6^2 + 160 \times 10 \times s = 4800s$	M1	Forms work/energy equation.
	Distance travelled by post = 0.9 m	A1	
		3	

Question	Answer	Marks	Guidance
2(a)	Correct 3 force diagram, including angles shown	**B1**	
		1	
2(b)	$T_1 \cos 60 = T_2 \cos 45$	**M1**	Resolving forces horizontally.
	$T_1 \sin 60 + T_2 \sin 45 = 8g$	**M1**	Resolving forces vertically.
	$T_1 \cos 60 = T_2 \cos 45$ and $T_1 \sin 60 + T_2 \sin 45 = 8g$	**A1**	
	Attempting to solve for either T_1 or T_2	**M1**	
	$T_1 = 58.6$ N	**A1**	
	$T_2 = 41.4$ N	**A1**	
	Alternative method for question 2(b)		
	$\frac{T_1}{\sin 135} = \frac{T_2}{\sin 150} = \frac{80}{\sin 75}$	**M1**	Applies Lami's Theorem – at least two terms correct.
		A1	
	$T_1 = \frac{80 \sin 135}{\sin 75}$	**M1**	Solves for T_1.
	$T_1 = 58.6$ N	**A1**	
	$T_2 = \frac{80 \sin 150}{\sin 75}$	**M1**	Solves for T_2.
	$T_2 = 41.4$ N	**A1**	
		6	

Question	Answer	Marks	Guidance
3(a)	$PE = 1.6 \times 10 \times 5$ [= 80J] **or** $v\downarrow = \sqrt{(2\times10\times5)}$ [= 10] $KE = \frac{1}{2} \times 1.6 \times 10^2$ [= 80 J]	**B1**	Either finds PE loss or uses $v^2 = u^2 + 2as$ to find the velocity and hence the kinetic energy on reaching the ground
	$1.6 \times 10 \times 5 = 1.6 \times 10 \times h + 8$ **or** $\frac{1}{2} \times 1.6 \times v^2 = 80 - 8$, $v\uparrow = \sqrt{90}$, $0 = 90 + 2\times(-10) \times h$ leading to $h = \ldots$ **or** $\frac{1}{2} \times 1.6 \times v^2 = 80 - 8$, $v\uparrow = \sqrt{90}$, $\frac{1}{2}\, m \times 90 = m \times 10 \times h$ leading to $h = \ldots$	**M1**	Using Initial PE = Final PE + Loss in KE or using $KE = \frac{1}{2}\, mv^2$ to find initial velocity upwards and either $v^2 = u^2 + 2as$ or KE loss = PE gain to form equation in h.
	$h = 4.5$ m	**A1**	
		3	
3(b)	$5 = 0 + \frac{1}{2} \times 10 \times t^2$ leading to $t = 1$ **or** $5 = \frac{1}{2} \times (0 + 10) \times t$ leading to $t = 1$ **or** $10 = 10t$ leading to $t = 1$	**M1**	Use of $s = ut + \frac{1}{2}\, gt^2$ for downward motion **or** use of $s = \frac{1}{2}\,(u + v)t$ for downward motion **or** use of $v = u + gt$ for downward motion.
	$4.5 = 0 - \frac{1}{2} \times (-10) \times t^2$ leading to $t = \sqrt{0.9}$ **or** $4.5 = \frac{1}{2} \times (\sqrt{90} + 0) \times t$ leading to $t = \sqrt{0.9}$ **or** $0 = \sqrt{90} - 10t$ leading to $t = \sqrt{0.9}$	**M1**	Use of $s = vt - \frac{1}{2}\,(-g)t^2$ for upward motion **or** use of $s = \frac{1}{2}\,(u + v)t$ for upward motion **or** use of $v = u - gt$ for upward motion.
	$t = 1.95$ s	**A1**	
		3	

Question	Answer	Marks	Guidance
4(a)(i)	[WD = 1250 × 36 × 8]	**M1**	For using Work Done = Force × Distance.
	WD = 360000 J	**A1**	or 360 kJ
		2	
4(a)(ii)	Power = 1250 × 36 or P = $\frac{360000}{8}$ [= 45000 J]	**B1 FT**	FT Work Done from $\frac{\mathbf{a(i)}}{8}$.
	= 45 kW	**B1**	
		2	
4(a)(iii)	DF = $\frac{57000}{36}$ [= 1583.3..]	**M1**	Use changed Power in P = DF × v.
	$\frac{57000}{36} - 1250 = 1400a$	**M1**	For using Newton's 2nd law applied to the car.
	$a = 0.238$ ms^{-2}	**A1**	
		3	
4(b)	$\frac{64000}{32} = 1250 + 1400g \sin \theta$	**M1**	For using DF = resistance + component of the weight of the car.
	θ = 3.1 [3.0708…]	**A1**	
		2	

Question	Answer	Marks	Guidance
5(a)	$a = 16k - kt^2, \quad v = 16kt - \frac{1}{3}kt^3$	M1	Uses $v = \int a \, dt$.
	$8 = 16k \times 4 - \frac{1}{3}k \times 4^3$ leading to $k = \ldots$	M1	Substitutes $t = 4$, $v = 8$.
	$v = 16kt - \frac{kt^3}{3}$ and $k = \frac{3}{16}$	A1	OE
	$s = 8kt^2 - \frac{1}{12}kt^4$ leading to $s = \frac{24}{16}t^2 - \frac{3}{192}t^4$	M1	Uses $s = \int v dt$ and attempts to find s in terms of t only. May be using $v = 3t - \frac{1}{16}t^3$.
	$s = \frac{1}{64}t^2(96 - t^2)$	A1	**AG**, no errors seen.
		5	
5(b)	$s = 0$, $t^2 = 96$, $t = 4\sqrt{6}$	M1	Attempt to find t when $s = 0$.
	$v = 16 \times \frac{3}{16} \times \sqrt{96} - \frac{3}{16} \times \frac{1}{3} \times \sqrt{96}^3$	M1	Attempt to find v at this t value
	Speed is 29.4 ms^{-1}	A1	Do not condone $v = -29.4$.
		3	
5(c)	$v = 0$, $t^2 = 48$, $t = 4\sqrt{3}$	M1	Determine the time, t (or t^2) at which $v = 0$
	$s = \frac{1}{64} \times 48 \times (96 - 48)$	M1	Use substitution of the t or t^2 value to find s.
	$s = 36$ m	A1	
		3	

Question	Answer	Marks	Guidance
6(a)	$R = 5g$, $F = 6g - 4g$	M1	For resolving forces to find F and R.
	$\mu = \frac{2g}{5g} = 0.4$	A1	**AG**
		2	
6(b)	$T_1 - 4g = 4a$ or $8g - T_2 = 8a$	M1	For applying Newton's 2nd law to the 4 kg particle or the 8 kg particle.
	$T_1 - 4g = 4a$ and $8g - T_2 = 8a$	A1	Both equations correct.
	$T_2 - T_1 - F = 5a$ and $F = 0.4 \times 5g$	B1	
	Adding gives $8g - 4g - 2g = 17a$ leading to $a = \ldots$.	M1	Attempt to solve for a, T_1 or T_2.
	$a = 1.18\,\text{ms}^{-2}$, $T_1 = 44.7$ N, $T_2 = 70.6$ N	A1	
		5	
6(c)	$T - 4g = 4a$, $-T - F = 5a$, $F = 2g$ or $-4g - 2g = 9a$	M1	Applying Newton's 2nd law to both active particles.
	$a = -\frac{60}{9}$	A1	
	$v^2 = 2 \times \frac{20}{17} \times 0.5 = \frac{20}{17}$ leading to $v = \ldots$ [$v = 1.0846\ldots$]	M1	Use of $v^2 = u^2 + 2as$ or equivalent to find v or v^2 when the 8 kg particle reaches the ground.
	$0 = \sqrt{\frac{20}{17}} - \frac{60}{9}t$	M1	Use of $v = u + at$ or equivalent to find t.
	$t = 0.163$ s	A1	From $t = 0.1626978\ldots$
		5	

Cambridge Assessment International Education

Cambridge International A Level

MATHEMATICS **9709/43**

Paper 4 Mechanics **May/June 2021**

MARK SCHEME

Maximum Mark: 50

Published

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WWW	Without Wrong Working
AWRT	Answer Which Rounds To

Question	Answer	Marks	Guidance
1	$0.4 \times 2.5 - 0.5 \times 1.5$	**M1**	Attempt momentum before impact.
	$0.4 \times 2.5 - 0.5 \times 1.5 = 0.4v + 0.5 \times 2v$	**M1**	Use of conservation of momentum, either case.
	$0.4 \times 2.5 - 0.5 \times 1.5 = 0.4v + 0.5 \times 2v$ or $0.4 \times 2.5 - 0.5 \times 1.5 = -0.4v + 0.5 \times 2v$	**A1**	One correct equation
	Speed is 0.179 m s^{-1} or 0.417 m s^{-1}	**A1**	Both values
		4	

Question	Answer	Marks	Guidance
2(a)	Forward force exerted by cyclist = $\frac{150}{4}$ N [= 37.5 N]	**B1**	OE. $P = Fv$ used correctly.
	$\frac{150}{4} - 20 = m \times 0.25$	**M1**	Use of Newton's second law
	$m = 70$ kg	**A1**	
		3	
2(b)	$150/3 - 20 - 70g\sin\theta = 0$	**M1**	For resolving up the plane
	$\theta = 2.5°$ to 1d.p.	**A1 FT**	From 2.456…. FT $\theta = \sin^{-1}\left(\frac{3}{m}\right)$ from **(a)**
		2	

Question	Answer	Marks	Guidance
3	$F \sin\theta + 20\sin 60 - 30\sin\alpha - 40\sin\beta = 0$	**M1**	For resolving in either direction
	Vertical: $F\sin\theta + 20\sin 60 - 30 \times 0.28 - 40 \times 0.6 = 0$ [$F\sin\theta = 15.07949\ldots$]	**A1**	
	Horizontal: $F\cos\theta + 40 \times 0.8 - 30 \times 0.96 - 20\cos 60 = 0$ [$F\cos\theta = 6.8$]	**A1**	
	$\theta = \tan^{-1}\dfrac{15.0794\ldots}{6.8}$	**M1**	For method for finding θ
	$F = \sqrt{15.07949\ldots^2 + 6.8^2}$	**M1**	For method for finding F
	$\theta = 65.7$, $F = 16.5$	**A1**	
		6	

Question	Answer	Marks	Guidance
4(a)	$24 = u \times 2 - \dfrac{1}{2}g \times 2^2$	**M1**	Use of $s = ut + ½at^2$
	$u = 22$	**A1**	AG
		2	

Question	Answer	Marks	Guidance
4(b)	At maximum height $0 = 22^2 - 2gs$	M1	Use of $v^2 = u^2 + 2as$ to find maximum height.
	Maximum height $s = 24.2$ m	A1	
	Height down $= 0.5g \times 1.8^2$ (=16.2)	M1	Find distance travelled down in 1.8 s.
	$h = 8$	A1	
	Alternative method for Question 4(b)		
	$0 = 22 - 10t$	M1	Use of $v = u - gt$ with $u = 22$ and $v = 0$ to find time to reach maximum height
	$t = 2.2$	A1	
	$h = 22 \times (2.2 - 1.8) - \frac{1}{2}g \times (2.2 - 1.8)^2$	M1	Use of $s = ut + \frac{1}{2}at^2$ to find value of h
	$h = 8$	A1	
	Alternative method for Question 4(b)		
	$22t - \frac{1}{2}gt^2 = 22 \times (t + 3.6) - \frac{1}{2}g \times (t + 3.6)^2$	M1	Use of $s = ut + \frac{1}{2}at^2$ for times t and $t + 3.6$ to find time taken to reach height h.
	$t = 0.4$ (or $t + 3.6 = 4$)	A1	
	$h = 22 \times 0.4 - \frac{1}{2}g \times 0.4^2$	M1	Use $s = ut + \frac{1}{2}at^2$ to find value of h.
	$h = 8$	A1	
		4	

Question	Answer	Marks	Guidance
5(a)	Increase in KE = ½ × 1900 × 30^2 – ½ × 1900 × 20^2 [= 475000 J]	**B1**	May be implied by energy equation.
	Loss of PE = 1900 × g × s sin 5 [= 1655.95s J]	**B1**	May be implied by energy equation.
	1900 × g × s sin 5 + 150 000 = ½ × 1900×30^2 – ½ × 1900 × 20^2	**M1**	For attempt at work/energy equation
		A1	Correct
	s = [Length of hill =] 196 m	**A1**	
		5	
5(b)	$30^2 = 20^2 + 2a \times 200$	**M1**	Use of $v^2 = u^2 + 2as$
	a = 1.25 m s^{-2}	**A1**	
	T – 100 + 500g sin 5 = 500a	**M1**	For applying Newton's second law to the trailer.
	T = 289 N	**A1**	
		4	

Question	Answer	Marks	Guidance
6(a)	$(2t-3)(t-1)=0$ leading to $t = \ldots\ldots$	M1	Attempt to solve $v = 0$
	$t = 1$ or $t = 1.5$	A1	
	Minimum velocity when $t = 1.25$ leading to $v = \ldots\ldots$ or $\frac{\mathrm{d}v}{\mathrm{d}t} = 4t - 5 = 0$ $t = 1.25$ leading to $v = \ldots\ldots$ or $v = 2\left[\left(t-\frac{5}{4}\right)^2 - \frac{25}{16}\right] + 3$ leading to $v = \ldots\ldots$	M1	Uses roots or $\mathrm{d}v/\mathrm{d}t=0$ to find t for v_{min} and attempts substitution to obtain v_{min}. Alternatively completes square.
	Minimum velocity is $-0.125\ \mathrm{m\,s^{-1}}$	A1	Allow $v = -\frac{1}{8}$
		4	
6(b)	Quadratic curve (two roots and $v(3) > v(0)$)	B1	
	Goes through (1.25, –0.125), (0, 3), (1, 0), (1.5, 0), (3,6)	B1	3 of the 5 key points shown on axes or as coordinates
	All five points shown on a totally correct graph	B1	
		3	
6(c)	$s = \frac{2}{3}t^3 - \frac{5}{2}t^2 + 3t$	M1	For use of $s = \int v\,\mathrm{d}t$
	$\left[\frac{2}{3}(1.5)^3 - \frac{5}{2}(1.5)^2 + 3(1.5)\right] - \left[\frac{2}{3}(1)^3 - \frac{5}{2}(1)^2 + 3(1)\right]$	M1	Correct use of limits (*their* 1 and 1.5)
	Distance = 0.0417 m	A1	A0 for –0.0417
		3	

Question	Answer	Marks	Guidance
7(a)	$R = 0.3g\cos\theta + 4\sin\theta = 3\times\frac{24}{25} + 4\times\frac{7}{25}$ [=4]	M1	Resolving forces perpendicular to the plane or parallel to the plane. Allow use of θ = 16.3°
	$F = 4\cos\theta - 0.3g\sin\theta = 4\times\frac{24}{25} - 3\times\frac{7}{25}$ [=3]	A1	Two correct equations
	$3 = \mu \times 4$	M1	For use of $F = \mu R$
	$\mu = \frac{3}{4}$	A1	AG Must be from correct and exact working, not using 16.3
		4	
7(b)	$F = \mu \times 0.3g\cos\theta = \frac{3}{4} \times 3 \times \frac{24}{25}$ $\left[= \frac{54}{25} = 2.16\right]$	B1	
	$4 - \frac{3}{4} \times 0.3g \times \frac{24}{25} - 0.3g \times \frac{7}{25} = 0.3a$	M1	Use of Newton's second law
	$a = \frac{10}{3}$ m s^{-2}	A1	
		3	

Question	Answer	Marks	Guidance
7(c)	$s_1 = \frac{1}{2} \times \frac{10}{3} \times 3^2 = 15$ and $v = \frac{10}{3} \times 3 = 10$	B1 FT	Distance s_1 in 3s and v after 3s; FT a from **(b)**
	$-0.3g \times \sin\theta - \mu \times 0.3g\cos\theta = 0.3a$ leading to $a = -10$ $0 = 10^2 + 2 \times (-10) \times s_2$	M1	Apply Newton's 2nd law after 4 N removed, find a and use $v^2 = u^2 + 2as$ to find extra distance s_2
	[$s_2 = 5$ leading to total distance $= s_1 + s_2 = 15 + 5 =$] 20 m	A1	
	Alternative method for Question 7(c)		
	Work done = $4 \times 0.5 \times \frac{10}{3} \times 3^2$ [= 60 J]	B1 FT	WD = Fs and $s = \frac{1}{2}at^2$ for 4 N force; FT a from **(b)**
	$60 = \mu \times 0.3g\cos\theta \times d + 0.3g \times d\sin\theta$	M1	WD by 4 N force = WD against F + PE gain
	$d = 20$ m	A1	
		3	

Cambridge Assessment International Education

Cambridge International AS & A Level

MATHEMATICS **9709/42**

Paper 4 Mechanics **May/June 2021**

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 2021 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 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.

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.

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.

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Question	Answer	Marks	Guidance
1	Initial KE $= \frac{1}{2}\times 0.6\times 4^2$ $[=4.8]$ Final KE $= \frac{1}{2}\times 0.6\times v^2$ PE loss $= 0.6\times g\times 15\sin 10$ $[=15.628]$	**B1**	Any one of the three expressions correct
	$0.6\times g\times 15\sin 10 + \frac{1}{2}\times 0.6\times 4^2 = \frac{1}{2}\times 0.6\times v^2$	**M1**	Apply energy equation, 3 terms, dimensions correct
	$v = 8.25$ ms^{-1}	**A1**	
		3	

Question	Answer	Marks	Guidance
2	Resolve either horizontally or vertically with correct number of terms.	**M1**	Allow θ and α as in the question for this mark
	$[X=]30-34\times\frac{8}{17}-26\times\frac{5}{13}[=4]$	**A1**	Allow $\pm X$ as they may resolve forces left or right Allow $[X=]30-34\sin 28-26\sin 23$ angle 2s.f. or better
	$[Y=]34\times\frac{15}{17}-26\times\frac{12}{13}[=6]$	**A1**	Allow $\pm Y$ as they may resolve forces up or down Allow $[Y=]\ 34\cos 28-26\cos 23$ angle 2s.f. or better
	$[R=]\sqrt{X^2+Y^2}$	**M1**	Attempt to solve for the magnitude of the force
	$[\beta=]\tan^{-1}\left(\frac{Y}{X}\right)$ or $[\beta=]\tan^{-1}\left(\frac{X}{Y}\right)$	**M1**	Attempt to solve for the direction of the resultant force

Question	Answer	Marks	Guidance
2 cont'd	$R = \sqrt{52} = 2\sqrt{13} = 7.21$ N **and** $\beta = 56.3$ above 30N force or anticlockwise from 30N force	**A1**	Both correct with correct explanation of the direction. Must be a correct and clear explanation.
		6	

Question	Answer	Marks	Guidance
3	Resolving along or perpendicular to the rod	**M1**	3 terms in either direction
	$8\sin 10 + R = 0.3g$	**A1**	
	$8\cos 10 - F = 0.3a$	**A1**	
	$F = 0.8R$ $[R = 1.61081\ldots, F = 1.28865\ldots]$	**M1**	Using $F = \mu R$, where R is 2 terms involving weight and a component of 8 N.
	$[a = 21.966\ldots]$ $0.6 = \frac{1}{2} \times 21.966 \times t^2$	**M1**	Complete method leading to an equation in t such as $s = ut + \frac{1}{2}at^2$ with $s = 0.6$, $u = 0$ and using *their* value of a found from a Newton's second law with 3 terms, namely, component of 8 N, any friction and $0.3a$.
	$t = 0.234$ seconds	**A1**	Allow use of $a = 22$ for M1 and A1
	Alternative method for Question 3		
	Resolving perpendicular to the rod	**M1**	
	$8\sin 10 + R = 0.3g$	**A1**	
	$F = 0.8R$ $[R = 1.61081\ldots, F = 1.28865\ldots]$	**M1**	Using $F = \mu R$, where R must involve $0.3g$ and a component of 8 N.

Question	Answer	Marks	Guidance
3	$8\cos 10 \times 0.6 = F \times 0.6 + \frac{1}{2} \times 0.3v^2 \quad [v = 5.134]$	**B1**	Work energy equation to find v after 0.6 metres.
	$0.6 = \frac{1}{2}(0 + 5.134) \times t$	**M1**	Using $s = \frac{1}{2}(u+v)t$ to find t.
	$t = 0.234$ seconds	**A1**	
		6	

Question	Answer	Marks	Guidance
4	For resolving either parallel to or perpendicular to the plane	**M1**	Three relevant terms in either equation.
	$P\cos 8 = F + 12g\sin 25$	**A1**	
	$12g\cos 25 = R + P\sin 8$	**A1**	
	$F = 0.3R$	**M1**	Use $F = 0.3R$, where R must involve components of both $12g$ and P.
	$P\cos 8 = 0.3(12g\cos 25 - P\sin 8) + 12g\sin 25$	**M1**	For attempting to solve for P, using equations with the correct number of relevant terms in both.
	$P = 80.8$	**A1**	From $P = 80.755\ldots$ Allow $P \leqslant 80.8$ If more than one case is considered for direction of friction then a choice must be made for final answer.
	Alternative mark scheme for Question 4		
	For resolving forces either vertically or horizontally	**M1**	Correct number of terms in either equation.
	$R\cos 25 + P\sin 33 = 12g + F\sin 25$	**A1**	

Question	Answer	Marks	Guidance
4	$P\cos 33 = F\cos 25 + R\sin 25$	A1	
	$F = 0.3R$	M1	Use $F = 0.3R$
	Solve a pair of simultaneous equations in P and R May see $R = 97.5$	M1	For attempting to solve for P, using equations with the correct number of relevant terms.
	$P = 80.8$	A1	From $P = 80.755\ldots$ Allow $P \leqslant 80.8$ If more than one case is considered for direction of friction then a choice must be made for final answer.
		6	

Question	Answer	Marks	Guidance
5(a)(i)	$P = (440 + 280) \times 30$	M1	Using $P = Fv$ with F as total resistance
	$P = 720 \times 30 = 21.6$ kW	A1	Answer must be in kW
		2	

Question	Answer	Marks	Guidance
5(a)(ii)	$P = 21600 - 8000$ W $\text{DF} = \dfrac{21600-8000}{30}$ $\left[= \dfrac{13600}{30} = 453.333..\right]$	B1 FT	Follow through on *their* power from **5(a)(i)** Allow Driving Force (DF) $= \dfrac{8000}{30} = 266.7$ as the force due to solely to the change in power provided correct equation(s) used.
	Car: $\text{DF} - 440 - T = 1250a$ Caravan: $T - 280 = 800a$ System: $\text{DF} - (440 + 280) = 2050a$	M1	Apply Newton's 2nd law to either the car or to the caravan or to the system. Must be correct number of relevant terms. If $\text{DF} = \dfrac{8000}{30}$ is used then the equations must be either $-\text{DF} = 2050a$ or $T - 280 = 800a$
	Solve for either a or T	M1	Using equation(s) with no missing/extra terms, $\text{DF} \neq 720$. Solving for a either from the system equation or from the car AND caravan equation. OR solving for T from the car AND caravan equation.
	$a = -0.13$ ms^{-2} and $T = 176$ N	A1	
		4	

Question	Answer	Marks	Guidance
5(b)(i)	System: $\text{DF} = 720 + 2050g \times 0.06$ $[= 1950]$ Car: $\text{DF} - 440 - T - 1250g \times 0.06 = 0$ Caravan: $T - 280 - 800g \times 0.06 = 0$	M1	Apply Newton's 2nd law with $a = 0$, either to the system OR by eliminating T between the equations for the car and the caravan, no extra or missing relevant terms, dimensionally correct, to find DF
	$1950v = 28000$	B1	$P = \text{DF} \times v$. $\dfrac{28000}{v}$ SOI.
	$v = 14.4$ ms^{-1}	A1	
		3	

Question	Answer	Marks	Guidance
5(b)(ii)	$PE = 800g \times d \times 0.06 = 800g \times 14.4 \times 60 \times 0.06$	**M1**	Using PE = *mgh* with *h* being height gained in 60 s, using *their* *v*
	$PE = 414\,000$ (J) or $PE = 414$ kJ	**A1**	Using $v = 560/39 = 14.359$
	Alternative method for Question 5(b)(ii)		
	$28\,000 \times 60 = \text{PE of Caravan} + 1250g \times d \times 0.06 + 720 \times d$ **and** $d = 60 \times 14.359 = 861.54$	**M1**	For use of $WD = P \times t$ to find an expression for PE of caravan and the distance travelled up the incline in 1 minute.
	$[PE = 28\,000 \times 60 - 1250g \times 861.54 \times 0.06 - 720 \times 861.54]$ $PE = 414\,000$ (J) or $PE = 414$ kJ	**A1**	
		2	

Question	Answer	Marks	Guidance
6	$s_A = \pm(30t - 5t^2)$ or $s_B = \pm 5t^2$	**B1**	Use of constant acceleration equations to find expressions for displacements of *A* or *B*.
	$s_A + s_B = 15$ leading to $15 = 30t$ leading to $t = 0.5$	**B1**	Use $s_A + s_B = 15$ to find time at which particles collide.
	$t = 0.5$ leading to $v_A = \pm 25$ and $v_B = \pm 5$	**B1**	Find speed of particles at $t = 0.5$ before collision.
	$t = 0.5$ leading to $h_A = \pm\left(30 \times 0.5 - \frac{1}{2}g \times 0.5^2\right) = \pm 13.75$	**B1**	Find position of *A* or *B* at which collision occurs at $t = 0.5$ Alternatively allow $h_B = \pm 1.25$ as displacement of *B*
	$25 \times (2m) - 5(m) = (3m)v \rightarrow v_1 = 15$ $25(m) - 5 \times (2m) = (3m)v \rightarrow v_2 = 5$	**M1**	Use of conservation of momentum, either case, using *their* v_A and $v_B \neq 0$ or 30, with 3 terms.
		A1	Both values of v correct

Question	Answer	Marks	Guidance
6	Particle C_1 $-13.75 = 15t - 5t^2$ Particle C_2 $-13.75 = 5t - 5t^2$	M1	Use of $s = ut + \frac{1}{2}at^2$ OE to find t, using either *their* numerical v_1 or numerical v_2 from a relevant conservation of momentum equation.
	$t_{C_1}, t_{C_2} = 3.74, 2.23$ leading to $T = 1 + \sqrt{5} - \sqrt{3} = 1.50$	A1	Find $T = t_{C_1} - t_{C_2}$ from $t_{C_1} = 3.736$ and $t_{C_2} = 2.232$
		8	Subscripts 1 and 2 refer to the two cases.
	Alternative method for the final two marks		
	$0 = 15 - gt_1$, $0 = 5 - gt_2$ $\rightarrow$ $t_1 = 1.5$, $t_2 = 0.5$ Total heights $h_1 = 13.75 + 11.25 = 25$ Or $h_2 = 13.75 + 1.25 = 15$ $25 = 5T_1^2$ and $15 = 5T_2^2$ $\rightarrow$ $T_1 = \sqrt{5}$, $T_2 = \sqrt{3}$	M1	Use of $v = u - gt$ to find time to highest point for either case and use of $v^2 = u^2 - 2gs$ to find total height reached for either case, using either *their* numerical v_1 or numerical v_2 from a relevant conservation of momentum equation. Use $s = 0 + \frac{1}{2}gT^2$ to find time to reach ground (either case).
	$T = 1.5 + \sqrt{5} - (0.5 + \sqrt{3}) = 1 + \sqrt{5} - \sqrt{3} = 1.50$	A1	Find difference in total times $T = (t_1 + T_1) - (t_2 + T_2)$

Question	Answer	Marks	Guidance
7(a)	$v = 6t + 2t^2 [+c]$ or $v = 14t[+c]$	**M1**	Attempt to integrate a in Stage 1 or Stage 2 or in Stage 2 for use of $v = u + at$
	$v = 6t + 2t^2$ and $v = 14t - 8$ or $v(t = 2) = 20$ $v(t = 4) = 20 + 14 \times 2 = 48$	**A1**	Velocity in Stage 1 and Stage 2 correct including correct constant Find v at $t = 2$ and use $v = u + 14t$ to find v at $t = 4$
	$v = 16t - t^2 [+c]$	***M1**	Attempt to integrate a in Stage 3.
	$55 = 16t - t^2$	**DM1**	Attempt to solve a relevant 3-term quadratic equation which comes from their 2 term v from Stage 3 equated to 55 and finding two values of t
	$t = 5$ and $t = 11$ only	**A1**	Allow only if $c = 0$ has been shown correctly.
	Alternative method for Question 7(a)		
	State or imply that only possible range is $4 \leqslant t \leqslant 16$	**B1**	Allow this method if candidates only consider Stage 3
	$v = 16t - t^2 + c$	**M1**	For attempt at integration.
	$c = 0$ shown	**A1**	Using $v = 0$ at $t = 16$
	Solve $55 = 16t - t^2$	**M1**	Must find 2 values of t and must be from equating *their* 2 term v to 55
	$t = 5$ and $t = 11$ only	**A1**	Allow only if $c = 0$ has been shown correctly.
		5	

Question	Answer	Marks	Guidance
7(b)	Positive quadratic for $0 \leqslant t < 2$ through (0,0) joining to the bottom of the given line or Negative quadratic for $4 \leqslant t \leqslant 16$ going through the point (16,0) and joining the top of the given line	**B1**	
	All correct with correct gradients (approx)	**B1**	Negative quadratic must have a maximum. There must be no point of inflexion particularly near $t = 16$. Ignore any curve drawn outside $0 \leqslant t \leqslant 16$.
		2	
7(c)	$s = \int\left(16t - t^2\right)\mathrm{d}t \quad \left[= 8t^2 - \frac{1}{3}t^3\left(+c\right)\right]$	**M1**	Attempt to integrate *their v*.
	$s = \left[8t^2 - \frac{1}{3}t^3\right]_8^{16}$ $s = \left[2048 - 1365\frac{1}{3}\right] - \left[512 - 170\frac{2}{3}\right]$	**A1**	Correct integral and the correct limits used correctly to find an unsimplified expression for the distance from $t = 8$ to $t = 16$ only.
	$s = 341\frac{1}{3}$	**B1**	Allow $s = 341$ to 3s.f. If no integration seen (calculator used) allow B1 (max 1 out of 3 marks)
		3	

Cambridge Assessment International Education

Cambridge International A Level

MATHEMATICS **9709/41**

Paper 4 Mechanics **May/June 2021**

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 2021 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 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.

Mathematics Specific Marking Principles	
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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.
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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.
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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.

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)
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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	Force exerted by winch $= 50g\sin 60 + 100[= 433.0 + 100 = 533.0]$	**M1**	For resolving forces along the plane
	Work done $= 5 \times (50g\sin 60 + 100)$	**M1**	Use of WD = Force × distance
	Work done = 2670 J	**A1**	
	Alternative method for Question 1		
	PE increase $= 50g \times 5\sin 60$	**M1**	Correct dimensions
	Work done $= 50g \times 5\sin 60 + 100 \times 5$	**M1**	Apply the work-energy equation, 3 terms
	Work done = 2670 J	**A1**	
		3	

Question	Answer	Marks	Guidance
2(a)	0.1 kg particle $T - 0.1g = 0.1a$ *m* kg particle $mg - T = ma$ System $mg - 0.1g = (m + 0.1)a$	**M1**	Apply Newton's 2nd law to either the 0.1 kg particle, the *m* kg particle or to the system, correct number of terms
		A1	Two correct equations
	Solve for *m* $[a = 5]$	**M1**	From 2 equations with the correct number of relevant terms
	$m = 0.3$	**A1**	
		4	

Question	Answer	Marks	Guidance
2(b)	$v^2 = 0 + 2 \times 5 \times 0.9$	**M1**	Use of $v^2 = u^2 + 2as$ with $u = 0$, $s = 0.9$ and *their* $a \neq \pm g$
	$v = 3 \text{ m s}^{-1}$	**A1 FT**	FT on $\sqrt{1.8a}$
		2	

Question	Answer	Marks	Guidance
3(a)	Use of conservation of momentum, 3 terms	**M1**	Correct dimensions
	$0.1 \times 5 + 0 = 0.1 \times (-1) + 0.2 \times (\pm v)$	**A1**	
	$v = 3 \text{ m s}^{-1}$	**A1**	A0 for $v = -3$
		3	
3(b)	$0.2 \times \textit{their}\, 3 + 0 = 0.2 \times u + 0.5V$	**M1**	Use of conservation of momentum, 3 terms, correct dimensions. Allow $u = 0$ used or if Q and R coalesce
	$u \geqslant -1$	**B1**	Allow $u = -1$. Allow equality for finding greatest value of V. Condition for no collision with P, may be a statement.
	Greatest $V = 1.6$	**A1 FT**	FT on *their* 3 from **3(a)** if $u = -1$ used.
		3	

Question	Answer	Marks	Guidance
4(a)	Isabella $v = 5 \times 1.1\ [= 5.5]$	B1	Isabella's constant speed for 10 seconds
	Use of $s = ut + ½at^2$ or use of v–t graph to find total distance	M1	For either Isabella or Maria, all sections included but allow one error in use of formulae
	$s_I = \frac{1}{2}\times 1.1\times 5^2 + 10\times 5.5 + \frac{1}{2}\times 1.1\times 5^2\ [= 82.5]$ or $s_I = \frac{1}{2}\times(20+10)\times 5.5\ [= 82.5]$	A1	For correct expression for Isabella, accept unsimplified
	$s_M = 27.5 + 5\times 10 + \frac{1}{2}\times 5\times 5\ [= 90]$	A1	For correct expression for Maria, accept unsimplified
	Distances for Isabella = 82.5 and Maria = 90, so Maria goes further	B1	
		5	
4(b)	$\frac{1}{2}a\times 5^2 + 10\times 5a + \frac{1}{2}a\times 5^2 = 90$ or $\frac{1}{2}\times(20+10)\times 5a = 90$	M1	Attempt total distance travelled by Isabella and set up an equation for a, using their value of $s_M = 90$. All parts included, allow one error.
	$a = 1.2$	A1	
		2	

Question	Answer	Marks	Guidance
5(a)	$v = \int \left(6t^{\frac{1}{2}} - 2t\right)\mathrm{d}t$	**M1**	For integration. $v = at$ is M0.
	$v = 4t^{\frac{3}{2}} - t^2\ (+c)$	**A1**	Allow unsimplified coefficients.
	$v = 0$ leading to $t = 0$ or $t^{\frac{1}{2}} = 4$ leading to $t = 16$	**A1**	
		3	
5(b)	$6t^{\frac{1}{2}} - 2t = 0$	**M1**	Attempt to solve $a = 0$, using valid algebra, reaching $t = \ldots$
	$t = 9$	**A1**	
	$s = \int \left(4t^{\frac{3}{2}} - t^2\right)\mathrm{d}t$ $\left[s = \frac{8}{5}t^{\frac{5}{2}} - \frac{1}{3}t^3\ (+c)\right]$	**M1**	For integration of their expression for v which includes a term with a fractional power. Allow unsimplified coefficients. $v = at$ is M0
	$s = \frac{8}{5}t^{\frac{5}{2}} - \frac{1}{3}t^3$	**A1**	For correct integral
	Distance = 145.8 m	**B1**	Allow $\frac{729}{5}$ or 146 to 3s.f.
		5	

Question	Answer	Marks	Guidance
6(a)	$20\cos 30 = 25\cos 60 + 10\cos\alpha$ $[17.32 = 12.5 + 10\cos\alpha,\ \to \cos\alpha = 0.4821]$	**M1**	For resolving forces horizontally, all relevant terms included
	$\alpha = 61.2$	**A1**	From $\alpha = 61.18$
	Resultant $= 20\sin 30 + 10\sin 61.2 - 25\sin 60$ $[= 10 + 8.761 - 21.651]$	**M1**	For resolving forces vertically, all relevant terms included
	Magnitude of resultant force = 2.89 N	**A1**	A0 for –2.89 N or for ±2.89 N. Allow 2.89 N downwards
		4	
6(b)	$X = 25\cos 60 + 10\cos 45 - 20\cos 30$ $= 12.5 + 7.07107 - 17.32051 = 2.25056$ $Y = 20\sin 30 + 10\sin 45 - 25\sin 60$ $= 10 + 7.07107 - 21.65064 = -4.57957$	**M1**	For either horizontal or vertical component, correct number of relevant terms. Allow $\pm X$ and/or $\pm Y$
		A1	For both correct, allow unsimplified
	$R = \sqrt{X^2 + Y^2}$	**M1**	OE. Using a method to find the resultant force, using expressions for X and Y with at least 5 relevant terms.
	$\alpha = \tan^{-1}\dfrac{Y}{X}$	**M1**	OE. A method to find the direction, using expressions for X and Y with at least 5 relevant terms.
	Resultant = 5.10 N, Direction = 63.8° below positive x-axis	**A1**	For both correct, angle clearly explained. May use a diagram with a correct arrow and arc for angle. Allow angle 296° (measured anticlockwise from +ve x-axis)
		5	

Question	Answer	Marks	Guidance
7(a)(i)	PE $= 35g \times 2.5\sin 30$	M1	
	$\frac{1}{2} \times 35v^2 = 35g \times 2.5\sin 30$	M1	Use of conservation of energy, 2 terms, correct dimensions
	$v = 5\ \text{m s}^{-1}$	A1	
	Alternative method for Question 7(a)(i)		
	$mg\sin 30 = ma$ leading to $a = 5$	M1	For applying Newton's 2nd law down the plane, 2 terms, correct dimensions
	$v^2 = 0 + 2 \times 5 \times 2.5$	M1	For using $v^2 = u^2 + 2as$, using *their* $a \neq \pm g$
	$v = 5\ \text{m s}^{-1}$	A1	
		3	

Question	Answer	Marks	Guidance
7(a)(ii)	$\frac{1}{2}\times 35\times 5^2 = 250d$	M1	Use of work-energy from the bottom of the slide until motion stops, 2 terms, correct dimensions, using *their* v
	$d = 1.75$ m	A1	
	Alternative method for Question 7(a)(ii)		
	$35g\times 2.5\sin 30 = 250d$	M1	Use of work-energy from the start until motion stops, 2 terms, correct dimensions.
	$d = 1.75$ m	A1	
	Alternative method for Question 7(a)(ii)		
	$-250 = 35a$ leading to $a = -\frac{50}{7} = -7.14$ $0 = 5^2 + 2(a)d$	M1	Newton's 2nd law on the horizontal section with resistance = 250 N to find a and use $v^2 = u^2 + 2as$ with $v = 0$, $u = 5$ and $s = d$.
	$d = 1.75$m	A1	
		2	

Question	Answer	Marks	Guidance
7(b)	$\frac{1}{2}\times 35v^2 = 250\times 1.05 \quad [v^2 = 15]$ or $-250 = 35a$ leading to $a = -\frac{50}{7}$ $0 = v^2 + 2\times -\frac{50}{7}\times 1.05 \quad [v^2 = 15]$	B1	Either use the correct work energy equation for motion on the horizontal section or use the fact that the frictional force on the horizontal section is 250 N in order to set up an equation that would lead to finding the speed at the bottom of the slide.
	$R = 35g\cos 30 [= 303.11]$	B1	
	$v^2 = 0 + 2\times a\times 2.5 = 15$ leading to $a = 3$ or PE change $= 35g\times 2.5\sin 30 [= 437.5]$	M1	For using $v^2 = u^2 + 2as$, with their v^2 to set up an equation that would lead to finding a.
	$35g\sin 30 - F = 35a$ or $[175 - F = 35a]$ or $35g\times 2.5\sin 30 = F\times 2.5 + \frac{1}{2}\times 35\times 15 \quad [437.5 = F\times 2.5 + 262.5]$	M1	For using Newton's 2nd law down the slope with correct dimensions. or For using energy equation, 3 relevant terms with correct dimensions.
	$F = \mu\times R$	M1	For using $F = \mu R$, where R is a component of $35g$.
	$\mu = 0.231$	A1	Allow $\mu = \frac{2\sqrt{3}}{15}$ OE

Question	Answer	Marks	Guidance
7(b)	**Alternative method for Question 7(b)**		
	$R = 35g\cos 30$	**B1**	
	PE change $= 35g \times 2.5\sin 30[= 437.5]$	**B1**	
	WD against friction on the flat $= 250 \times 1.05$	**B1**	WD = 262.5
	$35g \times 2.5\sin 30 = F \times 2.5 + 250 \times 1.05$ $[437.5 = F \times 2.5 + 262.5]$	**M1**	For using energy equation, 3 relevant terms with correct dimensions.
	$F = \mu \times R$	**M1**	For using $F = \mu R$ at any stage, where R is a component of $35g$.
	$\mu = 0.231$	**A1**	Allow $\mu = \frac{2\sqrt{3}}{15}$ OE
		6	

Cambridge Assessment International Education

Cambridge International AS & A Level

MATHEMATICS **9709/42**

Paper 4 Mechanics **March 2021**

MARK SCHEME

Maximum Mark: 50

Published

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WWW	Without Wrong Working
AWRT	Answer Which Rounds To

Question	Answer	Marks	Guidance
1	$\pm 0.2 \times 0.5$ or $\pm 0.3 \times 1$	**B1**	For initial momentum for either particle. Allow kg or g.
	$0.2 \times 0.5 + 0.3 \times (-1) = 0.2 \times v + 0$	**M1**	For conservation of momentum. Dimensions correct. Allow if 3 relevant momentum terms are seen regardless of sign.
	Speed = 1 m s^{-1}	**A1**	Allow if final answer given as $v = 1$ or speed = 1 from an equation whose solution is $v = -1$
		3	

Question	Answer	Marks	Guidance
2(a)	Driving force = DF $= \frac{22500}{v}$	**B1**	
	$DF - 1400g \times 0.1 - 600 = 0$	**M1**	Apply Newton's 2nd law to the car with $a = 0$, three relevant terms. May see term $1400g \sin 5.7°$.
	$v = 11.25$ m s^{-1}	**A1**	**AG** From exact working only, may be implied if using 5.7°.
		3	

Question	Answer	Marks	Guidance
2(b)	DF – 1400g sin 2 – 600 = 1400a	**M1**	Use of Newton's second law for the car, 4 relevant terms.
	$\frac{22500}{11.25} - 1400g \sin 2 - 600 = 1400a$	**A1**	
	$a = 0.651 \text{ m s}^{-2}$ (3sf)	**A1**	
		3	

Question	Answer	Marks	Guidance
3	For attempting to resolve forces in either direction.	**M1**	Correct number of relevant terms.
	$T_P \cos 60 = T_R \cos 30$	**A1**	
	$T_P \sin 60 = T_R \sin 30 + 0.2g$	**A1**	
	Attempt to solve simultaneously for either tension.	**M1**	From 2 equations, with correct number of relevant terms.
	$T_P = 3.46$ N and $T_R = 2$ N	**A1**	Both correct. Allow $T_P = 2\sqrt{3}$ N.
	Alternative method for question 3		
	$\frac{T_P}{\sin 60} = \frac{T_R}{\sin 150} = \frac{0.2g}{\sin 150}$	**M1**	Attempt one pair of Lami's equations. Correct angles.
	One pair correct	**A1**	
	Equations all correct	**A1**	
	Solve for T_P or T_R	**M1**	From equations of the correct form.
	$T_P = 3.46$ N and $T_R = 2$ N	**A1**	Both correct. Allow $T_P = 2\sqrt{3}$ N
		5	

Question	Answer	Marks	Guidance
4(a)	Acceleration = $\frac{4}{3}$ m s^{-2}	**B1**	Allow = 1.33 m s^{-2}.
		1	
4(b)	$\frac{1}{2}(7+4.5)\times 2=\frac{1}{2}(8.5+5)\times V$	**M1**	Equate expressions for the two areas (distances) leading to an equation in V.
	V = 1.7[0] (3sf)	**A1**	Allow $V=\frac{46}{27}$.
		2	
4(c)	Acceleration = −2 m s^{-2}	**B1**	Or Deceleration = 2.
	$T-1500g=1500\times(-2)$	**M1**	Apply Newton's second law to the lift, using an acceleration ($\neq\frac{4}{3}$ or *their* **4(a)**). Correct dimensions and number of relevant terms.
	T = 12 000 N	**A1**	
		3	

Question	Answer	Marks	Guidance
5(a)	$[2 = \frac{1}{2} \times a \times 25]$	M1	Use of $s = ut + ½at^2$ OE using $u = 0$, $s = 2$ and $t = 5$.
	$a = 0.16\ \text{m s}^{-2}$	A1	Allow $a = \frac{4}{25}$.
		2	
5(b)	$R = 5g - X \sin 30$	B1	
	$X \cos 30 - F = 5a$	M1	Apply Newton's 2nd law to the block, using their a.
	$X \cos 30 - 0.4(5g - X \sin 30) = 5 \times 0.16$	M1	Use $F = 0.4R$ to obtain an equation in X only, using their R which must involve $5g$ and a component of X only.
	$X = 19.5$ (3sf)	A1	
		4	
5(c)	$R = (5g - 25 \sin 30)$ $[R = 37.5]$	B1	
	$F = 25 \cos 30$ $\left[F = \frac{25\sqrt{3}}{2}\right]$	B1	
	$\mu = \frac{F}{R} = 0.577$ (3sf)	B1	Allow $\mu = \frac{\sqrt{3}}{3}$ or $\mu = \frac{1}{\sqrt{3}}$.
		3	

Question	Answer	Marks	Guidance
6(a)	$[s=]\int\left(t^2-8t^{\frac{3}{2}}+10t\right)\mathrm{d}t$	*M1	For attempting to integrate *v*.
	$[s=]\frac{1}{3}t^3-\frac{16}{5}t^{\frac{5}{2}}+5t^2\,[+C]$	A1	Allow unsimplified.
	For correct use of correct limits.	DM1	Use of limit at $t = 0$ may be implied.
	Displacement = 2.13 m (3sf)	A1	Allow displacement = $\frac{32}{15}$.
		4	

Question	Answer	Marks	Guidance
6(b)	For attempting to differentiate *v*.	*M1	
	$[a =]2t - 12t^{\frac{1}{2}} + 10$	A1	Allow unsimplified.
	$a = 0 \Rightarrow 2t - 12t^{\frac{1}{2}} + 10 = 0$	DM1	Dependent on *M1. Set $a = 0$ and attempt to solve their 3 term equation in $\sqrt{t}$ or t or $p\,(=\sqrt{t}\,)$ by treating it as a quadratic equation.
	$2\left(t^{\frac{1}{2}} - 5\right)\left(t^{\frac{1}{2}} - 1\right) = 0$ leading to $t = 1$ or $t = 25$	A1	Both correct.
	$\frac{da}{dt} = 2 - 6t^{-\frac{1}{2}}$	*DM1	Dependent on *M1. Determine the nature of the stationary point by: Either differentiating a and testing the sign of $\frac{da}{dt}$ or by substituting values either side of their t value(s) and attempt to determine the nature of the stationary point(s). If using $\frac{da}{dt}$ then must evaluate it at a t value for M1. Allow use with any t value from *their* 'quadratic'.
	Use $t = 25$ in $\frac{da}{dt} = 2 - 6 \times 25^{-\frac{1}{2}}$ Evaluating $\frac{da}{dt}$ correctly, hence a minimum.	A1	Or by using a convincing argument to show that $t = 25$ gives a minimum value of *v*. If evaluated then $\frac{da}{dt}$ must be 0.8.
	Minimum velocity $= 25^2 - 8 \times 25^{\frac{3}{2}} + 10 \times 25 = -125$ m s^{-1}	B1	**AG** This mark is awarded only if the previous 6 marks are awarded.
		7	

Question	Answer	Marks	Guidance
7(a)	Attempt Newton's 2nd law for either P, Q or the system.	**M1**	Correct number of relevant terms, dimensionally correct.
	For P: $0.8 + 0.5g \sin 30 - T = 0.5a$ For Q: $T - 0.3g \sin 45 = 0.3a$ System: $0.8 + 0.5g \sin 30 - 0.3g \sin 45 = 0.8a$	**A1**	For any one correct equation.
		A1	For two correct equations.
	Attempt to solve for T.	**M1**	Using two equations, each with the correct number of relevant terms. [$a = 1.4733$ may be seen].
	$T = 2.56$ N (3sf)	**A1**	Allow $T = \frac{99+75\sqrt{2}}{80}$.
		5	

Question	Answer	Marks	Guidance
7(b)	KE and PE for m kg particle: $\frac{1}{2}m \times 0.36 = 0.18m$ and $mg \sin 45 = 5\sqrt{2}m$	**B1**	Any 2 correct PE or KE terms.
	KE and PE for 0.5 kg particle: $\frac{1}{2} \times 0.5 \times 0.36 = 0.09$ and $0.5g \sin 30 = 2.5$	**B1**	All 4 correct PE and KE terms.
	Apply the work-energy equation to the system as: PE loss + WD by 0.8 N = KE gain + 0.5	**M1**	Must include at least 5 relevant terms only and no extra terms. All terms dimensionally correct.
	$0.5g \times 1 \times \sin 30 - mg \times 1 \times \sin 45 + 0.8 \times 1 = \frac{1}{2} \times (0.5 + m) \times 0.36 + 0.5$	**A1**	May be seen as: $2.5 - 5\sqrt{2}m + 0.8 = 0.09 + 0.18m + 0.5$
	$m = 0.374$	**A1**	
	Alternative method for question 7(b)		
	KE and PE for m kg particle: $\frac{1}{2}m \times 0.36 = 0.18m$ and $mg \sin 45 = 5\sqrt{2}m$	**B1**	Correct KE and PE for m kg particle.
	$a = 0.18$ and $3.3 - T = 0.5(0.18)$ leading to $T = 3.21$	**B1**	Evaluate the tension in the string using Newton's second law applied to the 0.5 kg particle.
	For m kg particle: WD by T = KE gain + PE gain + 0.5	**M1**	At least 3 relevant terms including tension. All terms dimensionally correct.
	$3.21 \times 1 = \frac{1}{2}m \times 0.36 + mg \sin 45 + 0.5$	**A1**	
	$m = 0.374$	**A1**	

Question	Answer	Marks	Guidance
7(b)	**Alternative method for question 7(b)**		
	KE and PE for *m* kg particle: $\frac{1}{2}m\times0.36=0.18m$ and $mg\sin45=5\sqrt{2}m$ KE and PE for 0.5 kg particle $\frac{1}{2}\times0.5\times0.36=0.09$ and $0.5g\sin30=2.5$	**B1**	Any 2 correct PE or KE terms.
		B1	All 4 correct PE and KE terms.
	Apply the work-energy equation to both particles as: $0.8\times1+0.5g\sin30=\frac{1}{2}\times0.5\times0.36+T\times1$ and $T\times1=\frac{1}{2}m\times0.36+mg\sin45+0.5$	**M1**	Must include at least 5 relevant terms only and tension terms in both. $[T=3.21]$ All terms dimensionally correct.
	$0.8\times1+0.5g\sin30-\frac{1}{2}\times0.5\times0.36=\frac{1}{2}m\times0.36+mg\sin45+0.5$	**A1**	
	$m = 0.374$	**A1**	
		5	

Cambridge Assessment International Education

Cambridge International AS & A Level

MATHEMATICS **9709/43**

Paper 4 Mechanics **October/November 2020**

MARK SCHEME

Maximum Mark: 50

Published

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

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

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Generic Marking Principles

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GENERIC MARKING PRINCIPLE 1:

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- 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	
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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.
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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.

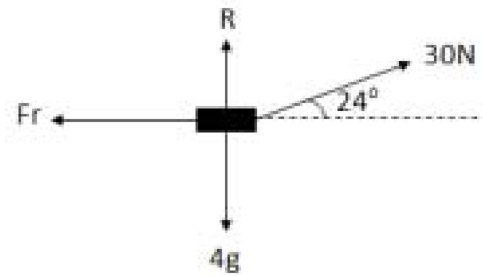
- A or B marks are given for correct work only (not for results obtained from incorrect working) unless follow through is allowed (see abbreviation FT above).
- For a numerical answer, allow the A or B mark if the answer is correct to 3 significant figures or would be correct to 3 significant figures 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.

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)	$v = 30$	B1	Use $v = u + at$ (or equivalent *suvat)* with $v = 0$, $a = -g$ and $t = 3$
		1	
1(b)	$[0 = 30^2 + 2(-10)s]$	M1	Using $v^2 = u^2 + 2as$ with $a = -g$, $v = 0$ and u = value from **1(a)**, or equivalent *suvat* method
	Greatest height is 45 m	A1	
		2	

Question	Answer	Marks	Guidance
2(a)	$WD = 40 \times 158 = 600$ J	B1	
		1	
2(b)	$[PE = 5 \times 10 \times 15 \sin 20]$	M1	Attempt PE gain
	257 J (256.5151... J)	A1	
		2	
2(c)	$WD = 40 \times 15 + 5 \times 10 \times 15 \sin 20 = 857$ J	B1 FT	FT 600 + 'PE'(> 0) from **2(b)**
		1	

Question	Answer	Marks	Guidance
3(a)		B1	4 forces, labelled
		1	
3(b)	For resolving horizontally or vertically	M1	
	$30\cos 24 = F$ ($F = 27.406\ldots$)	A1	
	$R + 30\cos 24 = 40$ ($R = 27.797\ldots$)	A1	
	$\mu = \frac{30\cos 24}{40 - 30\sin 24}$	M1	Using $\mu = F/R$
	$\mu = 0.986$ (0.9859…)	A1	
		5	

Question	Answer	Marks	Guidance
4	For using conservation of momentum (either case)	**M1**	
	$6 \times 4 = 3m + 4 \times 1.5$ **or** $6 \times 4 = 3m - 4 \times 1.5$	**A1**	
	$m = 6$ **and** $m = 10$	**A1**	
	KE_A initial = $\frac{1}{2} \times 4 \times 6^2$ (72 J) or KE_A after = $\frac{1}{2} \times 4 \times 1.5^2$ (4.5 J) or KE_B after = $\frac{1}{2} \times 6 \times 3^2$ (27 J) or KE_B after = $\frac{1}{2} \times 10 \times 3^2$ (45 J)	**B1 FT**	$KE = \frac{1}{2} \times m \times v^2$ FT $4.5m$ for KE_B
	KE loss = $[\frac{1}{2} \times 4 \times 6^2 - \frac{1}{2} \times 4 \times 1.5^2 - \frac{1}{2} \times 6 \times 3^2]$ or $[\frac{1}{2} \times 4 \times 6^2 - \frac{1}{2} \times 4 \times 1.5^2 - \frac{1}{2} \times 10 \times 3^2]$	**M1**	Uses KE loss = KE before – KE after
	Loss of KE = 40.5 J or 22.5 J	**A1**	
		6	

Question	Answer	Marks	Guidance
5(a)	$4t^2 - 20t + 21 = (2t - 3)(2t - 7) = 0 \to t = \ldots$	**M1**	For setting $v = 0$ and attempting to solve $v = 0$
	$t = 1.5$ and $t = 3.5$	**A1**	
		2	
5(b)	$a = 8t - 20$, $a(0) = \ldots$	**M1**	For using $a = dv/dt$ and evaluating for $t = 0$
	$a = -20$	**A1**	
		2	

Question	Answer	Marks	Guidance
5(c)	$8t - 20 = 0$, $t = 2.5 \to v = \ldots$ or $v = (2t-5)^2 - 4$, $v_{min} = \ldots$	**M1**	For setting $a = 0$, attempting to solve for t and substituting to obtain v, or for attempting to complete the square on the expression for v
	$v_{min} = -4\ \text{ms}^{-1}$	**A1**	
		2	
5(d)	$s = \int(4t^2 - 20t + 21)\,dt$	**M1**	For using $s = \int v\,dt$ and attempting integration
	$s = \frac{4}{3}t^3 - 10t^2 + 21t\,(+c)$	**A1**	Correct integration
	$\frac{49}{6} - \frac{27}{2}$	**M1**	Substitute their limits (1.5 and 3.5) into *their* integral
	Distance $= \frac{16}{3} = 5.33$ m	**A1**	
		4	

Question	Answer	Marks	Guidance
6(a)(i)	$P = 650 \times 25$	**M1**	Use $P = Fv$ with F = total resistance
	$P = 16\,250$ W = 16.25 kW	**A1**	Accept 16 300 W or 16.3 kW (3sf)
		2	

Question	Answer	Marks	Guidance
6(a)(ii)	DF = $\frac{39000}{25}$ (= 1560)	B1	For using DF = P/v
	For applying Newton's 2nd law to the system to form an equation in a, or to the caravan or the car to form an equation in T and a	M1	[$1560 - 650 = 2400 \times a$]
	$1560 - 650 = 2400a$ $T - 250 = 800a$ $1560 - 400 - T = 1600a$	A1	Two correct equations
	$\left[a = \frac{(1560 - 650)}{2400}\right]$	M1	For solving for a or for T
	$a = 0.379\ \text{ms}^{-2}$ (0.37916…) $T = 553$ N (553.33…)	A1	
		5	
6(b)	[DF = $650 + 2400 \times 10 \times 0.05$]	M1	Newton's 2nd law
	$32\,500 = (650 + 24\,000 \times 0.05)v$	M1	For using $P = Fv$
	$v = 17.6$	A1	Allow $v = \frac{650}{37}$
		3	

Question	Answer	Marks	Guidance
7(a)	[$T = 2g \sin 10$] or [$3g \sin 20 = F + T$]	M1	Resolve forces parallel to plane P for particle A or parallel to plane Q for Particle B
	$T = 2g \sin 10$ **and** $3g \sin 20 = F + T$	A1	
	$R = 30 \cos 20$ (= 28.19...)	B1	Resolving forces perpendicular to plane Q for particle B
	$\mu = \frac{3g\sin 20 - 2g\sin 10}{30\cos 20}$	M1	Using $\mu = F/R$
	$\mu = 0.241$ (=0.2407…)	A1	
		5	
7(b)	$3g \sin 20 - T = 3a$ or $T - 2g \sin 10 = 2a$ or System: $3g \sin 20 - 2g \sin 10 = 5a$	M1	For applying Newton's second law to either A or to B or to the system
	$a = \frac{(3g\sin 20 - 2g\sin 10)}{5}$	M1	For applying Newton's second law to the second particle and/or solving for a
	$a = 1.3575…$	A1	
	$h_1 = x \sin 20$ $h_2 = x \sin 10$ $x \sin 20 + x \sin 10 = 1$	B1	Using expressions for height change of each particle after each moves a distance x along the plane, to obtain equation in x
	$\frac{1}{\sin 10 + \sin 20} = 0 + \frac{1}{2} \times 1.3575 \times t^2$	M1	For using $s = ut + ½at^2$ for either particle with $s = x$, $u = 0$ and using *their a* (= 1.3575)
	$t = 1.69$	A1	
		6	

Cambridge Assessment International Education

Cambridge International AS & A Level

MATHEMATICS **9709/42**

Paper 4 Mechanics **October/November 2020**

MARK SCHEME

Maximum Mark: 50

Published

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WWW	Without Wrong Working
AWRT	Answer Which Rounds To

Question	Answer	Mark	Guidance
1(a)	Momentum = $0.2 \times 2 = 0.4$ kg ms^{-1}	**B1**	
		1	
1(b)	$0.4 = 0.2 \times 0.3 + 0.5v$	**M1**	Apply conservation of momentum, 3 terms
	$v = 0.68$ ms^{-1}	**A1 FT**	FT on answer in **1(a)**
		2	

Question	Answer	Mark	Guidance
2(a)	DF – 650 = 1800 × 0.5 [DF = 1550]	**M1**	Apply Newton's second law, 3 terms
	$\frac{P}{20} - 650 = 1800 \times 0.5$	**B1**	
	[Power P = 1550 × 20 =] 31 000 W or 31 kW	**A1**	
		3	
2(b)	$\frac{31000}{v} - 650 = 0$	**M1**	Use $P = Fv$ with $F = 650$
	$v = 47.7$ ms^{-1}	**A1 FT**	FT on *their* $P \neq 13\,000$ Allow $\frac{620}{13}$
		2	

Question	Answer	Mark	Guidance
3	$20\cos 60 = T\cos 45$	**M1**	Resolve forces horizontally, 2 terms
	$T = 10\sqrt{2}$ or $T = 14.1$	**A1**	
	$20\sin 60 + T\sin 45 = mg$ or W	**M1**	Resolve forces vertically, 3 terms
	$20\sin 60 + T\sin 45 = mg$	**A1**	
	$m = 2.73$ [$= \sqrt{3} + 1$]	**A1**	
	Alternative method for question 3		
	$\left[\dfrac{T}{\sin 150} = \dfrac{mg \text{ or } W}{\sin 75} = \dfrac{20}{\sin 135}\right]$	**M1**	Attempt at one pair of terms using Lami's Method
	$\dfrac{T}{\sin 150} = \dfrac{mg}{\sin 75} = \dfrac{20}{\sin 135}$	**A1**	All terms correct in Lami's Method
	Attempt to solve for either T or m or W	**M1**	
	$T = 10\sqrt{2}$ or $T = 14.1$	**A1**	
	$m = 2.73$ [$= \sqrt{3} + 1$]	**A1**	
		5	

Question	Answer	Mark	Guidance
3	**Alternative method for question 3**		
	$\left[\dfrac{T}{\sin 30} = \dfrac{mg \text{ or } W}{\sin 105} = \dfrac{20}{\sin 45}\right]$	**M1**	Attempt the triangle of forces method and state one equation which involves any two of the forces *T*, *m* and 20.
	$\dfrac{T}{\sin 30} = \dfrac{mg}{\sin 105} = \dfrac{20}{\sin 45}$	**A1**	All correct
	Attempt to solve for either *T* or *m* or *W*	**M1**	
	$T = 10\sqrt{2}$ or $T = 14.1$	**A1**	
	$m = 2.73$ [$= \sqrt{3} + 1$]	**A1**	
		5	

Question	Answer	Mark	Guidance
4(a)	$\left[2 = \frac{20}{T}\right] \to T = 10$	**B1**	
		1	
4(b)	Distance travelled before constant speed = $\frac{1}{2} \times 10 \times 20 + \frac{1}{2} \times (20 + V) \times 5$ $\frac{1}{2} \times 10 \times 20 + \frac{1}{2} \times (20 - V) \times 5 + 5V$ $[= 150 + 2.5V]$	**B1 FT**	May be implied if seen within total distance FT on T value from **4(a)**
	Distance travelled after constant speed $= 27.5V + \frac{1}{2} \times 5V$ $[= 30V]$	**B1**	May be implied if seen within total distance
	$\frac{1}{2} \times 10 \times 20 + \frac{1}{2} \times (20 + V) \times 5$ $= \frac{1}{3}\left[\frac{1}{2} \times 10 \times 20 + \frac{1}{2} \times (20 + V) \times 5 + 27.5V + \frac{1}{2} \times 5V\right]$	**M1**	For attempting to use $\frac{1}{2}$ or $\frac{1}{3}$ correctly and for obtaining an equation for V which includes all parts of the journey. or $\frac{1}{2} \times 10 \times 20 + \frac{1}{2} \times (20 + V) \times 5 = \frac{1}{2}\left[27.5V + \frac{1}{2} \times 5V\right]$
	$V = 12$	**A1**	
		4	

Question	Answer	Mark	Guidance
5(a)	$40 - gt = 0$ $[t = 4]$	M1	Using $v = u + at$ with $u = 40$, $v = 0$ and $a = -g$ to find the time taken to reach the highest point.
	Time to top of building = $4 - ½(4) = 2$	A1	May see $t = 4 + 2 = 6$ for A1
	$h = 40 \times 2 - ½ \times 10 \times 2^2$ $h = 40 \times 6 - ½ \times 10 \times 6^2$	M1	Using $s = ut + ½\, at^2$ with $u = 40$, $a = -g$ and $t = 2$ or $t = 6$ to set up an equation which enables the value of h, the height of the building, to be found.
	$h = 60$	A1	
	Alternative method for question 5(a)		
	$0 = 40^2 + 2 \times (-10) \times H$	M1	For using $v^2 = u^2 + 2as$ with $u = 40$, $v = 0$ and $a = -g$ in order to find H, the greatest height achieved
	$H = 80$	A1	
	$s = ½ \times 10 \times 2^2$	M1	Use either $s = vt - ½\, at^2$ with $v = 0$, $a = -g$, $t = 2$ or use $s = ut + ½\, at^2$ with $u = 0$, $a = g$, $t = 2$ to find the distance travelled either in the final 2 seconds going up or the first 2 seconds going down
	$s = 20$ and so $h = 80 - 20 = 60$	A1	
		4	

Question	Answer	Mark	Guidance
5(b)	Height of first particle above ground = $40t - \frac{1}{2} \times 10t^2$	B1	
	Height of second particle above top of building $= 20(t-1) - \frac{1}{2} \times 10 \times (t-1)^2$	B1	
	$60 + 20(t-1) - \frac{1}{2} \times 10 \times (t-1)^2 = 40t - \frac{1}{2} \times 10t^2$	M1	Set up an equation involving expressions for displacement to enable the time at which the particles reach the same height to be found.
	$t = 3.5$ seconds	A1	
	Alternative method for question 5(b)		
	$h_1 = 40 \times 1 - 5 \times 1^2$ [= 35] and $v_1 = 40 - 10 \times 1$ [= 30]	B1	Distance travelled **and** speed of first particle after 1 second
	$H_1 = 30T - 5 \times T^2$, $H_2 = 20T - 5 \times T^2$	B1	Distance travelled by both particles, T seconds after the second particle is projected.
	$30T - 5 \times T^2 = 20T - 5 \times T^2 + (60 - 35)$	M1	Set up an equation in T involving expressions for displacement to enable the time at which the particles are at the same height to be found.
	$T = 2.5$ and so time to meet $= 2.5 + 1 = 3.5$ seconds	A1	
		4	

Question	Answer	Mark	Guidance
6(a)	$R = 5g\cos 30$ [$= 25\sqrt{3}$]	B1	
	$40 - 5g\sin 30 - F > 0$	M1	State that the net force up the plane is positive, 3 terms
	$F = \mu \times 5g\cos 30$	M1	For using $F = \mu R$ with R as a component of $5g$ to obtain an equality/inequality in μ only with 3 terms
	$\mu < \frac{1}{5}\sqrt{3}$	A1	AG
	Alternative scheme for question 6(a)		
	$R = 5g\cos 30$ [$= 25\sqrt{3}$]	B1	
	$40 - 5g\sin 30 - F = 5a$	M1	Acceleration $a > 0$
	$F = \mu \times 5g\cos 30$ [$40 - 5g\sin 30 - \mu \times 5g\cos 30 = 5a$]	M1	For using $F = \mu R$ with R as a component of $5g$ to obtain an equality in μ and a
	$\mu < \frac{1}{5}\sqrt{3}$	A1	AG. From $\mu = \frac{1}{5}\sqrt{3} = \frac{a}{g}\cos 30$ with $a > 0$
		4	

Question	Answer	Mark	Guidance
6(b)	Attempt to resolve forces parallel to or perpendicular to the inclined plane, 3 relevant terms in either direction	M1	
	$R = 5g\cos 30 + 40\sin 30$ [$= 20 + 25\sqrt{3} = 63.3$]	A1	
	$F = 40\cos 30 - 5g\sin 30$ [$= 20\sqrt{3} - 25 = 9.64$]	A1	
	$\mu \geqslant 0.152$	B1	AG. Using $F \leqslant \mu R$
	Alternative method for question 6(b)		
	Attempt to resolve forces horizontally or vertically with 3 relevant terms in either direction	M1	
	$40 = R\sin 30 + F\cos 30$ [$40 = \frac{1}{2}R + \sqrt{3}/2F$]	A1	
	$5g = R\cos 30 - F\sin 30$ [$5g = \sqrt{3}/2R - \frac{1}{2}F$]	A1	
	$\mu \geqslant 0.152$	B1	AG. Solve for R and F and use $F \leqslant \mu R$

Question	Answer	Mark	Guidance
7(a)	$\int 0.1t^{3/2}dt$	*M1	For integrating a
	$v = 0.04t^{5/2} + 1.72$	A1	
	$0.04t^{5/2} + 1.72 = 3$	DM1	For attempting to solve the equation $v = 3$, to obtain t
	$t = 4$	A1	
		4	

Question	Answer	Mark	Guidance
7(b)	$\int\left(0.04t^{5/2}+1.72\right)dt$ $[\ s=\frac{2}{175}t^{7/2}+1.72t\left(+C'\right)\ ]$	*M1	For integrating v which itself has come from integration
	For using correct limits correctly	DM1	
	Displacement when $t = 2$ is 3.57 m	A1	
		3	

Question	Answer	Mark	Guidance
8(a)	For A: $T = 0.3a$ For B: $3.5 + 0.5g \sin 30 - T = 0.5a$ System: $3.5 + 0.5g \sin 30 = (0.3 + 0.5)a$	M1	For applying Newton's 2nd law for either particle A or to particle B or to the system. Correct number of terms.
		A1	Two correct equations
	For solving either for T or for a	M1	
	$a = 7.5\ \text{ms}^{-2}$	A1	
	$T = 2.25$ N	A1	
		5	
8(b)	$0.5g \sin 30 \times 0.6$ [= 1.5]	B1	PE loss by B
	Apply the work-energy equation to the system	M1	5 relevant terms, their PE for 0.5 kg, WD by 3.5 N, WD against friction and two relevant KE terms.
	$0.5g \sin 30 \times 0.6 + 3.5 \times 0.6 = ½ \times 0.8 \times v^2 + 1.1$	A1	
	$v = 2.5\ \text{ms}^{-1}$	A1	
		4	

Cambridge Assessment International Education

Cambridge International AS & A Level

MATHEMATICS **9709/41**

Paper 4 Mechanics **October/November 2020**

MARK SCHEME

Maximum Mark: 50

Published

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

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

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

Cambridge International is publishing the mark schemes for the October/November 2020 series for most Cambridge IGCSE™, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

Generic Marking Principles

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- 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).

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- 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, 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.

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)	$6 \times 2.5 = 2.5v + 5v$	**M1**	Apply conservation of momentum, 3 terms implied
	$v = 2\ \text{ms}^{-1}$	**A1**	
		2	
1(b)	Use KE = ½ mv^2 either before or after collision	**M1**	Allow this for either particle
	KE(before) = $0.5 \times 2.5 \times 6^2$ KE(after) = $0.5 \times 7.5 \times 2^2$	**A1 FT**	Both correct FT on v
	Loss of KE = 30 J	**A1**	
		3	

Question	Answer	Marks	Guidance
2(a)	$P = 350 \times 20$	**M1**	Using $P = Fv$
	$P = 7$ kW	**A1**	
		2	
2(b)	$15\,000 = \text{DF} \times 20$ [DF = 750]	**B1**	Using $P = Fv$
	$\text{DF} - 350 = 1400a$	**M1**	Use Newton's 2nd law, 3 terms
	$a = \dfrac{2}{7}\ \text{ms}^{-2}$	**A1**	$a = 0.286$
		3	

Question	Answer	Marks	Guidance
3	Resolve forces either horizontally or vertically	M1	Correct number of relevant terms
	$P\cos\theta = 12 + 8\cos 30 - 10\cos 45$ [= 11.857]	A1	
	$P\sin\theta = 10\sin 45 - 8\sin 30$ [= 3.071]	A1	
	$P = \sqrt{(11.857^2 + 3.071^2)}$	M1	OE. Use of correct method for finding *P*
	$\theta = \tan^{-1}\left(\frac{3.071}{11.857}\right)$	M1	OE. Use of correct method for finding θ
	$P = 12.2$ and $\theta = 14.5$	A1	Both correct
		6	

Question	Answer	Marks	Guidance
4	[$v = 3t^2 - 18t$ (+ C)]	*M1	Attempt to integrate *a*
	[$s = t^3 - 9t^2$ (+ C)]	#M1	Attempt to integrate *v*
	$v = 3t^2 - 18t$ $s = t^3 - 9t^2$	A1	Both integrals correct
	$v = 0$, $3t^2 - 18t = 0$ [$t = 6$]	*DM1	Attempt to find *t* when $v = 0$
	$s = 6^3 - 9 \times 6^2 -$ [0]	#DM1	Substitute limits correctly into *s*
	$s = 108$ m	A1	Answer must be positive
		6	

Question	Answer	Marks	Guidance
5(a)	$0.8g - T = 0.8a$, $T - 0.2g = 0.2a$, For system: $0.8g - 0.2g = (0.8 + 0.2)a$	M1	Apply Newton's 2nd law to either particle or to the system
		A1	Any 2 correct equations
	Attempt to solve for either a or T	M1	
	$a = 6$ ms^{-2} and $T = 3.2$ N	A1	AG. Both correct
		4	
5(b)	$v^2 = 2 \times 6 \times 0.5$	M1	Attempt to find v or v^2 as 0.8 kg particle reaches the ground using a from **5(a)**
	0 = 6 – 20s	M1	Attempt to find the extra height reached by 0.2 kg particle using v^2 from previous M1 mark
	Greatest height = 0.5 + 0.5 + 0.3 = 1.3 m	A1	
		3	

Question	Answer	Marks	Guidance
6(a)	KE (final) = $\frac{1}{2} \times 1500 \times 20^2 + \frac{1}{2} \times 750 \times 20^2$ KE (initial) = $\frac{1}{2} \times 1500 \times 30^2 + \frac{1}{2} \times 750 \times 30^2$	B1	Use KE = $\frac{1}{2}mv^2$ for any two of the four elements
	PE gain = $2250 \times 10 \times 800 \times 0.08$	B1	
	WD against friction = 600×800	B1	
	$\frac{1}{2} \times 2250 \times 30^2 + \text{DF} \times 800 = 600 \times 800 + \frac{1}{2} \times 2250 \times 20^2 + 2250 \times 10 \times 800 \times 0.08$	M1	Use energy equation.
	DF = 1700 N	A1	DF = 1696.875 N
		5	

Question	Answer	Marks	Guidance
6(b)	2400 – 600 = 2250a or T – 200 = 750a **and** 2400 – 400 – T = 1500a	**M1**	Apply Newton's second law to the system or to each of the car and trailer separately
		A1	Two correct equations
	Attempting to solve for a or for T	**M1**	
	T = 800 N and a = 0.8 ms^{-2}	**A1**	
		4	

Question	Answer	Mark	Guidance
7(a)	$0.2\times10\times0.5=\frac{1}{2}\times0.2\times v_B^2$	**M1**	Attempt PE or KE for motion from A to B
		M1	Attempt PE loss = KE gain from A to B
	$v_B^2=10$	**A1**	
	Alternative method for the first 3 marks		
	$0.2\times10\times\sin 30=0.2a$, $a=5$	**(M1)**	Attempt to find acceleration a for motion from A to B
	$v_B^2=0^2+2\times5\times1$	**(M1)**	Use $v^2=u^2+2as$ in attempt to find speed at B
	$v_B^2=10$	**(A1)**	

Question	Answer	Marks	Guidance
7(a)	**THEN, either this method for the next 5 marks**		
	$R = 0.2 \times 10 \times \cos 30 = \sqrt{3}$	**B1**	
	$F = \frac{\sqrt{3}}{2} \times 0.2 \times \frac{\sqrt{3}}{2} \times 10 = 1.5$	**M1**	For using $F = \mu R$ where R must be a component of $0.2g$
	PE loss = $0.2 \times 10 \times 0.5 = 1$ WD against $F = 1.5 \times 1$	**M1**	Attempt to find either PE loss or WD against F from B to C
	$\frac{1}{2}0.2 \times 10 + 0.2 \times 10 \times 0.5 = 1.5 \times 1 + \frac{1}{2}0.2v_C^2$	**M1**	Apply work-energy equation for motion from B to C as KE at B + PE at B = WD against F + KE at C with $v_B \neq 0$
	$v_c = \sqrt{5} = 2.24 \text{ ms}^{-1}$	**A1**	
	OR, this method for the next 5 marks		
	$R = 0.2 \times 10 \times \cos 30 = \sqrt{3}$	**(B1)**	
	$F = \frac{\sqrt{3}}{2} \times 0.2 \times \frac{\sqrt{3}}{2} \times 10 = 1.5$	**(M1)**	For using $F = \mu R$ where R must be a component of $0.2g$
	$0.2 \times 10 \sin 30 - 1.5 = 0.2a \quad a = -2.5$	**(M1)**	Attempt to find acceleration a for motion from B to C
	$v_c^2 = 10 + 2 \times -2.5 \times 1$	**(M1)**	Use $v^2 = u^2 + 2as$ in attempt to find v_c using $v_B \neq 0$
	$v_c = \sqrt{5} = 2.24 \text{ ms}^{-1}$	**(A1)**	
		8	

Question	Answer	Marks	Guidance
7(a)	**Alternative method for question 7(a)**		
	PE loss = $0.2 \times 10 \times 2 \sin 30 = 2$	**M1**	Attempt PE loss for motion from *A* to *C*
	KE gain $= \frac{1}{2} \times 0.2 \times v_C^2$	**M1**	Attempt KE gain for motion from *A* to *C*
	Both PE loss and KE gain correct	**A1**	
	$R = 0.2 \times 10 \times \cos 30 = \sqrt{3}$	**B1**	
	$F = \frac{\sqrt{3}}{2} \times 0.2 \times \frac{\sqrt{3}}{2} \times 10 = 1.5$	**M1**	For using $F = \mu R$ where R must be a component of $0.2g$
	WD against $F = 1.5 \times 1$	**M1**	Attempt WD against F
	$0.2 \times 10 \times 1 = 1.5 \times 1 + \frac{1}{2} \times 0.2 \times v_C^2$	**M1**	Attempt work-energy equation for motion from *A* to *C*
	$v_c = \sqrt{5} = 2.24 \text{ ms}^{-1}$	**A1**	
		8	

Question	Answer	Marks	Guidance
7(b)	$0 = 10 + 2a \quad [a = -5]$	M1	Attempt to find a for motion from B to C, using $v_B^2 = 10$, $v_C = 0$
	$0.2 \times 10 \times \sin 30 - F = 0.2 \times -5$	M1	Attempt Newton's 2nd law for motion from B to C
	$2 = \mu\sqrt{3}$	M1	Use $F = \mu R$ where R is a component of $0.2g$ but $R = 0.2g$ is M0
	$\mu = \frac{2}{\sqrt{3}}$	A1	Any correct exact form such as $^2/_3\sqrt{3}$
	Alternative method for question 7(b)		
	PE loss $= 0.2 \times 10 \times 1 \sin 30 = 1$	M1	Attempt PE loss for motion from B to C
	$1 + ½ \times 0.2 \times 10 = F \times 1$	M1	Work-Energy equation for motion from B to C in the form PE at B + KE at B = WD against F using $v_B^2 = 10$, $v_C = 0$
	$F = \mu\sqrt{3}$	M1	Use $F = \mu R$ leading to an equation in μ where R is a component of $0.2g$
	$\mu = \frac{2}{\sqrt{3}}$	A1	Any correct exact form such as $^2/_3\sqrt{3}$

Question	Answer	Marks	Guidance
7(b)	**Alternative method for question 7(b)**		
	PE loss = $0.2 \times 10 \times 2 \sin 30 = 2$	**M1**	Attempt PE loss for motion from *A* to *C*
	$2 = F \times 1$	**M1**	Work-Energy equation for motion from *B* to *C*
	$F = \mu\sqrt{3}$	**M1**	Use $F = \mu R$ leading to an equation in μ where *R* is a component of 0.2*g*
	$\mu = \frac{2}{\sqrt{3}}$	**A1**	Any correct exact form such as $^2/_3\sqrt{3}$
		4	

Cambridge Assessment International Education

Cambridge International AS & A Level

MATHEMATICS | **9709/43**

Paper 4 Mechanics | **May/June 2020**

MARK SCHEME

Maximum Mark: 50

Published

Students did not sit exam papers in the June 2020 series due to the Covid-19 global pandemic.

This mark scheme is published to support teachers and students and should be read together with the question paper. It shows the requirements of the exam. The answer column of the mark scheme shows the proposed basis on which Examiners would award marks for this exam. Where appropriate, this column also provides the most likely acceptable alternative responses expected from students. Examiners usually review the mark scheme after they have seen student responses and update the mark scheme if appropriate. In the June series, Examiners were unable to consider the acceptability of alternative responses, as there were no student responses to consider.

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AWRT	Answer Which Rounds To

Question	Answer	Marks
1	Use of conservation of momentum	**M1**
	$m \times 2 + 0 = m \times (-0.5) + 0.2 \times 1$	**A1**
	$m = 0.08$	**A1**
		3

Question	Answer	Marks
2(a)	$F - 900 = 4000 \times 0.5$ (**M1** for use of Newton's second law, 3 terms)	**M1**
	$F = 2900$ N	**A1**
2(b)	900×25 (**M1** for use of $P = Fv$ with F = resistance only)	**M1**
	22 500 W or 22.5 kW	**A1**

Question	Answer	Marks
3	Attempt to resolve, either direction with correct number of terms	M1
	$F\cos\alpha = 40\sin30 + 20\sin60 - 50\sin45$ (= 1.965...)	A1
	$F\sin\alpha = 50\cos45 + 20\cos60 - 40\cos30$ (= 10.714...)	A1
	Method for either F or α	M1
	$F = \sqrt{\left((1.965...)^2 + (10.714...)^2\right)} = 10.9(10.893)$	A1
	$\alpha = \tan^{-1}(10.714... / 1.965...) = 79.6$ (79.606...)	A1
		6

Question	Answer	Marks
4(a)	Trapezium shape with gradient of right-hand side approximately 2 times left side	B1
		1
4(b)	Constant velocity = 500/25 = 20 ms^{-1}	B1
	$20^2 = 0 + 2a \times 50$	M1
	$a = 4$	A1
		3
4(c)	Time to accelerate = 20/4 = 5 s	B1
	Deceleration time = 2.5 s	B1
	So total time = 5 + 25 + 2.5 = 32.5 s	B1
		3

Question	Answer	Marks
5(a)	Decrease in KE = $\frac{1}{2} \times 4 \times (12^2 - 8^2)$	M1
	160 J	A1
		2
5(b)	PE gained = $4g \times 10\sin 30$ (= 200)	B1
	Total work done = 200 – 160	M1
	Total work done = 40 J	A1 FT
		3
5(c)	$-4g\sin 30 = 4a$	M1
	$a = -5$	A1
	$-10 = 8t - \frac{1}{2} \times 5t^2$	M1
	$t = 4.16$ s	A1
		4

Question	Answer	Marks
6(a)	$a = 4 - t$ (**M1** for differentiation)	**M1**
	When $a = 0$, $t = 4$	**A1**
	At $t = 4$, $v = 12.5$	**A1**
		3
6(b)	Velocity = 0 when $4.5 + 4t - 0.5t^2 = 0$	**M1**
	$t = 9$ (reject $t = -1$)	**A1**
	$\int (4.5 + 4t - 0.5t^2)dt$	**M1**
	$4.5t + 2t^2 - \frac{1}{6}t^3$ [$+ c$]	**A1**
	Apply limits (0 and 9)	**M1**
	Distance = 81 m	**A1**
		6

Question	Answer	Marks
7(a)	$T - 2mg = 0$	B1
	$3mg \sin\theta - T = 0$ (**M1** for resolving forces parallel to the plane and solving for θ)	M1
	$\theta = 41.8$ (41.810...)	A1
		3
7(b)	$R = 3mg\cos 30$	B1
	Use of $F = \mu R$	M1
	$2mg - T = 0.1 \times 2m$ OR $T - 3mg\sin 30 - \mu \times 3mg\cos 30 = 0.1 \times 3m$	M1
	$2mg - 0.2m - 3mg\sin 30 - \mu \times 3mg\cos 30 = 0.1 \times 3m$	M1
	$\mu = \frac{\sqrt{3}}{10}$	A1
		5
7(c)	$v^2 = 0 + 2 \times 0.1 \times 0.8$ $(v = 0.4)$	M1
	$-3mg\sin 30 - \mu \times 3mg\cos 30 = 3ma$ $(a = -6.5)$	M1
	$0 = -0.4 - 6.5t$	M1
	$t = 0.4/6.5 = 0.0615$ s	A1
		4

Cambridge Assessment International Education

Cambridge International AS & A Level

MATHEMATICS **9709/42**

Paper 4 Mechanics **May/June 2020**

MARK SCHEME

Maximum Mark: 50

Published

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Generic Marking Principles

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Question	Answer	Marks
1(a)	Trapezium, deceleration steeper than acceleration	B1
	Time from 0 to 200	B1
		2
1(b)	$0.5(170+200)v=2775$	M1
	$v=15$	A1
		2
1(c)	$a=15\div 20$	M1
	$a=0.75$	A1
		2

Question	Answer	Marks
2	Resolving forces in either direction	**M1**
	$20\cos\theta = 4P\cos 30$	**A1**
	$4P + 2P\sin 30 = 20\sin\theta$	**A1**
	$\cos\theta = \frac{\sqrt{3}}{10}P$ $\sin\theta = \frac{P}{4}$ $\frac{3}{100}P^2 + \frac{1}{16}P^2 = 1$	**M1**
	$P = 3.29$	**A1**
	$\theta = 55.3$	**A1**
		6

Question	Answer	Marks
3	$T\sin 60 + R = 25\cos 20$	**B1**
	Attempt at resolving in any direction	**M1**
	$T\cos 60 = F + 25\sin 20$	**A1**
	$T\cos 60 + F = 25\sin 20$	**A1**
	Use of $F = \mu R$	**M1**
	$T\cos 60 = 25\sin 20 \pm 0.3(25\cos 20 - T\sin 60)$ $T = \dfrac{25\sin 20 \pm 0.3 \times 25\cos 20}{\cos 60 \pm 0.3\sin 60}$	**M1**
	$T = 6.26$	**A1**
	$T = 20.5$	**A1**
		8

Question	Answer	Marks
4(a)	$4\times10\ [+0]=4\times0.5v+2v$	M1
	$v_A=5$ and $v_B=10$	A1
		2
4(b)	Conservation of momentum *B, C* $2\times10\ [+0]=2\times v+3v$	M1
	$v=4$	A1
	$v_A>v_B$, hence another collision	A1
		3
4(c)	Conservation of momentum *A, B*	M1
	$4\times their5+2\times their4=4v+2v \quad v=\frac{14}{3}\ (\text{ms}^{-1})$	A1
	KE initial $=\frac{1}{2}\times4\times10^2$	M1
	KE final $=\frac{1}{2}\times6\times their(\frac{14}{3})^2+\frac{1}{2}\times1\times their12^2$	A1
	Loss of KE $=200-\frac{412}{3}=\frac{188}{3}$	A1
		5

Question	Answer	Marks
5(a)(i)	$DF = 750$	B1
	Power $= their(750) \times 32$ $= 24\text{kW}$	B1 FT
		2
5(a)(ii)	$16000 = DF \times 32$ $DF = 500$	M1
	$500 - 750 = 1250 \times a$	M1
	$a = [-]0.2$	A1
		3
5(b)	$DF = 1000 + 8v + 1250 \times 10 \times 0.096$	M1
	$2200 + 8v$	A1
	$60000 = (2200 + 8v)v$	M1
	$8v^2 + 2200v - 60000 = 0$	A1
	$v = 25$	A1
		5

Question	Answer	Marks
6(a)	Correct for $0 \le t \le 5$	**B1**
	Correct for $5 \le t \le 7$	**B1**
	Correct for $7 \le t \le 13.5$	**B1**
		3
6(b)	$a = -2t$ by differentiating	**M1**
	$a = -12$	**A1**
		2
6(c)	$s = \int_0^5 (2t+1)\,dt + \int_5^6 (36 - t^2)\,dt + \left\| \int_6^7 (36 - t^2)\,dt + \int_7^{13.5} (2t - 27)\,dt \right\|$	**M1**
	$s = \int_0^5 (2t+1)\,dt + \int_5^6 (36 - t^2)\,dt + \left\| \int_6^7 (36 - t^2)\,dt + \int_7^{13.5} (2t - 27)\,dt \right\|$	**A1**
	$s = [t^2 + t] + [36t - \frac{t^3}{3}] + t^2 - 27t$	**M1**
	All correct	**A1**
	$s = 84.25$	**A1**
		5

Cambridge Assessment International Education

Cambridge International AS & A Level

MATHEMATICS **9709/41**

Paper 4 Mechanics **May/June 2020**

MARK SCHEME

Maximum Mark: 50

Published

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Question	Answer	Marks
1	Resultant = $100 - 2 \times 50\cos\alpha$	**M1**
	20 N	**A1**
	Direction is to the left (or equivalent)	**B1**
		3

Question	Answer	Marks
2(a)	$[T - 100 = 400 \times 1.5]$	**M1**
	$T = 700$ N	**A1**
		2
2(b)	$F - 250 - 100 = 2200 \times 1.5$ ($F = 3650$ N) (**M1** for using Newton's second law for the system or for the car using the result from **2(a)**)	**M1**
	For use of power $= Fv$	**M1**
	73 000 W or 73 kW	**A1**
		3

Question	Answer	Marks
3(a)	$0 = 5^2 - 2gs$	**M1**
	$s = 1.25$	**A1**
	[Height above ground =] 4.05 m	**A1**
		3
3(b)	Use of $s = ut + ½ at^2$	**M1**
	$0.8 = 5t - 5t^2$	**A1**
	$t = 0.2$ or 0.8	**M1**
	Length of time = 0.6 s	**A1**
		4

Question	Answer	Marks
4(a)	Resolving forces in either direction	**M1**
	$R = T\sin30 + 0.1g$, $F = T\cos30$	**A1**
	$T\cos30 = 0.8\ (T\sin30 + 0.1g)$	**M1**
	$T = 1.72$ (1.7166...)	**A1**
		4
4(b)	$R = 3\sin30 + 0.1g$	**B1**
	$3\cos30 - 0.8(3\sin30 + 0.1g) = 0.1a$	**M1**
	$a = 5.98\ \text{ms}^{-2}$ (5.9807...)	**A1**
		3

Question	Answer	Marks
5(a)	Attempt at finding PE lost	**M1**
	PE lost = $35g\,(4\cos 22.5 - 4\cos 45)$	**A1**
	$\frac{1}{2} \times 35v^2 = 35g\,(4\cos 22.5 - 4\cos 45)$	**M1**
	Speed = 4.16 ms^{-1} (4.1643...)	**A1**
		4
5(b)	Use of the work-energy equation in the form: PE lost = KE gain + WD against resistance	**M1**
	$\frac{1}{2} \times 35 \times 4^2 = 35g\,(4 - 4\cos 45) - X$	**A1**
	$X = 130$ (130.05...)	**A1**
		3

Question	Answer	Marks
6(a)	$\int k\left(t^2 - 10t + 21\right)\mathrm{d}t$	M1
	$s = k\left(\frac{1}{3}t^3 + 5t^2 + 21t\right) + \mathrm{C}$	A1
	$2.85 = k\left(\frac{1}{3}\times 3^3 - 5\times 3^2 + 21\times 3\right) + \mathrm{C}$ or $2.4 = k\left(\frac{1}{3}\times 6^3 - 5\times 6^2 + 21\times 6\right) + \mathrm{C}$	M1
	$2.85 = 27k + \mathrm{C}$, $2.4 = 18k + \mathrm{C}$ (**A1** for both)	A1
	Solving for k	M1
	$k = 0.05$	A1
	$s = 0.05\left(\frac{1}{3}t^3 - 5t^2 + 21t\right) + 1.5$	A1
		7
6(b)	Differentiating v or completing the square for v	M1
	$a = 0.05(2t - 10)$	A1
	Min value of v is at $t = 5$.	M1
	Displacement at $t = 5$ is 2.58 m (2.5833...)	A1
		4

Question	Answer	Marks
7(a)	$0.3g\sin 30 = 0.3a$ $(a = 5)$ (**M1** for applying Newton's second law parallel to the plane)	**M1**
	$v^2 = 0 + 2 \times 2.5 \times a$	**M1**
	$v = 5$	**A1**
	$0.3 \times 5 + 0 = 0.3 \times 2 + 0.2\,w$	**M1**
	Velocity of $Q = 4.5$ ms^{-1}	**A1**
		5

Question	Answer	Marks
7(b)	$0.3 \times z + 0 = 0.5 \times 1.2$	M1
	Velocity of P before collision $z = 2$	A1
	Friction force on P after reaches horizontal plane $F = \mu \times 0.3\,g$	B1
	$\mu \times 0.3g \times 1.5 = \frac{1}{2} \times 0.3 \times 5^2 - \frac{1}{2} \times 0.3 \times 2^2$	M1
	Coefficient $\mu = 0.7$	A1
	Alternative method for question 7(b)	
	$0.3 \times z + 0 = 0.5 \times 1.2$	M1
	Velocity of P before collision $z = 2$	A1
	Friction force on P after reaches horizontal plane $F = \mu \times 0.3\,g$	B1
	$a = (5^2 - 2^2) / (2 \times 1.5) = 7$, $F = 0.3 \times 7$	M1
	Coefficient $\mu = 0.7$	A1
		5

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Cambridge International AS & A Level

MATHEMATICS **9709/42**

Paper 4 Mechanics **March 2020**

MARK SCHEME

Maximum Mark: 50

Published

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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, 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.

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SOI	Seen Or Implied
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WWW	Without Wrong Working
AWRT	Answer Which Rounds To

Question	Answer	Marks	Guidance
1(a)	Power = 750000/10 = 75000 W or 75 kW	**B1**	Power = WD/Time
		1	
1(b)	Driving force DF = 75000/25	**B1FT**	Using $P = \text{DF} \times v$
	[DF – 2400 = 16000a]	**M1**	Using Newton's 2nd law
	$a = 0.0375 \text{ ms}^{-2}$	**A1**	Allow $a = \dfrac{3}{80}$
		3	

Question	Answer	Marks	Guidance
2(a)	[$1.44 = 0 + ½ \times 2t^2$]	M1	For using a complete method which would lead to an equation for finding a value of t such as $s = ut + ½ at^2$ with $u = 0$, $s = 1.44$ and $a = 2$
	$t = 1.2$ s	A1	
		2	
2(b)	$R = 0.4g - 3 \times \frac{3}{5} = 0.4g - 3 \sin 36.9$ [= 2.2]	B1	
	[$3 \times \frac{4}{5} - F = 3 \cos 36.9 - F = 0.4 \times 2$] [$F = 1.6$]	M1	Use Newton's 2nd law, 3 terms, to find F.
	$\left[\mu = \frac{3\times\frac{4}{5} - 0.4\times 2}{0.4g - 3\times\frac{3}{5}} = \frac{1.6}{2.2}\right]$	M1	Use of $\mu = \frac{F}{R}$
	$\mu = 0.727$	A1	Allow $\mu = \frac{8}{11}$
		4	

Question	Answer	Marks	Guidance
3(a)	Initial KE = $\frac{1}{2} \times 0.2 \times 5^2$ or Final KE = $\frac{1}{2} \times 0.2 \times 3^2$	**B1**	
	$\frac{1}{2} \times 0.2 \times 5^2 = 0.2gh + \frac{1}{2} \times 0.2 \times 3^2$	**M1**	Use conservation of energy
	$h = 0.8$	**A1**	
		3	
3(b)	Apply work-energy equation from A to C	**M1**	
	$\frac{1}{2} \times 0.2 \times 5^2 - 3.1 + 0.2g \times 0.5 = \frac{1}{2} \times 0.2v^2$	**A1**	Correct work-energy equation
	Speed = 2 ms^{-1}	**A1**	
		3	

Question	Answer	Marks	Guidance
4(a)	Use the constant acceleration equations to obtain an expression for either s_{AB} or s_{BC} in terms of a	M1	
	$s_{AB} = 2 \times 4.5 - ½ \times a \times 2^2$	A1	**or** $s_{AB} = ½(v_A + v_B) \times 2 = 9 - 2a$
	$s_{BC} = 2 \times 4.5 + ½ \times a \times 2^2$	A1	**or** $s_{BC} = ½(v_B + v_C) \times 2 = 9 + 2a$
	$[2 \times 4.5 - ½a \times 2^2 = \frac{4}{5}\ (2 \times 4.5 + ½a \times 2^2)]$	M1	Use the given information to find a valid equation for a
	$a = 0.5$ ms^{-2}	A1	
	Alternative method for question 4(a)		
	$[4.5 = u + 2a,\ s_{AC} = 4u + 8a,\ s_{AB} = 2u + 2a]$	M1	Any two relevant equations in u, a, s_{AB} and s_{AC} where u is the velocity at A
	Two correct equations	A1	
	Three correct equations	A1	
	$[2(4.5 - 2a) + 6a = \frac{5}{4}\ \{2(4.5 - 2a) + 2a\}]$	M1	Use the given information that $BC = {}^5/_4 AB$ to find a valid equation such as the one shown OE involving a only
	$a = 0.5$ ms^{-2}	A1	
	Alternative method for question 4(a)		
	$[AC = 4.5 \times 4]$	M1	Using $AC = v_B \times 4$ since v_B is the average velocity over AC
	$BC = 5/9 \times AC$ **or** $AB = 4/9 \times AC$	M1	
	$BC = 10$ or $AB = 8$	A1	
	$[10 = 4.5 \times 2 + 2a$ **or** $8 = 4.5 \times 2 - 2a]$	M1	Using $s = ut + ½\ at^2$ for BC **or** $s = vt - ½\ at^2$ for AB
	$a = 0.5$ ms^{-2}	A1	

Question	Answer	Marks	Guidance
		5	
4(b)	$s_{AB} = 2 \times 4.5 - ½ \times 0.5 \times 2^2 = 8$ **OR** $s_{BC} = 2 \times 4.5 + ½ \times 0.5 \times 2^2 = 10$	**M1**	Attempt to find the value of s_{AB} or s_{BC} **OR** attempt to find s_{AB} directly as $s_{AC} = 3.5 \times 4 + ½ \times a \times 4^2$ or ½ (4.5 – 2a + 4.5 + 2a) × 4 **or** add the 2 expressions found in **4(a)** for s_{AB} and s_{BC}
	$s_{AC} = 8 + {}^5/_4 \times 8 = 18$ m **OR** $s_{AC} = 10 + {}^4/_5 \times 10 = 18$ m	**A1**	
		2	

Question	Answer	Mark	Guidance
5(a)	[4 sin 30 + F sin 60 – 6 = 0]	**M1**	Resolve forces vertically and equate to zero
	Correct equation	**A1**	
	$F = 4.62$	**A1**	Allow $F = \frac{8}{\sqrt{3}}$ or $F = \frac{8}{3}\sqrt{3}$
		3	

Question	Answer	Marks	Guidance
5(b)	Resolve forces either vertically or horizontally	**M1**	
	$F\sin\alpha + 4\sin 30 - 6 = 0$ and $F\cos\alpha + 3 - 4\cos 30 = 0$	**A1**	Both equations correct $[F\sin\alpha = 4]$ $[F\cos\alpha = 0.464102...]$
	$[F^2 = 4^2 + 0.464^2]$ or $\left[F = \frac{4}{\sin 83.4} = \frac{0.464}{\cos 83.4}\right]$	**M1**	Attempt to solve for F using Pythagoras or from a value found for α
	$\left[\alpha = \tan^{-1}\left(\frac{4}{0.464}\right)\right]$ or $\left[\alpha = \sin^{-1}\left(\frac{4}{4.03}\right) = \cos^{-1}\left(\frac{0.464}{4.03}\right)\right]$	**M1**	Attempt to solve for α using trigonometry or from a value found for F
	$F = 4.03$ and $\alpha = 83.4$	**A1**	Both correct as shown [$F = 4.0268…$, α = 83.382…]
		5	

Question	Answer	Marks	Guidance
6(a)	[$T - 200 = 700 \times -12$] Car: $-T - 600 - F = 1600 \times -12$ System: $-600 - 200 - F = 2300 \times -12$	**M1**	Apply Newton's 2nd law to the trailer or apply Newton's 2nd law to the car and to the system and eliminate the braking force, *F*.
	Magnitude of $T = 8200$ N	**A1**	
		2	
6(b)	Car [$T - F - 600 = 1600 \times -12$] or System [$-600 - 200 - F = 2300 \times -12$]	**M1**	Apply Newton's second law either to the car or to the system with braking force = *F* and use of *their T* from **6(a)**
	Braking force $F = 26800$ N	**A1**	
		2	
6(c)	[$v^2 = 22^2 + 2 \times -12 \times 17.5$]	**M1**	A complete method using constant acceleration equations which would lead to an equation for finding v, using $u = 22$, $s = 17.5$ and $a = -12$
	$v = 8 \text{ ms}^{-1}$	**A1**	AG
		2	
6(d)	[$2300 \times 8 + m \times 0 = 2300 \times 2 + m \times 5$]	**M1**	For applying the conservation of momentum equation to the system of car, trailer and van, where m = mass of the van
		A1	Correct equation
	$m = 2760$ kg	**A1**	
		3	

Question	Answer	Marks	Guidance
7(a)	[$v = 2t - 3$]	**M1**	For differentiation of s for $0 \leqslant t \leqslant 6$
	$t = 1.5$	**A1**	
		2	
7(b)	Velocity at arrival = 9 ms^{-1}	**B1**	$t = 6$ used in v
	$v = -\dfrac{24}{t^2} - 0.5t$	**M1**	For differentiation of s for $t \geqslant 6$
	Velocity when leaves = –3.67 ms^{-1}	**A1**	Allow $v = -11/3$
		3	
7(c)	At $t = 0$, $s = 2$ **or** at $t = 6$, $s = 20$	**B1**	SOI
	At $t = 1.5$, $s = -0.25$	**B1**	SOI
	At $t = 10$, $s = 2.4$	**B1**	SOI
	[Total distance = 2 + 0.25 + 0.25 + 20 + (20 – 2.4)]	**M1**	Evidence of distance rather than displacement involving all three sections, (0, 1.5), (1.5, 6) and (6, 10)
	So total distance travelled = 40.1 m	**A1**	
		5	

Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

MATHEMATICS **9709/43**

Paper 4 **October/November 2019**

MARK SCHEME

Maximum Mark: 50

Published

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AWRT Answer Which Rounds To

Question	Answer	Marks	Guidance
1	$F=\mu\times 500g$	B1	Use of $F=\mu R$
	$[2500=\mu\times 500g]$	M1	Resolving horizontally
	$\mu=0.5$	A1	
		3	

Question	Answer	Marks	Guidance
2	PE gain $=150000g \times 500\sin\alpha$ $(=75000000g\sin\alpha)$	B1	Correct expression for PE gain
	$\frac{1}{2}\times 150000\times 45^2 - \frac{1}{2}\times 150000\times 42^2$ $(=19575000)$	B1	Correct expression for KE loss
		M1	For 5 term work energy equation (or 4 terms if using loss in KE as 1 term)
	$150000g \times 500\sin\alpha=19575000+16000\times 500 - 4\times 10^6$	A1	
	$\alpha=1.8$	A1	
		5	

Question	Answer	Marks	Guidance
3	Resolving horizontally or vertically	M1	
	50cos20 + 60 – 100sin30 (=56.984…)	A1	
	100cos30 – 50sin20 (= 69.501…)	A1	
	$R = \sqrt{(56.984...^2 + 69.501...^2)}$ or $\alpha = \tan^{-1}\left(\frac{56.984...}{69.501...}\right)$	M1	Method to find either R or α
	R=89.9 (89.876…)	A1	
	α=39.3 (39.348…)	A1	
		6	

Question	Answer	Marks	Guidance
4(i)	$s_{PQ} = 20\times 10 - 0.5a\times 10^2$ **or** $s_{QR} = 20\times 10 + 0.5a\times 10^2$	M1	For use of $s = vt - \frac{1}{2}at^2$ or $s = ut + \frac{1}{2}at^2$ OE suvat to find *PQ* or *QR*
	$s = 200 – 50a$ **and** $1.5s = 200 + 50a$	A1	OE
	$1.5(200 – 50a) = 200 + 50a \rightarrow 100 = 125a \rightarrow a = 0.8$ ms^{-2}	B1	AG
		3	
4(ii)	Distance $QS = 20\times 20 + \frac{1}{2}\times 0.8\times 20^2$	M1	Using $s = ut + \frac{1}{2}at^2$
	Distance=560 m	A1	
	Average speed between *Q* and $S = \frac{560}{20} = 28\,\text{ms}^{-1}$	B1	
		3	

Question	Answer	Marks	Guidance
5(i)	Driving force $= \frac{240}{6}$ (= 40 N)	**B1**	Use of power = force × velocity
	[40 – R = 80 × 0.3]	**M1**	Use of Newton's Second Law (3 terms)
	Resistance is 16 N	**A1**	AG
		3	
5(ii)	$\left[\frac{240}{v} = 16\right]$	**M1**	Use of $P=Fv$ with DF=resistance
	Steady speed is 15 ms^{-1}	**A1**	
		2	
5(iii)	Use of Newton's Second Law	**M1**	(4 terms)
	$\frac{240}{4} - 16 - 80g\sin 3 = 80a$	**A1**	
	Acceleration is 0.0266 ms^{-2}	**A1**	
		3	

Question	Answer	Marks	Guidance
Q6(i)	$10 = 0.04 \times 5^3 + 5^2 c + 5k$ $\quad (5c + k = 1)$	B1	Use of t=5, v=10
	$s = \frac{0.04}{4}t^4 + \frac{ct^3}{3} + \frac{kt^2}{2} + (C)$	*M1	For use of $s = \int v\mathrm{d}t$
	$25 = 0.01 \times 5^4 + \frac{5^3}{3}c + \frac{5^2}{2}k$	DM1	Use of t = 0, s = 0 and t = 5, s = 25
	$6.25 + \frac{125}{3}c + \frac{25}{2}k = 25$ $\quad \left(\frac{125}{3}c + \frac{25}{2}k = 18.75\right)$	A1	
	Solving for c or for k	M1	
	$c = -0.3$ and $k = 2.5$	A1	
		6	
Q6(ii)	$a = 0.12t^2 - 0.6t + 2.5$	M1	For use of $a = \frac{\mathrm{d}v}{\mathrm{d}t}$
	$a' = 0.24t - 0.6 = 0 \rightarrow t = \ldots$ **or** $a = 0.12(t^2 - 5t + \ldots) = 0.12\left[(t-2.5)^2 + \ldots\right]$	M1	Uses $\frac{\mathrm{d}a}{\mathrm{d}t} = 0$ or completes the square for a
	Minimum when $t = 2.5$	A1	AG
		3	

Question	Answer	Marks	Guidance
7(i)	$\left[0.81 = 0 + \frac{1}{2} \times a \times 0.9^2\right]$	**M1**	For use of $s = ut + \frac{1}{2}at^2$
	$a = 2$	**A1**	
	$T - mg = ma$ **or** $kmg - T = kma$	**M1**	Use of Newton's Second Law for A or B or use of $a = \frac{(m_B - m_A)g}{(m_B + m_A)}$
	$T - mg = ma$ **and** $kmg - T = kma$ or $\left[a = \frac{(km - m)g}{(km + m)}\right]$	**A1**	
	$a = \frac{(kg - g)}{(k + 1)} = 2 \to k = ...$	**M1**	Solves to find k
	$k = 1.5$	**A1**	
	$T = 10m + 2m = 12m$ N	**B1**	AG
		7	
7(ii)	Velocity of A when string breaks $= 2 \times 0.9$ (=1.8 ms^{-1} upwards)	**B1FT**	For use of $v=u+at$ ft a from **(i)**
	$v^2=1.8^2+2g\times1.62 \to v=...$	**M1**	For use of *suvat* to find v_A at ground
	Speed is 5.97 ms^{-1}	**A1**	AG
	Time taken $= \frac{(1.8 + 5.97)}{g} = 0.777s$ (0.7769...)	**B1**	
		4	

Question	Answer	Marks	Guidance
7(iii)	Straight line from (0, 0) to (0.9, 1.8)	**B1**	
	Straight line from (0.9, 1.8) to approx. (1.7, –6)	**B1FT**	FT 0.9 + *t* from **(ii)** for 1.7
		2	

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MATHEMATICS **9709/42**

Paper 4 **October/November 2019**

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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	Mark	Guidance
1	$(v =)\ 3t^2 - 12t + 4$	***M1**	Attempt at differentiation of s to find v
	$(a =)\ 6t - 12$	***M1**	Attempt at differentiation of v to find a
	[When $a = 0$, $t = 2$]	**DM1**	Solve to find t when $a = 0$ and find v at this time
	$v = -8\ \text{ms}^{-1}$	**A1**	
	Alternative method for question 1		
	$(v =)\ 3t^2 - 12t + 4$	**M1**	Attempt at differentiation of s to find v
	$(v =)\ 3(t-2)^2 - 8$ or $t = \frac{-b}{2a} = \frac{12}{6} = 2$	**M1**	For using the method of completing the square or using the value of '$\frac{-b}{2a}$' to find the t value of the minimum velocity
		M1	Use of the t value at minimum velocity to find v
	$v = -8\ \text{ms}^{-1}$	**A1**	
		4	

Question	Answer	Mark	Guidance
2(i)	$\frac{(12-V)}{(35-30)}=0.8$ or $12 = V + 0.8 \times 5$	**M1**	Use gradient of graph or constant acceleration formulae to set up an equation in V
	$V=8$	**A1**	
		2	
2(ii)	$\left[25\times 8+5\times 10+15\times 6+\frac{1}{2}\times (U+8)\times 5=375\right]$	**M1**	Attempt to find total distance travelled by the tractor in 50s to set up an equation for U using EITHER areas OR suvat equations OR a combination of areas and suvat In either case total distance must be attempted
		A1FT	Correct equation FT on *their* V from **(i)**
	$U=6$	**A1**	
		3	

Question	Answer	Mark	Guidance
3	$T_A \times \frac{4}{5} + T_B \times \frac{3}{5} + 0.3g = 5$	**M1**	Resolving vertically
	$T_A \times \frac{3}{5} = T_B \times \frac{4}{5}$	**M1**	Resolving horizontally
		A1	Both correct
		M1	Solve for T_A or T_B
	$T_A = 1.6$ N and $T_B = 1.2$ N	**A1**	
	Alternative method for question 3		
	$\left[\frac{5-3}{\sin 90} = \frac{T_A}{\sin 126.9} = \frac{T_B}{\sin 143.1}\right]$	**M1**	Attempt one pair of Lami's equations
		M1	Attempt a second pair of Lami equations
		A1	Equations all correct
		M1	Evaluate T_A or T_B
	$T_A = 1.6$ N and $T_B = 1.2$ N	**A1**	

Question	Answer	Mark	Guidance
3	**Alternative method for question 3**		
	$T_A = 5\cos 36.9 - 3\cos 36.9 = 5\times\frac{4}{5} - 3\times\frac{4}{5}$	**M1**	Resolve along *PA*
	$TB = 5\cos 53.1 - 3\cos 53.1 = 5\times\frac{3}{5} - 3\times\frac{3}{5}$	**M1**	Resolve along *PB*
		A1	Both correct
		M1	Evaluate T_A or T_B
	$T_A = 1.6$ N and $T_B = 1.2$ N	**A1**	
	Alternative method for question 3		
	Forces 2N, T_A and T_B with angles 36.9 and 53.1	**M1**	Attempt to illustrate a triangle of forces
	[$T_A = 2\cos 36.9$, $T_B = 2\cos 53.1$]	**M1**	Use trigonometry in the triangle to find T_A and T_B
		A1	Both correct
		M1	Solve for T_A or T_B
	$T_A = 1.6$ N and $T_B = 1.2$ N	**A1**	
		5	

Question	Answer	Mark	Guidance
4(i)	$P = 3000 \times 30$	**M1**	Use of $P = Fv$ with F = resistance
	$P = 90000$ W = 90kW	**A1**	
		2	
4(ii)	PE gained = $25000gh$	**B1**	Correct expression for PE Allow PE = 25 000 g d sin 2
	Initial KE $= \frac{1}{2} \times 25000 \times 30^2$ [= 11 250 000] Final KE $= \frac{1}{2} \times 25000 \times 25^2$ [= 7 812 500]	**B1**	For either correct [KE loss = 3 437 500]
	Initial KE = Final KE + $25000gh + \frac{3000h}{\sin 2}$ OR Initial KE = Final KE + $25000gd\sin 2 + 3000d$	**M1**	For a 4 term work-energy equation, correct dimensions
		A1	Correct work-energy equation involving h or d
	$h = 10.2$ m (10.2318…)	**A1**	
		5	

Question	Answer	Mark	Guidance
5(i)	$h_A = 20t - \frac{1}{2} \times 10t^2$ or $h_B = \pm\frac{1}{2} \times 10(t-1)^2$	B1	OE $h_A = 20(T+1) - \frac{1}{2} \times 10(T+1)^2$ or $h_B = \pm\frac{1}{2} \times 10T^2$
	[Meet when $20t - \frac{1}{2} \times 10t^2 + \frac{1}{2} \times 10(t-1)^2 = 40$]	*M1	Set up an equation using *their* h_A, *their* h_B and 40
	$10t - 35 = 0$	DM1	Solve for t and attempt to find the height at collision.
	$t = 3.5$ so height at collision = 8.75 m	A1	$T = 2.5$ and height at collision = 8.75 m
	Alternative method for question 5(i)		
	$h_A = 20 \times 1 - \frac{1}{2} \times 10 \times 1^2 = 15$, $v = 20 - 10 \times 1 = 10$	B1	Finding distance travelled by A and its speed after 1 second
	$H_A + H_B = 25$ $\left(10T - \frac{1}{2} \times 10 \times T^2\right) + \frac{1}{2} \times 10 \times T^2 = 25$	*M1	T is the time beyond 1s until the particles reach same level H_A and H_B are distances travelled by A and B in T seconds.
	[$10T = 25 \rightarrow T = 2.5$]	DM1	Solve for T and attempt to find the height at collision
	$t = 3.5$ so height = 8.75 m	A1	
		4	

Question	Answer	Mark	Guidance
5(ii)	$v_A = 20 - gt = -15$ **or** $v_A^2 = 20^2 + 2(-g)(8.75)$	**M1**	Use of *their t* or *their h* $\leqslant 20$ from **5(i)** in a constant acceleration formula which would lead to finding v_A
	$v_B = -g(t-1) = -25$ **or** $v_B^2 = 2(g)(40 - 8.75)$	**M1**	Use of *their t* ± 1 or *their* $40 - h$ from **5(i)** in a constant acceleration formula which would lead to finding v_B
	Difference = 10 ms^{-1}	**A1**	CWO
		3	

Question	Answer	Mark	Guidance
6(i)	$4.5 = 0 + \frac{1}{2} \times a \times 5^2$	**M1**	For use of $s = ut + \frac{1}{2}at^2$ to find a
	$a = 0.36$	**A1**	
	$6 \times \frac{24}{25} - F = 3 \times 0.36$	**M1**	Resolving horizontally. Allow use of $\theta = 16.3$
	$F = 4.68$ N	**A1**	
		4	
6(ii)	$R = 3g - 6\sin 16.3 = 3g - 6 \times \frac{7}{25}$ $[= 28.32]$	**B1**	
	$4.68 = \mu \times 28.32$	**M1**	Use of $F = \mu R$
	$\mu = 0.165$ (0.165254…)	**A1**	AG. Allow $\mu = \frac{39}{236}$
		3	

Question	Answer	Mark	Guidance
6(iii)	$v = 5 \times 0.36$ [= 1.8] or $v = \sqrt{(2 \times 0.36 \times 4.5)}\,[=1.8]$	B1FT	For velocity at $t = 5$ ft on *their* a from **6(i)**
	$3a = -0.165 \times 3g$	M1	Using Newton's second law with new frictional force
	$0 = 1.8 - 0.165gt$ $(t = 1.09)$	M1	Using constant acceleration equations which would lead to a positive value of t
	Total time = 5 + 1.09 = 6.09 s	A1	
		4	

Question	Answer	Mark	Guidance
7(i)		M1	Use of Newton's second law for P or Q or the system
	For P: $T - 0.3g \times \frac{3}{5} = T - 0.3g\sin 36.9 = 0.3a$ For Q: $0.2g - T = 0.2a$ System: $0.2g - 0.3g \times \frac{3}{5} = (0.2 + 0.3)a$ or $0.2g - 0.3g\sin 36.9 = (0.2 + 0.3)a$	A1	Two correct equations Allow use of $\theta = 36.9$
	$[0.2g - 0.18g = 0.5a]$	M1	For solving either the system for a or for solving a pair of simultaneous equations for a or T
	$a = 0.4$ ms^{-2}	A1	
	$T = 1.92$ N	A1	
		5	

Question	Answer	Mark	Guidance
7(ii)	$0.8 = 0 + \frac{1}{2} \times 0.4 \times t^2$ a	M1	For use of the constant acceleration equations with *their a* from **7(i)** and $a \neq \pm g$ for a complete method to find t
	$t = 2$ s	A1	
		2	
7(iii)	Speed when Q hits the floor = 2 × 0.4 (= 0.8) or $v = \sqrt{(2\times 0.4\times 0.8)}[= 0.8]$	B1FT	Using $v = u + at$ with $u = 0$ Allow FT for *their* unsimplified $v = at$ or $v^2 = 2as$ with a from **(i)**, t from **(ii)** and $s = 0.8$
	$-0.3g \times \frac{3}{5} = -0.3g \sin 36.9 = 0.3a$ $[a = -6]$	M1	Using Newton's second law for P to find $a \neq \pm g$
	$0 = 0.8t + \frac{1}{2} \times (-6)t^2 \,(t = 0.2666...)$ or $0 = 0.8 - 6T$ ($T = 0.13333 = \frac{2}{15}$ and $t = 2T = 0.26666 = \frac{4}{15}$)	M1	Use of the constant acceleration equation(s) to find the time taken for P to return to the position where the string first became slack.
	Total time = 2 + 0.266... = $2 + \frac{4}{15} = 2.27 = \frac{34}{15}$ s	A1	
		4	

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

MATHEMATICS **9709/41**

Paper 4 **October/November 2019**

MARK SCHEME

Maximum Mark: 50

Published

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

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

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

Cambridge International is publishing the mark schemes for the October/November 2019 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 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.

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.

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
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WWW	Without Wrong Working
AWRT	Answer Which Rounds To

Question	Answer	Marks	Guidance
1	$20\,000 = V \times 1250g$	**M1**	Use of $P = Fv$ with $F = mg$
	$V = 1.6$	**A1**	
		2	

Question	Answer	Marks	Guidance
2	Initial $KE = \frac{1}{2} \times 75 \times 10^2$ Final $KE = \frac{1}{2} \times 75 \times 5^2$	**B1**	Either correct
	PE gained $= 75g \times 700 \sin 1.5$ [=13 743]	**B1**	
	WD by $F = F \times 700$	**B1**	For WD by $F = F \times d$
	WD by F + Initial KE = Final KE + PE gain + 2000	**M1**	Use of work-energy equation. 5 dimensionally correct terms.
	$F = 18.5$	**A1**	
		5	

Question	Answer	Marks	Guidance
3(i)	$R = 3g\cos 60$	B1	
	Use $F = \mu R$	M1	
	$[3g\sin 60 - \mu 3g\cos 60 - 15 = 0]$	M1	Resolve forces parallel to the plane, 3 terms
		A1	Correct equation
	$\mu = 0.732$	A1	Allow $\mu = \sqrt{3} - 1$
		5	
3(ii)	[Maximum force = $3g\sin 60 + F$ $= 3\sin 60 + \mu 3g\cos 60$]	M1	
	$X = 37(.0)$	A1	Allow $X = 15\left(2\sqrt{3} - 1\right)$
		2	

Question	Answer	Marks	Guidance
4(i)	Apply Newton's second law to either or to the system	**M1**	
	Block *A*: $T - 4g \times \frac{7}{25} = 4a$ Block *B*: $36 - T - 5g \times \frac{7}{25} = 5a$ System: $36 - 5g \times \frac{7}{25} - 4g \times \frac{7}{25} = 9a$	**A1**	Any two correct. Allow α = 16.3 used.
	Either solving the system for *a* or solving a pair of simultaneous equations for either *a* or *T*	**M1**	
	$a = 1.2\ \text{ms}^{-2}$	**A1**	
	$T = 16$ N	**A1**	
		5	
4(ii)	$\left[0.65 = 1 \times t + \frac{1}{2} \times 1.2t^2\right]$	**M1**	Use constant acceleration equation(s) with $u = 1$ and solve a 3 term quadratic equation to find t
	$t = 0.5$ s	**A1**	
	Alternative method for question 4(ii)		
	$v^2 = 1^2 + 2 \times 1.2 \times 0.65$ [$v = 1.6$] and $0.65 = \frac{1}{2}(1 + v) \times t$	**M1**	Use relevant constant acceleration equations with $u = 1$ in a complete method to find t
	$t = 0.5$ s	**A1**	
		2	

Question	Answer	Marks	Guidance
5(i)	Resolve forces either horizontally or vertically	M1	
	$7.5\cos60 + 4.5\cos20 = F\cos\theta$ [= 7.97861]	A1	
	$7.5\sin60 - 4.5\sin20 = F\sin\theta$ [= 4.95609]	A1	
	$F = \sqrt{(7.98^2 + 4.96^2)}$	M1	Use Pythagoras or use the value found for θ to find F
	$\theta = \tan^{-1}(\frac{4.96}{7.98})$	M1	Use trigonometry or the value found for F to find θ
	$F = 9.39$ and $\theta = 31.8$	A1	
	Alternative method for question 5(i)		
	$\frac{F}{\sin 80} = \frac{4.5}{\sin(120+\theta)} = \frac{7.5}{\sin(160-\theta)}$	M1	Attempt to use Lami
		A1	One correct pair of terms
		A1	A second correct pair of terms
	$[4.5\sin(160 - \theta) = 7.5\sin(120 + \theta)]$	M1	Attempt to solve for θ
	Use the θ value found by valid trigonometry to find F	M1	
	$F = 9.39$ and $\theta = 31.8$	A1	

Question	Answer	Marks	Guidance
5(i)	**Alternative method for question 5(i)**		
	Forces 4.5, 7.5, F opposite angles $60 - \theta$, $\theta + 20$, 100	**M1**	Illustrate a triangle of forces
	$[F^2 = 4.5^2 + 7.5^2 - 2 \times 4.5 \times 7.5 \times \cos 100]$	**M1**	For application of cosine rule to find F
		A1	Correct equation
	$\left[\frac{9.39}{\sin 100} = \frac{4.5}{\sin(60-\theta)} = \frac{7.5}{\sin(\theta+20)}\right]$	**M1**	One application of the sine rule to find θ
		A1	Correct equation
	$F = 9.39$ and $\theta = 31.8$	**A1**	
		6	
5(ii)	$9.5\cos 30 - 7.5\cos 60 - 4.5\cos 20 = m \times 1.5$	**M1**	Apply Newton's second law to the ring along AB (4 terms)
	$m = 0.166$ kg	**A1**	
		2	

Question	Answer	Marks	Guidance
6(i)	$0.4g \times 1.8 = \frac{1}{2} \times 0.4 \times v^2$	M1	KE gain = PE lost
	$v = 6 \text{ ms}^{-1}$	A1	
	Alternative method for question 6(i)		
	$v^2 = 0^2 + 2 \times g \times 1.8$	M1	Use constant acceleration equation(s) with $a = g$ to find v
	$v = 6 \text{ ms}^{-1}$	A1	
		2	
6(ii)	$0.4g - 5.6 = 0.4a$	M1	Use Newton's second law for the particle in the vertical (3 terms)
	$a = -4 \text{ ms}^{-2}$	A1	
	$0 = 6 - 4t$	M1	Use of constant acceleration equation(s) such as $v = u + at$ to find t
	$t = 1.5$ s	A1	
		4	
6(iii)	Straight line starting at (0,0) with positive gradient	B1	
	Second straight line starting at end of the first line with negative gradient and ending with $v = 0$	B1	
	All correct, start at (0, 0) with max velocity $v = 6$ at $t = 0.6$ i.e. (0.6, 6) and finishing at (2.1, 0)	B1FT	FT on *their* v from **(i)** and/or *their* t from **(ii)**
		3	

Question	Answer	Marks	Guidance
7(i)	$0.6t^2 - 0.12t^3 = 0$	**M1**	For attempting to solve $v = 0$
	$(t = 0$ or$)$ $t = 5$	**A1**	
	$\int v \, dt = 0.2t^3 - 0.03t^4$	***M1**	For integrating the velocity
	$OP = [0.2 \times 5^3 - 0.03 \times 5^4] - [0]$	**DM1**	Use limits to find OP
	Distance = 6.25 m	**A1**	AG
		5	
7(ii)	$k \times 5^3 + c \times 5^5 = 6.25$	**B1**	Using $s = 6.25$ at $t = 5$ to set up equation in k and c
	$v = 3kt^2 + 5ct^4$	***M1**	For differentiating s to find v
	$1.25 = 3k \times 5^2 + 5c \times 5^4$	**DM1**	For using the given value of $v = 1.25$ in the expression for v
	$125k + 3125c = 6.25$ $75k + 3125c = 1.25$	**M1**	For attempting to solve a pair of simultaneous equations in k and c and finding a value of either k or c
	$k = 0.1$, $c = -0.002$	**A1**	
		5	
7(iii)	$a = 0.6t - 0.04t^3$	**M1**	For differentiating their expression for v
	At $t = 5$, $a = -2$ Acceleration $= -2$ ms^{-2}	**A1**	
		2	

Cambridge International AS & A Level

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Cambridge International Advanced Subsidiary and Advanced Level

MATHEMATICS **9709/43**

Paper 4 **May/June 2019**

MARK SCHEME

Maximum Mark: 50

Published

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

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 Cambridge Assessment International Education

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.

Mark Scheme Notes

Marks are of the following three types:

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.

- 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 (or dep*) 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.

- The symbol 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 and B marks are not given for fortuitously "correct" answers or results obtained from incorrect working.

  - Note: B2 or A2 means that the candidate can earn 2 or 0.
    B2/1/0 means that the candidate can earn anything from 0 to 2.

  The marks indicated in the scheme may not be subdivided. If there is genuine doubt whether a candidate has earned a mark, allow the candidate the benefit of the doubt. Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored.

- Wrong or missing units in an answer should not lead to the loss of a mark unless the scheme specifically indicates otherwise.

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The following abbreviations may be used in a mark scheme or used on the scripts:

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)
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PA –1	This is deducted from A or B marks in the case of premature approximation. The PA –1 penalty is usually discussed at the meeting.

Question	Answer	Marks	Guidance
1	Trapezium	**B1**	Includes (0,0) and (...,0)
	(t = 0), t = 5, t = 29, t = 35	**B1**	Correct trapezium with key time values
	$v_{max} = 2.1 \times 5 = 10.5 \text{ ms}^{-1}$	**B1**	
	[½ × (24 + 35) × 10.5] or [½ × 5 × 10.5 + 24 × 10.5 + ½ × 6 × 10.5]	**M1**	Use of area property to find distance
	309.75 m or 310 m	**A1**	
		5	

Question	Answer	Marks	Guidance
2(i)	[24cos25° – 12cos65°]	**M1**	Resolving in x-direction
	16.7 N	**A1**	(16.679...)
	[30 – 24sin25° – 12sin65°]	**M1**	Resolving in y-direction
	8.98 N	**A1**	(8.981...)
		4	
2(ii)	$\left[\tan^{-1}\dfrac{8.98....}{16.67....}\right]$	**M1**	Uses trigonometry to find the angle
	28.3° (anticlockwise) from x-direction	**A1**	(28.300...) or equivalent
		6	

Question	Answer	Marks	Guidance
3(i)		**M1**	Use of Newton's Second Law (4 terms)
	$DF - 1550 - 1400g\sin 4° = 1400 \times 0.4$	**A1**	$(DF = 3086.59...)$
	$[30000 = (1400 \times 0.4 + 1550 + 1400g\sin 4°)v]$	**M1**	Use of $P = Fv$
	$v = 9.72 \text{ ms}^{-1}$	**A1**	
		4	
3(ii)	$[DF - 1550 - 1400g\sin 4° = 0]$	**M1**	$(DF = 2526.59...)$ Resolving up the hill
	$[P_{max} = (1550 + 1400g\sin 4°) \times 40]$	**M1**	Use of $P = Fv$
	$P = 101000$ W or 101 kW	**A1**	$(P = 101063.6...)$
		3	

Question	Answer	Marks	Guidance
4(i)	Particle A: $[1.3g - T = 1.3a]$ or Particle B: $[T - 0.7g = 0.7a]$	M1	Use of Newton's Second law for A or B or use of $a = (m_A - m_B)g/(m_A + m_B)$
	$1.3g - T = 1.3a$ and $T - 0.7g = 0.7a$ OR $a = \dfrac{(1.3-0.7)g}{(1.3+0.7)}$ and $1.3g - T = 1.3a$ or $T - 0.7g = 0.7a$	A1	Two correct equations
	$[6 = 2a, a = 3]$ or $[\dfrac{1.3g - T}{1.3} = \dfrac{T - 0.7g}{0.7}, T = 9.1]$	M1	Solves for a or for T
	$a = 3\text{ ms}^{-2}$ and $T = 9.1$ N	A1	$(a = 3)$
		4	
4(ii)	Distance while connected = 0.375 m	B1	
	$[v^2 = 0^2 + 2 \times 3 \times 0.375 \rightarrow v = ...]$	M1	Use of *suvat* to find v at 'break' $(v^2 = 2as)$
	$v = 1.5\text{ ms}^{-1}$	A1	Correct value or expression for v
	$[A: \ 1.375 = 1.5t + ½ gt^2 \rightarrow t = 0.395...]$	M1	Finds one time 'from break to floor'
	$[B: \ 1.375 = -1.5t + ½ gt^2$ or $-1.375 = 1.5t - ½ gt^2 \rightarrow t = 0.695...]$	M1	Finds second time 'from break to floor'
	Difference in times = 0.3 s	A1	
	Alternative Method 1 for 4(ii) (last 3 marks)		
	$[u_B = 1.5, v_B = 0, a = -g, 0 = 1.5 - gt \rightarrow t = 0.15]$	M1	Finds t_B from 'break' to maximum height
	Difference in times = 2 × 0.15	M1	
	Difference in times = 0.3 s	A1	

Question	Answer	Marks	Guidance
4(ii)	**Alternative Method 2 for 4(ii) (last 3 marks)**		
	[A: $0.375 = ½ \times 3t^2 \rightarrow t = 0.5$ $1.375 = 1.5t + ½\,gt^2 \rightarrow t = 0.395...$ t_A total = 0.5 + 0.395... = 0.895... s]	**M1**	Use of *suvat* to find total time for *A*
	[B: $0.375 = ½ \times 3t^2 \rightarrow t = 0.5$; $0 = 1.5 - gt \rightarrow t = 0.15$, $s = 1.5t - 1/2gt^2 = 0.1125$ $1.4875 = ½ \times gt^2 \rightarrow t = 0.545...$ t_B total = 1.195 s]	**M1**	Use of *suvat* to find total time for *B*
	Difference in times = 0.3 s	**A1**	
		6	

Question	Answer	Marks	Guidance
5(i)	(PE gain =) $18gd\sin30°$ **or** (KE loss =) $½ \times 18 \times 20^2$	**B1**	
	(PE gain =) $18gd\sin30°$ **and** (KE loss =) $½ \times 18 \times 20^2$	**B1**	
	[$18gd\sin30° = ½ \times 18 \times 20^2$] **or** [$18gh = ½ \times 18 \times 20^2$]	**M1**	Energy equation (PE gain = KE loss)
	Distance up plane = 40 m	**A1**	
		4	
5(ii)	$R = 18g\cos30°$ ($90\sqrt{3}$ or 155.884...)	**B1**	
	[$F = 0.25(18g\cos30°)$] ($45\sqrt{3}/2$ or 38.971...)	**M1**	Use of $F = \mu R$
	[$18g\sin30° + 0.25(18g\cos30°) = -18a \rightarrow a = ...$] ($a = -7.165..$)	**M1**	Newton's Second Law (3 term equation)
	[$0^2 = 20^2 + 2 \times -7.165.. \times s \rightarrow s = ...$]	**M1**	Use of *suvat* to find *s*
	$s = 27.913...$	**A1**	

Question	Answer	Marks	Guidance
5(ii)	[$18g\sin30° - 0.25(18g\cos30°) = 18a \rightarrow a = ...$]	M1	($a = 2.835..$) – Newton's Second Law (3 term equation)
	[$v^2 = 0^2 + 2 \times 2.835.. \times 27.913.. \rightarrow v = ...$]	M1	Use of *suvat* to find s
	$v = 12.6$ ms^{-1}	A1	(12.580...)
	Alternative Method 1 for 5(ii)		
	$R = 18g\cos30°$ ($90\sqrt{3}$ or 155.884...)	B1	
	[$F = 0.25(18g\cos30°)$] ($45\sqrt{3}/2$ or 38.971...)	M1	Use of $F = \mu R$
	[KE gain = $\frac{1}{2} \times 18 \times 20^2$ and PE loss = $18gh$ or $18gs(\sin30°)$]	M1	Use of KE = $1/2\ mv^2$ and PE = mgh
	[$\frac{1}{2} \times 18 \times 20^2 = 18gs(\sin30°) + 45\cos30° \times s$]	M1	Work / Energy equation (up plane)
	$s = 27.913...$	A1	
	[WD = $45\cos30° \times 27.91...$]	M1	Work done against friction
	[$\frac{1}{2} \times 18v^2 = (18g\sin30°) \times 27.91.. - 45\cos30° \times 27.91...$]	M1	Work / Energy equation (down plane)
	$v = 12.6$ ms^{-1}	A1	(12.580...)
	Alternative Method 2 for 5(ii) (last 3 marks)		
	[WD = $2 \times 45\cos30° \times 27.91...$]	M1	WD against friction (up and down)
	[$\frac{1}{2} \times 18 \times 20^2 - \frac{1}{2} \times 18v^2 = 2 \times 45\cos30° \times 27.91...$]	M1	Uses KE loss = total WD against friction
	$v = 12.6$ ms^{-1}	A1	(12.580...)
		8	

Question	Answer	Marks	Guidance
6(i)	[$v = 6t^2/2 - 12t + C$] $v = 3t^2 - 12t + C$	*M1	Use of $v = \int a\,dt$
	[$s = 3t^3/3 - 12t^2/2 + Ct + D$] $s = t^3 - 6t^2 + Ct + D$	*M1	Use of $s = \int v\,dt$
	[$5 = 1 - 6 + C + D$ $C + D = 10$ $1 = 27 - 54 + 3C + D$ $3C + D = 28$ $\rightarrow$ $C = ...$, $D = ...$]	DM1	Substitutes for s and t and solves equations. Dependent on both Ms.
	$s = t^3 - 6t^2 + 9t + 1$ or $p = 9$, $q = 1$	A1	
		4	
6(ii)	[$v = 0$, $3t^2 - 12t + 9 = 0\,(t-1)(t-3) = 0$ $\rightarrow$ $t = ...$]	M1	Solves $v = 0$ to find t values
	$t = 1$ or $t = 3$	A1	
		2	
6(iii)	[$\int_0^1 v\,dt + \int_1^3 v\,dt + \int_3^4 v\,dt$]	M1	Attempts to use at least three t intervals
	[For $0 \leqslant t \leqslant 1$, $s = (1 - 6 + 9 + 1) - 1 = 4$]	M1	Evaluates s for one time interval
	[$0 \leqslant t \leqslant 1$, $s = (1 - 6 + 9 + 1) - 1 = \mathbf{4}$; $1 \leqslant t \leqslant 3$, $s = (27 - 54 + 27 + 1) - 5 = {}^{-}\mathbf{4}$ $3 \leqslant t \leqslant 4$, $s = (64 - 96 + 36 + 1) - 1 = \mathbf{4}$]	A1	Correctly finds all at least two distances (ignoring signs)
	Total distance is 12 m	A1	
		4	

Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

MATHEMATICS **9709/42**

Paper 4 **May/June 2019**

MARK SCHEME

Maximum Mark: 50

Published

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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 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.

Mark Scheme Notes

Marks are of the following three types:

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.

- 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 (or dep*) 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.

- The symbol 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 and B marks are not given for fortuitously "correct" answers or results obtained from incorrect working.

  - Note: B2 or A2 means that the candidate can earn 2 or 0.
    B2/1/0 means that the candidate can earn anything from 0 to 2.

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Question	Answer	Marks	Guidance
1	[$P\cos\theta = 32\cos 20 - 17\sin 55$] [$P\sin\theta = 40 + 17\cos 55 - 32\sin 20$]	**M1**	Resolve forces horizontally or vertically 3 terms horizontally, 4 terms vertically
		A1	One correct
		A1	Both correct [$P\sin\theta = 38.8062$ $P\cos\theta = 16.1446$]
	$P = \sqrt{(17\cos 55 - 32\sin 20 + 40)^2 + (32\cos 20 - 17\cos 35)^2}$	**M1**	Either use Pythagoras to find P or use their value of θ to find P
	$\theta = \tan^{-1}\left[\frac{(17\cos 55 - 32\sin 20 + 40)}{(32\cos 20 - 17\cos 35)}\right]$	**M1**	Either use trigonometry to find θ or use their value of P to find θ [$\tan\theta = 2.4037$]
	$P = 42(.0)$ **and** $\theta = 67.4$	**A1**	
		6	

Question	Answer	Marks	Guidance
2	Possible equations include: $t = 0$ to $t = 5$ → $80 = 5u + 12.5a$ $t = 0$ to $t = 8$ → $160 = 8u + 32a$ $t = 5$ to $t = 8$ → $80 = 3(u + 5a) + 4.5a$ i.e. $80 = 3u + 19.5a$	**M1**	Use the equation $s = ut + ½at^2$ to set up one equation in u and a or using speeds as u (at $t = 0$), $u + 5a$ (at $t = 5$), $u + 8a$ (at $t = 8$) and then apply $s = ½ \times (u + v) \times t$
	$80 = 5u + ½ \times a \times 5^2$ → $5u + 12.5a = 80$	**A1**	One correct equation in a and u
	$160 = 8u + 0.5a \times 8^2$ → $8u + 32a = 160$	**A1**	Second correct equation in a and u
		M1	Attempt to solve a pair of valid simultaneous equations for a or u
	$a = \frac{8}{3}$	**A1**	Allow $a = 2.67$
	$u = \frac{28}{3}$	**A1**	Allow $u = 9.33$
		6	

Question	Answer	Marks	Guidance
3	$R = 13g\cos 22.6 = 13g \times (12/13)$, $[R = 120]$	B1	Resolve perpendicular to the plane
	$F = 0.3 \times 13g\cos 22.6$ $[F = 36]$	M1	Using $F = \mu R$
	$T = F + 13g\sin 22.6 = F + 13g \times (5/13)$, $[T = 86]$	M1	Apply Newton's second law parallel to the plane with $a = 0$
	WD = $T \times 2.5$ [= 86 × 2.5]	M1	WD = $T \times d$
	WD = 215 J	A1	
	Alternative method for question 3		
	$R = 13g\cos 22.6 = 13g \times (12/13)$, $[R = 120]$	B1	Resolve perpendicular to the plane
	$F = 0.3 \times 13g\cos 22.6$ $[F = 36]$	M1	Using $F = \mu R$
	PE gain = $13 \times g \times 2.5 \times (5/13)$ [= 125]	M1	Attempt PE gain. Allow sin 22.6 for 5/13
	[WD by $T = 13 \times g \times 2.5 \times (5/13) + F \times 2.5$]	M1	Using WD by T = PE gain + WD against F
	WD by T = 215 J	A1	
		5	

Question	Answer	Marks	Guidance
4	[1200 – 350 – 1250 × 10 × 0.05 = 1250a]	**M1**	Apply Newton's second law for motion up the hill
	[a = 225/1250 = 0.18]	**A1**	Correct Newton's law for motion up the hill
	[1200 – 350 + 1250 × 10 × 0.05 = 1250a]	**M1**	Apply Newton's second law for motion down the hill
	[a = 1475/1250 = 1.18]	**A1**	Correct Newton's law for motion down the hill
	Up the hill: $v^2 = 0 + 2 \times 0.18 \times 100$ Down the hill: $v^2 = 0 + 2 \times 1.18 \times 100$	**M1**	Use their a in the constant acceleration equations either to find v going up or going down the hill
	Up the hill: $v = 6$ ms^{-1}	**A1**	
	Down the hill: $v = 15.4$ ms^{-1}	**A1**	Allow $v = 2\sqrt{59}$
	Alternative method for question 4		
	[1200 × 100 = 350 × 100 + 1250g × 100 × 0.05 + ½ × 1250 × v^2]	**M1**	Attempt the work-energy equation for motion up the hill
		A1	Correct work-energy equation for motion up the hill
	[1200 × 100 + 1250g × 100 × 0.05 = 350 × 100 + ½ × 1250 × v^2]	**M1**	Attempt work-energy equation for motion down the hill
		A1	Correct work-energy equation for motion down the hill
		M1	Attempt to solve either energy equation to find either v going up the hill or v going down the hill
	Up the hill: $v = 6$ ms^{-1}	**A1**	
	Down the hill: $v = 15.4$ ms^{-1}	**A1**	Allow $v = 2\sqrt{59}$
		7	

Question	Answer	Marks	Guidance
5(i)	*A*: $4 - T = 0.4a$ *B*: $T - 2 = 0.2a$ System: $4 - 2 = (0.4 + 0.2)a$	**M1**	Apply Newton' second law to particle *A* (3 terms) or to particle *B* (3 terms) or to the system (4 terms implied)
		A1	Two correct equations
		M1	Either solve the system equation for *a* or solve two simultaneous equations for *a* or *T* or verify the given value of *a* by finding the same *T* value in both equations
	$a = \frac{10}{3}$, $T = \frac{8}{3}$	**A1**	Both correct **AG**
		4	
5(ii)		**M1**	Apply $v^2 = u^2 + 2as$ to particle *A* or particle *B* with $a = 10/3$
	$v^2 = 0 + 2 \times 10/3 \times 0.5$	**A1**	[$v = 1.83$ but not needed specifically]
	$0 = 10/3 - 2 \times 10 \times s$ [$s = \frac{1}{6}$]	**M1**	Apply $v^2 = u^2 + 2as$ to particle *B* to find *s*, the distance travelled by *B* after *A* has hit the ground
	Maximum height = $\frac{7}{6}$ = 1.17 m	**A1**	Maximum height = 1/2 + 1/2 + 1/6 = 7/6 = 1.17
		4	

Question	Answer	Marks	Guidance
6	Case 1: DF = 36000/18 or Case 2: DF = 21000/12	**B1**	DF = P/v in either case
	$18A + B$ = DF [$36000/18 = 18A + B = 2000$]	**M1**	Use DF = resistance (case 1)
	$18A + B = 2000$ oe	**A1**	Correct equation, unsimplified
	$12A + B$ = DF + weight component [$21000/12 = 12A + B + 1000\,g \times 1/20$]	**M1**	Use DF = resistance + weight component (case 2)
	$12A + B = 1250$ oe	**A1**	Correct equation, unsimplified
		DM1	Solve two simultaneous equations in A and B only for A or B Dependent on both previous M1's
	$A = 125$, $B = –250$	**A1**	Both correct
		7	

Question	Answer	Marks	Guidance
7(i)	Straight line, reaching positive v-axis and positive t-axis (negative gradient)	**B1**	
	Quadratic (U shape, through (0,0) and cutting t-axis at $t < 5$)	**B1**	
	Fully correct graphs with correct labelling with $t = 3$, $t = 5$, $v = 10$, $v = 60$ seen	**B1**	
		3	
7(ii)	$s = \int(10 - 2t)\,dt = 10t - t^2$ $(+ c)$ or use area of a triangle ½ × 10 × 5 [= 25]	**B1**	Use either integration to find s for Q or use a correct formula to find the area under the relevant triangle
		M1	Use integration to find the displacement for P
	$s = \int(6t^2 - 18t)\,dt = 2t^3 - 9t^2\,(+c)$	**A1**	Correct integration for P (unsimplified)
	$s(P) = \left[2t^3 - 9t^2\right]_0^5 = 25$ or solve $10t - t^2 = 2t^3 - 9t^2$	**B1**	**Either** evaluation of $s(P)$ at $t = 5$ and show that at $t = 5$, $s(P) = s(Q) = 25$ **or** show that $t = 5$ is a solution of the cubic by solving **or** verify $t = 5$ is a solution of the cubic by substitution.
		4	

Question	Answer	Marks	Guidance
7(iii)	Distance $PQ = \|s_P - s_Q\| = \pm(2t^3 - 8t^2 - 10t)$	**M1**	Find the distance between P and Q Allow either sign s_P and s_Q must have been found by integration
	Maximum s if $6t^2 - 16t - 10 = 0$	**M1**	Differentiate to obtain an equation in t and attempt to solve
	$t = 3.19$	**A1**	
	Maximum Distance $PQ = (–)48.4$ m	**A1**	
	Alternative method for question 7(iii)		
	$6t^2 - 18t = 10 - 2t$	**M1**	State that greatest distance between P and Q occurs when $v_P = v_Q$
	$6t^2 - 16t - 10 = 0$	**M1**	Rearrange and attempt to solve for t
	$t = 3.19$	**A1**	
	Maximum Distance $PQ = (–)48.4$ m	**A1**	
		4	

Cambridge International AS & A Level

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MATHEMATICS **9709/41**

Paper 4 **May/June 2019**

MARK SCHEME

Maximum Mark: 50

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Cambridge Assessment International Education

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

Mark Scheme Notes

Marks are of the following three types:

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.

- 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 (or dep*) 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.

- The symbol 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 and B marks are not given for fortuitously “correct” answers or results obtained from incorrect working.

  - Note: B2 or A2 means that the candidate can earn 2 or 0.
    B2/1/0 means that the candidate can earn anything from 0 to 2.

  The marks indicated in the scheme may not be subdivided. If there is genuine doubt whether a candidate has earned a mark, allow the candidate the benefit of the doubt. Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored.

- Wrong or missing units in an answer should not lead to the loss of a mark unless the scheme specifically indicates otherwise.

- For a numerical answer, allow the A or B mark if a value is obtained which is correct to 3 s.f., or which would be correct to 3 s.f. if rounded (1 d.p. in the case of an angle). As stated above, an A or B mark is not given if a correct numerical answer arises fortuitously from incorrect working. For Mechanics questions, allow A or B marks for correct answers which arise from taking g equal to 9.8 or 9.81 instead of 10.

Question	Answer	Mark	Guidance
1	(X =) 78 × 5/13 – 50 × 3/5 = 78 cos 67.4 – 50 cos 53.1 (Y =) 78 × 12/13 + 50 × 4/5 – 112 = 78 sin 67.4 + 50 sin 53.1 – 112	M1	Attempt to resolve forces either horizontally (2 terms) or vertically (3 terms)
	[X = 30 – 30 = 0 Y = 72 + 40 – 112 = 0]	A1	Correct expressions horizontally and vertically
	X = 0 and Y = 0	A1	From convincing exact calculations
	Alternative method for question 1		
	$$\frac{112}{\sin 59.5} = \frac{50}{\sin 157.4} = \frac{78}{\sin 143.1}$$	M1	Attempt to use Lami, one pair of terms
		A1	All terms correct
	$$\frac{112}{56/65} = \frac{50}{5/13} = \frac{78}{3/5} = 130$$	A1	Exact values seen and used and shown to be = 130 cos [180 – (θ + α)] = 33/65 and sin [180 – (θ + α)] = 56/65
		3	

Question	Answer	Mark	Guidance
2(i)	[0 = 25 – 10t]	M1	Use of $v = u + at$ with u = 25, v = 0 and $a = -g$ or other complete method for finding t to highest point
	t = 2.5	A1	
		3	

Question	Answer	Mark	Guidance
2(ii)	[$20 = 25t - ½ gt^2$]	**M1**	Applying $s = ut + ½at^2$ with $s = 20$, $u = 25$
	[$t = 1$ and $t = 4$]	**M1**	Solve a 3-term quadratic for t, factorising or formula
	Required time = 4 – 1 = 3 seconds	**A1**	
	Alternative method for question 2(ii)		
	[$v^2 = 25^2 + 2 \times (-10) \times 20 \quad \rightarrow \quad v = \pm 15$]	**M1**	Using $v^2 = u^2 + 2as$ with $u = 25$, $s = 20$ and $a = -g$
	[$-15 = 15 - 10T$] or equivalent	**M1**	Use v at $s = 20$ to find the time, T, taken to reach the maximum height and to return to $s = 20$
	Required time = 1.5 + 1.5 = 3 seconds	**A1**	
		3	
2(iii)	Max height reached at 2.5 s, hence reaches h after 2 s $h - 3 = 25 \times 2 - 5 \times 2^2$	**M1**	Using their t from 2(i) – 0.5 in $s = ut + ½at^2$ Allow finding h without taking note of the additional 3 m
	$h = 33$ m	**A1**	
	Alternative method for question 2(iii)		
	Maximum height = $½ \times (25 + 0) \times 2.5$ [= 31.25] o.e. In 0.5 s it falls distance $½ \times 10 \times 0.5^2$ [= 1.25]	**M1**	For attempting to find both the maximum height and the distance fallen in 0.5 seconds
	$h = 31.25 - 1.25 + 3 = 33$ m	**A1**	
		2	

Question	Answer	Mark	Guidance
3(i)	DF = 1500 + 12 000 × g × 0.08 [DF = 11100]	M1	Using DF = Resistance + weight component (3 terms)
	Power = DF × 5	M1	Using $P = Fv$ (their 2 term DF × 5)
	Power = 11 100 × 5 = 55.5 kW	A1	**AG**
		3	
3(ii)	$k \times 5^2 = 1500$, $k = 60$	B1	**AG**
		1	
3(iii)	DF = $60v^2$	B1	Using DF = resistance = $60v^2$
	55500 = DF × v = $60v^2 \times v = 60v^3$	M1	$P = Fv$ used and attempt to solve a 2-term cubic equation for v
	v = 9.74 ms^{-1}	A1	
		3	

Question	Answer	Mark	Guidance
4(i)	R = 13 cos 67.4 = 13 (5/13) [R = 5]	B1	Resolve forces perpendicular to plane. Allow 67.4 used
	F + 13 sin 67.4 = F + 13(12/13) = 20 [F = 8]	B1	Resolve forces parallel to plane. Allow 67.4 used
		M1	Use $F = \mu R$
	μ = 8/5 = 1.6	A1	**AG** Must be from exact working here
		4	

Question	Answer	Mark	Guidance
4(ii)	$13 \sin 67.4 - F = 1.3a$ $F = \mu R = 8 \quad \rightarrow \quad [4 = 1.3a]$	**M1**	For applying Newton's second law along the plane and also using $F = \mu R$ (3 terms)
	$a = 3.08 \text{ ms}^{-2}$	**A1**	Allow $a = 40/13$
		2	
4(iii)	$s = 0 + 0.5 \times (40/13) \times 2^2$ [= 80/13 = 6.15]	**M1**	Use $s = ut + \frac{1}{2}at^2$ with $u = 0$ and their $a \neq \pm g$ to find the distance moved in the first 2 seconds
	WD = 8 × 6.15	**M1**	WD = $F \times d$
	WD = 49.2 J	**A1**	Allow WD = 640/13 J
	Alternative method for question 4(iii)		
	$s = 0 + 0.5 \times (40/13) \times 2^2$ [= 80/13 = 6.15]	**M1**	
	[$v = (40/13) \times 2$] and [WD = $1.3g(80/13)(12/13) - \frac{1}{2} \times 1.3 \times (80/13)^2$]	**M1**	Finding v after 2 seconds and using WD = PE loss – KE gain
	WD = 49.2 J	**A1**	Allow WD = 640/13 J
		3	

Question	Answer	Mark	Guidance
5(i)	$a = 2t - 8$	**M1**	Differentiate to find a
	$a = 0 \rightarrow t = 4$	**M1**	Set $a = 0$ and solve for t
	Minimum $v = -4\ \text{ms}^{-1}$	**A1**	Full marks available for correct use of a v-t graph or correct use of "$t = -b/2a$"
	Alternative method for question 5(i)		
	$v = (t-4)^2 - 4$	**M1**	Attempt to complete the square for v
	[$t = 4$]	**M1**	Choose the t value which gives minimum v
	Minimum $v = -4\ \text{ms}^{-1}$	**A1**	
		3	
5(ii)	$v = 0$ when $(t-2)(t-6) = 0$	**M1**	Find values of t when $v = 0$, factorise or formula
	$t = 2$ or $t = 6$	**A1**	
	[$s = \frac{1}{3}t^3 - 4t^2 + 12t\ (+c)$]	**M1**	Integrate v to find s
		A1	Correct integration
	$0 \le t \le 2$ $s_1 = 8/3 - 16 + 24 = 32/3$ $2 \le t \le 6$ $s_2 = (216/3 - 144 + 72) - (8/3 - 16 + 24) = -32/3$ $6 \le t \le 8$ $s_3 = (512/3 - 4 \times 8^2 + 12 \times 8) - (216/3 - 144 + 72) = 32/3$	**M1**	Attempt to find s_1, s_2 and s_3 Look for consideration of the need for 3 intervals Allow use of symmetry when finding s_1, and s_3
		A1	2 correct values of displacement
	Total distance = 32 m	**A1**	All correct
		7	

Question	Answer	Mark	Guidance
6(i)	Particle A: $T = 4 \sin \theta$ Particle B: $T = 2$	**M1**	Resolve forces for A and for B
		M1	Eliminate T and solve for θ
	$\theta = 30$	**A1**	
		3	
6(ii)(a)	A: $T - 4 \sin 20 = 0.4a$ B: $2 - T = 0.2a$ System: $2 - 4 \sin 20 = (0.4 + 0.2)a$	**M1**	Apply Newton's second law to A or to B or to the system
		A1	Two correct equations
		M1	Solve for a or T
	$T = 1.79$ and $a = 1.05$	**A1**	Both correct
		4	
6(ii)(b)	$v^2 = 2 \times 1.053 \times 0.5 = 1.053$	**M1**	Attempt to find v using their $a \neq \pm g$
	$v = 1.03 \text{ ms}^{-1}$	**A1**	
		2	

Question	Answer	Mark	Guidance
6(ii)(c)	Loss in KE = ½ × 0.4 × 1.053 = 0.2106 Gain in PE = 0.4 × 10 × *d* sin 20	**M1**	Attempt KE loss or PE gain for particle *A* only after particle *B* hits the ground.
		A1ft	Both correct, *d* is distance moved up the plane after *B* hits ground
	½ × 0.4 × 1.053 = 0.4 × 10 × *d* sin 20	**M1**	Apply KE loss = PE gain
		A1	**FT** Correct energy equation
	Total dist *A* moves up plane = 0.5 + *d* = 0.654 m	**A1**	
		5	

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

MATHEMATICS **9709/42**

Paper 4 Mechanics **March 2019**

MARK SCHEME

Maximum Mark: 50

Published

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The following abbreviations may be used in a mark scheme or used on the scripts:

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 – often written by a 'fortuitous' answer
ISW	Ignore Subsequent Working
SOI	Seen or implied
SR	Special Ruling (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)

Penalties

MR –1	A penalty of MR –1 is deducted from A or B marks when the data of a question or part question are genuinely misread and the object and difficulty of the question remain unaltered. In this case all A and B marks then become "follow through" marks. MR is not applied when the candidate misreads his own figures – this is regarded as an error in accuracy. An MR –2 penalty may be applied in particular cases if agreed at the coordination meeting.
PA –1	This is deducted from A or B marks in the case of premature approximation. The PA –1 penalty is usually discussed at the meeting.

Question	Answer	Marks	Guidance
1	$R = 2.5 \cos 15$	**B1**	
	$[F = \mu \times 2.5 \cos 15]$	**M1**	Using $F = \mu R$
	$[2.5 \sin 15 = 0.03g + F]$	**M1**	Resolve forces along the rod
	$\mu = 0.144$	**A1**	
		4	

Question	Answer	Marks	Guidance
2(i)	$[0 = 30^2 + 2(-g)s]$	**M1**	Using $v^2 = u^2 + 2as$ with $v = 0$, $u = 30$ and $a = -g$ For any complete method for finding maximum height s
	s = maximum height = 900/20 = 45 m	**A1**	**AG**
		2	

Question	Answer	Marks	Guidance
2(ii)	[$33.75 = 30t - ½ gt^2$]	M1	Applying $s = ut + ½at^2$ with $s = 33.75$, $u = 30$ and $a = -g$
	[$5t^2 - 30t + 33.75 = 0$ or $4t^2 - 24t + 27 = 0$]	M1	Solve a 3-term quadratic for t
	$t = 1.5$ (reject $t = 4.5$)	A1	
	$v = 30 - 1.5g = 15$	B1ft	Use $v = u + at$ with $u = 30$ and $t = 1.5$ ft on t value found
	Alternative method for question 2(ii)		
	$v^2 = 30^2 - 2g(33.75) = 225 \rightarrow v = 15$	B1	Use $v^2 = u^2 + 2as$ with $u = 30$, $a = -g$ and $s = 33.75$ to find v
	[$33.75 = ½ (30 + 15) \times t$] or [$15 = 30 - 10t$]	M1	Use $s = ½ (u + v) \times t$ with $s = 33.75$, $u = 30$ and v as found. or Use $v = u - gt$ with $u = 30$ and v as found
		M1	Solve for t
	$t = 1.5$	A1ft	ft on v value found
		4	

Question	Answer	Marks	Guidance
3		**M1**	Attempt to resolve forces horizontally or vertically
	$F\cos\alpha = 15\cos 20 - 5$ (= 9.095...)	**A1**	
	$F\sin\alpha = 15\sin 20 + 25$ (= 30.13....)	**A1**	
	$F = \sqrt{(15\cos 20 - 5)^2 + (15\sin 20 + 25)^2}$	**M1**	Use Pythagoras or trigonometry to find *F*
	$\propto = \tan^{-1}\left[(15\sin 20 + 25)/(15\cos 20 - 5)\right]$	**M1**	Use trigonometry to find α
	α = 73.2 **and** *F* = 31.5	**A1**	
		6	

Question	Answer	Marks	Guidance
4(i)	Driving force = 6000/20 [= 300 N]	**B1**	Using *F* = *P*/*v*
	R = 300 – 80 = 220	**B1ft**	Net force on system = 300 – *R* – 220 = 0 ft on DF found
		2	

Question	Answer	Marks	Guidance
4(ii)	[New driving force DF = 12500/25 = 500 N Car: DF – T – R = 1500a Trailer: T – 80 = 300a System: DF – 80 – R = 1800a]	**M1**	Any one equation from the following: Apply Newton's 2nd law to the car Apply Newton's 2nd law to the trailer Apply Newton's 2nd law to the system of car and trailer.
	Two correct equations	**A1ft**	Correct DF = 500 must be used. ft on R value found
		M1	EITHER solve two dimensionally correct simultaneous equations in a and T to find a or T OR solve the system equation to find a
	a = 0.111 m s^{-2}	**A1**	Allow a = 1/9
	T = 113 N (= 113.3333...)	**A1**	Allow T = 340/3
		5	

Question	Answer	Marks	Guidance
5(i)	Velocity at t = 3 is 3 × 3 = 9	**B1**	
	[½ × 3 × 9 + ½ (9 + 7) × 2 + ½ × 3 × 7]	**M1**	Attempt distance travelled in the first 8 seconds using Distance = area under graph.
	Distance = 40 m	**A1**	
		3	

Question	Answer	Marks	Guidance
5(ii)	[32 = 40 + area of triangle]	**M1**	Use given displacement to set up equation for area of triangle or attempt to find distance or displacement from $t = 8$ to $t = 16$
	Area of triangle or displacement/distance = (–)8	**A1**	
	[Distance = ½ × 8 × V = (–)8]	**M1**	Set up an equation for the area of triangle involving V or use *suvat* equations to set up an equation involving V
	$V = –2$	**A1**	
		4	

Question	Answer	Marks	Guidance
6(i)	$[\int\left(0.4t^3 - 4.8t^{\frac{1}{2}}\right) \mathrm{d}t]$	**M1**	Attempt to integrate a
	$v = 0.1t^4 - 3.2t^{\frac{3}{2}}\ (+c)$	**A1**	
	$[v = 0 \rightarrow 0.1t^4 - 3.2t^{\frac{3}{2}} = 0]$	**DM1**	Attempt to solve $v = 0$, and reach the form $t^{a/b} = k$
	$[t^{\frac{5}{2}} = 32]$	**M1**	Attempt to solve an equation of the form $t^{a/b} = k$
	$t = 4$	**A1**	
	$a = 16\ \mathrm{m\,s^{-2}}$	**B1**	
		6	
6(ii)	$[s = \int 0.1t^4 - 3.2t^{\frac{3}{2}}\ \mathrm{d}t]$	**M1**	Attempt to integrate v
	Displacement = $\left[0.02t^5 - 1.28t^{\frac{5}{2}}\right]_0^5$	**A1**	Correct integration.
	Displacement = –9.05 m (–9.05417...)	**A1**	
		3	

Question	Answer	Marks	Guidance
7(i)	$R = 0.25g \times 0.6$ [= 1.5]	**B1**	
	[$F = 0.5 \times 0.25g \times 0.6$] [$F = 0.75$]	**M1**	Use $F = \mu R$
	[WD against friction = $F \times 8$]	**M1**	Using WD = Force × distance moved in direction of force
	WD = 6 J	**A1**	
		4	
7(ii)	[$\frac{1}{2} \times 0.25 \times 15^2 =$ $\frac{1}{2} \times 0.25 \times v^2 + 6 + 0.25g \times 8 \times 0.8$]	**M1**	Work-energy equation in the form Initial KE = Final KE + WD against F + PE gain
		A1ft	Correct Work–Energy equation for the motion to Q. ft on WD
		M1	Solving the work-energy equation for v
	$v = 7 \text{ m s}^{-1}$	**A1**	
	Alternative method for question 7(ii)		
	[$-F - 0.25g \sin \alpha = 0.25a$]	**M1**	Applying Newton's second law to the particle along the plane
	$a = -11 \text{ m s}^{-2}$	**A1ft**	ft on friction found in **(i)**
		M1	Finding the speed of the particle at Q by applying $v^2 = u^2 + 2as$ with $u = 15$, $s = 8$ or equivalent complete method
	$v = 7 \text{ m s}^{-1}$	**A1**	
		4	

Question	Answer	Marks	Guidance
7(iii)	[$\frac{1}{2} \times 0.25 \times 7^2 = 0.25 \times g \times H$] Or [$\frac{1}{2} \times m \times 7^2 = m \times g \times H$]	M1	KE lost from Q to R = PE gain from Q to R H is the height of R above Q
	$H = 7^2/2g = 2.45$ m	A1	
	Total height $h = 6.4 + H = 8.85$	A1	
	Alternative method for question 7(iii)		
	[$\frac{1}{2} \times 0.25 \times 15^2 = 6 + 0.25g \times h$]	M1	Work-energy from P to R
		A1	Correct Work-energy equation from P to R
	$h = 8.85$	A1	
		3	

Cambridge International AS & A Level

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Paper 4 **October/November 2018**

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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.

Mark Scheme Notes

Marks are of the following three types:

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.

- 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 (or dep*) 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.

- The symbol 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 and B marks are not given for fortuitously "correct" answers or results obtained from incorrect working.

  - Note: B2 or A2 means that the candidate can earn 2 or 0.
    B2/1/0 means that the candidate can earn anything from 0 to 2.

  The marks indicated in the scheme may not be subdivided. If there is genuine doubt whether a candidate has earned a mark, allow the candidate the benefit of the doubt. Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored.

- Wrong or missing units in an answer should not lead to the loss of a mark unless the scheme specifically indicates otherwise.

- For a numerical answer, allow the A or B mark if a value is obtained which is correct to 3 s.f., or which would be correct to 3 s.f. if rounded (1 d.p. in the case of an angle). As stated above, an A or B mark is not given if a correct numerical answer arises fortuitously from incorrect working. For Mechanics questions, allow A or B marks for correct answers which arise from taking g equal to 9.8 or 9.81 instead of 10.

The following abbreviations may be used in a mark scheme or used on the scripts:

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 – often written by a 'fortuitous' answer
ISW	Ignore Subsequent Working
SOI	Seen or implied
SR	Special Ruling (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)

Penalties

MR –1	A penalty of MR –1 is deducted from A or B marks when the data of a question or part question are genuinely misread and the object and difficulty of the question remain unaltered. In this case all A and B marks then become "follow through" marks. MR is not applied when the candidate misreads his own figures – this is regarded as an error in accuracy. An MR –2 penalty may be applied in particular cases if agreed at the coordination meeting.
PA –1	This is deducted from A or B marks in the case of premature approximation. The PA –1 penalty is usually discussed at the meeting.

Question	Answer	Marks	Guidance
1	[$T\sin70 + T\sin45 = 0.2g$]	**M1**	Resolving vertically
	$T = 1.21$ N (1.21447…)	**A1**	
	[$P + T\cos70 = T\cos45$]	**M1**	Resolving horizontally
	$P = 0.443$ (0.443389…)	**A1**	
		4	

Question	Answer	Marks	Guidance
2	$R = mg + 50\sin20$	**B1**	
	[$F = 0.3(mg + 50\sin20)$]	**M1**	Use of $F = \mu R$
		M1	Resolving horizontally
	$50\cos20 – 0.3(mg + 50\sin20) = 0$	**A1ft**	ft R (R containing term in m)
	$m = 14.0$ kg (13.9514…)	**A1**	
		5	

Question	Answer	Marks	Guidance
3(i)	$[\frac{1}{2} \times 1.2 \times 7.5^2 - \frac{1}{2} \times 1.2 \times v^2 = 25]$	M1	For use of KE and 25 in a 3 term equation
	$v = 3.82$ m s^{-1} (3.81881…)	A1	
		[2]	
3(ii)	$1.2gd\sin 30$	B1	Correct expression for PE
	$[\frac{1}{2} \times 1.2 \times 7.5^2 - 25 + 1.2gd\sin 30 = \frac{1}{2} \times 1.2 \times 9^2]$	M1	For 4 term work / energy equation
	$d = 6.64$ m (6.64166…)	A1	
		3	

Question	Answer	Marks	Guidance
4(i)		B1	Three correct straight lines
	$v = 6$ m s^{-1}, $t = 5$ s and $t = 17$ s	B1	Correct trapezium with key values
	$[\frac{1}{2} \times 6 \times (12 + 20)]$ or $[\frac{1}{2} \times 5 \times 6 + 12 \times 6 + \frac{1}{2} \times 3 \times 6]$	M1	Use of trapezium area or use of suvat formulae
	Total distance = 96 m	A1	**AG**
		4	

Question	Answer	Marks	Guidance
4(ii)	[½ × 20 × v = 96]	M1	Uses area of triangle = 96 or uses $s = ut + ½ at^2$ to form equation in a
	v = 9.6 m s^{-1} or 48 = ½ a (10)^2	A1	
	Acceleration = 9.6 / 10 = 0.96 m s^{-2}	A1	
		3	

Question	Answer	Marks	Guidance
5(i)	[$T - 0.3g = 0.3a$ or $0.5g - T = 0.5a$]	M1	Use of Newton's second law for P or Q or use of $a = (m_Q - m_P)g / (m_P + m_Q)$
	$T - 0.3g = 0.3a$ and $0.5g - T = 0.5a$ or $a = (0.5g - 0.3g) / (0.5 + 0.3)$	A1	
	[$0.5g - 0.3g = 0.8a$]	M1	Solve for a
	$a = 2.5$	A1	
	[$h = 0 + ½ × 2.5 × 0.6^2$]	M1	For use of $s = ut + ½at^2$
	$h = 0.45$	A1	
		6	

Question	Answer	Marks	Guidance
5(ii)	Velocity of P when Q reaches floor = $0 + 0.6 \times 2.5 = 1.5\ \text{m s}^{-1}$	**B1ft**	ft a from **(i)** × 0.6
	$[0 = 1.5 - gt \rightarrow t = \ldots]$ ($t = 0.15$)	**M1**	Use of *suvat* to find time to highest point
	Total time = $2 \times 0.15 + 0.6 = 0.9$ s	**A1**	
		3	

Question	Answer	Marks	Guidance
6(i)	Driving force = 36000 / 20	**B1**	For use of power = Fv
	$[36000 / 20 - R = 3200 \times 0.2]$	**M1**	Use of Newton's Second Law
	$R = 1160$ N	**A1**	
		[3]	
6(ii)	Driving force $F = 3200g\sin 1.5 + 1160$	**M1**	Resolving along plane
	[Power = $(3200g\sin 1.5 + 1160) \times 30$]	**M1**	Use of $P = Fv$
	Power = 59900 W (59929.87…)	**A1**	
		3	

Question	Answer	Marks	Guidance
6(iii)	[– (3200*g*sin1.5 + 1160) = 3200*a*]	M1	Use of Newton's Second Law
	(*a* = –0.62426…)	A1	
	$[0^2 = 30^2 + 2as]$	M1	Use of $v^2 = u^2 + 2as$ to find *s*
	Distance *s* = 721 m (720.84…)	A1	
		4	
	OR:		
6(iii)	[3200*g*sin1.5*s*] or [½ × 3200 × 900]	M1	For PE gain or KE loss
	3200*g*sin1.5*s* and ½ × 3200 × 900	A1	For PE gain and KE loss
	[½ × 3200 × 900 = 1160*s* + 3200*g*sin1.5*s*]	M1	For work / energy equation
	Distance *s* = 721 m (720.84…)	A1	
		4	

Question	Answer	Marks	Guidance
7(i)	Acceleration = 0 when *t* = 5 from $25 - t^2 = 0$	B1	
	$[v = 25t - \frac{1}{3}t^3]$	M1	Use of integration
	$[\text{Max speed} = 25 \times 5 - \frac{1}{3} \times 5^3]$	M1	Substitution for *t*
	Max speed = $83\frac{1}{3}$ m s^{-1}	A1	
		4	

Question	Answer	Marks	Guidance
7(ii)	[$s = 12\frac{1}{2}t^2 - \frac{1}{12}t^4$]	**M1**	Use of integration
	Distance = 260 m (260.4166…)	**A1**	
		2	
7(iii)	At $t = 9$, $v = 25 \times 9 - \frac{1}{3} \times 9^3 = -18$	**B1ft**	ft v from **(i)**
	[$s = \int_9^{25} \left(-3t^{-\frac{1}{2}}\right) dt = \left[-6t^{\frac{1}{2}}\right]$]	**M1**	Use of integration
	[Change in velocity from $t = 9$ to $t = 25 = \left[-6t^{\frac{1}{2}}\right] = -6 \times 5 + 6 \times 3 = -12$]	**M1**	Substituting limits
	Velocity at $t = 25$ is $-18 - 12 = -30$ m s^{-1}	**A1**	
		4	
	OR:		
7(iii)	At $t = 9$, $v = 25 \times 9 - \frac{1}{3} \times 9^3 = -18$	**B1ft**	ft v from **(i)**
	[$s = \int -3t^{-\frac{1}{2}} dt = -6t^{\frac{1}{2}} (+ C)$]	**M1**	Use of integration
	[$t = 9$, $v = -18 \rightarrow C = 0$, $t = 25$, $v = -6 \times 25^{\frac{1}{2}}$]	**M1**	Finds C and substitutes $t = 25$
	Velocity at $t = 25$ is -30 m s^{-1}	**A1**	
		4	

Cambridge International AS & A Level

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MATHEMATICS **9709/42**

Paper 4 **October/November 2018**

MARK SCHEME

Maximum Mark: 50

Published

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Cambridge Assessment International Education

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.

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PA –1	This is deducted from A or B marks in the case of premature approximation. The PA –1 penalty is usually discussed at the meeting.

Question	Answer	Marks	Guidance
1	[$T \cos 45 + T \cos 45 = 2.5 \cos 45$]	M1	For resolving horizontally
	$T = 1.25$ N	A1	
	[$2.5 \sin 45 = mg$]	M1	For resolving vertically
	Mass of ring = 0.177 kg	A1	Allow $m = \sqrt{2}/8$
	First alternative method for Q1		
	[$2.5 = T + mg \cos 45$]	M1	Resolve forces along BR
	[$T = mg \cos 45$]	M1	Resolve forces perpendicular to BR and eliminate T or m
	$T = 1.25$ N	A1	
	Mass of ring = 0.177 kg	A1	Allow $m = \sqrt{2}/8$
	Second alternative method for Q1		
	$\frac{2T \cos 45}{\sin 135} = \frac{2.5}{\sin 90} = \frac{mg}{\sin 135}$ or $\frac{2.5 - T}{\sin 135} = \frac{T}{\sin 135} = \frac{mg}{\sin 90}$	M1	Attempt to apply Lami's theorem,
		M1	All three terms of Lami attempted
	$T = 1.25$ N	A1	
	Mass of ring = 0.177 kg	A1	Allow $m = \sqrt{2}/8$
		4	

Question	Answer	Marks	Guidance
2	$R = 5g \cos 6$	**B1**	
	$[F = 0.3 \times 5g \cos 6]$	**M1**	Use of $F = \mu R$
	$[T = 5g \sin 6 + F]$	**M1**	For resolving along the plane
	$T = 20.1$ N (20.14425...)	**A1**	
		4	

Question	Answer	Marks	Guidance
3(i)	Acceleration = -1 m s^{-2}	**B1**	Allow deceleration = 1 m s^{-2}
		1	
3(ii)	[$V/4 = 1$ or $(V + 2)/6 = 1$]	**M1**	Use of gradient of line between $t = 4$ and $t = 10$ or use of similar triangles to find V
	$V = 4$	**A1**	
		2	
3(iii)	[Distance = Area = ½ (6 + 2) × 2 = 8]	**M1**	Attempt distance travelled in first 6 seconds
	Distance AB = 3 × 8 = 24 m	**A1**	
	[½ × (T – 6) × 4 = 24]	**M1**	Attempt to find the distance travelled from $t = 6$ to $t = T$ and set up an equation for T
	$T = 18$	**A1**	
		4	

Question	Answer	Marks	Guidance
4(i)	$T = 0.7g$	**B1**	
	$R = 0.4g \times {}^{4}/_{5}$ [$= {}^{16}/_{5} = 3.2$]	**B1**	Normal reaction on particle P
	[$X + 0.4g \times {}^{3}/_{5} - F - T = 0$]	**M1**	Attempt to resolve forces along the plane
	$X = 6.2$	**A1**	**AG**
		4	
4(ii)	[$0.7g - T = 0.7a$] [$T - 0.8 - 0.4g \times {}^{3}/_{5} - F = 0.4a$] [$0.7g - 0.8 - 0.4g \times {}^{3}/_{5} - F = (0.7 + 0.4)a$] System	**M1**	For using Newton's 2nd law for both particle P and particle Q or the system equation
		A1	Both equations correct or system equation correct
		M1	Solve either the system equation or solve two simultaneous equations to find a
	$a = 2\ \text{m s}^{-2}$	**A1**	
		4	

Question	Answer	Marks	Guidance
5(i)	$[1.2T^{1/2} - 0.6T = 0]$	**M1**	Attempt to find time of maximum v, set $a = 0$ and solve for T
	$T^{1/2} = 2 \rightarrow T = 4$	**A1**	
		2	
5(ii)	$[\mathrm{d}a/\mathrm{d}t = 0.6t^{1/2} - 0.6]$	**M1**	Attempt to differentiate a
	$t = 1$	**A1**	Solve $\mathrm{d}a/\mathrm{d}t = 0$ and find t
	$[v = 0.8t^{3/2} - 0.3t^2 (+ C)]$	**M1**	Attempt to integrate a to find v
		A1	Correct integration
	$[C = 1]$	**M1**	Use $v = 1$ at $t = 0$ either finding C or by using limits as $v(1) - v(0) = [0.8(1)^{3/2} - 0.3(1)^2] - [0.8(0)^{3/2} - 0.3(0)^2]$
	Velocity when acceleration is max is 1.5 ms^{-1}	**A1**	$v = 1.5$
		6	

Question	Answer	Marks	Guidance
6(i)	Power = 350 × 15 = 5250 W	**B1**	Allow 5.25 kW
		1	
6(ii)		**B1**	Using Driving force DF = $P/15$
	DF + 1200g sin 1 – 350 = 1200 × 0.12	**M1**	For using Newton's 2nd law down the slope
	P = 4270 W (4268.56...)	**A1**	
		3	
6(iii)	[1200g sin 1 – 350 = 1200a]	**M1**	Using Newton's 2nd law down the slope
		A1	Correct equation
	[$18^2 = 20^2 + 2as$]	**M1**	Using constant acceleration formulae with a complete method to find distance, s, travelled.
	Distance travelled s = 324 m (324.39)	**A1**	

Question	Answer	Marks	Guidance
6(iii)	**Alternative method for Q6(iii)**		
	PE loss = $1200g \times s \sin 1$ KE loss = $\frac{1}{2} \times 1200 \times (20^2 - 18^2)$	**M1**	Attempt either PE loss or KE loss
		A1	Both PE loss and KE loss correct
	[$1200g \times s \sin 1 + \frac{1}{2} \times 1200 \times (20^2 - 18^2) = 350s$]	**M1**	Apply work-energy equation to the car
	Distance travelled s = 324 m (324.39)	**A1**	
		4	

Question	Answer	Marks	Guidance
7(i)	At liquid surface, speed = $0 + g \times 0.8$ [= 8] or $0.3g \times ½\,(0 + v) \times 0.8 = ½\,(0.3)\,v^2 \rightarrow v = 8$	**B1**	Using constant acceleration equation $v = u + at$ or PE loss = KE gain
	PE lost in water = $0.3g \times 1.25$ [= 3.75]	**B1**	
	[$½ \times 0.3 \times (8^2 - v^2) + 0.3g \times 1.25 = 1.2$]	**M1**	Using work-energy for downward motion in the tank PE loss + KE loss = Work done against resistance
	$v = 9$ m s^{-1}	**A1**	
	Alternative method for Q7(i)		
	Height above tank = $½ \times g \times 0.8^2$ [= 3.2]	**B1**	
	Total PE loss = $0.3g \times (3.2 + 1.25)$ [= 13.35]	**B1**	
	[$0.3g \times (3.2 + 1.25) = ½ \times 0.3 \times v^2 + 1.2$]	**M1**	Work-energy equation for the total downward motion
	$v = 9$ m s^{-1}	**A1**	
		4	

Question	Answer	Marks	Guidance
7(ii)	[$-0.3g - 1.8 = 0.3a$]	**M1**	Using Newton's 2nd law for the upward motion in the tank
	$a = -16$	**A1**	
	[$1.25 = 7T + ½ \times (-16) \times T^2$]	**M1**	Using constant acceleration equations to find the time, T, for the particle to travel from the bottom to the surface of the liquid
	$T = 0.25$ (or 0.625, on the way down)	**A1**	
	[v at surface $= 7 + (-16) \times 0.25 = 3$]	**B1**	Using $v = u + aT$ or equivalent to find v at surface
	[$0 = 3 - gt \rightarrow t = 0.3$]	**M1**	Attempt to find the time, t, taken for the particle to travel from the surface to reach maximum height using their $v \neq 7$
	Total time $= T + t = 0.55$ s	**A1**	

Question	Answer	Marks	Guidance
7(ii)	**Alternative method for Q7(ii)**		
	[$-0.3g - 1.8 = 0.3a$]	**M1**	Using Newton's 2nd law for the upward motion in the tank
	$a = -16$	**A1**	
	$v^2 = 7^2 + 2 \times (-16) \times 1.25 = 9 \rightarrow v = 3$	**B1**	Using constant acceleration equations to find v at the surface
	$1.25 = ½ (7 + 3) \times T$ or $3 = 7 + (-16) \times T$	**M1**	Using $s = ½ (u + v) \times T$ or $v = u + aT$ to find the time, T, for the particle to travel from the bottom to the surface of the liquid
	$T = 0.25$	**A1**	
	[$0 = 3 - gt \rightarrow t = 0.3$]	**M1**	Attempt to find the time, t, taken for the particle to travel from the surface to reach maximum height using their $v \neq 7$
	Total time = $T + t = 0.55$ s	**A1**	

Question	Answer	Marks	Guidance
7(ii)	**Second Alternative method for Q7(ii)**		
	[$\frac{1}{2} \times 0.3 \times (7^2 - v^2) = 0.3g \times 1.25 + 1.8 \times 1.25$]	**M1**	Work-energy equation for motion from bottom to surface
		A1	Correct equation
	$v = 3$	**B1**	Find v at surface from rearrangement of work-energy
	[$1.25 = \frac{1}{2}(7 + 3) \times T$]	**M1**	Using $s = \frac{1}{2}(u + v) \times T$ to find the time T, for the particle to travel from the bottom to the surface of the liquid
	$T = 0.25$	**A1**	
	[$0 = 3 - 10t \rightarrow t = 0.3$]	**M1**	Attempt to find the time, t, taken for the particle to travel from the surface to reach maximum height using their $v \neq 7$
	Total time = $T + t = 0.55$ s	**A1**	
		7	

Cambridge International AS & A Level

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MATHEMATICS **9709/41**

Paper 4 **October/November 2018**

MARK SCHEME

Maximum Mark: 50

Published

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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.

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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.

Mark Scheme Notes

Marks are of the following three types:

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).

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- 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 (or dep*) 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.

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  - Note: B2 or A2 means that the candidate can earn 2 or 0.
    B2/1/0 means that the candidate can earn anything from 0 to 2.

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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 – often written by a 'fortuitous' answer

ISW Ignore Subsequent Working

SOI Seen or implied

SR Special Ruling (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)

Penalties

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PA –1 This is deducted from A or B marks in the case of premature approximation. The PA –1 penalty is usually discussed at the meeting.

Question	Answer	Marks	Guidance
1	$4.5 = 2.5 + a \times 5$	**M1**	For use of $v = u + at$
	$a = 0.4$	**A1**	
	$F - 1.5 = 0.2a$	**M1**	For use of Newton's second law
	$F = 1.58$	**A1**	
		4	

Question	Answer	Marks	Guidance
2(i)	Resistance = Driving force = $\frac{4080000}{85}$ = 48 000 N	**B1**	Correct use of $P = Fv$ and using DF = Resistance
		1	
2(ii)	$\text{DF} = \frac{P}{85}$	**B1**	$\text{DF} = \frac{P}{v}$
	$\text{DF} - 48\,000 - 490\,000\,g \times \frac{1}{200} = 0$	**M1**	For applying Newton's second law (3 terms)
	$P = 72\,500 \times 85 = 6.16$ MW	**A1**	
		3	

Question	Answer	Marks	Guidance
3	[KE gained $= \frac{1}{2} \times 2500 \times (30^2 - 20^2)(= 625000\text{ J})$ PE lost $= 2500g \times 400 \sin 4 (= 697564.7\text{ J})$	M1	KE gained or PE lost attempted
		A1	Both KE and PE correct
	[WD by engine $+ 2500g \times 400 \sin 4 + \frac{1}{2} \times 2500 \times 20^2$ $= 600 \times 400 + \frac{1}{2} \times 2500 \times 30^2$]	M1	Using work-energy equation in the form WD by engine + PE lost = WD against F + KE gain
	Work done by engine + PE lost $= 600 \times 400 + 625\,000$	A1	Work-energy equation all correct
	Work done = 167 000 J (167 435.2…)	A1	
		5	

Question	Answer	Marks	Guidance
4(i)	$0.6^2 = 0 + 2a \times 0.8$	M1	For use of $v^2 = u^2 + 2as$
	$a = 0.225$	A1	
	$T - 0.3g = 0.3a$	M1	For using Newton's second law for the 0.3 kg particle
	$T = 3.07$ N (3.0675 N)	A1	
		4	

Question	Answer	Marks	Guidance
4(ii)	$mg - T = ma,\ m(10 - 0.225) = 3.0675$	**M1**	For using Newton's second law applied to the *m* kg particle
	$m = 0.314$ kg (0.31381…)	**A1**	
		2	

Question	Answer	Marks	Guidance
5(i)		**M1**	For resolving forces horizontally or vertically o.e.
	25 cos 30 – 15 cos 40 (= 10.1599…)	**A1**	
	25 sin 30 + 15 sin 40 – 30 (= –7.8581…)	**A1**	
		M1	For using a method for either magnitude or direction
	Magnitude = $\sqrt{(10.15...^2 + 7.858...^2)}$ = 12.8 N	**A1**	Magnitude = 12.844…
	Angle 37.7° below the horizontal in the direction *BA*	**A1**	
		6	

Question	Answer	Marks	Guidance
5(ii)	$F \cos 40 = 25 \cos 30$	**M1**	For equating forces in the direction BC to zero
	$F = 28.3$	**A1**	$F = 28.2628\ldots$
	New resultant force $= 28.26\ldots\sin 40 + 25 \sin 30 - 30 = 0.667$ N upwards	**B1**	
		3	

Question	Answer	Marks	Guidance
6(i)		**M1**	For using constant acceleration equations such as $s = ut + \frac{1}{2}at^2$ or equivalent complete methods to find expressions for PQ or QR or PR
	For PQ $0.8 = 0.6u + 0.18a$	**A1**	
	For PR $1.6 = 1.6u + 1.28a$	**A1**	or for QR $0.8 = (u + a \times 0.6) \times 1 + 0.5a$
		M1	Solving simultaneously two relevant equations in u and a
	Deceleration $= \frac{2}{3}$ ms^{-2}	**A1**	**AG**
	$u = \frac{23}{15}$	**B1**	
		6	

Question	Answer	Marks	Guidance
6(ii)	$R = mg\cos 3$	B1	
	$F = \mu mg\cos 3$	M1	For use of $F = \mu R$
	$-mg\sin 3 - \mu \times mg\cos 3 = m \times \left(-\frac{2}{3}\right)$	M1	For using Newton's second law (3 terms)
	$\mu = 0.0144$ (0.014350…)	A1	
		4	

Question	Answer	Marks	Guidance
7(i)	$v = \int (5.4 - 1.62t)\,dt$	M1	For using integration of a to find v
	$v = 5.4t - 0.81t^2\ (+C)$	A1	
	$5.4t - 0.81t^2 = 0$	M1	For solving $v = 0$
	$t = 6\frac{2}{3} = \frac{20}{3}s$	A1	
		4	
7(ii)	$v(10) = -27\ \text{ms}^{-1}$	B1	
	Inverted parabola	B1	
	$v = 0$ at $t = 0$, negative at $t = 10$ and through $\left(6\frac{2}{3}, 0\right)$	B1	
		3	

Question	Answer	Marks	Guidance
7(iii)	$s=\int\left(5.4t-0.81t^2\right)dt$	M1	For using integration of v to find s
	$s=2.7t^2-0.27t^3\left(+C\right)$	A1	
	At $t=6\frac{2}{3}$, displacement $=40$	M1	For evaluating the integral at the time when $v=0$
	At $t=10$ displacement $=0$	M1	For evaluating the integral at time $t=10$
	Total distance $=80$ m	A1	
		5	

Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

MATHEMATICS **9709/43**

Paper 4 **May/June 2018**

MARK SCHEME

Maximum Mark: 50

Published

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1(i)	0.4 (m s^{-2})	**B1**	
	Total:	**1**	
1(ii)	$[9040 = \frac{1}{2}(600 + T) \times 16]$	**M1**	Equating area of the trapezium to the total distance or using $s = ½ (u + v)t$ or equivalent
	Time is 530 (s)	**A1**	
	Total:	**2**	
1(iii)	$[s = \frac{1}{2} \times (600 - 530 - 40) \times 16]$	**M1**	Use of triangular area, or equivalent
	Distance is 240 (m)	**A1**	
	Total:	**2**	

Question	Answer	Marks	Guidance
2	$[V^2 = 5^2 + 2 \times g \times 7.2]$	**M1**	Use of *uvast* to find V
	$V = 13$	**A1**	
	$[13 = 5 + gt \quad t = \ldots\ldots]$ 0.8 (s)	**M1**	Use of *uvast* to find time for A to reach ground
	$[0 = 6.5 - gt \quad t = \ldots\ldots]$ 0.65 (s)	**M1**	Use of *uvast* to find time from ground to B
	Total time is 1.45 (s)	**A1**	
	Total:	**5**	

Question	Answer	Marks	Guidance
3		**M1**	For resolving forces in any one direction
	E.g. $X = 18 + 12\sin 60° - 8\sin 30°$ $14 + 6\sqrt{3}$	**A1**	One correct equation or expression
	E.g. $Y = 8\cos 30° + 12\cos 60°$ $6 + 4\sqrt{3}$	**A1**	Second correct equation or expression (X and Y may denote components of resultant of given 3 forces or may be components of the fourth force that would produce equilibrium)
	$[(14 + 6\sqrt{3})^2 + (6 + 4\sqrt{3})^2]$ or $[\tan^{-1}(6 + 4\sqrt{3})/(14 + 6\sqrt{3})]$	**M1**	Use of Pythagoras or appropriate trig to find magnitude or angle
	Magnitude is 27.6 (N)	**A1**	Not for resultant
	Direction is 27.9° below 'negative *x*-axis'	**A1**	Not for 27.9° only; direction must be clearly specified
	Total:	**6**	

Question	Answer	Marks	Guidance
4	$[\frac{1}{2} \times 0.8 \times v^2]$ or $[\frac{1}{2} \times 1.6 \times v^2]$	**M1**	For KE of either particle
	Gain in KE $= \frac{1}{2}\times 0.8\times v^2 + \frac{1}{2}\times 1.6\times v^2$	**A1**	Total KE
	[Gain in $PE_A = 0.8g \times 0.5 \times \sin\theta$] or [Loss in $PE_B = 1.6g \times 0.5$]	**M1**	For PE change of either particle (irrespective of sign)
	Loss in PE $= 1.6g \times 0.5 - 0.8g \times 0.5 \times 0.6$	**A1**	Change of PE
	$[1.2v^2 = 8 - 2.4]$	**M1**	Energy equation originating from 4 terms
	Speed is 2.16 (m s^{-1})	**A1**	
	Total:	**6**	
			SC for using Newton II equations and $v^2 = u^2 + 2as$ (**max 2/6**) $[16 - T = 1.6a$ and $T - 8\sin\theta = 0.8a] \rightarrow a = 4.67$ (ms^{-2}) **B1** $[v^2 = 2 \times \frac{14}{3} \times 0.5] \rightarrow$ speed is 2.16 (ms^{-1}) **B1**
	Alternative method 1 for Question 4		
	$[\frac{1}{2} \times 0.8 \times v^2]$ or $[0.8g \times 0.5 \times \sin\theta]$	**M1**	For KE gain or PE gain of particle *A*
	$\frac{1}{2} \times 0.8 \times v^2 + 0.8g \times 0.5 \times 0.6$	**A1**	Total energy gain for particle *A*
	$[16 - T = 1.6a$ and $T - 8\sin\theta = 0.8a \rightarrow T = ...]$ 8.53	**M1**	Forms and solves Newton II equations to find tension *T*
	$WD_T = \frac{128}{15} \times 0.5$	**A1**	Finds $WD_{Tension}$
	$[\frac{1}{2} \times 0.8 \times v^2 + 0.8g \times 0.5 \times 0.6 = \frac{128}{15} \times 0.5]$	**M1**	Energy equation (3 terms)

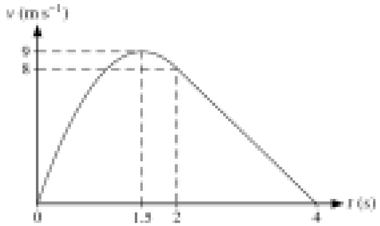
Question	Answer	Marks	Guidance
4	Speed is 2.16 (m s^{-1})	**A1**	
	Total:	**6**	
	Alternative method 2 for Question 4		
	$[\frac{1}{2} \times 1.6 \times v^2]$ or $[1.6\,g \times 0.5]$	**M1**	For KE gain or PE loss of particle *B*
	$1.6\,g \times 0.5 - \frac{1}{2} \times 1.6 \times v^2$	**A1**	Energy change for particle *B*
	$[16 - T = 1.6a$ and $T - 8\sin\theta = 0.8a \rightarrow T = ...]$ 8.53	**M1**	Forms and solves Newton II equations to find tension T
	$WD_T = \frac{128}{15} \times 0.5$	**A1**	Finds $WD_{Tension}$
	$1.6\,g \times 0.5 - \frac{1}{2} \times 1.6 \times v^2 = \frac{128}{15} \times 0.5]$	**M1**	Energy equation (3 terms)
	Speed is 2.16 (m s^{-1})	**A1**	
	Total:	**6**	

Question	Answer	Marks	Guidance
5	$R = 3g\cos 20°$	**B1**	Correct normal reaction stated or used
	[$F = 0.35 \times 3g\cos 20°$]	**M1**	For use of $F = \mu R$
	[$P_1 + F = 3g\sin 20°$]	**M1**	Attempted resolving equation for minimum case
	$P_1 = 0.394$ **(AG)**	**A1**	Correct given answer from correct work
	[$P_2 = F + 3g\sin 20°$]	**M1**	Attempted resolving equation for maximum case
	$P_2 = 20.1$ (N)	**A1**	
	Total:	**6**	

Question	Answer	Marks	Guidance
6(i)	[$\frac{P}{56} = 40 \times 56$]	**M1**	For equating $\frac{\text{Power}}{\text{Velocity}}$ to Resistance, or equivalent
	Power is 125 (kW)	**A1**	
	Total:	**2**	
6(ii)	Driving force is $\frac{125\,440}{32}$	**B1ft**	Follow through their power from **(i)**
	[$\frac{125\,440}{32} - 40 \times 32 = 1400a$]	**M1**	For 3-term Newton II equation
	$a = 1.89$ (m s^{-2})	**A1**	
	Total:	**3**	

Question	Answer	Marks	Guidance
6(iii)	$[\frac{60\,000}{50} + 1400g\sin\theta - 40\times 50 = 0]$	M1	For 3-term Newton II equation
		A1	Correct equation
	$[\sin\theta° = \frac{800}{14\,000}]$	M1	
	$\theta = 3.3$	A1	
	Total:	**4**	

Question	Answer	Marks	Guidance
7(i)	$[\frac{dv}{dt} = 12 - 8t]$ or e.g. $[-4[(t-1.5)^2 - 2.25]]$	M1	For attempted differentiation of $12t - 4t^2$ (or for alternative e.g. completing the square)
	[Maximum v when $t = 1.5 \Rightarrow v = 12\times 1.5 - 4\times 1.5^2$]	M1	For finding and using t
	Maximum velocity is 9 (m s^{-1})	A1	
	Total:	**3**	
7(ii)	$[\frac{dv}{dt} = 12 - 8t = -4]$	M1	Finding acceleration for $0 \leqslant t \leqslant 2$ when t = 2
	Acceleration for $2 \leqslant t \leqslant 4$ is –4 No instantaneous change	A1	Both values correct, with correct statement
	Total:	**2**	

Question	Answer	Marks	Guidance
7(iii)		**B1**	Quadratic shape (with max) for $0 \leqslant t \leqslant 2$
		B1	Line with negative gradient from (2, …) to (4,0)
		B1	All correct, smooth join and key values indicated
	Total:	**3**	
7(iv)	Area of triangle is 8	**B1**	(May be obtained by integrating $16 - 4t$ or use of *uvast*)
	$[\int (12t - 4t^2)\,dt = 6t^2 - \frac{4}{3}t^3]$	**M1**	Integration attempt for $0 \leqslant t \leqslant 2$
	$[6 \times 2^2 - \frac{4}{3} \times 2^3 - 6 \times 0^2 + \frac{4}{3} \times 0^3]$	**DM1**	Use of limits 0 and 2; condone absence of zero terms
	Area under curve is $\frac{40}{3}$ or 13.3	**A1**	
	Distance travelled is $\frac{64}{3}$ (m) or 21.3 (m)	**A1**	
	Total:	**5**	

Cambridge International AS & A Level

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Cambridge International Advanced Subsidiary and Advanced Level

MATHEMATICS **9709/42**

Paper 4 **May/June 2018**

MARK SCHEME

Maximum Mark: 50

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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.

- 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 (or dep*) 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.

- The symbol 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 and B marks are not given for fortuitously "correct" answers or results obtained from incorrect working.

  - Note: B2 or A2 means that the candidate can earn 2 or 0.
    B2/1/0 means that the candidate can earn anything from 0 to 2.

  The marks indicated in the scheme may not be subdivided. If there is genuine doubt whether a candidate has earned a mark, allow the candidate the benefit of the doubt. Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored.

- Wrong or missing units in an answer should not lead to the loss of a mark unless the scheme specifically indicates otherwise.

- For a numerical answer, allow the A or B mark if a value is obtained which is correct to 3 s.f., or which would be correct to 3 s.f. if rounded (1 d.p. in the case of an angle). As stated above, an A or B mark is not given if a correct numerical answer arises fortuitously from incorrect working. For Mechanics questions, allow A or B marks for correct answers which arise from taking *g* equal to 9.8 or 9.81 instead of 10.

The following abbreviations may be used in a mark scheme or used on the scripts:

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)

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CWO Correct Working Only – often written by a 'fortuitous' answer

ISW Ignore Subsequent Working

SOI Seen or implied

SR Special Ruling (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)

Penalties

MR –1 A penalty of MR –1 is deducted from A or B marks when the data of a question or part question are genuinely misread and the object and difficulty of the question remain unaltered. In this case all A and B marks then become "follow through" marks. MR is not applied when the candidate misreads his own figures – this is regarded as an error in accuracy. An MR –2 penalty may be applied in particular cases if agreed at the coordination meeting.

PA –1 This is deducted from A or B marks in the case of premature approximation. The PA –1 penalty is usually discussed at the meeting.

Question	Answer	Marks	Guidance
1	KE gain = $\frac{1}{2} \times 80 \times (5.5^2 - 4^2)$ [= 570]	**B1**	Either initial or final KE correct
	WD against Res = $60P$	**B1**	
	[$\frac{1}{2} \times 80 \times (5.5^2 - 4^2) + 60P = 1200$]	**M1**	Four term work-energy equation
	$P = 10.5$	**A1**	
		4	

Question	Answer	Marks	Guidance
2	Driving force DF = $\frac{P}{15}$	**B1**	Correct use of $P = Fv$
	$\left[\text{DF} - 240\ 000g \sin 4 - 18\ 000 = 240\ 000 \times (-0.2)\right]$	**M1**	A four-term Newton 2nd law equation
		A1	Correct equation
	Power is 2 060 000 (W)	**A1**	Allow 2060 kW or 2.06 MW
		4	

Question	Answer	Marks	Guidance
3	[3 cos 60 = 2 cos θ]	M1	Attempt to resolve forces horizontally (2 terms)
	θ = 41.4	A1	
	[P = 3 sin 60 + 2 sin θ]	M1	Attempt to resolve forces vertically (3 terms)
	P = 3.92	A1	
		4	
	First alternative method for Q3		
	$\frac{P}{\sin(120-\theta)} = \frac{2}{\sin 150} = \frac{3}{\sin(90+\theta)}$	M1	Attempt two terms of Lami's equation which can be used to find θ
	θ = 41.4	A1	
		M1	Attempt an equation which can be used to find P
	P = 3.92	A1	
	Second alternative method for Q3		
	[Triangle with sides 2, 3, P and angles opposite of 30, 90 – θ, 60 + θ] $\frac{P}{\sin(60+\theta)} = \frac{2}{\sin 30} = \frac{3}{\sin(90-\theta)}$	M1	Attempt two terms from the triangle of forces which can be used to find θ
	θ = 41.4	A1	
		M1	Attempt an equation which can be used to find P
	P = 3.92	A1	

Question	Answer	Marks	Guidance
4(i)	For example $100 = 4u + 8a$ or $100 = \frac{1}{2}(u + v) \times 4$ or $148 = 4v + 8a$ or any equation in two of the variables u, v, w, a	**M1**	Any relevant use of constant acceleration equations in any two of the variables below a is acceleration u is speed at A v is speed at B w is speed at C
		A1	One correct equation
	For example $248 = 8u + 32a$ or two further correct equations in 3 unknowns such as $148 = 4v + 8a$ **and** $v = u + 4a$ or $148 = \frac{1}{2}(v + w) \times 4$ and $248 = \frac{1}{2}(u + w) \times 8$	**A1**	A second correct equation in the same two variables or two further correct equations leading to three equations in three of the unknowns u, v, w, a
		M1	Attempt to solve for a or u This must reach $a = \ldots$ or $u = \ldots$
	$a = 3$	**A1**	**AG**
	$u = 19$	**B1**	
		6	

Question	Answer	Marks	Guidance
4(ii)	$61^2 = 19^2 + 2 \times 3 \times s$	M1	Attempt equation for $s = AD$
	$[s = 560 \rightarrow CD = 560 - 248]$	M1	Attempt to find CD
	Distance CD is 312	A1	
		3	
	Alternative method for 4(ii)		
	Speed at C is 19 + 8 × 3 [= 43]	M1	Attempt to find speed at C
	$\left[61^2 = 43^2 + 2 \times 3 \times CD\right]$	M1	Attempt to find CD
	Distance CD is 312	A1	

Question	Answer	Marks	Guidance
5	$R = 20g \cos 60$ [= 100]	**B1**	
	$F = \mu \times 20g \cos 60$ [= 100μ]	**M1**	Use $F = \mu R$
		M1	Resolve along plane in either case
	(P_{max} =) $20g \sin 60 + F$	**A1**	One correct equation
	(P_{min} =) $20g \sin 60 - F$	**A1**	Second correct equation
	$20g \sin 60 + F = 2(20g \sin 60 - F)$	**M1**	Use of $P_{max} = 2P_{min}$ to give four term equation in F or μ or P
	$\mu = \frac{\sqrt{3}}{3} = 0.577$	**A1**	
		7	
	lternative solution for final 3 marks if P_{min} is taken as acting down the plane		
	$P_{min} = F - 20g \sin 60$	**A1**	
	$20g \sin 60 + F = 2(F - 20g \sin 60)$	**M1**	
	$\mu = 3\sqrt{3} = 5.196$	**A1**	

Question	Answer	Marks	Guidance
6(i)		M1	Attempt to integrate a
	$v = 6t - 0.12t^2\ (+ c)$	A1	
	$0 = 6 \times 20 - 0.12 \times 20^2 + c$	DM1	Substitute $v = 0$, $t = 20$ in an equation with arbitrary constant
	$0.12t^2 - 6t + 72 = 0$	DM1	Substitute $v = 0$ and attempt to solve a 3-term quadratic
	$t = 30$	A1	
		5	
6(ii)	$s = 3t^2 - 0.04t^3 - 72t\ (+ k)$	M1	Attempt to integrate v
	$s(30) - s(20) = -540 - (-560)$	DM1	Use of limits 20 and their 30
	Distance travelled = 20	A1	
		3	

Question	Answer	Marks	Guidance
7(i)	[$T = 1.6a$, $2.4g \sin 30 - T = 2.4a$] System is $2.4g \sin 30 = 4a$	**M1**	Attempt Newton's 2nd law for *A* or *B* or for the system
		A1	Two correct equations
		M1	Solve for *a* or *T*
	$a = 3$	**A1**	
	$T = 4.8$	**A1**	
		5	
7(ii)	Friction force on *A* is $F = 0.2 \times 1.6g$ [= 3.2]	**B1**	From $F = \mu R$
	$T - F = 1.6a$ $2.4g \sin 30 - T = 2.4a$ System is $2.4g \sin 30 - F = 4a$	**M1**	Attempt Newton's 2nd law for both particles or for the system
		A1	Correct equations for *A* and *B* or correct system equation
		M1	Attempt to solve for *a*
	$a = 2.2$	**A1**	
	$v^2 = 2 \times 2.2 \times 1$	**M1**	Attempt to find v or v^2 when *B* reaches the barrier
	Subsequent acceleration of *A* is –2	**B1**	
	$4.4 = 2 \times 2 \times s$	**M1**	Attempt to find distance *A* travels while decelerating to $v = 0$
	Total distance travelled is 2.1 m	**A1**	
		9	

Question	Answer	Marks	Guidance
7(ii)	**Alternative method for Q7 [Work-Energy applied to *A* and *B*]**		
	$F = 0.2 \times 1.6g$ [= 3.2]	**B1**	From $F = \mu R = 0.2 \times 1.6g = 3.2$
		M1	Attempt PE loss as *B* reaches the barrier
	PE loss = $2.4g \sin 30$ [= 12]	**A1**	
		M1	Attempt KE gain for both *A* and *B*
	KE gain = $\frac{1}{2}(1.6 + 2.4)v^2$ [= $2v^2$]	**A1**	
	[$2.4g \sin 30 = \frac{1}{2} \times 4 \times v^2 + 3.2 \times 1$] [$v^2 = 4.4$]	**M1**	Apply work-energy equation for the motion until *B* reaches the barrier (Three relevant terms)
	KE loss = $\frac{1}{2} \times 1.6 \times 4.4$	**B1**	Find KE loss as *A* comes to rest after *B* has stopped
	[$\frac{1}{2} \times 1.6 \times 4.4 = 3.2d$] [$d = 1.1$]	**M1**	Apply work-energy equation where *d* is the extra distance travelled by *A* leading to a positive value for *d*
	Total distance = 2.1 m	**A1**	Distance = $d + 1$

Question	Answer	Marks	Guidance
7(ii)	**Alternative scheme for first 6 marks of 7(ii) [Work-energy applied to *A*]**		
	Friction = 0.2 × 1.6g [= 3.2]	**B1**	
	[2.4g sin 30 – T = 2.4a T – F = 1.6a]	**M1**	Apply Newton's 2nd law to *A* and *B* and solve for *T*
	T = 6.72	**A1**	
	[$\frac{1}{2}$ × 1.6 × v^2]	**M1**	Attempt KE for *A* only
		A1	Correct KE for *A*
	[6.72 × 1 = $\frac{1}{2}$ × 1.6 × v^2 + 3.2 × 1]	**M1**	Use work/energy equation for *A*
	Alternative scheme for first 6 marks of 7(ii) [Work-energy applied to *B*]		
	Friction = 0.2 × 1.6g [= 3.2]	**B1**	
	[2.4g sin 30 – T = 2.4a T – F = 1.6a]	**M1**	Apply Newton's 2nd law to *A* and *B* and solve for *T*
	T = 6.72	**A1**	
		M1	Find energy loss/gain for *B* Allow either term
	±($\frac{1}{2}$ × 2.4 × v^2 – 2.4g sin 30)	**A1**	
	2.4g sin 30 = $\frac{1}{2}$ × 2.4 × v^2 + 6.72 × 1	**M1**	Use work/energy equation for *B*

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

MATHEMATICS	**9709/41**
Paper 4	**May/June 2018**
MARK SCHEME	
Maximum Mark: 50	

Published

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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:

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Mark Scheme Notes

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Question	Answer	Marks	Guidance
1	$-5 = 24t - 5t^2$	**M1**	Use $s = ut + \frac{1}{2}at^2$
	$5t^2 - 24t - 5 = 0$	**M1**	Solve relevant 3 term quadratic
	$t = 5$	**A1**	
		3	
	Alternative scheme for Question 1		
	$0 = 24 - 10t_1 \rightarrow t_1 = 2.4$	**M1**	Attempt to find the time taken to reach the highest point
	$0 = 24^2 + 2 \times (-10) \times h \rightarrow h = 28.8$ And $33.8 = \frac{1}{2}gt_2^2 \rightarrow t_2 = 2.6$	**M1**	Find total height h reached and attempt to find time taken from highest point to ground level
	$t = t_1 + t_2 = 5$	**A1**	

Question	Answer	Marks	Guidance
2	[$10 \cos \alpha = 8$ or $10 \cos \beta = 6$]	**M1**	Introduce α or β, an angle between the 10N force and the vertical or horizontal and attempt to resolve forces
	$\alpha = 36.9$ or $\beta = 53.1$	**A1**	
	Angle between 6N and 10N is 126.9	**B1**	
	Angle between 8N and 10N is 143.1	**B1**	
		4	
	Alternative scheme for Question 2		
	$\frac{10}{\sin 90} = \frac{6}{\sin \gamma} = \frac{8}{\sin \delta}$	**M1**	Attempt to use Lami's theorem γ (8 and 10), δ (6 and 10)
	All correct	**A1**	
	Angle between 8N and 10N is $\gamma = 143.1$	**B1**	
	Angle between 6N and 10N is $\delta = 126.9$	**B1**	

Question	Answer	Marks	Guidance
3(i)		M1	Attempt to resolve forces along the plane (2 terms)
	$100 \cos \theta = 8g \sin 30 \rightarrow \theta = 66.4$	A1	
	$[R = 8g \cos 30 + 100 \sin \theta]$	M1	Resolve forces perpendicular to the plane (3 terms)
	$R = 161$	A1	
		4	
3(ii)	$100 \cos 30 - 8g \sin 30 = 8a$	M1	Apply Newton's 2nd law parallel to the plane (3 terms)
	$a = 5.83$	A1	
		2	

Question	Answer	Marks	Guidance
4(i)		M1	Attempt differentiation
	$v = 3t^2 - 8t + 4$	A1	
		2	
4(ii)	$3t^2 - 8t + 4 = 0$	M1	Set $v = 0$ and attempt to solve a relevant 3 term quadratic
	$t = \frac{2}{3}$ and $t = 2$	A1	
		2	

Question	Answer	Marks	Guidance
4(iii)	$[6t - 8 = 0]$	**M1**	Differentiate v and equate to 0
	$[t = \frac{4}{3}, v = 3(\frac{4}{3})^2 - 8(\frac{4}{3}) + 4]$	**M1**	Solve for t and attempt v
	$v = -\frac{4}{3}$	**A1**	
		3	
	Alternative scheme for Question 4(iii)		
	$[v = 3(t^2 - \frac{8}{3}t) + 4 = 3(t - \frac{4}{3})^2 + ...]$	**M1**	Attempt to complete the square for v
	$[t = \frac{4}{3}, v = 3(t - \frac{4}{3})^2 - \frac{4}{3}]$	**M1**	Find value of t for minimum v and attempt to find v
	$v = -\frac{4}{3}$	**A1**	

Question	Answer	Marks	Guidance
5(i)	$[s_1 = \frac{1}{2}(0 + 12) \times 6]$	**M1**	Use constant acceleration equations or find area in (t,v) graph to find the distance s_1 travelled in the first 6 seconds
	$[s_2 = 10 \times 12]$	**M1**	Use constant acceleration equations or find area in (t,v) graph to find s_2 the distance travelled between 6s and 16s
	Distance for first 16 s is $36 + 10 \times 12 = 156$	**A1**	
	Curve concave up for $0 < t < 6$ starting at (0 , 0) ending at (6 , 36)	**B1**	Co-ordinates refer to (t,s) in a displacement-time graph
	Line, positive gradient, $6 < t < 16$ starts at (6 , 36) ends at (16 , 156)	**B1**	
	Curve concave down, $16 < t < 20$ from (16 , 156) to (20 , 200)	**B1**	
		6	
5(ii)	$[44 = \frac{1}{2}(12 + V) \times 4]$	**M1**	Use relevant constant acceleration equations or the area property of a v–t graph
	$V = 10$	**A1**	
		2	

Question	Answer	Marks	Guidance
6(i)	[$P = \text{DF} \times v = 850 \times 36$]	M1	Apply $P = \text{DF} \times v$ with DF = Resistance force
	Power = rate of working = 30.6 kW	A1	
		2	
6(ii)	[DF = 1250 g × 0.1 + 850]	M1	Driving force comprising of resistance plus a weight component
	$\text{DF} = \frac{63000}{v}$	M1	$\text{DF} = \frac{P}{v}$
	$v = 30$ so speed of car is 30 ms^{-1}	A1	
		3	
6(iii)	Gain in KE = $\frac{1}{2} \times 1250 \times (24^2 - 20^2)$	B1	[= 110 000]
	Loss in PE = 1250 g × 176 × 0.1	B1	[= 220 000]
	WD by car's engine = 20 000 × 8	B1	[= 160 000]
	[160 000 + 220 000 = WD against resistance + 110 000]	M1	4 term work energy equation
	WD = 270 000 J = 270 kJ	A1	
		5	

Question	Answer	Marks	Guidance
7(i)	*A* $T - 0.8g \sin 45 = 0.8a$ *B* $1.2g \sin 30 - T = 1.2a$ System $1.2g \sin 30 - 0.8g \sin 45 = 2a$	**M1**	Apply Newton 2nd law to either *A* or to *B* or to the system
		A1	One correct equation
		A1	A second correct equation
	$a = 0.171$	**M1**	Solve for *a*
	$v^2 = 2 \times a \times 0.4$	**M1**	Use $v^2 = u^2 + 2as$ with $u = 0$
	$v = 0.370$ so speed of *A* is 0.370 ms^{-1}	**A1**	
		6	
	Alternative scheme for Question 7(i)		
		M1	Attempt KE gain or PE loss
	KE gain = $\frac{1}{2} \times 0.8 \times v^2 + \frac{1}{2} \times 1.2 \times v^2$	**A1**	*v* is the required speed of *A*
	PE loss = $1.2g \times 0.4 \sin 30 - 0.8g \times 0.4 \sin 45$	**A1**	
	$\frac{1}{2} \times 0.8 \times v^2 + \frac{1}{2} \times 1.2 \times v^2 =$ $1.2g \times 0.4 \sin 30 - 0.8g \times 0.4 \sin 45$	**M1**	4 term energy equation
		M1	Solving for *v*
	$v = 0.370$ so speed of *A* is 0.370 ms^{-1}	**A1**	

Question	Answer	Marks	Guidance
7(ii)	$R_A = 0.8g\cos 45 = 4\sqrt{2}$ $R_B = 1.2g\cos 30 = 6\sqrt{3}$	B1	For either R_A or R_B
	$F_A = 4\sqrt{2}\ \mu$ and $F_B = 6\sqrt{3}\ \mu$	M1	Either F_A or F_B used
	A $0.8\ g \sin 45 + F_A = T$ B $1.2\ g \sin 30 - F_B = T$ or system equation: $12 \sin 30 - 8 \sin 45 = F_A + F_B$	M1	Resolve parallel to the plane either for both particles A and B **or** for the system equation
	Correct equation(s)	A1	
		M1	Eliminate T and solve for μ
	$\mu = \dfrac{(6-4\sqrt{2})}{(6\sqrt{3}+4\sqrt{2})}$ $= 0.0214$	A1	
		6	

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MATHEMATICS **9709/42**

Paper 4 Mechanics **March 2018**

MARK SCHEME

Maximum Mark: 50

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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.

Mark Scheme Notes

Marks are of the following three types:

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.

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1	$[T - 2 = 0.2a \quad 8 - T = 0.8a]$ System is $0.8g - 0.2g = (0.2 + 0.8)a$ and $T = 2(0.2)(0.8)g/(0.8 + 0.2)$	M1	Attempt Newton's 2nd law for either particle or use a formula for the system for a and/or T
		A1	Two correct equations
	Attempt to solve for a or T	M1	
	$a = 6$ $T = 3.2$	A1	Both correct NB $a = 6$ **AG**
		4	

Question	Answer	Marks	Guidance
2	*EITHER:* $2P \sin \theta = P \sin 60$	(M1	Resolve vertically (2 terms)
	$\theta = 25.7$	A1	
	$2P \cos \theta + P \cos 60 = 10$	M1	Resolve horizontally (3 terms)
	$P = 4.34$	A1)	
	OR1: $\left[\frac{2P}{\sin 120} = \frac{P}{\sin(180 - \theta)} = \frac{10}{\sin(60 + \theta)}\right]$	(M1	Attempt Lami's theorem using one pair of terms
	$\theta = 25.7$	A1	Solve for θ
	Use a second Lami equation	M1	
	$P = 4.34$	A1)	
	OR2: Use sine or cosine rule with triangle of forces using forces P, $2P$ and 10 and with angles 60, θ and $120 - \theta$ between	(M1	
	$\theta = 25.7$	A1	
	Use a second relationship from the triangle of forces	M1	
	$P = 4.34$	A1)	
		4	

Question	Answer	Marks	Guidance
3(i)	$\frac{1}{2}\times 40\times v^2 = 40\times g\times 7.2$	**M1**	Use of KE gain = PE loss
	$v = 12\ \text{m s}^{-1}$	**A1**	
		2	
3(ii)	Work done against friction(WDF) $\text{WDF} = 40\times g\times 7.2 - \frac{1}{2}\times 40\times 10^2\ [= 880]$	**M1**	May be calculated as $\frac{1}{2}\times 40\times 12^2 - \frac{1}{2}\times 40\times 10^2$
	$\frac{1}{2}\times 40\times V^2 + 40\times g\times 7.2 = \frac{1}{2}\times 40\times 11^2 + 880$ **or** $\frac{1}{2}\times 40\times V^2 = \frac{1}{2}\times 40\times 11^2 - \frac{1}{2}\times 40\times 10^2$	**M1**	For 4-term work-energy equation with numerical attempt at work done or using the fact that WDF is the same in both cases, extra initial KE = difference in final KEs
	$V = \sqrt{21} = 4.58$	**A1**	
		3	

Question	Answer	Marks	Guidance
4	[$R = 12g \cos 25 + P \sin 25$ $P \cos 25 = F + 12g \sin 25$] or [$P = F \cos 25 + R \sin 25$ $R \cos 25 = F \sin 25 + 12g$]	**M1**	Attempt resolving of forces in any one direction, parallel to, perpendicular to plane or horizontally, vertically
		A1	Any one correct equation
		A1	Any second correct equation
	$F = 0.8R$	**M1**	Use of $F = \mu R$
	Complete method to find P from 2 equations(3 terms each)	**M1**	
	$P = 242$	**A1**	
		6	

Question	Answer	Marks	Guidance
5(i)	$200 = ½ \times (0 + v) \times 10$	**M1**	Use of *suvat*
	$v = 40$ m s^{-1}	**A1**	**AG**
	$200 = ½ \times a \times 10^2$	**M1**	Second use of *suvat*
	$a = 4$ m s^{-2}	**A1**	
		4	
5(ii)	$0 = 40^2 - 2 \times g \times s$	**M1**	Use of *suvat* with $a = g$
	$s = 80$ so height above ground = 280 m	**A1**	
		2	
5(iii)	*EITHER:* $0 = 40 - gt_1$	**(M1**	Use of *suvat* to find extra time to highest point
	$t_1 = 4$	**A1**	
	$280 = ½gt_2^2$	**M1**	Use of *suvat* to find time from highest point to ground
	$t_2 = \sqrt{56} = 7.48...$ so total time = 21.5 s	**A1)**	
	OR: $-200 = 40t_3 - ½gt_3^2$	**(M1**	Use of $s = ut + ½at^2$ with 200, 40 and g used
	$5t_3^2 - 40t_3 - 200 = 0$ o.e. $[t_3^2 - 8t_3 - 40 = 0]$	**A1**	Correct quadratic for time under gravity
	$[t_3 = 4 \pm \sqrt{56} = 4 \pm 7.48]$	**M1**	Solution of relevant 3-term quadratic
	$t_3 = 11.48$ so total time is 21.5 s	**A1)**	
		4	

Question	Answer	Marks	Guidance
6(i)	Driving force = 35×60	**M1**	
	Power = $35 \times 60^2 = 126000$ W	**A1**	
		2	

Question	Answer	Marks	Guidance
6(ii)	Driving force is $DF = \dfrac{126000}{30}$	B1FT	
	$DF - 35 \times 30 = 1200a$	M1	For 3-term Newton's 2nd law equation, dimensionally correct
	$a = \dfrac{3150}{1200} = \dfrac{21}{8} = 2.625\ \text{m s}^{-2}$	A1	AG
		3	
6(iii)	$DF = \dfrac{126000}{v}$	M1	For $F = \dfrac{P}{v}$
	$\dfrac{126000}{v} = 35v + 1200g \times \dfrac{7}{48}$	M1	For 3-term force equation, or equivalent
		A1	For correct (unsimplified) equation
	$35v^2 + 1750v - 126000 = 0$ or $v^2 + 50v - 3600 = 0$	M1	For simplifying and solving of a 3-term quadratic attempted
	$v = 40\ \text{ms}^{-1}$	A1	$v = -90$ rejected or ignored
		5	

Question	Answer	Marks	Guidance
7(i)	0.2 (m s^{-2})	B1	
		1	
7(ii)	$a = -1600t^{-3}$	M1	For attempted differentiation of $-2 + \dfrac{800}{t^2}$
	Acceleration at $t = 20$ is –0.2 (m s^{-2})	A1	
		2	
7(iii)	Straight line joining $t = 0$, $v = 4$ to $t = 10$, $v = 6$	B1	
	Curve with correct concavity joining end of line to $t = 20$, $v = 0$	B1	
	Correct labelling on axes provided the curves pass through (0,4), (10,6), (20,0)	B1	
		3	

Question	Answer	Marks	Guidance
7(iv)	Trapezium area = 50	B1	or from integration of 4 + 0.2t
	$\int\left(-2+800t^{-2}\right)\mathrm{d}t=-2t-800t^{-1}$	M1	Integration attempted
		A1	Correct indefinite integral
	$\left[-2t-800t^{-1}\right]_{10}^{20}$ $=-40-40+20+80$	M1	Correct use of the limits t = 10 and t = 20
	Distance is 50 + 20 = 70 m	A1	Correct total
		5	

Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

MATHEMATICS **9709/43**

Paper 4 Paper 4 **October/November 2017**

MARK SCHEME

Maximum Mark: 50

Published

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Question	Answer	Marks	Guidance
1	(X=) 20 cos 60 + 30 cos 60 – F	**B1**	
	[F = 20 cos 60 + 30 cos 60]	**M1**	Use of horizontal component of resultant = 0
	F = 25	**A1**	
		3	

Question	Answer	Marks	Guidance
2(i)	[F = 1480 + 7850g sin 3] (= 5588)	**M1**	
	[$\frac{P}{10}$ = 1480 + 7850g sin 3] →P = …	**M1**	Using $P = Fv$ and solving for P
	Power = 55 900 W	**A1**	
		3	
2(ii)	[F + 7850g sin 3 – 1480 = 7850 × 0.8] (F = 3652)	**M1**	Use of Newton's Second Law
	[$\frac{P}{15}$ + 7850g sin 3 – 1480 = 7850 × 0.8] →P = …	**M1**	Using $P = Fv$ and solving for P
	Power = 54800 W	**A1**	
		3	

Question	Answer	Marks	Guidance
3(i)	$R = mg$ cos 25	**B1**	
	[F = 0.4mg cos 25]	**M1**	Using $F = \mu R$
	[mg sin 25 – 0.4mg cos 25 = ma]	**M1**	Use of Newton's Second Law
	a = 0.601 ms^{-2}	**A1**	
		4	
3(ii)	[s = ½ × 0.601 × 3^2]	**M1**	Use of $s = ut + ½at^2$
	Distance = 2.70 m	**A1 FT**	FT 4.5 × a from **(i)**
		2	

Question	Answer	Marks	Guidance
4(i)	*EITHER:* [$T - 0.35g = 0.35a$ or $0.45g - T = 0.45a$ or $0.45g - 0.35g = 0.8a$]	**(M1**	Applies Newton's Second Law to one of the particles or forms system equation in a ($m_Bg - m_Ag = (m_A + m_B)a$)
	[$0.45g - T = 0.45a$ or $T - 0.35g = 0.35a$] $\rightarrow a = \ldots$	**M1**	Applies Newton's Second Law to form second equation in T and a and solves for a or solves system equation for a
	$a = 1.25$ m s^{-2}	**A1**	
	[$v^2 = 2 \times 1.25 \times 0.64$] (= 1.6)	**M1**	Using $v^2 = u^2 + 2as$
	Velocity = 1.26 ms^{-1}	**A1)**	
	OR: [PE loss = $0.45g \times 0.64 - 0.35g \times 0.64$]	**(M1**	Attempts PE loss
	[KE gain = ½ (0.35 + 0.45) v^2]	**M1**	Attempts KE gain
	PE loss = $0.45g \times 0.64 - 0.35g \times 0.64$ and KE gain = ½ (0.35 + 0.45) v^2	**A1**	
	[½ (0.8) $v^2 = 0.1g \times 0.64$] ($v^2 = 1.6$)	**M1**	Using PE loss = KE gain
	Velocity = 1.26 ms^{-1}	**A1)**	
		5	
4(ii)	*EITHER:* [$0 = 1.6 - 2\,gs$] ($s = 0.08$)	**(M1**	Using $v^2 = u^2 + 2as$
	Distance = 0.16 m	**A1)**	
	OR: [$0.35gh$ = ½ (0.35) × 1.6] ($h = 0.08$)	**(M1**	Using PE gain = KE loss for particle A
	Distance = 0.16 m	**A1)**	
		2	

Question	Answer	Marks	Guidance
5(i)	$v = \int k(3t^2 - 12t + 2)\,dt$ $= k(3t^3/3 - 12t^2/2 + 2t) + C$	*M1	Use of $v = \int a\,dt$
	$v = k\left(t^3 - 6t^2 + 2t\right) + C$	A1	Condone C missing
	$C = 0.4$	B1	
	$0.1 = k(1 - 6 + 2) + 0.4$ [$-0.3 = -3k$]	DM1	Substitutes $t = 1$, $v = 0.1$
	$k = 0.1$	A1	AG
		5	
5(ii)	[$s = \int 0.1(t^3 - 6t^2 + 2t) + 0.4\,dt$ $= 0.1(t^4/4 - 6t^3/3 + 2t^2/2) + 0.4t + C$]	M1	Use of $s = \int v\,dt$
	$s = 0.025t^4 - 0.2t^3 + 0.1t^2 + 0.4t$	A1	$C = 0$ seen or implied
		2	
5(iii)	Substitutes $t = 2$ to show $s = 0$	B1	AG
		1	

Question	Answer	Marks	Guidance
6(i)	[Area = ½ (10 + 4) × 6 = 42 m] Displacement = 42 m	B1	
		1	
6(ii)	$\frac{v}{2} = \frac{6}{4}$ or [gradient =1.5, $v = 6 + 1.5 \times 6$]	M1	Using similar triangles or using acceleration = gradient and $v = u + at$
	$v = 3\ \text{ms}^{-1}$	A1	
		2	
6(iii)	Total distance travelled $= 42 + ½\,(T - 10) \times 3$	B1 FT	Area found with FT distance from **(i)** and FT speed from **(ii)**
	[$42 + ½\,(T - 10) \times 3 = 49.5$] $\rightarrow T = \ldots$	M1	For equation and solving for T
	$T = 15$ s	A1	
		3	

Question	Answer	Marks	Guidance
6(iv)	$V = 1.75 \times 4 = 7$ ms^{-1}	**B1**	
	Q travels [½ (13 + 6) × 7 = 66.5 m] Distance apart = [66.5 + 42 – 7.5]	**M1**	Finding area for Q and interpreting total distance between particles
	Distance between P and Q = 101 m	**A1**	
		3	

Question	Answer	Marks	Guidance
7(i)	$R = 0.2g \cos 30 - T \sin 15$	**B1**	
	$[F = 0.3 \times (0.2g \cos 30 - T \sin 15)]$	**M1**	Use of $F = \mu R$
		M1	For resolving along the plane
	$T \cos 15 + 0.3 \times (0.2g \cos 30 - T \sin 15)$ $= 0.2g \sin 30$	**A1**	
		M1	For solving a 4 term equation for T
	$T = 0.541$	**A1**	
		6	
7(ii)	$0.3 \times 0.2g \cos 30 \times 3$ [= 1.5588 J]	**B1**	WD against F = friction × distance
	WD = 0.25 × 3 [= 0.75 J]	**B1**	WD against 0.25 force
	$0.2g \times 3 \sin 30$ [= 3 J]	**B1**	PE loss = mgh
	[½ (0.2) v^2 = 3 – 1.5588 – 0.75]	**M1**	Work/Energy equation
	Speed = 2.63 ms^{-1}	**A1**	
		5	

Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

MATHEMATICS	**9709/42**
Paper 4	**October/November 2017**
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1(i)	$F = 0.2g \sin 20 = 0.684$ N	**B1**	AG
		1	
1(ii)	$R = 0.2g \cos 20$	**B1**	
	$F = \mu R$ [$= 0.6 \times 0.2g \cos 20$]	**M1**	Using $F = \mu R$ $F = 1.1276\ldots$
	[$0.9 + 0.2g \sin 20 - F = 0.2a$]	**M1**	Use of Newton's 2nd law along the plane (4 relevant terms)
	$a = 2.28$ ms^{-2}	**A1**	
		4	

Question	Answer	Marks	Guidance
2	*EITHER:*	**(M1**	Attempt to resolve (either direction with correct number of terms and dimensionally correct)
	$T \sin \theta + 120 \sin 45 = 15g$	**A1**	Resolving vertically
	$T \cos \theta = 120 \cos 45$	**A1**	Resolving horizontally
	[$\tan \theta = \frac{(15g - 120\sin 45)}{(120\cos 45)}$ or $T = \sqrt{65.15^2 + 84.85^2}$]	**M1**	For using division to find θ or for using Pythagoras to find T
	$\theta = 37.5$	**A1**	
	$T = 107$	**A1)**	
	OR1: $\frac{120}{\sin(90+\theta)} = \frac{T}{\sin 135} = \frac{15g}{\sin(135-\theta)}$	**(A1**	One correct equation
		A1	A second correct equation
		M1	Attempt to solve for θ or T
	$\theta = 37.5$	**A1**	
	$T = 107$	**A1**	
		M1)	Attempt to use triangle of forces

Question	Answer	Marks	Guidance
	OR2: $\frac{T}{\sin 45} = \frac{15g}{\sin(45+\theta)} = \frac{120}{\sin(90-\theta)}$	**(A1**	One correct equation
		A1	A second correct equation
		M1	Attempt to solve for θ or T
	$\theta = 37.5$	**A1**	
	$T = 107$	**A1)**	
	OR3: $[T^2 = 150^2 + 120^2 - 2(150)(120)\cos 45]$	**(M1**	Use cosine rule in a triangle with sides 120, 150 and T and with corresponding angles $90 - \theta$, $45 + \theta$, 45
		A1	Correct equation
	$T = 107$	**A1**	
		M1	Use sin rule or cosine rule in an attempt to find θ
	$120/\sin(90 - \theta) = 106.97/\sin 45$	**A1**	A correct equation in θ such as this
	$\theta = 37.5$	**A1)**	
		6	

Question	Answer	Marks	Guidance
3(i)	$s_{AB} = 14 \times 5 + ½a \times 5^2$	**B1**	or $s_{AB} = ½(14 + 14 + 5a) \times 5$ OE
	$s_{AC} = 14 \times 8 + ½a \times 8^2$	**B1**	or $s_{AC} = ½(14 + 14 + 8a) \times 8$ OE
	$[112 + 32a = 2(70 + 12.5a)]$	**M1**	Using $AC = 2AB$ and solving for a or for substituting $a = 4$ and finding AB and AC
	$a = 4$ m s^{-2}	**A1**	AG, If substituting $a = 4$ must show $AB = 120$ and $AC = 240$ OE
		4	
3(ii)	$[v = 14 + 4 \times 8]$	**M1**	Use of $v = u + at$ or any complete method to find v
	Velocity = 46 m s^{-1}	**A1**	
		2	

Question	Answer	Marks	Guidance
4(i)	[$12t - ½gt^2 = 0$] or [$0 = 12 - gT$] with $t = 2T$ used	**M1**	Using $s = ut + ½at^2$ or equivalent such as finding time T to highest point and doubling.
	$t = 2.4$ s	**A1**	
		2	
4(ii)	Critical point at $t = 1.2$	**B1**	Seen in **4(ii)**
	Critical point at $t = 2$	**B1**	Seen in **4(ii)**
	Both moving in same direction $1 < t < 1.2$	**B1**	
	Both moving in same direction $2 < t < 2.4$	**B1**	
		4	

Question	Answer	Marks	Guidance
5(i)	*EITHER:* Resistance force = $\frac{600}{25}$ = 24 N	**(B1**	
	Weight component = $80\,g\,(0.04)$ = 32 N	**B1**	For correct unsimplified numerical form of the weight component
	[Power = 56×4]	**M1**	For use of $P = Fv$ where F is from two relevant force terms
	Power = 224 W	**A1)**	
		4	
	OR: PE gain = $80g \times 25\ (0.04)$ = 800	**(B1**	For a correct unsimplified numerical expression for PE
	Time taken = $\frac{25}{4}$ = 6.25	**B1**	
	[WD by cyclist = $P \times 6.25 = 800 + 600$]	**M1**	For using WD = $P \times t$ where WD is from two relevant terms
	Power = 224 W	**A1)**	
		4	

Question	Answer	Marks	Guidance
5(ii)	Work done by cyclist = 224 × 10 (= 2240J)	**B1 FT**	For stating WD = power × time FT on P value found in **5(i)**
	Initial KE = ½ × 80 × 4^2 [= 640 J]	**B1**	
	[½ × 80v^2 = 640 + P×10 –1200]	**M1**	For using Work/Energy equation
	Speed = 6.48 m s^{-1}	**A1**	Allow speed = √42
		4	

Question	Answer	Marks	Guidance
6(i)	$R = mg \cos \alpha \quad (R = 9.6m)$	**B1**	Allow use of α = 16.3° throughout
	[$T = mg$ $F = mg \sin \alpha + T$]	**M1**	For resolving forces on P and Q and eliminating T **or** for considering the equilibrium of the system
	$F = mg \sin \alpha + mg$	**A1**	(F = 12.8m)
		M1	For use of $F = \mu R$
	Coefficient of friction = 1⅓ = $\frac{4}{3}$	**A1**	**AG** so must be from exact working
		5	

Question	Answer	Marks	Guidance
6(ii)	*EITHER:* P equation is $10 - mg \sin \alpha - F - T = 2.5\, m$ Q equation is $T - mg = 2.5m$	**(*M1**	For applying Newton's 2nd law to P (5 terms) **or** Q (3 terms)
		***M1**	For applying Newton's 2nd law to the other particle and eliminate T
	$10 - mg \sin \alpha - \mu mg \cos \alpha$ $- mg = 2m\,(2.5)$	**A1**	If evaluated then this is $10 - 2.8m - 12.8m - 10m = 5m$
		DM1	For solving this equation for m as far as $m =$ Dependent on one or other of the previous M marks having been scored
	$m = 0.327$	**A1)**	Allow $m = \dfrac{50}{153}$
	OR: $[10 - mg \sin \alpha - F - mg = m(2.5 + 2.5)]$	**(*M1**	For applying Newton's 2nd law to the system. Allow with 5 terms
		***M1**	System equation with all 6 terms
	$10 - mg \sin \alpha\ - \mu mg \cos \alpha$ $- mg = 2m\,(2.5)$	**A1**	
		DM1	For solving this equation for m as far as $m =$ Dependent on one or other of the previous M marks having been scored
	$m = 0.327$	**A1)**	Allow $m = \dfrac{50}{153}$
		5	

Question	Answer	Marks	Guidance
7(i)	$-0.01t(t^2 - 22t + 40) = 0$ $-0.01t(t - 20)(t - 2) = 0$	**M1**	Attempting to solve $v = 0$ for t for a solvable quadratic using factors or quadratic formula and obtaining two non-zero solutions
	$t = 2$ or $t = 20$	**A1**	
		2	
7(ii)	$a = -0.03t^2 + 0.44t - 0.4$	**M1**	For differentiation
	a is greatest (maximum) when $0.44 - 0.06t = 0$	**M1**	For differentiation **or** finding values of $t = t_1$ and $t = t_2$ where $a = 0$ and using $t = ½(t_1 + t_2)$ **or** completing the square **or** other method to find maximum value
	Max acceleration when $t = 7.33$	**A1**	Allow $t = \frac{22}{3}$
		3	
7(iii)	$\int\left(-0.01t^3 + 0.22t^2 - 0.4t\right)\mathrm{d}t$	***M1**	For using integration.
	$s(t) = -\frac{0.01}{4}t^4 + \frac{0.22}{3}t^3 - 0.2t^2$	**A1**	Correct Integration Allow + C included
	$s(20) - s(2)$	**DM1**	Limits 2 and 20 used correctly Dependent on previous M1 having been scored
	Distance = 107 m	**A1**	Distance = $\frac{2673}{25}$ = 106.92
		4	

Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

MATHEMATICS **9709/41**

Paper 4 **October/November 2017**

MARK SCHEME

Maximum Mark: 50

Published

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This document consists of **7** printed pages.

 Cambridge Assessment International Education

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PA –1 This is deducted from A or B marks in the case of premature approximation. The PA –1 penalty is usually discussed at the meeting.

Question	Answer	Marks	Guidance
1	[12 cos 25 = 3a]	M1	For use of Newton's second law
	a = 4 cos 25 = 3.625	A1	
	[s = ½ × 4cos 25 × 5^2]	M1	For use of $s = ut + ½at^2$ OE
	Distance = 45.3 m	A1	
		4	

Question	Answer	Marks	Guidance
2(i)	Power = 1150 × 12 = 13 800W	B1	For use of $P = F \times v$ Allow 13.8 kW
		1	
2(ii)	Driving force = $\frac{25000}{12}$	B1	Using $F = \frac{P}{v}$
	$\frac{25000}{12} - 1150 - 3700g \sin 4 = 3700a$	M1	For applying Newton's 2nd law up the slope, 4 terms
	a = –0.445 m s^{-2}	A1	
		3	
2(iii)	$\frac{25000}{v} - 1150 - 3700g\sin 4 = 0$	M1	For stating the equation for constant v, with 3 terms, and solving for v
	v = 6.70 m s^{-1}	A1	
		2	

Question	Answer	Marks	Guidance
3(i)	640 × 18	M1	For use of work done = $F \times d$
	Work done = 11 520 J	A1	
		2	
3(ii)	KE at start = ½ × 840 × 14^2 = 82 320 J	B1	
	PE gained = 840g × 8sin 30 – 840g × 10sin 20 = 4870 J	B1	
	½ × 840 × v^2 = 82 320 – 11 520 – 4870	M1	For using work – energy equation with 4 terms and solving for v
	v = 12.5 m s^{-1}	A1	
		4	

Question	Answer	Marks	Guidance
4(i)	Acceleration = $\frac{(-25)}{2.5} = -10 \text{ m s}^{-2}$	**B1**	AG
		1	
4(ii)	$V = -15 + 7.5 \times 4$	**M1**	Using v–t graph OE
	$V = 15 \text{ m s}^{-1}$	**A1**	
		2	
4(iii)	Using $v = 0$ at $t = 4.5$ and $t = 8$	**B1**	
		M1	Attempting to use area to find total distance travelled
	$\frac{1}{2} \times (4.5 + 2) \times 10$ $+ \frac{1}{2} \times (8 - 4.5) \times 15$ $+ \frac{1}{2} \times (T - 8) \times 15 = 100$	**M1**	For setting up an equation for total distance travelled and solving for T
	$T = 13.5$	**A1**	
		4	

Question	Answer	Marks	Guidance
5(i)	Acceleration = 0.4 m s^{-2}	**B1**	
		1	
5(ii)	$\frac{100}{t^2} - 0.1t = 0$	**M1**	For setting $v = 0$ and solving for t
	$t = 10$ s	**A1**	
		2	
5(iii)	Distance $t = 0$ to $t = 5$ is $\frac{1}{2}(1.5 + 3.5) \times 5 = 12.5$	**B1**	Trapezium rule or integration
	$s(t) = \int \left(\frac{100}{t^2} - 0.1t\right) dt$	**M1**	For integration
	$= -\frac{100}{t} - 0.05t^2 (+C)$	**A1**	Correct integration
	$s(10) - s(5)$	**M1**	Use limits 5 and 10 used or find $+ C$
	Total distance = 12.5 + 6.25 = 18.75 m	**A1**	
		5	

Question	Answer	Marks	Guidance
6(i)		M1	For resolving forces (either direction)
	$X = 75 + 50 \cos 60$ (= 100) $Y = 50 \sin 60$ (= 43.3)	A1	For both equations, unevaluated
	Resultant = $\sqrt{(100^2 + 43.3^2)} = 109$ N	B1	
	Angle = $\arctan\left(\frac{43.3}{100}\right) = 23.4°$	B1	Must state anticlockwise from the positive x-axis or show in a diagram
		4	
6(ii)	$50 \cos \alpha - F \cos 50 = 0$	B1	Resolving forces horizontally
	$50 \sin \alpha - 3F - F \sin 50 = 0$	B1	Resolving forces vertically
	$\tan \alpha = \frac{(3F + F\sin 50)}{(F\cos 50)}$	M1	For division to find θ or for using Pythagoras to find F
	$\alpha = 80.3$	A1	
	$F = 13.1$	A1	
		5	

Question	Answer	Marks	Guidance
7(i)		M1	For applying Newton's 2nd law to either particle (correct number of terms)
	$T - 0.9\,g \sin 15 = 0.9a$	A1	
	$2.5 + 0.4\,g \sin 25 - T = 0.4a$	A1	
	$1.3a = 1.86…$	M1	Solving simultaneously for a
	$a = 1.43$ m s^{-2}	A1	
		5	

Question	Answer	Marks	Guidance
7(ii)	$F = 0.8 \times 0.4g \cos 25$	**B1**	
	$2.5 + 0.4\,g \sin 25 - T - F = 0$	**M1**	For using equilibrium of forces acting on particle *B* with 4 terms
	$T - 0.9\,g \sin \theta = 0$	**M1**	For using equilibrium of forces acting on particle *A* with 2 terms
		M1	For solving for θ
	$\theta = 8.2°$	**A1**	
		5	

Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

MATHEMATICS **9709/43**

Paper 4 Paper 4 **October/November 2017**

MARK SCHEME

Maximum Mark: 50

Published

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1	(X=) 20 cos 60 + 30 cos 60 – F	**B1**	
	[F = 20 cos 60 + 30 cos 60]	**M1**	Use of horizontal component of resultant = 0
	F = 25	**A1**	
		3	

Question	Answer	Marks	Guidance
2(i)	[F = 1480 + 7850g sin 3] (= 5588)	**M1**	
	[$\frac{P}{10}$ = 1480 + 7850g sin 3] →P = …	**M1**	Using $P = Fv$ and solving for P
	Power = 55 900 W	**A1**	
		3	
2(ii)	[F + 7850g sin 3 – 1480 = 7850 × 0.8] (F = 3652)	**M1**	Use of Newton's Second Law
	[$\frac{P}{15}$ + 7850g sin 3 – 1480 = 7850 × 0.8] →P = …	**M1**	Using $P = Fv$ and solving for P
	Power = 54800 W	**A1**	
		3	

Question	Answer	Marks	Guidance
3(i)	$R = mg$ cos 25	**B1**	
	[F = 0.4mg cos 25]	**M1**	Using $F = \mu R$
	[mg sin 25 – 0.4mg cos 25 = ma]	**M1**	Use of Newton's Second Law
	a = 0.601 ms^{-2}	**A1**	
		4	
3(ii)	[s = ½ × 0.601 × 3^2]	**M1**	Use of $s = ut + ½at^2$
	Distance = 2.70 m	**A1 FT**	FT 4.5 × a from **(i)**
		2	

Question	Answer	Marks	Guidance
4(i)	*EITHER:* [$T - 0.35g = 0.35a$ or $0.45g - T = 0.45a$ or $0.45g - 0.35g = 0.8a$]	(M1	Applies Newton's Second Law to one of the particles or forms system equation in a ($m_Bg - m_Ag = (m_A + m_B)a$)
	[$0.45g - T = 0.45a$ or $T - 0.35g = 0.35a$] $\rightarrow a = \ldots$	M1	Applies Newton's Second Law to form second equation in T and a and solves for a or solves system equation for a
	$a = 1.25$ m s^{-2}	A1	
	[$v^2 = 2 \times 1.25 \times 0.64$] (= 1.6)	M1	Using $v^2 = u^2 + 2as$
	Velocity = 1.26 ms^{-1}	A1)	
	OR: [PE loss = $0.45g \times 0.64 - 0.35g \times 0.64$]	(M1	Attempts PE loss
	[KE gain = ½ (0.35 + 0.45) v^2]	M1	Attempts KE gain
	PE loss = $0.45g \times 0.64 - 0.35g \times 0.64$ and KE gain = ½ (0.35 + 0.45) v^2	A1	
	[½ (0.8) $v^2 = 0.1g \times 0.64$] ($v^2 = 1.6$)	M1	Using PE loss = KE gain
	Velocity = 1.26 ms^{-1}	A1)	
		5	
4(ii)	*EITHER:* [$0 = 1.6 - 2gs$] ($s = 0.08$)	(M1	Using $v^2 = u^2 + 2as$
	Distance = 0.16 m	A1)	
	OR: [$0.35gh = ½ (0.35) \times 1.6$] ($h = 0.08$)	(M1	Using PE gain = KE loss for particle A
	Distance = 0.16 m	A1)	
		2	

Question	Answer	Marks	Guidance
5(i)	$v = \int k(3t^2 - 12t + 2)\,dt$ $= k(3t^3/3 - 12t^2/2 + 2t) + C$	*M1	Use of $v = \int a\,dt$
	$v = k\left(t^3 - 6t^2 + 2t\right) + C$	A1	Condone C missing
	$C = 0.4$	B1	
	$0.1 = k(1 - 6 + 2) + 0.4$ $[-0.3 = -3k]$	DM1	Substitutes $t = 1$, $v = 0.1$
	$k = 0.1$	A1	AG
		5	
5(ii)	$[s = \int 0.1(t^3 - 6t^2 + 2t) + 0.4\,dt$ $= 0.1(t^4/4 - 6t^3/3 + 2t^2/2) + 0.4t + C]$	M1	Use of $s = \int v\,dt$
	$s = 0.025t^4 - 0.2t^3 + 0.1t^2 + 0.4t$	A1	$C = 0$ seen or implied
		2	
5(iii)	Substitutes $t = 2$ to show $s = 0$	B1	AG
		1	

Question	Answer	Marks	Guidance
6(i)	[Area = ½ (10 + 4) × 6 = 42 m] Displacement = 42 m	B1	
		1	
6(ii)	$\frac{v}{2} = \frac{6}{4}$ or [gradient =1.5, $v = 6 + 1.5 \times 6$]	M1	Using similar triangles or using acceleration = gradient and $v = u + at$
	$v = 3\ \text{ms}^{-1}$	A1	
		2	
6(iii)	Total distance travelled = 42 + ½ (T – 10) × 3	B1 FT	Area found with FT distance from **(i)** and FT speed from **(ii)**
	[42 + ½ (T – 10) × 3 = 49.5] →T= …	M1	For equation and solving for T
	T = 15 s	A1	
		3	

Question	Answer	Marks	Guidance
6(iv)	$V = 1.75 \times 4 = 7$ ms^{-1}	**B1**	
	Q travels [½ (13 + 6) × 7 = 66.5 m] Distance apart = [66.5 + 42 – 7.5]	**M1**	Finding area for Q and interpreting total distance between particles
	Distance between P and Q = 101 m	**A1**	
		3	

Question	Answer	Marks	Guidance
7(i)	$R = 0.2g \cos 30 - T \sin 15$	**B1**	
	[$F = 0.3 \times (0.2g \cos 30 - T \sin 15)$]	**M1**	Use of $F = \mu R$
		M1	For resolving along the plane
	$T \cos15 + 0.3 \times (0.2g \cos30 - T \sin15)$ $= 0.2g\sin30$	**A1**	
		M1	For solving a 4 term equation for T
	$T = 0.541$	**A1**	
		6	
7(ii)	$0.3 \times 0.2g \cos 30 \times 3$ [= 1.5588 J]	**B1**	WD against F = friction × distance
	WD = 0.25 × 3 [= 0.75 J]	**B1**	WD against 0.25 force
	$0.2g \times 3 \sin 30$ [= 3 J]	**B1**	PE loss = mgh
	[½ (0.2) v^2 = 3 – 1.5588 – 0.75]	**M1**	Work/Energy equation
	Speed = 2.63 ms^{-1}	**A1**	
		5	

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

MATHEMATICS **9709/42**

Paper 4 **October/November 2017**

MARK SCHEME

Maximum Mark: 50

Published

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Question	Answer	Marks	Guidance
1(i)	$F = 0.2g \sin 20 = 0.684$ N	B1	AG
		1	
1(ii)	$R = 0.2g \cos 20$	B1	
	$F = \mu R$ [$= 0.6 \times 0.2g \cos 20$]	M1	Using $F = \mu R$ $F = 1.1276\ldots$
	[$0.9 + 0.2g \sin 20 - F = 0.2a$]	M1	Use of Newton's 2nd law along the plane (4 relevant terms)
	$a = 2.28$ ms^{-2}	A1	
		4	

Question	Answer	Marks	Guidance
2	*EITHER:*	(M1	Attempt to resolve (either direction with correct number of terms and dimensionally correct)
	$T \sin \theta + 120 \sin 45 = 15g$	A1	Resolving vertically
	$T \cos \theta = 120 \cos 45$	A1	Resolving horizontally
	[$\tan \theta = \frac{(15g - 120\sin 45)}{(120\cos 45)}$ or $T = \sqrt{65.15^2 + 84.85^2}$]	M1	For using division to find θ or for using Pythagoras to find T
	$\theta = 37.5$	A1	
	$T = 107$	A1)	
	OR1: $\frac{120}{\sin(90+\theta)} = \frac{T}{\sin 135} = \frac{15g}{\sin(135-\theta)}$	(A1	One correct equation
		A1	A second correct equation
		M1	Attempt to solve for θ or T
	$\theta = 37.5$	A1	
	$T = 107$	A1	
		M1)	Attempt to use triangle of forces

Question	Answer	Marks	Guidance
	OR2: $\dfrac{T}{\sin 45} = \dfrac{15g}{\sin(45+\theta)} = \dfrac{120}{\sin(90-\theta)}$	**(A1**	One correct equation
		A1	A second correct equation
		M1	Attempt to solve for θ or T
	$\theta = 37.5$	**A1**	
	$T = 107$	**A1)**	
	OR3: $[T^2 = 150^2 + 120^2 - 2(150)(120) \cos 45]$	**(M1**	Use cosine rule in a triangle with sides 120, 150 and T and with corresponding angles $90 - \theta$, $45 + \theta$, 45
		A1	Correct equation
	$T = 107$	**A1**	
		M1	Use sin rule or cosine rule in an attempt to find θ
	$120/\sin(90 - \theta) = 106.97/\sin 45$	**A1**	A correct equation in θ such as this
	$\theta = 37.5$	**A1)**	
		6	

Question	Answer	Marks	Guidance
3(i)	$s_{AB} = 14 \times 5 + ½a \times 5^2$	**B1**	or $s_{AB} = ½(14 + 14 + 5a) \times 5$ OE
	$s_{AC} = 14 \times 8 + ½a \times 8^2$	**B1**	or $s_{AC} = ½(14 + 14 + 8a) \times 8$ OE
	$[112 + 32a = 2(70 + 12.5a)]$	**M1**	Using $AC = 2AB$ and solving for a or for substituting $a = 4$ and finding AB and AC
	$a = 4$ m s^{-2}	**A1**	AG, If substituting $a = 4$ must show $AB = 120$ and $AC = 240$ OE
		4	
3(ii)	$[v = 14 + 4 \times 8]$	**M1**	Use of $v = u + at$ or any complete method to find v
	Velocity = 46 m s^{-1}	**A1**	
		2	

Question	Answer	Marks	Guidance
4(i)	[$12t - \frac{1}{2}gt^2 = 0$] or [$0 = 12 - gT$] with $t = 2T$ used	M1	Using $s = ut + \frac{1}{2}at^2$ or equivalent such as finding time T to highest point and doubling.
	$t = 2.4$ s	A1	
		2	
4(ii)	Critical point at $t = 1.2$	B1	Seen in **4(ii)**
	Critical point at $t = 2$	B1	Seen in **4(ii)**
	Both moving in same direction $1 < t < 1.2$	B1	
	Both moving in same direction $2 < t < 2.4$	B1	
		4	

Question	Answer	Marks	Guidance
5(i)	*EITHER:* Resistance force = $\frac{600}{25}$ = 24 N	(B1	
	Weight component = $80g$ (0.04) = 32 N	B1	For correct unsimplified numerical form of the weight component
	[Power = 56×4]	M1	For use of $P = Fv$ where F is from two relevant force terms
	Power = 224 W	A1)	
		4	
	OR: PE gain = $80g \times 25$ (0.04) = 800	(B1	For a correct unsimplified numerical expression for PE
	Time taken = $\frac{25}{4}$ = 6.25	B1	
	[WD by cyclist = $P \times 6.25 = 800 + 600$]	M1	For using WD = $P \times t$ where WD is from two relevant terms
	Power = 224 W	A1)	
		4	

Question	Answer	Marks	Guidance
5(ii)	Work done by cyclist = 224 × 10 (= 2240J)	B1 FT	For stating WD = power × time FT on P value found in **5(i)**
	Initial KE = ½ × 80 × 4^2 [= 640 J]	B1	
	[½ × $80v^2$ = 640 + P×10 –1200]	M1	For using Work/Energy equation
	Speed = 6.48 m s^{-1}	A1	Allow speed = √42
		4	

Question	Answer	Marks	Guidance
6(i)	$R = mg \cos \alpha$ ($R = 9.6m$)	B1	Allow use of $\alpha = 16.3°$ throughout
	[$T = mg$ $F = mg \sin \alpha + T$]	M1	For resolving forces on P and Q and eliminating T **or** for considering the equilibrium of the system
	$F = mg \sin \alpha + mg$	A1	($F = 12.8m$)
		M1	For use of $F = \mu R$
	Coefficient of friction = 1⅓ = $\frac{4}{3}$	A1	**AG** so must be from exact working
		5	

Question	Answer	Marks	Guidance
6(ii)	*EITHER:* P equation is $10 - mg \sin \alpha - F - T = 2.5\,m$ Q equation is $T - mg = 2.5m$	(*M1	For applying Newton's 2nd law to P (5 terms) **or** Q (3 terms)
		*M1	For applying Newton's 2nd law to the other particle and eliminate T
	$10 - mg \sin \alpha - \mu mg \cos \alpha$ $- mg = 2m\,(2.5)$	A1	If evaluated then this is $10 - 2.8m - 12.8m - 10m = 5m$
		DM1	For solving this equation for m as far as m = Dependent on one or other of the previous M marks having been scored
	$m = 0.327$	A1)	Allow $m = \frac{50}{153}$
	OR: $[10 - mg \sin \alpha - F - mg = m(2.5 + 2.5)]$	(*M1	For applying Newton's 2nd law to the system. Allow with 5 terms
		*M1	System equation with all 6 terms
	$10 - mg \sin \alpha\ - \mu mg \cos \alpha$ $- mg = 2m\,(2.5)$	A1	
		DM1	For solving this equation for m as far as m = Dependent on one or other of the previous M marks having been scored
	$m = 0.327$	A1)	Allow $m = \frac{50}{153}$
		5	

Question	Answer	Marks	Guidance
7(i)	$-0.01t(t^2 - 22t + 40) = 0$ $-0.01t(t - 20)(t - 2) = 0$	**M1**	Attempting to solve $v = 0$ for t for a solvable quadratic using factors or quadratic formula and obtaining two non-zero solutions
	$t = 2$ or $t = 20$	**A1**	
		2	
7(ii)	$a = -0.03t^2 + 0.44t - 0.4$	**M1**	For differentiation
	a is greatest (maximum) when $0.44 - 0.06t = 0$	**M1**	For differentiation **or** finding values of $t = t_1$ and $t = t_2$ where $a = 0$ and using $t = ½(t_1 + t_2)$ **or** completing the square **or** other method to find maximum value
	Max acceleration when $t = 7.33$	**A1**	Allow $t = \frac{22}{3}$
		3	
7(iii)	$\int\left(-0.01t^3 + 0.22t^2 - 0.4t\right)\mathrm{d}t$	***M1**	For using integration.
	$s(t) = -\frac{0.01}{4}t^4 + \frac{0.22}{3}t^3 - 0.2t^2$	**A1**	Correct Integration Allow + C included
	$s(20) - s(2)$	**DM1**	Limits 2 and 20 used correctly Dependent on previous M1 having been scored
	Distance = 107 m	**A1**	Distance = $\frac{2673}{25}$ = 106.92
		4	

Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

MATHEMATICS | **9709/41**

Paper 4 | **October/November 2017**

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1	[12 cos 25 = 3*a*]	M1	For use of Newton's second law
	a = 4 cos 25 = 3.625	A1	
	[$s = \frac{1}{2} \times 4\cos 25 \times 5^2$]	M1	For use of $s = ut + \frac{1}{2}at^2$ OE
	Distance = 45.3 m	A1	
		4	

Question	Answer	Marks	Guidance
2(i)	Power = 1150 × 12 = 13 800W	B1	For use of $P = F \times v$ Allow 13.8 kW
		1	
2(ii)	Driving force = $\frac{25000}{12}$	B1	Using $F = \frac{P}{v}$
	$\frac{25000}{12} - 1150 - 3700g \sin 4 = 3700a$	M1	For applying Newton's 2nd law up the slope, 4 terms
	$a = -0.445$ m s^{-2}	A1	
		3	
2(iii)	$\frac{25000}{v} - 1150 - 3700g\sin 4 = 0$	M1	For stating the equation for constant *v*, with 3 terms, and solving for *v*
	$v = 6.70$ m s^{-1}	A1	
		2	

Question	Answer	Marks	Guidance
3(i)	640 × 18	M1	For use of work done = $F \times d$
	Work done = 11 520 J	A1	
		2	
3(ii)	KE at start $= \frac{1}{2} \times 840 \times 14^2 = 82\,320$ J	B1	
	PE gained = $840g \times 8\sin 30$ $- 840g \times 10\sin 20 = 4870$ J	B1	
	$\frac{1}{2} \times 840 \times v^2 = 82\,320 - 11\,520 - 4870$	M1	For using work – energy equation with 4 terms and solving for *v*
	$v = 12.5$ m s^{-1}	A1	
		4	

Question	Answer	Marks	Guidance
4(i)	Acceleration = $\frac{(-25)}{2.5} = -10 \text{ m s}^{-2}$	**B1**	AG
		1	
4(ii)	$V = -15 + 7.5 \times 4$	**M1**	Using v–t graph OE
	$V = 15 \text{ m s}^{-1}$	**A1**	
		2	
4(iii)	Using $v = 0$ at $t = 4.5$ and $t = 8$	**B1**	
		M1	Attempting to use area to find total distance travelled
	$\frac{1}{2} \times (4.5 + 2) \times 10$ $+ \frac{1}{2} \times (8 - 4.5) \times 15$ $+ \frac{1}{2} \times (T - 8) \times 15 = 100$	**M1**	For setting up an equation for total distance travelled and solving for T
	$T = 13.5$	**A1**	
		4	

Question	Answer	Marks	Guidance
5(i)	Acceleration = 0.4 m s^{-2}	**B1**	
		1	
5(ii)	$\frac{100}{t^2} - 0.1t = 0$	**M1**	For setting $v = 0$ and solving for t
	$t = 10$ s	**A1**	
		2	
5(iii)	Distance $t = 0$ to $t = 5$ is $\frac{1}{2}(1.5 + 3.5) \times 5 = 12.5$	**B1**	Trapezium rule or integration
	$s(t) = \int\left(\frac{100}{t^2} - 0.1t\right)dt$	**M1**	For integration
	$= -\frac{100}{t} - 0.05t^2 (+C)$	**A1**	Correct integration
	$s(10) - s(5)$	**M1**	Use limits 5 and 10 used or find + C
	Total distance = 12.5 + 6.25 = 18.75 m	**A1**	
		5	

Question	Answer	Marks	Guidance
6(i)		M1	For resolving forces (either direction)
	$X = 75 + 50\cos 60\ (= 100)$ $Y = 50\sin 60\ (= 43.3)$	A1	For both equations, unevaluated
	Resultant = $\sqrt{(100^2 + 43.3^2)} = 109$ N	B1	
	Angle = $\arctan\left(\frac{43.3}{100}\right) = 23.4°$	B1	Must state anticlockwise from the positive x-axis or show in a diagram
		4	
6(ii)	$50\cos\alpha - F\cos 50 = 0$	B1	Resolving forces horizontally
	$50\sin\alpha - 3F - F\sin 50 = 0$	B1	Resolving forces vertically
	$\tan\alpha = \frac{(3F + F\sin 50)}{(F\cos 50)}$	M1	For division to find θ or for using Pythagoras to find F
	$\alpha = 80.3$	A1	
	$F = 13.1$	A1	
		5	

Question	Answer	Marks	Guidance
7(i)		M1	For applying Newton's 2nd law to either particle (correct number of terms)
	$T - 0.9g\sin 15 = 0.9a$	A1	
	$2.5 + 0.4g\sin 25 - T = 0.4a$	A1	
	$1.3a = 1.86\ldots$	M1	Solving simultaneously for a
	$a = 1.43$ m s^{-2}	A1	
		5	

Question	Answer	Marks	Guidance
7(ii)	$F = 0.8 \times 0.4g \cos 25$	**B1**	
	$2.5 + 0.4\,g \sin 25 - T - F = 0$	**M1**	For using equilibrium of forces acting on particle B with 4 terms
	$T - 0.9\,g \sin \theta = 0$	**M1**	For using equilibrium of forces acting on particle A with 2 terms
		M1	For solving for θ
	$\theta = 8.2^{\circ}$	**A1**	
		5	

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MATHEMATICS **9709/42**

Paper 4 Mechanics **March 2017**

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Question	Answer	Marks	Guidance
1(i)	KE = ½ × 0.4 × 12^2 = 28.8 J	**B1**	
	Total:	**1**	
1(ii)	PE gain = 0.4*gh* [= 4*d* sin 30]	**B1**	*h* = height gained *d* = distance travelled up the plane
	4*h* = 28.8	**M1**	Using KE loss = PE gain
	h = 7.2 *h* = *d* sin 30 *d* = 14.4 m	**A1**	
	Total:	**3**	

Question	Answer	Marks	Guidance
2		**M1**	Resolve forces horizontally and/or vertically
	$T_A \sin 20 + T_B \sin 40 = 16$	**A1**	Correct vertical equation
	$T_A \cos 20 = T_B \cos 40$	**A1**	Correct horizontal equation
		M1	Attempt to solve for T_A and/or T_B
	$T_A = 14.2$ N	**A1**	$T_A = 14.1528...$
	$T_B = 17.4$ N	**A1**	$T_B = 17.3610...$
	Total:	**6**	
	Alternative method for Question 2		
		M1	Attempt to use Lami's Theorem
	$\frac{16}{\sin 120} = \frac{T_A}{\sin 130}$	**A1**	
	$\frac{16}{\sin 120} = \frac{T_B}{\sin 110}$	**A1**	
		M1	Attempt to solve for T_A and/or T_B
	$T_A = 14.2$ N	**A1**	
	$T_B = 17.4$ N	**A1**	
	Total:	**6**	

Question	Answer	Marks	Guidance
3	$R = 0.6g \cos 21$ [= 5.60]	**B1**	
	$F = 0.3R = 1.8 \cos 21$ [= 1.68]	**M1**	Using $F = \mu R$
	$P + F = 6 \sin 21$[= 2.15]	**M1**	Slipping down
	$P = 2.15 – 1.68 = 0.470$ **AG**	**A1**	Least possible value
	$P – F = 6 \sin 21$	**M1**	Slipping up
	$P = 2.15 + 1.68 = 3.83$	**A1**	Greatest possible value
	Total:	**6**	

Question	Answer	Marks	Guidance
4(i)	$36000 = 800v$	**M1**	Using $P = Fv$
	$v = 45\,\text{m s}^{-1}$	**A1**	Speed of the car
	$AB = 45 \times 120 = 5400\,\text{m}$	**A1**	
	Total:	**3**	
4(ii)	$-800 = 900a$ [$a = -8/9$]	**M1**	Using Newton's 2nd law
	$v^2 = 45^2 - \frac{16}{9} \times 450$	**M1**	Using $v^2 = u^2 + 2as$
	$v = 35\ \text{m s}^{-1}$	**A1**	Speed of the car at C
	Total:	**3**	
	Alternative method for Question 4(ii)		
	$0.5 \times 900 \times (45 – v^2)$	**M1**	Attempt change in KE
	$0.5 \times 900 \times (45 – v^2) = 800 \times 450$	**M1**	KE loss = WD against Friction
	$v = 35\ \text{m s}^{-1}$	**A1**	Speed of the car at C
	Total:	**3**	

Question	Answer	Marks	Guidance
4(iii)	$CD = 6637.5 - 5400 - 450 = 787.5$	B1	
	$0 = 35^2 - 2d \times 787.5$	M1	Using $v^2 = u^2 + 2as$, $a = -d$
	$d = 7/9 = 0.778\,\text{m s}^{-2}$	A1	d = deceleration
	$P = 900 \times (7/9) = 700$	A1	Using $F = ma$
	Total:	4	

Question	Answer	Marks	Guidance
5(i)	$0 = a + b \times 35^2$ $40 = a + b \times 15^2$	M1	For matching velocities at $t = 15$ and using $v = 0$ at $t = 35$
	[$1000b = -40 \rightarrow b = -0.04$] [$a = 0.04 \times 352 = 49$]	M1	Solve for a and b
	$a = 49$ and $b = -0.04$ **AG**	A1	
	Total:	3	
5(ii)	$0 \leqslant t \leqslant 5$ correct	B1	Increasing quadratic, from (0,0) to (5,20), concave up
	$5 \leqslant t \leqslant 15$ correct	B1	Line from (5,20) to (15,40)
	$15 \leqslant t \leqslant 35$ correct	B1	Decreasing quadratic, from (15,40) to (35,0), concave down
	20 and 40 seen correct on v-axis	B1	
	Total:	4	
5(iii)	$A_1 = \int_0^5 0.8t^2 \mathrm{d}t = \frac{100}{3}$	B1	
	$A_2 = \frac{1}{2}(20 + 40) \times 10 = 300$	M1	Using trapezium rule or integration for $t = 5$ to $t = 15$
	$A_3 = \int_{15}^{35} (a + bt^2)\mathrm{d}t$ $= 49t - \frac{0.04}{3}t^3$	M1	Attempt to integrate the quadratic function from $t = 15$ to $t = 35$
	$A_3 = 453.3333 = 1360/3$	A1	
	Total Distance = $2360/3 = 787\,\text{m}$	A1	
	Total:	5	

Question	Answer	Marks	Guidance
6(i)		**M1**	Apply Newton's law to either of the particles
	$12 - T = 1.2a$ and $T - 8 = 0.8a$	**A1**	Both equations correct
		M1	Solve for a and T
	$a = 2\,\text{m s}^{-2}$ and $T = 9.6\,\text{N}$	**A1**	
	Total:	**4**	
6(ii)	$[0.64 = ½ \times 2 \times t_1^2]$ $[v = 2t_1]$	**M1**	Attempt to find time t_1 taken for 1.2 kg particle to reach ground and/or its speed v at the ground
	$t_1 = 0.8$	**A1**	
	$v = 2 \times 0.8 = 1.6$	**A1**	
	$[0 = 1.6 - 10t_2]$ $[1.6^2 = 2 \times 10 \times s_2]$	**M1**	For attempting to find the time t_2 and/or distance travelled s_2 as 0.8 kg particle comes to rest
	$t_2 = 0.16$	**A1**	
	$s_2 = 0.128$	**A1**	
	$t_3 = 1 - 0.8 - 0.16 = 0.04$ $s_3 = ½ \times 10 \times 0.04^2$	**B1**	Finding the distance s_3 travelled downwards in t_3 seconds
	Total distance travelled = $0.64 + 0.128 + 0.008 = 0.776\,\text{m}$	**B1**	
	Total:	**8**	

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

MATHEMATICS **9709/43**

Paper 4 **October/November 2016**

MARK SCHEME

Maximum Mark: 50

Published

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

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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).

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- The symbol $\sqrt{}$ 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 and B marks are not given for fortuitously "correct" answers or results obtained from incorrect working.

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CWO Correct Working Only – often written by a 'fortuitous' answer

ISW Ignore Subsequent Working

SOI Seen or implied

SR Special Ruling (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)

Penalties

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PA –1 This is deducted from A or B marks in the case of premature approximation. The PA –1 penalty is usually discussed at the meeting.

1 (i)	PE gain = $50g \times 3.5$ (=1750)	**B1**		
	[WD = $50g \times 3.5 + 25 \times 3.5$]	**M1**		For using WD = PE gain + WD against resistance
	Work done = 1837.5 J or 1840 J	**A1**	[3]	
(ii)	[P = 1837.5/2] or [$P/v = 50g + 25$ **and** $3.5 = 2v$]	**M1**		For using P = WD/t or for using $P = Fv$ **and** $s = vt$
	Power = 919 W	**A1**	[2]	
2		**M1**		For resolving horizontally
		M1		For resolving vertically
	$T_A \cos 50° - T_B \cos 10° = 0$ **and** $T_A \sin 50° - T_B \sin 10° - 20g = 0$	**A1**		
		M1		For solving equations to find T_A and T_B
	Tension in PA is 306 N Tension in PB is 200 N	**A1**	[5]	
	Alternative (Lami's Theorem)			
	[$T_A/\sin 80° = T_B/\sin 140° = 20g/\sin 140°$]	**M1**		For applying Lami's Theorem
	[$T_A = 20g \sin 80°/\sin 140°$]	**M1**		For solving for T_A
	Tension in PA is 306 N	**A1**		
	[$T_B = 20g \sin 140°/\sin 140°$]	**M1**		For solving for T_B
	Tension in PB is 200 N	**A1**	[5]	

3	(i)	$[7g - T = 7a$ **and** $T - 3g = 3a]$ or $[7g - 3g = 10a]$	M1		For applying Newton's second law to P **and** to Q or for using $m_Pg - m_Qg = (m_P + m_Q)a$
		Acceleration is $4\,\text{ms}^{-2}$	A1		
		$[v^2 = 0 + 2 \times 4 \times 0.4]$ $(v^2 = 3.2)$	M1		For using $v^2 = u^2 + 2as$
		Speed is $1.79\,\text{ms}^{-1}$	A1	[4]	
	(ii)	$[0 = 3.2 + 2 \times (-g) \times s]$ $(s = 0.16)$	M1		For using $0 = u^2 + 2(-g)s$
		$0.16 + 0.4 = 0.56$ So particle Q does not come to rest before it reaches the pulley	A1	[2]	
		Alternative			
		$[v^2 = 3.2 + 2 \times (-g) \times 0.1]$	M1		For using $v^2 = u^2 + 2(-g)(0.1)$
		$v = \sqrt{1.2}$ $(= 1.10)$ So particle Q does not come to rest before it reaches the pulley	A1	[2]	
4	(i)	$s_A = \frac{1}{2}g \times 2.5^2$ $(= 31.25)$	B1		
		$[s_B = 20 \times 1.5 - \frac{1}{2}g \times 1.5^2]$ $(= 18.75)$	M1		For using $s = ut + \frac{1}{2}at^2$
		$\frac{1}{2}g \times 2.5^2 + 20 \times 1.5 - \frac{1}{2}g \times 1.5^2$ Height is 50 m AG	A1	[3]	
	(ii)	$50 = 0.5gt_A^2$ $(t_A = 3.16)$	B1		For using $s = \frac{1}{2}at^2$
		$t_B = \sqrt{10} - 1 = 2.16$	B1		
		To top, $0^2 = 20^2 - 2gs_B$ $\rightarrow s_B = 20$	B1		
		To top, $[0 = 20 - gt_B]$ $\rightarrow t_B = 2$ Downwards, $[s_B = \frac{1}{2}g(0.16)^2]$ $(= 0.13)$	M1		For using $v = u + at$ to find time to top for B **and** $s = \frac{1}{2}at^2$ to find downwards distance for B
		Total distance is 20.1 m	A1	[5]	

5	**(i)**	$6t - 0.3t^2 = 0 \rightarrow t = 20$ (or 0)	**B1**		
		[$s = 6t^2/2 - 0.3t^3/3$ (+C)]	**M1**		For integrating $v(t)$ to obtain $s(t)$
		[$s = 6(20)^2/2 - 0.3(20)^3/3$]	**DM1**		For evaluating $s(t)$ when v=0
		Distance OX is 400 m	**A1**	[4]	
	(ii)	[$v = kt - 6t^2$ (+C)]	**M1***		For integrating $a(t)$ to obtain $v(t)$
		[$s = kt^2/2 - 6t^3/3$]	**M1***		For integrating $v(t)$ to obtain $s(t)$ and for using $s(0) = 0$
		[$400 = 0.5k \times 10^2 - 2 \times 10^3$]	**DM1**		For using $t = 10$ and $s = 400$ to form equation in k
		$k = 48$	**A1**	[4]	
6	**(i)**	Driving force = 160/5 (= 32 N)	**B1**		
		[$160/5 - 20 = m \times 0.15$]	**M1**		For using Newton's Second Law
		Total mass is 80 kg AG	**A1**	[3]	
	(ii)	[$300/v - 20 - 80g\sin 2° = 0$]	**M1**		For resolving up hill
		Speed is 6.26 ms^{-1} AG	**A1**	[2]	
	(iii)	Driving force = $300/(0.9 \times 6.26)$ (= 53.2 N)	**B1**		
			M1		For using Newton's Second Law
		$300/(0.9 \times 6.26) - 20 - 80g\sin 2° = 80a$	**A1**		
		Acceleration is 0.0666 ms^{-2}	**A1**	[4]	

7	(i)	$R = 50g\cos 10°$ and $F = 50g\sin 10°$	B1		
		$\mu \geqslant 0.176$	B1	[2]	$\mu \geqslant F \div R$ Allow $\mu \geqslant \tan 10°$
	(ii)	PE loss = $50g \times d\sin 10°$	B1		$d = 5$ or $d = 10$
		WD against friction = $0.19 \times 50g\cos 10° \times d$	B1		$d = 5$ or $d = 10$
			M1		For using WD by 50 N force + PE loss – WD against friction = KE gain
		$50 \times 5 + 50g \times 10\sin 10° - 0.19 \times$ $50g\cos 10° \times 10 = 0.5 \times 50v^2$	A1		
		Speed is $2.70\,\text{ms}^{-1}$	A1	[5]	
					SC for candidates using Newton's Second law: max 2/5 B1 $v = 2.94\,\text{ms}^{-1}$ after 5 m B1 Speed is $2.70\,\text{ms}^{-1}$
	(iii)	$50g\sin 20° -$ $0.19 \times 50g\cos 20° = 50a$	M1		For using Newton's Second Law
		Acceleration is $1.63\,\text{ms}^{-2}$	A1	[2]	

Cambridge International AS & A Level

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Cambridge International Advanced Subsidiary and Advanced Level

MATHEMATICS **9709/42**

Paper 4 **October/November 2016**

MARK SCHEME

Maximum Mark: 50

Published

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CAMBRIDGE International Examinations

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1	**(i)**	$3.5 = 10a \rightarrow a = 0.35\,\text{ms}^{-2}$	**B1**		Allow $a = 3.5/10$
		$[10\cos 15 - F = 2 \times 0.35]$	**M1**		For applying Newton's 2nd law to the particle
		$F = 8.96\,\text{N}$ AG	**A1**	[3]	
		Alternative to 1(i)			
		$s = ½ (0 + 3.5) \times 10 = 17.5\,\text{m}$	**B1**		Distanced moved in 10 secs
		$[10\cos 15 \times 17.5 = F \times 17.5 + ½\, 2\, (3.5)^2]$	**M1**		Work done by 10 N force = WD against F + KE gain
		$F = 8.96\,\text{N}$ AG	**A1**	[3]	
	(ii)	$[R = 2g - 10\sin 15]$	**M1**		Resolving forces vertically
		$[\mu = 8.96/(2g - 10\sin 15)]$	**M1**		Using $F = \mu R$
		$\mu = 0.515$	**A1**	[3]	
2	**(i)**	$[v = 4t - 40t^{0.5}]$	**M1***		For differentiating s to find v
		$[a = 4 - 20t^{-0.5}]$	**M1***		For differentiating v to find a
		$[4 - 20t^{-0.5} = 0]$	**DM1**		For setting $a = 0$ and attempt to solve to find t
		$t = 25\,\text{s}$	**A1**	[4]	
	(ii)	Substitute their t into s **or** v	**M1**		
		Displacement $= -2083.3\,\text{m}$ $(= -2080$ 3sf) **and** Velocity $= -100\,\text{ms}^{-1}$	**A1**	[2]	or Displacement = $-6250/3$

3 (i)	[$X = 60\cos25 + 50\cos15$]	**M1**		For resolving both forces in the direction of river
	$= 103$ N	**A1**	[2]	Value of X is 102.7 N
(ii)	$Y = 60\sin25 - 50\sin15$ [= 12.4]	**B1**		Component perpendicular to the direction of the river
	[$R^2 = X^2 + Y^2$] or [$\alpha = \arctan(Y/X)$]	**M1**		For using Pythagoras or for using arctan to find the resultant force or its direction
	Magnitude is 103 N (or $\alpha = 6.9^o$ with direction specified unambiguously)	**A1**		Magnitude is 103.4 N
	$\alpha = 6.9^o$ with direction specified unambiguously (or Magnitude = 103 N)	**B1**	[4]	
4 (i)	PE loss = $mg \times 100\sin20$	**B1**		
	[$½mv^2 - ½m \times 5^2 = mg \times 100\sin20$]	**M1**		Using KE gain = PE loss
	$v = 26.6$ ms^{-1}	**A1**	[3]	
	Alternative method for 4(i)			
	$a = g\sin 20$ [= 3.42]	**B1**		
	[$v^2 = 5^2 + 2 \times a \times 100$]	**M1**		Using $v^2 = u^2 + 2as$
	$v = 26.6$ ms^{-1}	**A1**	[3]	
(ii)	KE = $\pm(0.5m \times 441 - 0.5m \times 25)$ [= $\pm 208m$]	**B1**		
	[$mg \times 100\sin20 = 8500 + 208m$]	**M1**		For using PE loss = WD against Friction + KE gain
	Mass $m = 63.4$ kg	**A1**	[3]	

5	$F = \mu mg\cos30$	**B1**		
	$[10 + F - mg\sin30 = 0]$	**M1**		Resolving up, first case
	$[75 - F - mg\sin30 = 0]$	**M1**		Resolving up, second case
	$[85 = 2mg\sin30]$ or $[10 + \mu mg\cos30 - mg\sin30 = 0$ $75 - \mu mg\cos30 - mg\sin30 = 0]$	**M1**		Either attempt to solve for m or Solve a pair of two 3 term simultaneous equations for either m or μ
	$m = 8.5$ kg or $\mu = 0.442$	**A1**		
	$\mu = 0.442$ or $m = 8.5$ kg	**B1**	[6]	
6 (i)	[Power = 400 × 25]	**M1**		For using $P = Fv$ where $F =$ resistance = 400 N
	Power = 10000 W	**A1**	[2]	Allow 10 kW
(ii)	Tension = 100 N	**B1**	[1]	Considering the trailer
(iii)	New driving force = 25000/20 = 1250 N	**B1**		Driving force = P/v at the instant when $v = 20$
	$[\text{DF} - 300 - T - 3000\,g\sin4 = 3000a]$ or $[T - 100 - 500\,g\sin4 = 500a]$ or $[\text{DF} - 400 - 3500\,g\sin4 = 3500a]$	**M1**		For using Newton's second law applied **either** to the van **or** to the trailer **or** to the system of van and trailer.
		M1		For using N2 applied to one of the other cases
	$[a = -0.4547$ may be seen$]$	**M1**		Solving or using substitution to find T
	$T = 221$ N	**A1**	[5]	Allow $T = 1550/7$ N

7	(i)	$v = 3 \times 10 = 30\,\text{ms}^{-1}$	B1		Velocity after 10 seconds
		[$s = ½ (30 + 40) \times 30$] or equivalent complete method	M1		For determining distance travelled in first 40 seconds
		Total distance = 1050 m	A1	[3]	
	(ii)	[Distance = 450 m Time taken = 450 / 15 = 30 s]	M1		For finding distance covered in deceleration stage and time taken for this stage
		Total time of motion for car = 70 s	A1		May be implied by time for motorcycle = 50 s
		[Motorcycle takes 50 s to travel 1500 m $1500 = ½ (30 + 50) \times V$ or $1500 = 30V + 0.5 \times 20V$]	M1		For setting up an equation for distance travelled by M / C (v–t graph or other) involving V or a and up to one other variable.
		$V = 37.5\,\text{ms}^{-1}$	A1		
		[20 s is split between 5 s accelerating and 15 s decelerating]	M1		For finding time taken to accelerate to speed V
		$a = 37.5 / 5 = 7.5\,\text{ms}^{-2}$	A1	[6]	
	(iii)	Displacement-time graph	B1		Two of the three graph stages correct with correct curvature
			B1		All three stages of the graph correct with correct curvature
			B1	[3]	Correct graph, fully labelled t=10,40,70s = 150,1050, 1500

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MATHEMATICS **9709/41**

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1	[$0.4g - T = 0.4a$ $T = 0.6a$ System equation $0.4g = (0.4 + 0.6)a$]	**M1** **M1**		For applying Newton's 2nd law to either particle or to the system For applying Newton's 2nd law to the other particle and attempt to solve for a and T
	$a = 4\,\text{m s}^{-2}$	**A1**		
	$T = 2.4\,\text{N}$	**A1**	[4]	
2 (i)	$2 = 5a \rightarrow a = 0.4\,\text{ms}^{-2}$	**B1**		
	[$0.1g\sin 20 - F = 0.1 \times 0.4$]	**M1**		For applying Newton's 2nd law to the particle
	$F = 0.302\,\text{N}$ AG	**A1**	[3]	
(ii)	[$R = 0.1g\cos 20$ (= 0.9397)]	**M1**		For attempting to find R and using $\mu = F/R$
	$\mu = 0.3020/0.9397 = 0.321$	**A1**	[2]	
3 (i)	[$0 = 6^2 - 2g \times s$]	**M1**		For using $v^2 = u^2 + 2as$
	$s = 1.8$	**A1**		
	Total height = 2.3 m	**B1**	[3]	
	Alternative for 3(i)			
	[$6^2 = u^2 - 2g \times 0.5$]	**M1**		For using $v^2 = u^2 + 2as$ to find the initial velocity
	$u^2 = 46$	**A1**		
	$0^2 = 46 - 2gs \rightarrow s$ = total height = 2.3 m	**B1**	[3]	

(ii)	$[2.3 = 0 + 0.5gt^2]$	M1		For using $s = ut + 0.5gt^2$ to find time to reach the ground
	$t = 0.678$	A1		
	Total time = 2 × 0.678 = 1.36 s	B1	[3]	
	Alternative for 3(ii)			
	$[\,0 = \sqrt{46} - gt\,]$	M1		Using $v = u - gt$ to find time taken to the highest point
	$t = \dfrac{\sqrt{46}}{10} = 0.678$	A1		
	Total time = 2 × 0.678 = 1.36 s	B1	[3]	
4		M1		For resolving forces horizontally
	$2F + F\cos 60 = 15\cos\alpha$	A1		
		M1		For resolving forces vertically
	$F\sin 60 = 15\sin\alpha$	A1		
		M1		For using Pythagoras or for using tan α to find F **and** α
	$F = 5.67$ and $\alpha = 19.1$	A1	[6]	Allow $F = 15\sqrt{7}/7$
5 (i)	$a = 0.5\,\text{m s}^{-2}$	B1	[1]	
(ii)	[Distance $= 25 + 100 + 5(5 + V) + 30V + 10V$]	M1		For attempting to find the distance travelled
	$150 + 45V$ AG	A1		
	$150 + 45V = 465 \rightarrow V = 7\,\text{m s}^{-1}$	B1	[3]	
(iii)	$\frac{1}{2} \times 80 \times 7^2 - \frac{1}{2} \times 80 \times 5^2$ [= 960]	M1		For change in KE
	$20 \times (5 + 7)/2 \times 10$ [=1200]	M1		For work done against friction using $F \times d$
	$[80gh = 960 + 1200]$	M1		For using PE loss = KE gain + WD against Res.
	$h = 2.7\,\text{m}$	A1	[4]	

6	(i)	[Work done = 50 cos10 × 20]	M1		Using WD = $Fd \cos\theta$
		= 984.8 J	A1	[2]	
	(ii)	[984.8 = ½ × 25v^2 + 30 × 20]	M1		Using WD by DF = KE gain + WD against Res.
		v = 5.55 m s^{-1}	A1	[2]	
	(iii)		M1		For using Power = Fv
		Max power = 50cos10 × 5.55 = 273 W	A1	[2]	Greatest power is at v_{max}
	(iv)	[50 cos10 – 30 – 25g sin5 = 25a]	M1		For using Newton's 2nd law up the plane
		a = – 0.102 m s^{-2}	A1		
		[0 = 5.55 – 0.102t]	M1		For using $v = u + at$
		Time t = 54.4 s	A1	[4]	
		Alternative for 6(iv)			
			M1		For using WD by DF + KE loss = PE gain + WD against Res to find distance s up plane
		50 cos 10 × s + ½ × 25 × 5.55^2 = 25g × s sin 5 + 30 × s	A1		s = 151 m
			M1		For using s = ½($u + v$)t
		t = 302/5.55 = 54.4 s	A1	[4]	
7	(i)	[15 – 6t = 0]	M1		For differentiation
		Max acceleration when t = 2.5 s	A1		May be stated from an a-t diagram
		Max acceleration = 18.75 m s^{-2}	A1	[3]	
	(ii)	[Speed = 7.5t^2 – t^3 (+ c)]	M1		For using integration to obtain speed
		[Distance = 2.5t^3 – 0.25t^4 (+ ct + d)]	M1		For using integration to obtain distance
		= 2.5×125 – 0.25×625 = 156.25 m	A1	[3]	Allow distance = 625/4

(iii)	$v(5) = 7.5\times25 - 125 = 62.5\,\text{m s}^{-1}$	**B1**		Allow $v(5) = 125/2$
	$\int_5^k -\frac{625}{t^2}\,dt = \left[\frac{625}{t}\right]_5^k$	**M1**		Integral with correct limits
	$= \frac{625}{k} - \frac{625}{5} = \frac{625}{k} - 125$	**A1**		
	$\frac{625}{k} - 125 = v(k) - v(5) = -62.5$	**M1**		Use of $v(5) = 62.5$ and $v(k) = 0$
	$k = 10$	**A1**	[5]	
	Alternative for 7(iii)			
	$v(5) = 7.5\times25 - 125 = 62.5\,\text{m s}^{-1}$	**B1**		
	$v(t) = \int -\frac{625}{t^2}\,dt = \frac{625}{t} + c$	**M1**		Using indefinite integration
	$[c = -62.5]$ $v(t) = \frac{625}{t} - 62.5$	**A1**		For using $v(5) = 62.5$ to find c and setting $v(k) = 0$
	$v(k) = \frac{625}{k} - 62.5 = 0$	**M1**		
	$k = 10$	**A1**	[5]	

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

MATHEMATICS **9709/43**

Paper 4 **May/June 2016**

MARK SCHEME

Maximum Mark: 50

Published

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Qu	Answer	Part Marks	Marks	Notes
1 (i)	[PE gain = $8g \times 20\sin30°$]	M1		For using PE gain = mgh
	Change in PE is 800 J	A1	2	
(ii)	[$8g$ x $20\sin30° + 20F = 1146$]	M1		For using PE gain + WD against friction = 1146
	Frictional force is 17.3 N	A1	2	
2 (i)	$s_B = \frac{1}{2} \times 1.2 \times 5^2$ Distance travelled is 15 m	B1		
	$v_B = 1.2 \times 5$ Speed is 6 ms^{-1}	B1	2	
(ii)	[$4T = 15 + 6(T - 10)$] or [$4(T + 5) = 15 + 6(T - 5)$] or [$4(T + 10) = 15 + 6T$]	M1		For using $s_A = s_B$ after T seconds or after $T + 5$ seconds or after $T + 10$ seconds
	$T = 22.5$or $T = 17.5$or $T = 12.5$	A1		
	Distance OP = $4 \times 22.5 = 90$ m	B1	3	
3		M1		For resolving forces horizontally and/or vertically
	$12\cos75° + P\cos\theta° = 18\cos65°$	A1		
	$18\sin65° + 12\sin75° = 15 + P\sin\theta°$	A1		
	[$P^2 = (18\sin65° + 12\sin75° - 15)^2 + (18\cos65° - 12\cos75°)^2$] or [$\theta = \tan^{-1}(18\sin65° + 12\sin75° - 15)/(18\cos65° - 12\cos75°)$]	M1		For eliminating either θ or P from the simultaneous equations
	$P = 13.7$ or $\theta = 70.8$	A1		
	$\theta = 70.8$ or $P = 13.7$	B1	6	

Qu	Answer	Part Marks	Marks	Notes
4	$R = 15g\cos 20^{\circ}$	B1		140.95
	$F = \mu R = 0.2 \times 15g\cos 20^{\circ}$	B1		28.19
		M1		For resolving parallel to the plane (F acting up plane)
	$X + 0.2 \times 15g\cos 20^{\circ} = 15g\sin 20^{\circ}$	A1		
	Least value of X is 23.1	A1		AG
	[$X = 15g\sin 20^{\circ} + 0.2 \times 15g\cos 20^{\circ}$]	M1		For resolving parallel to the plane (F acting down plane)
	Greatest value of X is 79.5	A1	7	
5 (i)	[$20000/v = 650$]	M1		For using DF = P/v and for resolving forces along the direction of motion
	Speed is 30.8 ms^{-1}	A1	2	
(ii)	[DF = $650 + 1400g \times {}^{1}/_{7}$]	M1		For resolving forces along the direction of motion
	$P/10 = 650 + 1400g \times {}^{1}/_{7}$	M1		For using DF = P/v
	Power is 26500 W	A1	3	
(iii)	$P = 0.8 \times 26500(21200)$	B1√		ft $0.8 \times P$ from (ii)
	[$21200/20 + 1400g \times {}^{1}/_{7} - 650 = 1400a$]	M1		For using Newton's Second Law
	Acceleration is 1.72 ms^{-2}	A1	3	
6 (i) (a)		M1		For applying Newton's Second Law to one particle or for using $m_1g - m_2g = (m_1 + m_2)a$
	$1.3g - T = 1.3a$ and $T - 0.7g = 0.7a$ or $1.3g - 0.7g = (1.3 + 0.7)a$ and either $1.3g - T = 1.3a$ or $T - 0.7g = 0.7a$	A1		
	Tension is 9.1 N	B1		

Qu	Answer	Part Marks	Marks	Notes
(b)	Acceleration is $3\ \text{ms}^{-2}$	B1		
	$[2 = ½ \times 3 \times t^2]$	M1		For using $s = ½ at^2$
	Time taken is 1.15 seconds	A1	6	
(ii)	$[v^2 = 2 \times 3 \times 2]$	M1		For using $v^2 = u^2 + 2as$ to find the speed on reaching plane
	$v = \sqrt{12}(3.464)$	A1ft		ft$\sqrt{(4a)}$orat from (i)
	$[0 = 12 – 2gs \rightarrow s = ...]$	M1		For using $v^2 = u^2 + 2as$ to find the distance 0.7 kg particle continues upwards
	Greatest height is 4.6 m	A1	4	
	Alternative			
(ii)	$[1.3g \times 2 = ½ (1.3)v^2 + 9.1 \times 2]$ or $[9.1 \times 2 = ½ (0.7)v^2 + 0.7g \times 2]$	M1		For using PE loss = KE gain + WD_T for 1.3 kg or for using WD_T = KE gain + PE gain for 0.7 kg
	$v = \sqrt{12}(3.464)$	A1ft		ft$\sqrt{(4a)}$ or at from (i)
	$[½ \times 0.7v^2 = 0.7gs \rightarrow s = ...]$	M1		For using KE loss = PE gain
	Greatest height is 4.6 m	A1	4	
7 (i)	$[6t – 2 < 0 \rightarrow t < .....]$	M1		For solving $a(t) < 0$
	$0 < t < 1/3$	A1	2	
(ii)	$[v = 3t^2 – 2t + c]$	M1		For using $v(t) = \int a(t)dt$
		M1		For using $s(t) = \int v(t)dt$
	$s = t^3 – t^2 + ct + d$	A1		
	[c + d = 7 3c + d = 11 $\rightarrow$ c = ... , d = ...]	M1		For using t=1, s=7 and t=3, s=29 to form and solve simultaneous equations
	$s = t^3 – t^2 + 2t + 5$	A1	5	
(iii)	$[3t^2 – 2t + 2 = 10]$	M1		For using $v(t) = 10$
		DM1		For solving 3 term quadratic $v(t) = 10$
	$t = 2$	A1	3	

MATHEMATICS **9709/42**

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1	[$X = 7 - 8\cos\alpha - 6\sin\alpha = -3$]	M1		For resolving forces horizontally
	$X = 7 - 8 \times (4/5) - 6 \times (3/5) = -3$	A1		Allow α = 36.9 used
	[$Y = 8\sin\alpha - 6\cos\alpha = 0$]	M1		For resolving forces vertically
	$Y = 8 \times (3/5) - 6 \times (4/5) = 0$	A1		Allow α = 36.9 used
	Resultant force is 3N to the left	B1	5	
2 (i)	$4t^2 - 8t + 3 = 0$ $(2t-3)(2t-1)$	M1		Set $v = 0$ and attempt to factorise or use the quadratic formula or completing the square.
	$t = 0.5$ and $t = 1.5$	A1	2	
(ii)	$s = -\int(4t^2 - 8t + 3)\mathrm{d}t$	M1		Integrating v to find s. Allow minus sign omitted.
	$-\left[\frac{4}{3}t^3 - 4t^2 + 3t\right]_{0.5}^{1.5}$	M1		Attempted integration with limits substituted and then subtracted but not necessarily fully evaluated. [= – (0 – 2/3)] Allow first minus sign omitted
	Distance travelled =2/3 m	A1	3	Must justify sign of answer
3 (i)	[$80x \sin 22.6$ or $80x(5/13)$]	M1		For using PE change = mgh PE change = $8 \times g \times x \sin\alpha$
	$= \frac{400}{13}x = 30.8x$	A1	2	Allow α = 22.6 used
(ii)	WD against friction = $15 \times x$	B1		
	$\frac{1}{2} \times 8 \times 5^2$	B1		
	$\frac{1}{2} \times 8 \times 5^2 = \frac{400}{13}x + 15x$	M1		For using KE loss = PE gain + WD against friction
	$x = \frac{260}{119} = 2.18$	A1	4	

Qu	Answer	Part Marks	Mark	Notes
4 (i)	½ × 6 × 8.2 + 36 × 8.2 Or½ × 8.2 × (36 + 42)	M1		For using distance = total area under graph
	Distance = 319.8 m	A1	2	
(ii)	$s = 80.2$	B1√		Distance from $t = 42$ to $t = 52$
	$80.2 = \frac{8.2 + V}{2} \times 10$	M1		For equating remaining distance to total area under graph between $t = 42$ and $t = 52$
	$V = 7.84$	A1	3	**AG**
(iii)		M1		Use gradient property for deceleration
	$d = \frac{8.2 - 7.84}{10} = 0.036$	A1	2	
	Alternative for 4(iii)			
(iii)	$80.2 = 8.2 \times 10 + ½\, a \times 10^2$	M1		For using $s = ut + ½at^2$ between $t = 42$ and $t = 52$
	$a = –0.036$ ms^{-2} or $d = 0.036$ ms^{-2}	A1	2	
5		M1		For resolving forces perpendicular to the plane (3 term equation)
	$R + T \sin 20 = 2.5g \cos 30$	A1		
	$F = 0.25 \times R$	B1		May be implied
		M1		For resolving forces parallel to the plane (3 term equation)
	$T \cos 20 = F + 2.5g \sin 30$	A1		
		M1		For solving and obtaining T
	$T = 17.5$	A1	7	

Qu	Answer	Part Marks	Mark	Notes
	Alternative scheme			
5	$F = 0.25 \times R$	B1		May be implied
		M1		For resolving forces horizontally (3 term equation)
	$T \cos 50 = F \cos 30 + R \sin 30$	A1		
		M1		For resolving forces vertically (4 term equation)
	$R \cos 30 + T \sin 50 = F \sin 30 + 2.5g$	A1		
		M1		For solving and obtaining T
	$T = 17.5$	A1	7	
6 (i) (a)	Power = 1550 × 40 W	M1		Using Power = Fv where F = Resistance force
	Power = 62000 W = 62 kW	A1	2	Answer must be in kW
(b)	(62000 – 22000) = DF × 40 [DF = 1000]	B1ft		For stating P – 22000 = DF × 40 to find the new driving force. ft on Power found in **(i)(a)**
	DF – 1550 = 1100a	M1		For applying Newton's second law to the car (3 terms)
	$a = -0.5$ ms^{-2} or $d = 0.5$ ms^{-2}	A1	3	
(ii)	DF = 1100g sin 8 + 1550 [= 3081]	M1		For stating the equilibrium of the three forces
	80000 = 3081v	M1		For using $P = Fv$ with F involving a weight and a resistance term
	v = 26(.0) ms^{-1}	A1	3	

Qu	Answer	Part Marks	Mark	Notes
7 (i)	[$2.4g - T = 2.4a$ $T = 1.6a$ or the system equation $2.4g = (1.6 + 2.4)a$]	M1		For applying Newton's second law to one of the particles or to the combined system
		M1		For applying Newton's second law to a second particle if needed and/or solving for a
	$a = 6$ ms^{-2}	A1		
	$0.5 = ½ \times 6 \times t^2$	M1		For using $s = ut + ½at^2$
	$t = 0.408$s	A1	5	Accept $t = \sqrt{6}/6$
	Alternative for 7(i)			
(i)	[PE loss = $2.4 \times g \times 0.5 = 12$ KE gain = $½(1.6 + 2.4)v^2 = 2v^2$]	M1		For attempting to find PE and KE as B reaches the ground
	[$12 = 2v^2$]	M1		Using PE loss = KE gain
	$v^2 = 6 \rightarrow v = 2.45$ ms^{-1}	A1		
	[$0.5 = ½ \times (0 + 2.45) \times t$]	M1		Using $s = ½(u + v)t$
	$t = 0.408$s	A1	5	Accept $t = \sqrt{6}/6$
(ii)	$R = 1.6g = 16$ and $F = 3/8\ R = 6$	B1		
	System is [$2.4g - 6 = (1.6 + 2.4)a$]	M1		For using Newton's second law for both particles or the system
	$2.4g - T = 2.4a$ and $T - 6 = 1.6a$	A1		Both or system equation
	[$a = 4.5$]	M1		For finding a and using $v^2 = u^2 + 2as$ to find v as B reaches the ground
	$v = \sqrt{2 \times 4.5 \times 0.5} = \sqrt{4.5} = 2.12$ ms^{-1}	A1		
	$-6 = 1.6a \rightarrow a = -3.75$ ms^{-2} $0 = 4.5 + 2 \times (-3.75) \times (s - 0.5)$	M1		For finding the deceleration of A and using $v^2 = u^2 + 2as$ to find s the total distance travelled by A
	$s = 1.1$ m	A1	7	

Qu	Answer	Part Marks	Mark	Notes
First Alternative for 7(ii)				
(ii)	$R = 1.6g = 16$ and $F = 3/8\ R = 6$	**B1**		
		M1		For attempting PE loss **and** KE gain as *B* reaches the ground
	PE loss = $2.4 \times g \times 0.5$ [= 12] KE gain = $½ \times (1.6 + 2.4) \times v^2$ [= $2v^2$]	**A1**		For both PE and KE correct
		M1		For using PE loss = KE gain + WD against *F*
	$12 = 2v^2 + 6 \times 0.5 \rightarrow v^2 = 4.5 \rightarrow v = 2.12$	**A1**		
	Loss of KE = WD against *F* [$½ \times 1.6 \times 4.5 = 6 \times (s - 0.5)$]	**M1**		For considering the motion of *A* after *B* reaches the ground to find *s* the total distance travelled
	$s = 1.1$ m	**A1**	7	

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

MATHEMATICS **9709/41**

Paper 4 **May/June 2016**

MARK SCHEME

Maximum Mark: 50

Published

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Qu	Answer	Part Mark	Marks	Guidance
1 (i)	Trapezium seen	B1		v–t graph with three straight lines, with positive, zero and negative gradients, continuous
	0, 3, 9, 13 shown on the t axis	B1		
	$v = 2.7$ soi in either part	B1	[3]	
(ii)	[$0.5 \times (6 + 13) \times 2.7$]	M1		Using area of trapezium
	Total distance = 25.65 m	A1	[2]	Allow Distance = 513/20 m
Alternative method for 1(ii)				
(ii)	Stage 1 $s_1 = 0.5 \times 0.9 \times 3^2 = 4.05$ Stage 2 $s_2 = 2.7 \times 6 = 16.2$ Stage 3 $s_3 = 0.5 \times (2.7 + 0) \times 4 = 5.4$	M1		Complete method to find the total distance travelled by the lift using constant acceleration equations for all three stages
	Total distance = 25.65 m	A1	[2]	
2 (i)	WD = $40 \times 36 = 1440$ J	B1	[1]	
(ii)		M1		Using PE = mgh
	PE = $25 \times g \times 36 \sin 20 = 3080$ J	A1	[2]	[PE = 3078.18]
(iii)	WD by pulling force = **(i) + (ii)**	M1		For using WD by pulling force = Gain in PE + WD against F
	WD = 4520 J	A1	[2]	[WD = 4518.18]
Alternative for (iii)				
(iii)	[$(25g \sin 20 + 40) \times 36$]	M1		For attempting to find the pulling force and multiply it by 36 to find the work done
	WD = 4520 J	A1	[2]	[WD = 4518.18]

Qu	Answer	Part Mark	Marks	Guidance
3 (i)	Driving Force = 300	**B1**		Using DF = Resistance
	$P = 300 \times 40$	**M1**		Using $P = Fv$
	$P = 12000$ W = 12 kW	**A1**	[3]	Must give answer in kW
(ii)	$P = 0.9 \times 12000 = 10800$	**B1**√		ft on 12000
	$\frac{10\,800}{25} - 300 = 1000a$	**M1**		Applying Newton's second law with 3 terms to the car
	$a = 132/1000 = 0.132$ ms^{-2}	**A1**	[3]	
4	$P \cos \theta = 48 \cos \alpha - 14 \sin \alpha$ and/or $P \sin \theta = 50 - 48 \sin \alpha - 14 \cos \alpha$	**M1**		For resolving forces horizontally and/or vertically
	$P \cos \theta = 48(24/25) - 14(7/25)$ $= 42.16$	**A1**		Allow $\alpha = 16.3$ used throughout
	$P \sin \theta = 50 - 48(7/25) - 14(24/25)$ $= 23.12$	**A1**		
		M1		For attempting to find P or θ
	$P = \sqrt{42.16^2 + 23.12^2} = 48.1$	**A1**		Allow $P = 34\sqrt{2}$
	$\tan \theta = \frac{23.12}{42.16}$ $\theta = 28.7$	**B1**	[6]	

Qu	Answer	Part Mark	Marks	Guidance
5	$R = 5g\cos\alpha = 4g$ $F = 0.5 \times 4g = 2g$	**B1**		For finding the normal reaction R acting on the 5 kg particle and using $F = \mu R$
		M1		For applying Newton's second law to one or both particles or to the system
	$T - 2g - 5g\sin\alpha = 5a \rightarrow$ $T - 5g = 5a$	**A1**		System equation is $10g - 5g\sin\alpha - 2g = 5g = 15a$
	$10g - T = 10a$	**A1**		
	$[5g = 15a]$	**M1**		For eliminating T and solve for a
	$a = g/3 = 3.33\text{ ms}^{-2}$	**A1**		
	$T = 10g - 10(g/3)$ $= 20g/3 = 66.7\text{ N}$	**B1**	[7]	
6 (i)	$a = 12t - 30$	**M1**		For differentiating v to find a
	$t < 2.5$	**A1**	[2]	
(ii)	$v = 0$ at $t = 1$ and $t = 4$	**B1**		Using $v = 6(t-4)(t-1)$
	$s = \int\left(6t^2 - 30t + 24\right)dt$ $= \frac{6}{3}t^3 - \frac{30}{2}t^2 + 24t$	**M1**		For using integration to find s
	$s = \left[2t^3 - 15t^2 + 24t\right]_1^4$	**M1**		For using limits
	Distance = 27 m	**A1**	[4]	
(iii)	$2t^3 - 15t^2 + 24t = 0$	**M1**		State $s = 0$
	$2t^2 - 15t + 24 = 0$	**M1**		Reduce to a quadratic and attempt to solve
	$t = 2.31$ and $t = 5.19$	**A1**	[3]	

Qu	Answer	Part Mark	Marks	Guidance
7 (i) (a)	$200 - 30g \sin 20 = 30a$	M1		For applying Newton's second law with 3 terms parallel to the plane
	$a = 3.25$ ms^{-2}	A1	[2]	[$a = 3.2465$]
(b)	[$v^2 = 2 \times 3.2465 \times 12 = 77.9$]	M1		For using $v^2 = u^2 + 2as$ and attempting to find KE change
	KE change = $0.5 \times 30 \times 77.9 = 1170$ J	A1	[2]	[KE = 1168.7 J]
Alternative method for 7(i)(b)				
(b)	KE change = $200 \times 12 - 30g \times 12 \sin 20$	M1		Using KE gain = WD by DF – PE gain
	KE change = 1170 J	A1	[2]	
(ii) (a)	$N = 30g \cos 20$	B1		[$N = 281.9$]
	$F = 0.12 \times 30g \cos 20$ [= 33.8]	M1		Using $F = \mu Na$
	$200 - 30g \sin 20 - 33.8 = 30a$	M1		For using Newton's second law with 4 terms applied to the particle
	$a = 2.12$ ms^{-2}	A1	[4]	
(b)	$N + 200 \sin 10 = 30g \cos 20$ [$N = 247.2$]	M1		For resolving forces perpendicular to the plane. Three term equation.
	$F = 0.12\,N$ [$= 0.12 \times 247.2 = 29.66$]	M1		N must be from a 3 term equation
	$200 \cos 10 - 29.66 - 30g \sin 20 = 30a$	M1		For using Newton's second law with 4 terms applied to the particle
	$a = 2.16$ ms^{-2}	A1	[4]	

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Subsidiary and Advanced Level

MARK SCHEME for the March 2016 series

9709 MATHEMATICS

9709/42 Paper 4 (Mechanics), maximum raw mark 50

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1		M1		Attempt KE gain **or** WD against Res
	KE gain = ½ × 105 × $(10^2 - 5^2)$ WD against Resistance = 50 × 40	A1		Both correct (unsimplified) KE gain = 3937.5 J WD = 2000 J
	Total WD = 5937.5 J	B1	3	WD = KE gain + WD against Res
	Alternative method			
	$10^2 = 5^2 + 2 \times 50 \times a$ [$a = 0.75$] DF – 40 = 105a	M1		Using $v^2 = u^2 + 2as$ and applying Newton's 2nd law to the system
	DF = 40 + 105 × 0.75 = 118.75	A1		
	Total WD = 118.75 × 50 = 5937.5 J	B1	3	WD = DF × 50
2 (i)	DF = 1350	B1		
	P = 1350 × 32 = 43.2 kW	B1	2	
(ii)	DF – 1350 – 1200g × 0.1 = 0 [DF = 2550]	M1		For using Newton's 2nd law applied to the car up the hill (3 terms) Allow use of θ = 5.7°
	DF = 76500/v	M1		For using DF = P/v
	$v = 30\,\text{ms}^{-1}$	A1	3	
3 (i)		M1		For resolving forces horizontally
	$R_x = 40 \times (24/25) - 30 \times (7/25)$ [= 30]	A1		Allow $R_x = 40 \cos 16.3 - 30 \sin 16.3$
		M1		For resolving forces vertically
	$R_y = 50 - 40 \times (7/25) - 30 \times (24/25)$ [= 10]	A1		Allow $R_y = 50 - 40 \sin 16.3 - 30 \cos 16.3$
	$R = \sqrt{R_x^2 + R_y^2}$ **and** $\theta = \tan^{-1}\left(\frac{R_y}{R_x}\right)$	M1		For using Pythagoras to find the resultant force R **and** trigonometry to find the angle θ made by the resultant with the x-axis
	R = 31.6 N **and** θ = 18.4° with the positive x-axis	A1	6	

Alternative method for 3(i)

(i)		**M1**		Resolve forces along 40 N direction
	$R_1 = 40 - 50 \times (7/25)$ [= 26]	**A1**		Allow $R_1 = 40 - 50 \sin 16.3$
		M1		Resolve forces along 30 N direction
	$R_2 = 30 - 50 \times (24/25)$ [= –18]	**A1**		Allow $R_2 = 30 - 50 \cos 16.3$
	$R^2 = R_1^{\ 2} + R_2^{\ 2}$ **and** $\arctan(-R_2/R_1)$	**M1**		Use Pythagoras **and** trigonometry
	$R = 31.6$ N **and** direction is $34.7 - \alpha = 18.4°$ with positive x–axis	**A1**	6	Using arctan(18/26) = 34.7° is the angle between R and the 40 N force
(ii)	$P = 40$	**B1**	1	
4 (i)	$5\cos\alpha = F$ [$F = 4$]	**M1**		For resolving forces horizontally Allow use of $\alpha = 36.9^{\circ}$ throughout
	$R + 5\sin\alpha = 8$ [$R = 5$]	**M1**		For resolving forces vertically
	$4 = 5\mu$	**M1**		For using $F = \mu R$
	$\mu = 0.8$	**A1**	4	
(ii)	$R + 10\sin\alpha = 8$ [$R = 2$] **and** $F = 0.8 \times R$ [$F = 1.6$]	**B1**		For resolving forces vertically to find the new value of R **and** using $F = \mu R$
	$10\cos\alpha - F = 0.8a$	**M1**		For resolving horizontally
	$a = 8\,\text{ms}^{-2}$	**A1**	3	
5 (i)	[$2500 - 2000g \times 0.1 - 250 = 2000a$]	**M1**		For using Newton's 2nd law for the system or for applying Newton's 2nd law to the car and to the trailer and for solving for a Allow use of $\alpha = 5.7^{\circ}$ throughout
	$a = 1/8 = 0.125\,\text{ms}^{-2}$	**A1**		
	$2500 - T - 100 - 1200g \times 0.1 = 1200 \times 0.125$ or $T - 150 - 800g \times 0.1 = 800 \times 0.125$	**M1**		For applying Newton's 2nd law either to the car or to the trailer to set up an equation for T
	$T = 1050$ N	**A1**	4	

(ii)	$-2000g \times 0.1 - 250 = 2000a$ $[a = -1.125]$	**M1**		For applying Newton's 2nd law to the system with no driving force to set up an equation for a
	$0 = 30 - 1.125t$	**M1**		For using $v = u + at$
	$t = 26.7$ s	**A1**	3	Allow $t = 80/3$ s
Alternative method for 5(ii)				
(ii)	$[\frac{1}{2}(2000)\,30^2 =$ $250s + 2000 \times g \times 0.1s]$ $\rightarrow s = 400$	**M1**		Apply work/energy equation to find s the distance travelled up the plane with no driving force (3 terms) as: KE loss = WD against F + PE gain
	$[400 = \frac{1}{2}(30 + 0)t]$	**M1**		For using $x = \frac{1}{2}(u + v)t$
	$t = 26.7$ s	**A1**	3	Allow $t = 80/3$ s
6 (i)	$[T = 0.8a$ for A $2 - T = 0.2a$ for B $0.2g = (0.2 + 0.8)a$ system]	**M1**		For applying Newton's 2nd law either to particle A or to particle B or to the system
		M1		For applying N2 to a second particle (if needed) and solving for a
	$[a = 2]$	**A1**		
	$[2.5 = \frac{1}{2} \times 2 \times t^2]$	**M1**		A complete method for finding t such as using $s = ut + \frac{1}{2}at^2$
	$t = 1.58$ s	**A1**	5	Allow $t = \frac{1}{2}\sqrt{10}$
First Alternative Method for 6(i)				
(i)	$[0.2 \times g \times 2.5$ or $\frac{1}{2}(0.2 + 0.8)v^2]$	**M1**		Finding PE loss or KE gain (system)
	$[0.2 \times g \times 2.5 = \frac{1}{2}(0.2 + 0.8)v^2]$	**M1**		Using PE loss = KE gain and find v
	$[v^2 = 10]$	**A1**		
	$[2.5 = \frac{1}{2}(0 + \sqrt{10})t]$	**M1**		For using $s = \frac{1}{2}(u + v)t$
	$t = 1.58$ s	**A1**	5	Allow $t = \frac{1}{2}\sqrt{10}$

Second Alternative Method for 6(i)

(i)	[$T = 0.8a$ $2 - T = 0.2a$ $\rightarrow$ $T = 1.6$ N]	**M1**		Apply N2 to A and B and solve for T
	[$T \times 2.5 = ½ (0.8) v^2$]	**M1**		Use WD by T = KE gain by A, find v
	[$v^2 = 10$]	**A1**		
	[$2.5 = ½ (0 + \sqrt{10})t$]	**M1**		Using $s = ½(u + v)t$
	$t = 1.58$ s	**A1**	5	Allow $t = \frac{1}{2}\sqrt{10}$
(ii)	$N = 8$ and $F = 0.1 \times N = 0.8$	**B1**		
	$T - 0.8 = 0.8a$ and $2 - T = 0.2a$ or $0.2g - 0.8 = (0.2 + 0.8)a$	**M1**		For applying N2 to both particles or to the system and solving for a
	$a = 1.2$	**A1**		
	$v^2 = 0 + 2 \times 1.2 \times 2.5$	**M1**		For using $v^2 = u^2 + 2as$
	$v = \sqrt{6} = 2.45$ ms^{-1}	**A1**	5	

First Alternative Method for 6(ii)

(ii)	$N = 8$ and $F = 0.1 \times N = 0.8$	**B1**		
	[$0.2 \times g \times 2.5 = ½ (0.8 + 0.2) v^2 + 0.8 \times 2.5$]	**M1**		Apply work/energy to the system as PE loss = KE gain + WD against resistance
		A1		Correct Work/Energy equation
		M1		For solving for v
	$v = \sqrt{6} = 2.45$ ms^{-1}	**A1**	5	

Second Alternative Method for 6(ii)

(ii)	$N = 8$ and $F = 0.1 \times N = 0.8$	**B1**		
	$T - 0.8 = 0.8a$ and $2 - T = 0.2a$	**M1**		Use N2 for A and B and solve for T
	$T = 1.76$ N	**A1**		
	[$T \times 2.5 = 0.8 \times 2.5 + ½ (0.8) v^2$]	**M1**		Apply Work/Energy equation to A
	$v = \sqrt{6} = 2.45$ ms^{-1}	**A1**	5	

7 (i)	$k = 40$	B1	1	
(ii)	Correct for $0 \leqslant t \leqslant 4$	B1√		Quadratic curve with minimum at $t = 1$ approximately, $v = 0$ at $t = 2$ and $v = k$ at $t = 4$. ft on k
	Correct for $4 \leqslant t \leqslant 14$	B1√		Horizontal line at $v = k$. ft on k
	Correct $14 \leqslant t \leqslant 20$	B1√	3	Line with negative gradient from (14, k) to (20, 28). ft on k
(iii)	For $0 \leqslant t \leqslant 4$ $a = 10t - 10$	M1		Attempting to differentiate to find a
	$1 < t \leqslant 4$	A1	2	
(iv)	$\int (5t^2 - 10t)dt =$ $\frac{5}{3}t^3 - 5t^2$	M1		For attempting to integrate the given quadratic expression and attempting to apply limits over the interval $t = 0$ to $t = 4$
	$A = \left[\frac{5}{3}t^3 - 5t^2\right]_0^2 =$ $\left(\frac{5}{3}2^3 - 5\times 2^2\right)$ $-\left(\frac{5}{3}0^3 - 5\times 0^2\right)$			Use of limits to obtain A, the integral from $t = 0$ to $t = 2$ and B, the integral from $t = 2$ to $t = 4$ Full evaluation of A not necessary at this stage $\left[A = -\frac{20}{3}\right]$
	$B = \left[\frac{5}{3}t^3 - 5t^2\right]_2^4 =$ $\left(\frac{5}{3}4^3 - 5\times 4^2\right)$ $-\left(\frac{5}{3}2^3 - 5\times 2^2\right)$	A1		Full evaluation of B not necessary at this stage $\left[B = \frac{100}{3}\right]$
	$C = (40 \times 10) + 0.5 \times (40 + 28) \times 6$	B1√		For finding the distance travelled in the interval $t = 4$ to $t = 20$ using area properties or integration. ft on k
	$-A + B + C =$ [20/3 + 100/3 + 400 + 204]	M1		For attempting to evaluate the total distance travelled by P in the interval $t = 0$ to $t = 20$. The distance travelled in the first 4 seconds must have been found using integration methods.
	Total distance travelled = 644 m	A1	5	

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Subsidiary and Advanced Level

MARK SCHEME for the October/November 2015 series

9709 MATHEMATICS

9709/43 Paper 4, maximum raw mark 50

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1	Tension is 30 N	**B1**		
	$[R = (4g - 30) \times 0.8]$	**M1**		For resolving forces acting on *B*, perpendicular to the plane.
	Normal component is 8 N	**A1**	3	
2	$F = T\cos\alpha = 0.96T$	**B1**		
	$R = 0.2g - T\sin\alpha = 2 - 0.28T$	**B1**		
	$[0.96T = 0.25(2 - 0.28T)]$	**M1**		For using $F = \mu R$
	$[(0.96 + 0.07)T = 0.5 \rightarrow T = ...]$	**M1**		For solving resultant equation for T
	$T = 0.485$	**A1**	5	
3		**M1**		For resolving forces in the x or $-x$ direction
	$120\cos75^\circ = 150 - 100 - P\cos\theta^\circ$	**A1**		
		M1		For resolving forces in the y direction
	$120\sin75^\circ = P\sin\theta^\circ$	**A1**		
	$[P^2 = 14400 - 12000\cos75^\circ + 2500]$ or $\tan\theta = [120\sin75^\circ/(50 - 120\cos75^\circ)]$	**M1**		For using $P^2 = (P\cos\theta)^2 + (P\sin\theta)^2$ or for using $P\sin\theta / P\cos\theta = \tan\theta$
	$P = 117$ or $\theta = 80.7$	**A1**		
	$\theta = 80.7$ or P = 117	**B1**	7	
4 (i)		**M1**		For applying Newton's second law to *A* or to *B* or for using $m_Ag - m_Bg = (m_A + m_B)a$
	$0.35g - T = 0.35a$ $T - 0.15g = 0.15a$ $(0.35 - 0.15)g = (0.35 + 0.15)a$	**A1**		Two of the three equations
	Acceleration is 4 ms^{-2}	**B1**		
	Tension is 2.1 N	**B1**	4	
(ii)	$[v_1^2 = 0 + 8 \times 1.6\ (= 12.8)]$	**M1**		For using $v_1^2 = 0 + 2a \times 1.6$
	$[H = 1.6 + (-12.8) \div (-20)]$	**M1**		For using $H = 1.6 + (0 - v_1^2)/(-2g)$ or for using $h = (0 - v_1^2)/(-2g)$
	Greatest height is 2.24 m	**A1**	3	

5 (i)	$a =$ $(5^2 - 3^2) \div (2 \times 500) = 0.016$	B1		
		M1		For using Newton's 2nd law
	$DF + 90g \times 0.05 - R = 90 \times 0.016$	A1		
	$[R = \frac{420}{v} - 90(0.016 - 0.5)]$	M1		For using $DF = P/v$
	$R = \frac{420}{v} + 43.56$	A1	5	AG **SR** for assuming constant R and DF (max 2/5) PE loss = 90g(500)(0.05) and KE gain = $\frac{1}{2}(90)(5^2 - 3^2)$ B1 WD_{DF}+PE loss = KEgain+WD_R $\rightarrow R = 420/v + 43.56$ B1
(ii)	$v_M^2 = 3^2 + 2 \times 0.016 \times 250 \rightarrow$ speed at mid-point is 4.12ms^{-1}	B1		
	[Decrease in R from top to mid-way $=420[(1 \div 3) - (1 \div \sqrt{17})]$ or [Decrease in R from midway to b'm = $420[(1 \div \sqrt{17}) - (1 \div 5)]$	M1		For finding the difference in R for either top to midway or midway to bottom
	38.1 and 17.9	A1	3	
6 (i)	Time taken $= \frac{0.08}{0.0002} = 400$ s	B1		
	$v = \frac{dx}{dt} = 0.16t - 0.0006t^2$	B1		
	[speed $= -0.16 \times 400 + 0.0006 \times 400^2$]	M1		For evaluating $\pm v(400)$
	Speed at O is 32 ms^{-1}	A1	4	
(ii) (a)	Time to furthest point is 0.16/0.0006 s	B1√		√ $v = 0.16t - kt^2$ or $v = kt - 0.0006t^2$ from part (i)
	$[0.08(800/3)^2 - 0.0002(800/3)^3]$ (×2)	M1*		For evaluating $x(t_{\text{furthest point}})$ (×2)
	Distance moved is 3790 m	A1	3	
(b)	[speed = 3790/400 ms^{-1}]	dM1*		For using 'average speed = total distance moved/time taken'
	Average speed is 9.48 ms^{-1}	A1	2	

7 (i)	Gain in KE $= \frac{1}{2}\, 1250(8^2 - 5^2)$	B1		
	Loss in PE = $1250g \times 400\sin 4°$	B1		
		M1		For using WD by *DF* = Gain in KE – Loss in PE + WD by resistance
	$400(DF) = \frac{1}{2}\, 1250\,(8^2 - 5^2) - 1250g \times 400\sin 4° + 2000 \times 400$	A1		
	Driving force is 1189 N or 1190 N	A1	5	
				SR for using Newton's second law (max 2/5) $DF + 1250g\sin 4° - 2000 = 1250a$ B1 $a = (8^2 - 5^2)/2 \times 400 \to DF = 1190$ N B1
(ii)		M1		For using Newton's second law to find acceleration or for finding v_C and using $v^2 = u^2 + 2as$ to find acceleration
	$1189 \times 2 - 2000 = 1250a$ or $22.75^2 = 8^2 + 2a \times 750$	A1√		√ *DF* from part (i)
	Acceleration is 0.302 ms^{-2}	A1	3	
(iii)	$v_c^2 = 64 + 2 \times 0.302 \times 750$	B1√		√ acceleration from part (ii)
	$[P/\ 22.75 - 2000 = 1250 \times 0.302]$	M1		
	Power is 54.1 kW or 54100 W	A1	3	

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1 (i)		**M1**		For resolving forces in the x direction
	$15 + F\cos 60^\circ = F\cos 30^\circ$	**A1**		
	$F = 41.0$	**A1**	3	**AG** $F = 15(1 + \sqrt{3})$
(ii)	$[G = F(\sin 30^\circ + \sin 60^\circ)]$	**M1**		For resolving forces in the y direction
	$G = 56.0$	**A1**	2	Allow $15(2 + \sqrt{3})$
2 (i)	$[V^2 = (V - 10)^2 + 2g \times 35]$	**M1**		For using $v^2 = u^2 + 2gs$ to obtain an equation in V only **or** to obtain two equations in V and H and attempting to eliminate H
	$20V = 100 + 70g$	**A1**		
	$V = 40$	**A1**	3	
	Alternative for 2(i)			
(i)		**M1**		A complete method to find V by considering the final 35 m using $v = u + at$ and either $s = ut + \frac{1}{2}at^2$ or $s = (u + v)/2 \times t$
	$V = V - 10 + 10t \rightarrow t = 1$ and $35 = (V - 10) \times 1 + \frac{1}{2} \times 10 \times 1^2$ or $35 = (V - 10 + V)/2 \times 1$	**A1**		
	$V = 40$	**A1**	3	
(ii)	$[40^2 = 0^2 + 20H]$	**M1**		For using $v^2 = u^2 + 2gs$
	$H = 80$	**A1**	2	
3 (i)	$[a(t) = 0.00012t^2 - 0.012t + 0.288]$	**M1***		For attempting to differentiate $v(t)$
	$[a(t) = 0.00012(t^2 - 100t + 2400)$ $= 0.00012(t - 40)(t - 60) = 0]$	**dM1***		For setting $a(t) = 0$ and attempting to solve a three term quadratic
	$a(t) = 0$ when $t = 40$ and $t = 60$	**A1**	3	
(ii)	$[0.00001t^4 - 0.002t^3 + 0.144t^2]$	**M1†**		For attempting to integrate $v(t)$
	$[0.00001(100)^4 - 0.002(100)^3 + 0.144(100)^2]$	**dM1†**		Integration attempted using correct limits $t = 0$ to $t = 100$
	Displacement is 440 m	**A1**	3	

4		M1		For using $R = 2\cos 45^{o}$ and $F = \mu R$
	Frictional force $= 0.4 \times 2\cos 45 = 0.4\sqrt{2}$	A1		
	KE gain $= \frac{1}{2} \times 0.2 \times V_C^2$ and PE loss $= 0.2 \times g \times (2.5 + 2\sqrt{2})$	B1		
		M1		For using KE gain from A to C = PE loss from A to C – Work done by frictional force
	$0.1\ V_C^2 = (5 + 4\sqrt{2}) - 0.4\sqrt{2} \times 4$	A1		
	Speed at C is $9.16\ \text{ms}^{-1}$	A1	6	
First alternative for the last four marks				
	$\frac{1}{2} \times 0.2 \times V_B^2 = 0.2 \times g \times 2.5 \rightarrow V_B^2 = 50$	B1		
		M1		For using KE gain from B to C = PE loss from B to C – Work done by frictional force
	$0.1\ (V_C^2 - V_B^2) = 0.2 \times g \times (4 \div \sqrt{2}) - 0.4\sqrt{2} \times 4$	A1		
	Speed at C is $9.16\ \text{ms}^{-1}$	A1		
Second alternative for the last four marks				
	$\frac{1}{2} \times 0.2 \times V_B^2 = 0.2 \times g \times 2.5 \rightarrow V_B^2 = 50$	B1		
		M1		For using Newton's 2nd law to find acceleration along BC **and** using $v^2 = u^2 + 2as$ to find V_C
	$\sqrt{2} - 0.4\sqrt{2} = 0.2a \rightarrow a = 3\sqrt{2}\ \text{ms}^{-2}$ and $V_C^2 = V_B^2 + 2 \times 3\sqrt{2} \times 4$	A1		
	Speed at C is $9.16\ \text{ms}^{-1}$	A1		

5 (i)		**M1**		For applying Newton 2nd law to P **or** to Q **or** for applying N2 to the system
	$0.5g \times \frac{7}{25} - T = 0.5a$ $T - 0.1g = 0.1a$ $1.4 - 1 = 0.6a$	**A1**		Any two correct Allow sin 16.3 for 7/25
	For eliminating T and obtaining $a = \frac{2}{3}$ ms^{-2}	**B1**		
		M1		For substituting for a to find T
	Tension is 1.07 N	**A1**	5	Allow $T = 16/15$ N
(ii)	$[v^2 = 2 \times \left(\frac{2}{3}\right) \times 0.7]$	**M1**		For using $v^2 = u^2 + 2as$ to find the speed of the particles immediately before the string breaks
	$[2^2 = 2 \times \frac{2}{3} \times 0.7 + 2 \times 0.28g \times s]$	**M1**		For applying $v^2 = u^2 + 2as$ for the motion of P when the string is slack and s is the distance travelled by P after the break until it reaches the floor
	Length of string = $2.5 - s = 1.95$ m	**A1**	3	Allow length = 41/21 m
6 (i)	$[0.195 \cos \theta = F]$	**M1**		For resolving forces horizontally
	$F = 0.195\cos 22.6 = 0.195 \times \frac{12}{13}$ $= 0.18 = \frac{9}{50}$	**A1**		
	$[R = 0.24 + 0.195 \sin \theta]$	**M1**		For resolving forces vertically
	$R = 0.24 + 0.195\sin 22.6 =$ $0.24 + 0.195 \times \frac{5}{13} = 0.315$ $= \frac{63}{200}$	**A1**		
		M1		For using $\mu = F/R$
	Coefficient $\mu = 4/7$ or 0.571	**A1**	6	

(ii)	$R = 0.24 - 0.195\sin 22.6$ $= 0.24 - 0.195 \times \frac{5}{13}$ $= 0.165 = \frac{33}{200}$	B1		
		M1		For using Newton's second law for motion along the rod
	$0.195 \times \frac{12}{13} - \left(\frac{4}{7}\right) \times 0.165$ $= 0.024a$	A1		
	Acceleration is $3.57\,\text{ms}^{-2}$	A1	4	Allow acceleration = 25 / 7
7 (i)	[WD = 14000 × 25]	M1		For using $P = \text{WD} \div \Delta t$
	Work done is 350 kJ or 350 000 J	A1	2	
(ii)		M1		For using DF = P / v and Newton's 2nd law to find the speed of the car at *A* **or** at *B*
	$14000 / v_A - 235 = 1600 \times 0.5 \rightarrow$ $v_A = 13.53\,\text{ms}^{-1}$	A1		$v_A = 2800 / 207$
	$14000 / v_B - 235 = 1600 \times 0.25 \rightarrow$ $v_B = 22.05\,\text{ms}^{-1}$	A1		$v_B = 2800 / 127$
	[KE gain = $\frac{1}{2}\,1600(22.05^2 - 13.53^2)$]	M1		For using KE gain $= \frac{1}{2}\,m(v_B^2 - v_A^2)$
	KE gain = 242.5 kJ or 242 500 J	A1	5	
(iii)		M1		For using WD by DF = KE gain + resistance × *AB*
	350 000 = 242 500 + 235 × *AB*	A1√		
	Distance *AB* is 457 m	A1	3	

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1 (i)	$200g \times 0.7$	M1		For using WD = $mg \times h$
	Work done = 1400 J	A1	2	
(ii)	1400/1.2	M1		For using Power = WD/Time
	Average Power = 1170 W	A1√	2	
2 (i)	$a = g\sin30 = 5$	B1		
	$2.5 = 0 + 5t$	M1		Using $v = u + at$
	$t = 0.5$ Time = 0.5 s	A1	3	
(ii)	$v^2 = 0 + 2 \times 5 \times 3 = 30$	B1		
	$-1 = 0.5a \rightarrow a = -2$			For applying Newton's second law to the particle and using
	$0 = 30 + 2 \times (-2) \times s$	M1		$v^2 = u^2 + 2as$
	Distance = 7.5 m	A1	3	
	First alternative method for 2(ii)			
	$v^2 = 0 + 2 \times 5 \times 3 = 30$	B1		
	$0.5 \times 0.5 \times 30 = 1 \times$ distance	M1		KE lost = WD against Friction
	Distance = 7.5 m	A1	3	
	Second alternative method for 2(ii)			
	PE lost = $0.5 \times 10 \times 3\sin30 = 7.5$	B1		Using PE lost = mgh
	$7.5 = 1 \times$ distance	M1		PE lost = WD against Friction
	Distance = 7.5 m	A1	3	
3 (i)		M1		For applying Newton's second law to the lorry up the hill
	$F - 24000g\sin3 - 3200 = 24000 \times (0.2)$	A1		[$F = 20561$]
	Power = $Fv = 20561 \times 25$	M1		Using $P = Fv$
	Power = 514 kW	A1	4	
(ii)	DF = $3200 + 24000g\sin3$ [=15761]	M1		Using Newton's second law up the hill in the steady case
	$v = 500000/15761 = 31.7\ \text{ms}^{-1}$	A1	2	$P = Fv$ so $v = P/F$

4	$F = 0.2 \times mg\cos 35$	B1		Maximum value of F
		M1		For resolving forces along the plane in either case
	$5g - mg\sin 35 - 0.2\,mg\cos 35 = 0$	A1		Equilibrium, on the point of moving up the plane
	$5g - Mg\sin 35 + 0.2\,Mg\cos 35 = 0$	A1		Equilibrium, on the point of moving down the plane
	$m = 6.78$ or $M = 12.2$	M1		For solving either
	$6.78 \leqslant \text{mass} \leqslant 12.2$	A1	6	
5 (i)		M1		For resolving forces either horizontally or vertically
	$F\cos 70 + 20 - 10\cos 30 = R\cos 15$	A1		
	$10\sin 30 - F\sin 70 = R\sin 15$	A1		
		M1		For solving simultaneously
	$F = 1.90$ N **and** $R = 12.4$ N	A1	5	
	Alternative method for 5(i)			
	$[X = 0.342\,F + 11.34$ $Y = 0.94\,F - 5]$	M1		For finding components of the forces in the x and y directions
	$(0.342\,F + 11.34)^2 + (0.94\,F - 5)^2 = R^2$	A1		
	$\tan 15 = (5 - 0.94F) / (0.342F + 11.34)$	A1		
		M1		Solve the tan 15 equation for F and substitute to find R
	$F = 1.90$ N **and** $R = 12.4$ N	A1	5	
(ii)	$11.7^2 = 0 + 2a \times 3$			
	$a = 22.815$	B1		
	$R\cos 15 = m \times 22.815$	M1		Applying Newton's second law to the particle in direction AB
	Mass of bead = 0.526 kg	A1	3	

6	**(i)**	$s = 0.3t^2 - 0.01t^3$	**M1**		For integration
		$s(5) = 0.3 \times 5^2 - 0.01 \times 5^3 = 6.25$	**A1**		
		$a = 0.6 - 0.06t$	**M1**		For differentiation
		$a(5) = 0.6 - 0.0 \times 5 = 0.3$ ms^{-2}	**A1**	4	
	(ii)	Maximum velocity is when $0.6 - 0.06t = 0$	**M1**		For setting $a = 0$
		$[t = 10]$	**M1**		For solving $a = 0$
		Max velocity = 3 ms^{-1}	**A1**		
		$0.6t - 0.03t^2 = 1.5$			Setting velocity = half its maximum and attempting to solve a three term quadratic
		$[t^2 - 20t + 50 = 0]$	**M1**		
		Times are 2.93 s	**A1**		
		and 17.07 s	**A1**	6	

7 (i)	$36 = 0 + 0.5 \times 0.5t^2$			
	$t = 12$	B1		
	$v^2 = 0 + 2 \times 0.5 \times 36$			
	$v = 6$	B1		
	$s = 6 \times 25$			
	remaining distance $= 210 - 36 - 150 = 24$	B1		
	$24 = (6 + 0)/2 \times t$	M1		Using $s = (u + v)t/2$
	$t = 8$			
	Total Time = 12 + 25 + 8 = 45 s	A1	5	
(ii)	Distance travelled by cyclist $= 36 + 6(t - 12)$	M1		For attempting distance travelled by cyclist for $t > 12$
	Distance travelled by car $= 0.5 \times 4 \times (t - 24)^2$	M1		For attempting distance travelled by car
	$2t^2 - 96t + 1152 = 36 + 6t - 72$ $[t^2 - 51t + 594 = 0]$	M1		Equating expressions and attempting to solve a three term quadratic equation
	$t = 33$ or $t = 18$	A1		
	Time = 33 s	B1	5	Choosing the correct solution

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Subsidiary and Advanced Level

MARK SCHEME for the May/June 2015 series

9709 MATHEMATICS

9709/43 Paper 4, maximum raw mark 50

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CAMBRIDGE
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1		[WD = 500 × 2.75 × 40]	M1		For using WD = Fs or for using WD = Pt
		Work done = 55000 J	A1		
			M1		For using Power = ΔWD÷Δt or for using $P = Fv$
		Power = $\frac{55000}{40}$ = 1375 W or Power = 500 × 2.75 = 1375 W	A1	4	
2	(i)		B1	1	After B reaches the floor, A continues at constant speed until it reaches the pulley (no tension and the surface is smooth). Thus A's speed when B reaches the floor is the same as A's speed (3 ms^{-1}) when it reaches the pulley. Until the instant when B reached the floor, A and B have the same speed and hence B reaches the floor with speed 3 ms^{-1}.
	(ii)	Loss of PE = 0.15gh	B1		
		Gain of KE = $\frac{1}{2}$ (0.35 + 0.15) × 3^2	B1		
		1.5h = 0.25 × 9	M1		For using loss of PE = gain of KE
		h = 1.5	A1	4	
		Alternative Method for part (ii)			
	(ii)	[0.15g – T = 0.15a and T = 0.35a or 0.15g = (0.35+0.15)a] ➔ a = ...	M1		For applying Newton's second law to A and to B or for using $m_B g = (m_A+m_B)a$ to find a
		a = 3ms^{-2}	A1		
		[3^2 = 0 + 2 × 3h]	M1		For using $v^2 = u^2 + 2as$
		h = 1.5	A1	4	

Alternative Method for part (ii)				
(ii)	[$0.15g - T = 0.15a$ and $T = 0.35a$ ➔ $T = ...$	M1		For applying Newton's second law to *A* and to *B* to find *T*
	$T = 1.05$N	A1		
	$\left[0.15gh - \frac{1}{2} \times 0.15 \times 3^2 = 1.05h\right]$ or $\left[\frac{1}{2} \times 0.35 \times 3^2 = 1.05h\right]$	M1		For using PE_B loss – KE_B gain= WD against *T* or for using KE_A gain = WD by *T*
	$h = 1.5$	A1	4	
3		M1		For using DF = *P*/*v* and for applying Newton's 2nd law at one or both points
	$\frac{P}{4.5} - R = 860 \times 4$	A1		
	$\frac{P}{22.5} - R = 860 \times 0.3$	A1		
		M1		For eliminating *R* to find *P* or for eliminating *P* to find *R*
	$\frac{P}{4.5} - \frac{P}{22.5} = 860(4 - 0.3)$ ➔ $P = 17900$ or $-4.5R + 22.5R = 860(4 \times 4.5 - 0.3 \times 22.5)$ ➔ $R = 537.5$	A1		
	$R = 537.5$	B1	6	Accept 538
4	KE loss = $\frac{1}{2} \times 12000(24^2 - 16^2)$	B1		
	PE gain = $12000g \times 25$	B1		
		M1		For using WD by DF = PE gain – KE loss + WD against resistance

	WD by DF = 3000000 – 1920000 + 7500×500	A1		
		M1		For using DF = WD by DF÷500
	Driving force = 4830000÷500 Driving force is 9660 N	A1	6	
Alternative Method for 4				
4	[$16^2 = 24^2 + 2 \times 500a$]	M1		For using $v^2 = u^2 + 2as$
	$a = -0.32$ ms^{-2}	A1		
	Weight component down hill = $12000g \times 25/500$	B1		
		M1		For using Newton's 2nd law
	$\text{DF} - 7500 - 12000g \times \frac{25}{500} = 12000 \times (-0.32)$	A1		
	Driving force is 9660 N	A1	6	
5 (i)	x-component = 4+8cos30°+12cos60° [= 10 + 4√3]	B1		16.928
	y-component = 8sin30°+12sin60°+16 [= 20 + 6√3]	B1		30.392
		M1		For using $R^2 = X^2 + Y^2$ or $\tan\theta = Y \div X$
	$R = 34.8$ or $\theta = 60.9°$ with the 4N force	A1		
	$\theta = 60.9°$ with the 4N force or $R = 34.8$	B1	5	
(ii)	$R = 34.8$	B1√		ft R from **(i)**
	$\theta = 29.1°$ with the 16N force	B1√	2	ft 90 – θ from **(i)**

6 (i)		M1		For resolving forces down the plane
	$20 + 5g\sin10° - F = 0$	A1		
	$R = 5g\cos10°$	B1		
	$[\mu = (20 + 8.6824) \div 49.24]$	M1		For using $\mu = F \div R$
	Coefficient of friction is 0.582	A1	5	
(ii)	$5g\sin10° - 0.582 \times 49.24 = 5a$	M1 A1√		For using Newton's 2nd law ft μ from **(i)** ($\mu > 0$)
	$[0 = 2.5^2 - 2 \times 4s]$	M1		For using $v^2 = u^2 + 2as$
	Distance is 0.781 m	A1	4	
	Alternative Method for part (ii)			
(ii)	PE loss = $5gd\sin10°$	B1		
		M1		For using KE loss + PE loss = WD against friction
	$\frac{1}{2} \times 5 \times 2.5^2 + 5gd\sin10° = 0.582 \times 5gd\cos10°$	A1√		ft μ ($\mu > 0$)
	Distance is 0.781 m	A1	4	
7 **(i)**	$[0.0001t(t - 50)(t - 100) = 0$ or $v(0) = 0, v(50) = 0, v(100) = 0]$	M1		Either factorise $v(t)$ and solve $v(t) = 0$ or evaluate $v(0)$, $v(50)$ and $v(100)$
	$v(t) = 0$ when $t = 0, 50$ & 100	A1	2	
(ii)	$[0.0003t^2 - 0.03t + 0.5 = 0]$	M1		For using $a(t) = \frac{dv}{dt}$
	$t^2 - 100t + 1667 = 0 \rightarrow$ $t = \left[\frac{1}{2}\left\{100 \pm \sqrt{(100^2 - 4 \times 1667)}\right\}\right]$	dM1		For solving $a(t) = 0$

	$a = 0$ when $t = 21.1$ and when $t = 78.9$	A1		
	$v(21.1) = 4.81$	B1		
	$v(78.9) = -4.81$	B1		
	Convex curve from (0,0) to (50,0) with $v > 0$ and has a maximum point.	B1		
	The curve for (50, 0) to (100, 0) is exactly the same as the first curve positioned by rotating the first curve through 180° about the point (50, 0).	B1	7	
(iii)		M1		For integrating $v(t)$ to obtain $s(t)$
	$s(t) = 0.000025t^4 - 0.005t^3 + 0.25t^2 (+ c)$	A1		
	[156.25 – 625 + 625]	M1		For using lower and upper limits of 0 and 50 respectively.
	Greatest distance is 156 m	A1	4	

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Cambridge International Advanced Subsidiary and Advanced Level

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9709/42 Paper 4, maximum raw mark 50

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1 (i)	$\left[s = 0.3 \times 5 + \frac{1}{2} \quad 0.5 \times 5^2\right]$ [v = 0.3 + 0.5 × 5 = 2.8m] Complete method for finding s required	M1		For using $s = ut + \frac{1}{2}at^2$ **or** using $v = u + at$ followed by **either** $v^2 = u^2 + 2as$ **or** $s = \frac{(u+v)}{2}t$ **or** $s = vt - \frac{1}{2}at^2$
	Distance = 7.75 m	A1	2	
(ii)	[WD = 8 × 7.75 × 0.5]	M1		For using WD = $Td\cos 60°$
	Work done is 31 J	A1	2	
2 (i)	$\left[\frac{P}{5} = 80 \times 1.2\right]$	M1		For using DF = $\frac{P}{v}$ and Newton's 2nd law
	P = 480	A1	2	
(ii)	$\frac{450}{3.6} - 80g \times 0.035 = 80a$	M1 A1		For using $\frac{P}{v} - W\sin\alpha = ma$
	Acceleration is 1.21 ms^{-2}	A1	3	Allow $a = \frac{97}{80}$
3 (i)	KE gain $\left[= \frac{1}{2} \times 8 \times 4.5^2\right] = 81$ J	B1		
	$\left[\text{Decrease} = 8g \times 12 \times \left(\frac{1}{8}\right)\right]$	M1		For using PE = mgh and $h = d\sin\alpha$
	PE loss = 120 J	A1	3	
(ii)	[81 = 120 – 12R]	M1		For using KE gain = PE loss –WD by resistance
	Resisting force is 3.25 N	A1	2	Allow $R = \frac{13}{4}$

Alternative method for (ii)				
(ii)	$[4.5^2 = 2 \times a \times 12]$ ➔ $[a = \frac{27}{32} = 0.84375]$ $[8g \sin\alpha - R = 8 \times \frac{27}{32}]$	M1		For using $v^2 = u^2 + 2as$ to find a **and** using Newton's 2nd law to find R
	Resisting force is 3.25 N	A1	2	
4 (i)		M1		For integrating to obtain $v(t)$.
	$v(t) = 0.025t^3 - 0.75t^2 + 5t \quad (+0)$	A1		
		M1		For integrating to obtain $s(t)$.
	$s(t) = 0.00625t^4 - 0.25t^3 + 2.5t^2 \quad (+0)$	A1	4	
(ii)		M1		For setting $s = 0$ (t not zero) in their attempt at s which was obtained using integration only.
	$[t^4 - 40t^3 + 400t^2 = 0$ ➔ $t^2(t - 20)^2 = 0]$	M1		For attempting to solve a quartic equation for $s = 0$ where s was obtained using integration only.
	Time taken is 20 s	A1	3	$t = 20$ only
5 (i)		M1		For using $v = u - gt$ to find the time taken by Q. Must be for a complete method for the total time taken to return to point A
	$-20 = 20 - 10t$ ➔ time taken is 4s or $0 = 20 - 10t$ ➔ time taken is 2×2s = 4s	A1		
	$[30 = 0 + 4a]$	M1		For using $v = u + at$ to find the acceleration of P
	Acceleration of P is 7.5 ms^{-2}	A1√	4	ft on an incorrect positive value of the time taken

(ii)		M1		For using $v^2 = u^2 + 2as$ **or** $s = \frac{(u+v)}{2}t$ **or** $s = ut + \frac{1}{2}at^2$ **or** $s = vt - \frac{1}{2}at^2$ to find the distance OA
	Either $30^2 = 2 \times 7.5 \times OA$ **or** $OA = \frac{(0+30)}{2} \times 4$ **or** $OA = \frac{1}{2} \times 7.5 \times 4^2$ **or** $OA = 30 \times 4 - \frac{1}{2} \times 7.5 \times 4^2$ ➔ Distance OA is 60 m	A1	2	
6 (i)	$\left[h = \frac{1}{2} \times 0.5 \times 2\right]$	M1		For using area property of the graph or constant acceleration formulae
	$h = 0.5$	A1	2	
(ii)	$[a = 2 \div 0.5]$	B1		State the value of a using the gradient property of the graph
	$[T - mg = ma$ and $(1 - m)g - T = (1 - m)a$ or $a = \{(1 - 2m) \div (1 - m + m)\}g]$	M1		For applying both • Newton's 2nd law to P (while Q is moving) • Newton's 2nd law to Q (while Q is moving) or using $a = [(M - m) \div (M + m)]g$
		M1		For eliminating T or rearranging to find m
	$m = 0.3$	A1		
	$[T - 0.3 \times 10 = 4 \times 0.3$ or $0.7 \times 10 - T = 4 \times 0.7]$	M1		For substituting a and m into • Newton's 2nd law to P (while Q is moving) • Newton's 2nd law to Q (while Q is moving) to find T (tension)
	Tension is 4.2 N	A1	6	

(iii)		M1		For using the gradient property of the graph with acceleration $-g$
	$(-2 - 2) \div (t - 0.5) = -10$	A1		
	$T = 0.9$	A1	3	
	First Alternative method for (iii)			
(iii)	$[-2 = 2 - 10t]$	M1		For using $v = u + at$ to find the total time that string is slack
	$t = 0.4$	A1		
	Required time = 0.5 + 0.4 = 0.9	A1	3	
	Second Alternative method for (iii)			
(iii)	$t = 0.2$ s	B1		Obtaining the time taken from $v = 0$ to $v = 2$ OR $v = 0$ to $v = -2$
	$t = 0.2 \times 2 = 0.4$ s	B1		Obtaining the total time that the string is slack.
	Total time = 0.9 s	B1	3	For completing the solution using 0.4 + 0.5 = 0.9 s
7 (i)		M1		For resolving forces at J horizontally **or** vertically
	$0.8T_A + 0.6T_R = 5.6$	A1		Allow $T_A \cos 36.9 + T_R \cos 53.1 = 5.6$ oe
	$0.6T_A = 0.8T_R$	A1		Allow $T_A \sin 36.9 = T_R \sin 53.1$ oe
		M1		For solving the simultaneous equations for T_A and T_R
	Tension in AJ is 4.48 N **and** tension in RJ is 3.36 N	A1	5	
	First Alternative Method for (i)			
(i)	$\frac{5.6}{\sin 90} = \frac{T_A}{\sin\alpha} = \frac{T_R}{\sin(270-\alpha)}$ m	M1		For applying Lami's theorem to two of the three forces T_A, T_R, and 5.6 where α is an obtuse angle
	$\frac{5.6}{\sin 90} = \frac{T_A}{0.8} = \frac{T_R}{0.6}$ m	A1 A1		Allow sin126.9 for 0.8 and sin143.1 for 0.6 here
		M1		Solve for T_A **and** T_R
	$T_A = 4.48$ **and** $T_R = 3.36$	A1	5	

Second Alternative Method for (i)				
(i)	$\frac{5.6}{\sin 90} = \frac{T_A}{\sin\alpha} = \frac{T_R}{\sin(90-\alpha)}$ m	M1		For applying triangle of forces to two of the three forces T_A, T_R, and 5.6
	$\frac{5.6}{\sin 90} = \frac{T_A}{0.8} = \frac{T_R}{0.6}$ m	A1 A1		Allow sin 53.1 for 0.8 and sin 36.9 for 0.6 here
		M1		Solve for T_A **and** T_R
	$T_A = 4.48$ **and** $T_R = 3.36$	A1	5	
(ii)	$0.2g + F = T_R \times \cos 36.9$	B1ft		ft on T_R and 36.9
	$N = T_R \times \sin 36.9$	B1ft		ft on T_R and 36.9
	$[0.2g + \mu \times T_R \times 0.6 = T_R \times 0.8]$	M1		For using $\mu = F \div N$ and obtaining an equation in μ
	$\mu = 0.688 \div 2.016 = 0.341$	A1	4	AG
(iii)	$[0.2g + mg = \mu N + 0.8T_R]$	M1		For a four term equation from resolving forces acting on R vertically.
	$0.2g + mg = 0.341 \times 2.016 + 3.36 \times 0.8$	A1		
	$m = 0.137$ or 0.138	A1	3	

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Subsidiary and Advanced Level

MARK SCHEME for the May/June 2015 series

9709 MATHEMATICS

9709/41 Paper 4, maximum raw mark 50

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International Examinations

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1 (i)	$[20 + 25\sin\theta = 2.7g]$	M1		For resolving forces vertically
	$\sin\theta = 0.28$	A1	2	**AG**
(ii)	$[25 \times 5 \times \sqrt{(1 - 0.28^2)}]$	M1		For using WD = $Fd\cos\theta$
	Work done is 120 J	A1	2	
2		M1		For resolving components of F in x and y directions
	$F_x = F\cos\theta = 25 \times 0.8 = 20$, $F_y = F\sin\theta = 63 - 25 \times 0.6 = 48$	A1		
		M1		For using $F = \sqrt{(F_x^2 + F_y^2)}$ <u>or</u> for using $\tan\theta = F_y \div F_x$
	$F = 52$ N <u>or</u> $\tan\theta = 2.4$	A1		
	$\tan\theta = 2.4$ <u>or</u> $F = 52$ N	B1	5	
3	$F = 0.25\left(6.1 \times \frac{60}{61}\right)$ [= 1.5]	B1		Allow $F = 0.25(6.1\cos 10.4)$
	$[W\sin\alpha - F = ma]$	M1		For using Newton's 2nd law
	$6.1 \times \left(\frac{11}{61}\right) - 0.25\left(6.1 \times \frac{60}{61}\right) = 0.61a$ or $6.1\sin 10.4 - 0.25 \times 6.1\cos 10.4 = 0.61a$	A1		$\left[a = -\frac{40}{61} = -0.656\right]$ The value of a may be seen but is not a required answer.
		M1		For using $0 = v_A^2 + 2as$
	Distance is $4 \div \left(2 \times \frac{40}{61}\right)$ = 3.05 m	A1	5	
	Alternative method			
	$F = 0.25\left(6.1 \times \frac{60}{61}\right)$ [= 1.5]	B1		Allow $F = 0.25(6.1\cos 10.4)$
	KE loss = $\frac{1}{2} \times 0.61 \times 2^2$	B1		Finding loss of KE
	PE loss = $0.61 \times 10 \times x\left(\frac{11}{61}\right)$	B1		Finding loss of PE
	$[1.5x = 1.22 + 1.1x]$	M1		Using WD against F = KE loss + PE loss
	$0.4x = 1.22 \rightarrow$ distance = 3.05 m	A1	5	

4 (i)		M1		For using KE gain = $\frac{1}{2}mv_B^2$ or PE loss = $mg \times AB\sin\theta$
	For KE gain = 4032×10^3 or PE loss = $42 \times 10^6\sin\theta$	A1		
	PE loss = $42 \times 10^6\sin\theta$ or KE gain = 4032×10^3	B1	3	
(ii)		M1		For using WD by DF = KE gain – PE loss + WD by resistance
	$5000 = 4032 - 42000\sin\theta + 3360$	A1√		
	$\theta = 3.3°$	A1	3	
5		M1		For using DF = $\frac{P}{v}$ for DF up and down
		M1		For applying Newton's 2nd law up and down
	$\frac{P}{3} - R - 84g \times 0.1 = 84 \times 1.25$	A1		
	$\frac{P}{10} - R + 84g \times 0.1 = 84 \times 1.25$	A1		
	$\left[P\left(\frac{1}{3} - \frac{1}{10}\right) - 168 = 0\right]$	M1		For solving equations for P
	$P = 720$	A1		
	$\left[R = \frac{720}{3} - 84 - 105\right]$	M1		For substitution for P to obtain R
	$R = 51$	A1	8	
6 (i)		M1		For integrating $a(t)$ to find $v(t)$
	$v(t) = 0.05t - 0.0001t^2$ (+ 0)	A1		
	$v(200) = 10 - 4 = 6$ ms^{-1}	A1		
	$v(500) = 25 - 25 = 0$	A1	4	
(ii)		M1		For integrating $v(t)$ between limits 0 to 500 to obtain the distance A travels

	$\int_0^{500}\left(0.05t-0.0001t^2\right)dt$ $\left[\frac{0.05t^2}{2}-\frac{0.0001t^3}{3}\right]_0^{500}$	A1		
	Distance = 0.025 × 500^2 – 0.0001 × 500^3 ÷ 3 = 2083 m	A1		Accept 2080
		M1		For using area property of graph or $s = \frac{1}{2}(u+v)t$ or $s = ut + \frac{1}{2}at^2$ to find distance travelled by *B*
	Distance = $\frac{1}{2}$ × 6 × 500 = 1500 m **or** distance = $\frac{1}{2}(0+6)\times200+\frac{1}{2}(6+0)\times300$ **or** distance = $\left(0+\frac{1}{2}0.03\times200^2\right)$ $+\left(6\times300+\frac{1}{2}(-0.02)300^2\right)$	A1		
	Distance between *A* and *B* is 2083 – 1500 = 583 m	B1√	6	Can only be scored if distance travelled by *A* has been found using integration
7 (i)		M1		For using Newton's 2nd law for both particles
	$T - 0.2 \times 3 = 0.3a$ and $7 - T = 0.7a$	A1		
	Acceleration = 6.4 ms^{-2}	A1		
	[$v = 0 + 6.4 \times 0.25$]	M1		For using $v = 0 + at$ to find speed when string breaks
	v = 1.6 ms^{-1}	A1		
	$\left[\text{Distance} = 0+\frac{1}{2}6.4\times0.25^2\right]$	M1		For using $s = ut + \frac{1}{2}at^2$ to find distance moved before break
	Distance = 0.2 m	A1		
	[$v^2 = 1.6^2 + 2g \times (0.5 - 0.2)$]	M1		For using $v^2 = u^2 + 2gs$ to find speed when *B* hits floor
	Speed is 2.93 ms^{-1}	A1	9	

(ii)		M1		For finding distance travelled by A after break from $v^2 = u^2 + 2as$
	Distance travelled after break $= (0 - 1.6^2) \div (2 \times -2) = 0.64$	A1		For A, $F = 0.2 \times 3$ and so $-0.2 \times 3 = 0.3a$ so $a = -2$
	Total distance travelled $= 0.2 + 0.64 = 0.84$	B1	3	Distance = 0.84 m
	Alternative method for 7(ii)			
(ii)	$T = 2.52$, $F = 0.2 \times 3$ WD by $T = 2.52 \times 0.2$ WD by $F = 0.2 \times 3 \times d$	B1		For stating WD by T on A and WD by F
	$[0.6d = 2.52 \times 0.2]$	M1		Using WD by F = WD by T (No change in KE or PE for A)
	WD by T = WD by $F \rightarrow d = 0.84$	A1	3	Distance = 0.84 m

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9709/43 Paper 4, maximum raw mark 50

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1	(i)	DF = $P \div 18$	B1		
		$[P \div 18 - 800 = 1400 \times 0.5]$	M1		For using DF – $R = ma$
		$P = 27000$	A1	3	
	(ii)	$[1080 - 800 = 1400a]$	M1		For using DF = $P \div 25$ **and** DF – $R = ma$
		Acceleration is $0.2\,\text{ms}^{-2}$	A1	2	
2			M1		For applying Newton's 2nd law to P or to Q
		$0.65 \times 10 \times (63/65) - T = 0.65a$ **or** $T - 0.65 \times 10 \times (16/65) = 0.65a$	A1		
		$T - 0.65 \times 10 \times (16/65) = 0.65a$ **or** $0.65 \times 10 \times (63/65) - T = 0.65a$ **or** $0.65 \times 10 \times (63 - 16)/65 = 2 \times 0.65a$	B1		
		$[T - 1.6 = 6.3 - T]$ **or** $[T = 6.3 - 0.65 \times (47/13)]$ **or** $[T = 1.6 + 0.65 \times (47/13)]$	M1		For eliminating a
		Tension is 3.95 N	A1	5	
3	(i)	$[W\cos\alpha + 7 \times 0.6 = 8]$	M1		For resolving forces acting at O vertically
		$W\cos\alpha = 3.8$ (cwo)	A1		AG
		$W\sin\alpha = 5.6$	B1	3	
	(ii)		M1		For using $W^2 = (W\sin\alpha)^2 + (W\cos\alpha)^2$ **or** $\tan\alpha = (W\sin\alpha \div W\cos\alpha)$
		$W = 6.77$ or $\alpha = 55.8$	A1		
		$\alpha = 55.8$ or $W = 6.77$	B1	3	
4	(i)	$v(8) = 0.25 \times 8 = 2$	B1		
		$2 = -6.4 + 19.2 - k \rightarrow k = 10.8$	B1√	2	ft $(12.8 - v)$
	(ii)	$[dv/dt = -0.2t + 2.4$ (= 0 when $t = 12$) $v_{max} = -0.1 \times 144 + 2.4 \times 12 - 10.8]$	M1		For finding t when $dv/dt = 0$ and substituting into $v(t)$
		Maximum speed is $3.6\,\text{ms}^{-1}$	A1√	2	ft (14.4 – incorrect k)

(iii)	Displacement $s_1 = ½\ 0.25 \times 8^2$ (= 8)	B1		
	[Displacement $s_2 = [-0.1t^3/3 + 1.2t^2 - 10.8t]_8^{18}$ (=26.7)]	M1		For using displacement $s_2 = \int_8^{18}\left(-0.1t^2 + 2.4t - 10.8\right)dt$
	Displacement is 34.7 m	A1	3	
5	$[P - 8g\sin 5^o - F = 8a]$	M1		For using Newton's 2nd law (either case)
	$7X - 8g\sin 5^o - F = 8 \times 0.15$ **and** $8X - 8g\sin 5^o - F = 8 \times 1.15$	A1		
	$X = 8$	A1		
		M1		For obtaining a numerical expression for F
	$F = 56 - 8g\sin 5^o - 8 \times 0.15$ **or** $F = 64 - 8g\sin 5^o - 8 \times 1.15$ **or** $F = 56 \times 1.15 - 64 \times 0.15 - 8g\sin 5^o$ **or** $F = 47.8(275...)$	A1√		ft X either from error for one term in X/F equation or from error in solution of correct X/F equations
	$R = 8g\cos 5^o$ (= 79.695...)	B1		
	$[\mu = 47.8 \div 79.7]$	M1		For using $\mu = \frac{F}{R}$
	Coefficient is 0.600 (accept 0.6)	A1	8	
6 (i)		M1		For using the gradient property for acceleration
	Acceleration is 4 ms^{-2}	A1		
		M1		For applying Newton's 2nd law to both particles or using the formula $(M + m)a = (M - m)g$ and for using $m + M = 1$
	For $T - mg = 4m$ **and** $(1 - m)g - T = 4(1 - m)$ **or** $4 = (1 - m - m)g$	A1		
	P has mass 0.3 kg and Q has mass 0.7 kg	A1	5	

(ii)	For using the area property of the graph or $h = ½\ at^2$ to obtain $h = 2$	B1	1	
(iii)	Distance travelled upwards by $P = ½\ 1.4 \times 4$	B1		
	Height is 4.8 m	B1	2	
7 (i)	$4^2 = 0^2 + 2a \times 12.5 \rightarrow a = 0.64$	B1		
	$[35 \times 0.96 - 3g \times 0.6 - F = 3 \times 0.64]$	M1		For using Newton's 2nd law to find F
	$F = 13.68$	A1		
	WD against $F = 13.68 \times 12.5 = 171$ J	B1	4	
(ii)	$R_{\text{from O to A}} = 3g \times 0.8 - 35 \times 0.28$	B1		
	$[\mu = 13.68 \div 14.2\ (= 0.96338)]$	M1		For using $\mu = F \div R$
	Coefficient is 0.963 (accept 0.96)	A1	3	
(iii)	$[-3g \times 0.6 - 0.96338 \times (3g \times 0.8) = 3a]$	M1		For applying Newton's 2nd law to the block to find a
	Acceleration is $-13.7\ \text{ms}^{-2}$	A1		
	$[0 = 16 + 2(-13.7)s]$	M1		For using $v^2 = u^2 + 2as$ to find s
	Distance travelled is 0.584 m	A1	4	
	Alternative for part (i)			
(i)	Gain in KE = $½\ 3 \times 4^2$ (= 24 J)	B1		
	Gain in PE = $3g \times 12.5 \times 0.6$ (= 225 J)	B1		
	$[\text{WD} = 35 \times 12.5 \times 0.96 - ½\ 3 \times 4^2 - 3g \times 12.5 \times 0.6]$	M1		For using WD against F = WD by applied force – KE gain – PE gain
	WD against F is 171 J	A1	4	
	Alternative for part (iii)			
	WD against $F = 0.96(338..) \times 3g \times 0.8s$	B1		
		M1		For using KE loss = PE gain + WD against friction
	$½\ 3 \times 4^2 = 3gs(0.6) + 0.96(338..) \times 3g \times 0.8s$	A1		
	Distance travelled is 0.584 m	A1	4	

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MARK SCHEME for the October/November 2014 series

9709 MATHEMATICS

9709/42 Paper 4, maximum raw mark 50

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1 (i)	[$-11 = 11 - 10t$] Time after projection is 2.2 seconds	M1 A1	 2	For using $v = u - gt$ (or equivalent method) to find the duration of motion
(ii)	$h = 0 + ½ g \times 2.2^2 = 24.2$ $V = 0 + g \times 2.2 = 22$	B1√ B1√	 2	
2 (i)	[$X = 25 \times 0.96 - 30 \times 0.8 = 0$] Component in x-direction is zero	M1 A1	 2	For resolving forces in the x direction AG
(ii)	[$Y = 25 \times 0.28 - 20 + 30 \times 0.6 = 5$] Resultant has magnitude 5 N and acts in the positive y direction	M1 A1	 2	For resolving forces in the y direction
(iii)	Replacement has magnitude 30 N and acts in the –ve y direction	B1	1	
3 (i)	[$v_B = 1.2 \times 28 \div 0.96$] Speed of the train at B is 35 ms^{-1}	M1 A1	 2	For using $P = Fv$ and the factors 1.2 and 0.96 and an equation in v_B only AG
(ii)	KE increase = $100\,000(35^2 - 28^2)$ WD by engine = $44.1 \times 10^6 + 2.3 \times 10^6$ J Work done is 46 400 kJ or 46.4×10^6 J	B1 M1 A1	 3	 For using WD by engine = KE increase + WD against resistance or 46 400 000 J
4 (i)	[$X\cos30° = 40\cos60°$] $X = 23.1$ (= $40 / \sqrt{3}$)	M1 A1	 2	For resolving forces horizontally
(ii)	[$X\cos30° - 10 = 40\cos60°$] $X = 60 \div \sqrt{3}$ or 34.6 [$R + X\sin30° + 40\sin60° = 15g$] [$\mu = 10 \div (150 - 30/\sqrt{3} - 20\sqrt{3})$] Coefficient is 0.102	M1 A1 M1 M1 A1	 5	For resolving forces horizontally For resolving forces vertically ($R = 98.038$) For using $F = \mu R$

5 (i) (a)	[$F = 0.7 \times 3$, WD $= 2.1 \times 0.9$]	M1		For using $F = \mu R$ and WD $= Fs$
	Work done is 1.89 J	A1	2	
(b)	Loss of PE $= 3 \times 0.9 = 2.7$ J	B1	1	
(c)	[KE gain $= 2.7 - 1.89$]	M1		For 'gain in KE = loss in PE – WD by friction'
	Gain in KE $= 0.81$ J	A1	2	
(ii)	$\frac{1}{2}(0.3 + 0.3)v_{\text{at break}}^2 = 0.81$]	M1		For using $\frac{1}{2}(m_A + m_B)v^2$ = gain in KE
	$v_{\text{floor}}^2 = v_{\text{at break}}^2 + 2g \times 0.54$	M1		For using $v^2 = u^2 + 2gs$
	Speed at the floor is 3.67 ms^{-1}	A1	3	
	Alternative method for (i) (c) and (ii)			
(c)	[$T - 2.1 = 0.3a$ and $3 - T = 0.3a$ $\rightarrow$ $a = 1.5$] [$v^2 = 2 \times 1.5 \times 0.9 = 2.7$]	M1		For applying Newton's 2nd law to both particles and finding a **and** using $v^2 = 0 + 2as$ **and** attempting KE
	KE $= 0.5 \times (0.3 + 0.3) \times 2.7 = 0.81$ J	A1	2	
(ii)	[$v_{\text{at break}}^2 = 2.7$]	M1		For using their v^2 in (i)(c) as $v_{\text{at break}}^2$
	$v_{\text{floor}}^2 = v_{\text{at break}}^2 + 2g \times 0.54$	M1		For using $v^2 = u^2 + 2gs$
	Speed at floor $= 3.67$ ms^{-1} ($= 1.5\sqrt{6}$)	A1	3	
	Alternative method for (ii)			
(ii)	[$0.3 \times g \times 0.54$] **or** [$\frac{1}{2} \times 0.3 \times (v^2 - 2.7)$]	M1		For attempting PE loss or KE gain for the falling particle only
	[$1.62 = \frac{1}{2} \times 0.3 \times (v^2 - 2.7)$]	M1		For using PE loss = KE gain of this particle
	Speed at floor $= 3.67$ ms^{-1} ($= 1.5\sqrt{6}$)	A1	3	
6 (i) (a)	(a) Acceleration is 2.8 ms^{-2}	B1		Using acceleration $= g \sin \alpha$
(b)	[$mg \times 0.28 - 0.5mg \times 0.96 = ma$]	M1		For using Newton's 2nd law
	Acceleration is -2 ms^{-2}	A1	3	

(ii)		M1		For using $v^2 = u^2 + 2as$ for AB and for BC and using $AB + BC = 5$
	$v_B{}^2 = 2 \times 2.8(AB)$ and $2^2 = 5.6(AB) - 2 \times 2(5 - AB)$	A1ft		ft incorrect answers in (i)
	Distance is 2.5 m	A1	3	
Alternative method for (ii)				
	$[mg \times 5 \times 0.28 = ½\, m\, 2^2 + \mu \times mg \times 0.96 \times BC]$	M1		For using Loss in PE = Gain in KE + WD against Friction for the motion from A to C
	$14 = 2 + 4.8 \times BC$	A1		Correct equation
	$BC = 12/4.8 = 2.5$ m	A1	3	
(iii)		M1		For using $t = 2s \div (u + v)$ for AB and BC
	$T = 2 \times 2.5 \div (0 + \sqrt{14}) + 2 \times 2.5 \div (\sqrt{14} + 2)$	A1		
	Time taken is 2.21 s	A1	3	
7 (i)	$v = -4.8$	B1		
	$[\pm 4.8 = 3a]$	M1		For using $v = 0 + at$
	Magnitude of acceleration is 1.6 ms^{-2}	A1	3	
(ii)	$[-0.4t + 4$ (= 0 when $t = 10$)]	M1		For finding the value of t when $dv/dt = 0$
		M1		For evaluating $v(10)$ as v_{max} (the graph excludes the possibility of $v(10)$ as v_{min})
	$v_{max} = -0.2 \times 100 + 4 \times 10 - 15 \rightarrow$ Maximum velocity is 5 ms^{-1}	A1	3	
(iii) (a)	Distance 0 to 3 s = ½ × 3 × 4.8 (= 7.2)	B1		
	Distance 3 to 5s $= -\int_3^5 (-0.2t^2 + 4t - 15)\,dt$	M1		Attempt to integrate and use limits
	Distance = ± 4.5333…m	A1		
	Average speed = (7.2 + 4.533) ÷ 5 = 2.35 ms^{-1}	B1		

(b)	Distance *BC* $= \left[-\frac{0.2t^3}{3} + 2t^2 - 15t \right]_5^{15}$ and Av speed = (*AB* + *BC*) ÷ 15	M1		ft for errors in coefficients in cubic expression
	Av speed = (45.066 ÷ 15) = 3.00 ms^{-1}	A1	6	

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Subsidiary and Advanced Level

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9709 MATHEMATICS

9709/41 Paper 4, maximum raw mark 50

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1		M1		For using Newton's 2nd law with three terms
	DF – R = 800 × 1.2	A1		
	DF = 22500/18 [= 1250]	B1		
	Resistance is 290 N	A1	4	
2		M1		For a triangle of forces with sides 18, R and W for A or for B – or – for resolving forces acting on A or on B parallel to line of greatest slope
	For A: right angle between 18 and R **and** 30° opposite 18 **or** $W_A\sin30° = 18$ **or** For B: right angle between 18 and W **and** 30° opposite 18 **or** $W_B\sin30° = 18\cos 30°$	A1		
	For B: right angle between 18 and W **and** 30° opposite 18 **or** $W_B\sin30° = 18\cos 30°$ **or** For A: right angle between 18 and R **and** 30° opposite 18 **or** $W_A\sin30° = 18$	B1		
	Weight of A is 36 N and weight of B is 31.2 N	A1	4	
3 (i)		M1		For resolving forces parallel to slope with three terms
	$F + W\sin\alpha = 7.2$	A1		
	[$\mu \times 7.5\cos\alpha \geqslant 7.2 - 7.5\sin\alpha$]	M1		For using $F \leqslant \mu R$
	$\mu \geqslant 17/24$	A1	4	**AG**
(ii)	[$7.2 + 7.5 \times (7/25) - \mu(7.5 \times 24/25) > 0$]	M1		For using 'resultant force down the plane is > 0' and $F = \mu R$
	$\mu < 31/24$	A1	2	**AG**
4 (i)	End speed = 1.3 + 0.1 × 20	B1		
	$v_Q(t) = 0.008t^2 + v_Q(0)$	B1		
	[$3.3 = 0.008 \times 20^2 + v_Q(0)$]	M1		For substituting end speed and $t = 20$
	Speed of Q when $t = 0$ is 0.1 ms^{-1}	A1	4	

(ii)	Distance $AO = (3.3^2 - 1.3^2) \div (2 \times 0.1)$ or $20 \times ½ (1.3 + 3.3)$ [= 46] Distance $OB = 0.008 \times 20^3 \div 3 + 0.1 \times 20$ [= 70/3 = 23.3] Distance AB is 69.3 m	B1 B1 B1	 3	or $AO = 1.3(20) + ½(0.1) \times 20^2$
5 (i)	 Frictional force = $\mu \times 0.25g$ $0.3g = 0.2g + \mu 0.25g$ ➔ Coefficient of friction is 0.4	M1 B1 A1	 3	For resolving forces horizontally on B, including the frictional force and using tensions in PB and BQ being equal to the weights of P and Q respectively.
(ii)	 $0.2g - T = 0.2a$ **or** $T - 0.4 \times 0.25g = 0.25a$ $T - 0.4 \times 0.25g = 0.25a$ **or** $0.2g - T = 0.2a$ **or** $0.2g - \mu 0.25g = (0.2 + 0.25)a$ Acceleration is 2.22 ms^{-2} Tension is 1.56 N	M1 A1 B1 M1 B1 A1	 6	For applying Newton's 2nd law to P or to B For solving for a and for T
6 (i)	[$3g - R = 3 \times 5.5$] Resistance is 13.5 N	M1 A1	 2	For using Newton's 2nd law
(ii)	Graph consists of two line segments; the first starts at the origin and has a positive gradient. The second starts where first one ends and has positive but less steep gradient.	B1 B1	 2	

(iii)	[$v_S^2 = 2 \times 10 \times 5 = 100$ **or** $v_B^2 = v_T^2 + 2 \times 5.5 \times 4$]	M1		For using $v^2 = u^2 + 2as$ (for either stage)
	$v_S = 10$ ms^{-1} at surface **and** $v_B = 12$ ms^{-1} at bottom – both shown on sketch	A1		
	[$10 = 0 + 10t_1$ or $12 = 10 + 5.5(t_2 - t_1)$]	M1		For using $v = u + at$ (for either stage)
	$t_1 = 1$ s at surface and shown on sketch	A1		
	$t_2 = 1.36$ s at bottom and shown on sketch.	A1	5	
7		M1		To obtain PE change or KE change
	PE change = $60g \times 17.5$ **or** KE change = ½ $60(8.5^2 - 3.5^2)$	A1		[PE = 10500]
	KE change = ½ $60(8.5^2 - 3.5^2)$ **or** PE change = $60g \times 17.5$	B1		[KE = 1800]
	WD against resistance = 6×250	B1		[= 1500]
	WD by pulling force = $50\cos\alpha \times 250$	B1		
		M1		For using 'WD by the pulling force is a linear combination of PE change, KE change and WD against resistance.'
	WD = 10500 – 1800 + 1500	A1√		
	WD by the pulling force is 10200 J or 10.2 kJ	A1		
	For using WD = $Fd\cos\alpha$	M1		
	$10200 = 50 \times 250 \cos\alpha$	A1		
	$\alpha = 35.3$	A1	11	

Alternative solution				
		M1		Using $v^2 = u^2 + 2as$
	$(3.5)^2 = (8.5)^2 + 2a(250)$	A1		
	$a = -3/25 = -0.12$	A1		
		M2		Applying Newton's 2nd law with 4 relevant terms [Allow M1 with 3 relevant terms]
	$50 \cos \alpha - 6 - 60g(17.5/250) = 60(-0.12)$	A4		One mark for each correct term
	[$\cos \alpha = 102/125$]	M1		Solve for $\cos \alpha$
	$\alpha = 35.3$	A1	11	

CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

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9709/43 Paper 4 (Mechanics 1), maximum raw mark 50

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1 (i)	[N + component of X = Weight of B]	M1		For resolving forces acting on the block vertically (3 terms required)
	Normal component is (70 – $X\cos15^o$) N	A1	[2]	
(ii)	F = $X\sin15^o$	B1		
	[$X\sin15^o = 0.4(70 - X\cos15^o)$]	M1		For using F = μR
	Value of X is 43.4	A1	[3]	
2		M1		For using Newton's 2nd law
	DF – 600 – 1250 × 0.02g = 1250 × 0.5	A1		
		M1		For using DF = 23000/v
	v = 23000 ÷ (625 + 600 + 250)	A1ft		ft error in one term for DF above (1st A mark)
	Speed of car is 15.6 ms^{-1}	A1	[5]	
	Alternative Method			
		M1		For using WD by driving force = KE gain + PE gain + WD against resistance
	WD = 1250 × 0.5s + 1250g × 0.02s + 600s	A1		
		M1		For using WD by driving force = DF × s and DF=23000/v
	v = 23000 ÷ (625 + 600 + 250)	A1ft		ft error in one term for WD above (1st A mark)
	Speed of car is 15.6 ms^{-1}	A1	[5]	
3		M1		For resolving forces acting on *P* horizontally.
	$0.8T_1 + 12T_2/13 = 2.24$	A1		
		M1		For resolving forces acting on *P* vertically.
	$0.6T_1 - 5T_2/13 = 1.4$	A1		
		M1		For solving for T_1 and T_2
	$T_1 = 2.5$ <u>and</u> $T_2 = 0.26$	A1	[6]	
				SR for using Lami's Rule for T_1, T_2 and 2.24 N (weight missing) (max 3/6) T_1/sin157.38 = 2.24/sin59.49 B1 T_2/sin143.13 = 2.24/sin59.49 B1 T_1 = 1(.00) and T_2 = 1.56 B1

4 (i)	PE loss = 0.4g × 5 J = 20 J	B1		
	Initial KE_{up} = 0.4g × 5 – 12.8 = 7.2 J	B1		
	[0.4gh = 2g – 12.8]	M1		Uses PE gain = KE loss to form equation in h
	Height reached is 1.8 m	A1	[4]	AG
(ii)	$5 = 0 + \frac{1}{2} gt_{down}^2$ (t_{down} = 1)	B1		
	$0 = 6 - gt_{up}$ or $1.8 = \frac{1}{2} gt_{up}^2$ (t_{up} = 0.6)	B1		
	Total time is 1.6 s	B1	[3]	
	First Alternative for part (i)			
	$v^2 = 2 \times 10 \times 5 \rightarrow$ (v = 10)	B1		
	KE loss = $\frac{1}{2}$ $0.4(10^2 - v_{up}^2) = 12.8$	B1		
	[v_{up} = 60, $0 = 6^2 - 2gh$]	M1		Uses $v^2 = u^2 - 2gs$ to form equation in h
	Height reached is 1.8 m	A1	[4]	AG
	Second Alternative for part (i)			
	0.4gh = 12.8	M1		Uses PE gain = KE loss
	h = 3.2 m	A1		
	[Height reached = 5 – 12.8/0.4g]	M1		Uses height reached = 5 – 'height not reached'
	Height reached is 1.8 m	A1	[4]	AG
	Third Alternative for part (i)			
	$\frac{1}{2} \times 0.4v^2 = 12.8$ (v=8) and [$8^2 = 0^2 + 2gh$]	M1		Uses KE loss = 12.8 and $v^2=u^2+2gs$
	h = 3.2 m	A1		
	[Height reached = 5 – 3.2]	M1		Uses height reached = 5 – 'height not reached'
	Height reached is 1.8 m	A1	[4]	AG

5 (i)		M1		For using WD by driving force = Gain in PE + WD against resistance
	WD against resistance $= 4500 \times 1200 - 16000g \times 18$	A1		
	WD against resistance $= 2.52 \times 10^6$ J	A1	[3]	
	Alternative Method for part (i)			
	[$R + 16000g \times 18/1200 = 4500$]	M1		For resolving along the plane
	[WD=$(4500 - 16000g \times 18/1200) \times 1200$]	M1		For using WD against resistance = Rs
	WD against resistance $= 2.52 \times 10^6$ J	A1	[3]	
(ii)	KE gain $= \frac{1}{2}\ 16000(21^2 - 9^2)$ J	B1		
		M1		For using F = (KE gain + 2000 × 2400) ÷ 2400
	$F = 7680000 \div 2400 = 3200$	A1	[3]	
				SR (max 1/3) for using $v^2=u^2+2as$ and Newton's 2nd law $21^2 - 9^2 = 2a \times 2400$, $a = 0.075$ $F - 2000 = 16000 \times 0.075$ $F = 3200$ B1
(iii)	[$P_A = (3200 + 1280) \times 9$ and $P_B = (3200 - 1280) \times 21$]	M1		For using P = Fv to find P_A and P_B
	$P_A = P_B = 40320$ W	A1	[2]	
6 (i)	Velocity immediately before is $1.2\,\text{ms}^{-1}$	B1		
	Velocity immediately after is $-1\ \text{ms}^{-1}$	B1	[2]	
(ii)		M1		For using distance OW = ∫vdt with limits 0 to 60 (W is wall) or For using distance WA = – ∫vdt with limits 60 to 100
	Distance OW $= 0.025 \times 60^2 - 0.0005 \times 60^3 \div 3$	A1		
	Distance WA = $-[(0.0125 \times 100^2 - 2.5 \times 100) - (0.0125 \times 60^2 - 2.5 \times 60]$	A1		
	Distance is $54 + 20 = 74$ m	A1	[4]	

(iii)	[$dv/dt = 0.05 - 0.001t = 0$ or $0.0005t(100 - t) = 0 \to t = 0$ or 100]	M1		For using v_{max} occurs when $dv/dt = 0$ or when t = the midpoint of the roots of the quadratic equation $v = 0$.
	Maximum speed (= $0.05 \times 50 - 0.0005 \times 50^2$) is $1.25\,ms^{-1}$	A1		
	Plausible quadratic curve starting at (0,0), with max. at (50, 1.25) and terminating at (60, 1.2)	B1		
	Straight line segment from (60,–1) to (100,0)	B1	[4]	
7 (i)		M1		For applying Newton's 2nd law to P or to Q
	For $T - (40 \div 160) \times 0.76g = 0.76a$ <u>or</u> $0.49g - T = 0.49a$	A1		
	For $0.49g - T = 0.49a$ <u>or</u> $T - (40 \div 160) \times 0.76g = 0.76a$ <u>or</u> $0.49g - (400 \div 160) \times 0.76g = (0.49 + 0.76)a$	B1		
	Acceleration is $2.4\,ms^{-2}$ and tension is 3.72 N (3.724 exact)	A1	[4]	
(ii)	[$v^2 = 2 \times 2.4 \times 0.3$]	M1		For using $v^2 = 0 + 2as$
	Speed is $1.20\,ms^{-1}$	A1ft	[2]	ft a from (i) ($a \neq \pm g$)
(iii)		M1		For using $v^2 = u^2 + 2as$ with $v = 0$ and $a = -(40 \div 160)g$
	Distance while Q is on the ground $= (2 \times 2.4 \times 0.3) \div 2(40g \div 160)$ (= 0.288 m)	A1ft		ft a from (i) and/or s = 30
	Distance travelled is 0.588 m	A1	[3]	

CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the May/June 2014 series

9709 MATHEMATICS

9709/42 Paper 4, maximum raw mark 50

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BOD Benefit of Doubt (allowed when the validity of a solution may not be absolutely clear)

CAO Correct Answer Only (emphasising that no "follow through" from a previous error is allowed)

CWO Correct Working Only – often written by a 'fortuitous' answer

ISW Ignore Subsequent Working

MR Misread

PA Premature Approximation (resulting in basically correct work that is insufficiently accurate)

SOS See Other Solution (the candidate makes a better attempt at the same question)

SR Special Ruling (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)

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PA –1 This is deducted from A or B marks in the case of premature approximation. The PA –1 penalty is usually discussed at the meeting.

1 (i)	DF = 22500 ÷ 18	B1		
		M1		For using Newton's second law with 3 terms
	22500/18 – R = 600 × 1.4	A1		
	R = 410 N	A1	4	
(ii)	Rate of working is 6150 W	B1√	1	ft on incorrect R, i.e. R × 15
2 (i)		M1		For using $s = ut + ½at^2$ to obtain an equation in T from $s_{AP} + s_{BP} = 10$
	$½\,0.5T^2 + 0.75T = 10$	A1		
	$[T^2 + 3T – 40 = 0 = (T + 8)(T – 5)]$	M1		For solving the resulting 3 term quadratic equation either by factorising or formula and finding a value for T
	T = 5 only	A1	4	Reject/ignore T = – 8
	Alternative mark scheme for 2(i)			
(i)	$x = ½\,½\,T^2$ $10 – x = ¾\,T$ Eliminate T $x = ¼\,[4/3(10 – x)]^2$	M1		Set up an equation for x, the distance travelled by particle A
	$x = 6.25$	A1		Solve for x reject/ignore $x = 16$
	$10 – 6.25 = ¾\,T$ or $6.25 = ¼\,T^2$	M1		Substitute for x into either of the above equations
	T = 5	A1		Reject/ignore T = –5
(ii)	Speed is $2.5\,\text{ms}^{-1}$	B1√	1	ft for speed = 0.5T
3		M1		For resolving forces acting on P horizontally (3 terms)
	$0.8T_1 + 0.96T_2 = 10$ or $T_1 \cos 36.9 + T_2 \cos 16.3 = 10$	A1		
		M1		For resolving forces acting on P vertically (3 terms)
	$0.6T_1 – 0.28T_2 = 0.7g$ or $T_1 \sin 36.9 – T_2 \sin 16.3 = 0.7g$	A1		
		M1		For solving simultaneous equations and finding both T_1 and T_2
	$T_1 = 11.9$ **and** $T_2 = 0.5$	A1	6	

4 (i)		M1		For differentiation to find *a(t)* for $t \geqslant 8$
	$a(t) = t^{-1/3}/3$	A1		
	[0.25 – (1/2) / 3 = 1/4 – 1/6]	M1		Decrease = $a(8^-) - a(8^+)$
	Decrease is 1/12 ms^{-2}	A1	4	AG
(ii)		B1		$s_1 = ½ ¼ 8^2 = 8$
	$s_2 = \int_8^{27} \frac{1}{2} t^{2/3} dt = [0.3t^{5/3}]_8^{27}$	M1		Using definite integration to find s_2
	Distance is 71.3 m	A1	3	$s_1 + s_2 = 71.3$
Alternative method for the final two marks				
	$s = \int \frac{1}{2} t^{2/3} dt = 0.3t^{5/3} + c$ $s(8) = 8$ gives $c = -1.6$	M1		Using indefinite integration to find *s* and finding the constant of integration by using the value of s_1
	$s(27) = 0.3(27)^{5/3} - 1.6 = 71.3$	A1		Finding $s(27)$
5 (i)	KE gain is $10.5v^2$ J	B1	1	
(ii) (a)	[PE Loss = 16 (10) x – 5 (10) x sin 30]	M1		For use of PE = mgh and Loss by system = loss by B – gain by A
	PE loss by system is $135x$ J	A1	2	
(b)	R = 5 (10) × (√3 ÷ 2)	B1		
	F = 25	B1		
	Work done is $25x$ J	B1√	3	ft incorrect F
(iii)	[$10.5v^2 = 135x - 25x$]	M1		For using 'Gain in KE = Loss in PE – WD against friction'
	$21v^2 = 220x$	A1	2	AG
6 (i)	$v^2 = 2 \times g \times 7.2$ ➔ speed at surface is 12 ms^{-1}	B1		
	[$6^2 = 12^2 + 2a \times 0.8$]	M1		For using $6^2 = v^2 + 2as$ and finding *a*
	Deceleration is 67.5 ms^{-2}	A1		
	[$0.2g - R = -0.2 \times 67.5$]	M1		For using Newton's 2nd law with three terms for P in the liquid
	R = 15.5	A1	5	

(ii)	[$3.6 = \frac{1}{2} a \times 4^2$]	M1		For using $s = 0 + \frac{1}{2} at^2$ and finding a
	$a = 0.45\,ms^{-2}$	A1		
	[$T - R - 0.2g = 0.2 \times 0.45$]	M1		For using Newton's 2nd law with P in the liquid
	Tension is 17.6 N (17.59 exact)	A1√	4	ft incorrect R
	Alternative Energy Method			
(i)		M1		For using PE lost = WD by R in liquid + KE gain
	$0.2g \times 8 = R(0.8) + \frac{1}{2}(0.2)\,6^2$	A1		
	R = 15.5	A1		Finding R
	$0.2g - 15.5 = 0.2a$	M1		For using Newton's 2nd law in the liquid
	$a = -67.5$	A1	5	
(ii)		M1		For using $s = (0 + v)/2 \times t$ to find v at surface of liquid
	$3.6 = v/2 \times 4$ $v = 1.8$	A1		
	$T(3.6) = R(3.6) + 0.2g(3.6) + \frac{1}{2}(0.2)1.8^2$	M1		For using WD by T = WD by R + PE gain + KE gain
	T = 17.6 N	A1	4	
7 (i)	[$T_A - 2.5 = 0.25 \times a$] [$7.5 - T_B = 0.75 \times a$]	M1		For applying Newton's 2nd law to either particle A or particle B
	$T_A = 2.5 + 0.25a$	A1		
	$T_B = 7.5 - 0.75a$	A1	3	
(ii)	$F = 0.4 \times 5$	B1		
	[$T_B - T_A - F = 0.5a$]	M1		For using Newton's 2nd law for P with friction and both tensions represented (4 terms)
	$7.5 - 0.75a - (2.5 + 0.25a) - 2 = 0.5a \rightarrow a = 2$	A1	3	AG

	Alternative method for (ii)			
(ii)	$F = 0.4 \times 5$	B1		
	$a = 2$ used to find $T_A = 3$, $T_B = 6$ and used in $T_B - T_A - F = 0.5 \times a$	M1		Assume given value of a, find T_A and T_B and use the values in 4 term Newton's 2nd law
	$a = 2$	A1		Justify the value $a = 2$
(iii)	$[v^2 = 2 \times 2 \times 0.36]$	M1		For using $v^2 = 2as$ with $s = 1 - ½\,(5.28 - 4)$
	Speed is 1.2 ms^{-1}	A1	2	
(iv)	$-T_A - 2 = 0.5a$ and $T_A - 2.5 = 0.25a$	M1		For applying Newton's 2nd law to particle P **and** substituting for T_A
	Deceleration is 6 ms^{-2}	A1	2	$a = -6$ or $d = 6$

CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Level

MARK SCHEME for the May/June 2014 series

9709 MATHEMATICS

9709/41 Paper 4 (Mechanics 1), maximum raw mark 50

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PA –1	This is deducted from A or B marks in the case of premature approximation. The PA –1 penalty is usually discussed at the meeting.

1	DF = 28000	B1		
	[1330 000 = 28000V]	M1		For using P = (DF)V
	V = 47.5	A1	[3]	
2 (i)	2.4 = 0.25g cosα	B1		
	α = 16.3	B1	[2]	
(ii)	[μ = 0.28÷0.96]	M1		For using μ = F/R or μ = tanα
	Least possible value of μ is 7/24 or 0.292	A1	[2]	
3		M1		For finding the component of the forces in the *x* direction
	$X = 5 - 7\cos 60^\circ - 3\cos 30^\circ$ (= – 1.098)	A1		
		M1		For finding the component of the forces in the *y* direction
	$Y = 7\sin 60^\circ - 3\sin 30^\circ - 4$ (= 0.5622)	A1		
		M1		For using $R^2 = X^2 + Y^2$ and tan θ = Y/X
	Resultant is 1.23 N and Direction is 152.9° anticlockwise from +ve *x*-axis oe	A1	[6]	
4		M1		For using $0 = u^2 - 2gs$ for the upwards motion
	For s = 4.05	A1		
	Total distance = 4.05 + (3.15 + 4.05) = 11.25 m	B1		
	$t_{upwards} = 0.9$	B1		
	For downwards motion	B1		
	$(3.15 + 4.05) = \frac{1}{2}gt^2 \rightarrow t = 1.2$			
	Time taken is 2.1 s	B1	[6]	

	Alternative Mark Scheme for final 3 marks			
	$[-3.15 = 9T + \frac{1}{2}(-g)T^2]$	M1		For using $s = ut + \frac{1}{2}at^2$ for the total displacement and time
	$[100t^2 - 180t - 63 = 0]$	M1		For solving a quadratic equation for the total time T
	$(10T - 21)(10T + 3) = 0$	A1		T = 2.1 only
5 (i)	KE gain = $550v^2$	B1		
	PE gain = $1000x$	B1		
	$[1800x = 550v^2 + 1000x + 700x]$	M1		
	$k = 5.5$	A1√	[4]	ft for incorrect coeff(s) of v^2 and/or of x
(ii)	At A $5.5v^2 = 1760 \rightarrow v^2 = 320$	B1		
		M1		For using from A, KEgain= WD by DF –WD against R
	$550(v^2 - 320) = 1800(x - 1760) - 700(x - 1760)$	A1		
	$v^2 = 2x - 3200$ (cwo)	A1	[4]	AG
	Alternative for part (ii) $[1800 - 700 = 1100a$ and $5.5v^2 = 1760]$	M1		For applying Newton's 2nd Law to find acceleration along AB **and** for using $kv^2 = x$ to find v^2 at A
	$a = 1$ and $v^2 = 320$	A1		
	$[v^2 = 320 + 2 \times 1 \times (x - 1760)]$	M1		For using $v^2 = u^2 + 2as$ for motion from A to B
	$v^2 = 2x - 3200$	A1	[4]	
6 (i)		M1		For using Newton's second law for both particles and eliminating T, or using $(M + m)a = (M - m)g$
	Acceleration is $5\,ms^{-2}$	A1		
		M1		For using $s = 0 + \frac{1}{2}at^2$
	Distance is 0.9 m	A1	[4]	
(ii)	$\frac{1}{2}0.6 \times V = 0.9 \rightarrow V = 3$	B1√		ft distance in (i)
		M1		For using $0 = V - g(T - 0.6)$
	T = 0.9	A1	[3]	

(iii)	[$s_{up} = \frac{1}{2}\ 0.9 \times 3$ and $s_{down} = 0 + \frac{1}{2}g(1.6 - 0.9)^2$]	M1		For using area property in graph or equivalent
	Distance upwards is 1.35 m and distance downwards is 2.45 m	A1		
	h = 1.1	B1√	[3]	ft $s_{down} - s_{up}$
7 (i)		M1		For using $s = ut + \frac{1}{2}at^2$ to find the distance AB, or for using v = u + at to find P's speed at B
	$AB = 3 \times 400 + \frac{1}{2}\ 0.005 \times 400^2 = 1600$ m (AG) or $v_B = 3 + 0.005 \times 400 = 5\ ms^{-1}$	A1		
	$v_B = 3 + 0.005 \times 400 = 5\ ms^{-1}$ or $AB = 3 \times 400 + \frac{1}{2}\ 0.005 \times 400^2 = 1600$ m (AG)	B1	[3]	
(ii)		M1		For using $\int_0^{400} v\,dt = 1600$
	$[0.02t^2 - 0.0001t^3/3 + kt]_0^{400} = 1600$	A1		
	$400k = 1600 - 0.02 \times 400^2 + 0.0001 \times 400^3 \div 3 \rightarrow$ $k = 4 - 8 + 16/3 = 4/3$	A1		
	[dv/dt = 0.04 – 0.0002t (= 0 when t = 200))	M1		For differentiating and solving dv/dt = 0
	$v_{max} = 0.04 \times 200 - 0.0001 \times 200^2 + 4/3$	A1√		ft incorrect k or incorrect value of t from dv/dt = 0
	Maximum speed is 5.33 ms^{-1}	A1	[6]	
(iii)		M1		For using constant speed 5 ms^{-1} = 1400/T
	Time taken is 280 s	A1		
	[$1400 = 4/3 \times 280 + \frac{1}{2}\ 280^2a$]	M1		For using $s = ut + \frac{1}{2}at^2$ to find a
	a = 0.0262	A1	[4]	

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9709/43 Paper 4, maximum raw mark 50

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1 (i)	[–(1 ÷ 3)(Wcosα) – Wsinα = (W/g)a]	M1		For using Newton's 2nd law and F = μR
	(–0.32 – 0.28)g = a	A1		
	a = –6.	A1	3	AG
(ii)	[0 = 5.4^2 + 2(–6)s] or [mgs(0.28) = ½ m$(5.4)^2$ –mgs(0.96)/3]	M1		For using 0 = u^2 + 2as or for using PE gain = KE loss – WD against friction
	Distance is 2.43 m	A1	2	
2		M1		For using a = (M – m)g/(M+m) or for applying Newton's 2nd law to A and to B and solving for a.
	a = 5	A1		
	When B reaches the floor v^2 = 2 × 5 × 1.6; speed is 4ms^{-1}	B1ft		ft a a≠g v = √(3.2a)
		M1		For using 0 = u^2 – 2gs or for using PE gain = KE loss
	0 = 16 – 20s (s = 0.8)	A1ft		ft speed
	h + 1.6 + 0.8 = 3 → h = 0.6	B1	6	
3		M1		For resolving forces on P vertically
	T_A(1/2.6) + T_B(1/1.25) = 10.5	A1		
		M1		For resolving forces on P horizontally
	T_A(2.4/2.6) = T_B(0.75/1.25)	A1		
		M1		For solving for T_A and T_B
	Tension in AP is 6.5 N and tension in BP is 10 N.	A1	6	

	First Alternative			
		M1		For finding two angles in the triangle of forces
	$75.7(5)^o$ opposite to 10.5 N $36.8(7)^o$ opposite to T_A $67.3(8)^o$ opposite to T_B	A1		
		M1		For using the sine rule to find equations for T_A and T_B
	$T_A \div \sin 36.8(7) = 10.5 \div \sin 75.7(5)$ and $T_B \div \sin 67.3(8) = 10.5 \div \sin 75.7(5)$	A1		
		M1		For solving for T_A and T_B
	Tension in AP is 6.5 N and tension in BP is 10 N.	A1	6	
	Second Alternative			
		M1		For finding angles at P in the space diagram.
	$104.2(5)^o$ opposite to 10.5 N $143.1(3)^o$ opposite to T_A $112.6(2)^o$ opposite to T_B	A1		
		M1		For using Lami's rule to find equations for T_A and T_B
	$T_A \div \sin 143.1(3) = 10.5 \div \sin 104.2(5)$& $T_B \div \sin 112.6(2) = 10.5 \div \sin 104.2(5)$	A1		
		M1		For solving for T_A and T_B
	Tension in AP is 6.5 N and tension in BP is 10 N.	A1	6	
4 (i)	[$W\sin\alpha + F = 40$]	M1		For resolving forces parallel to the plane
	$F = 40 - 300 \times 0.1$ (= 10)	A1		
	$R = 300\sqrt{(1 - 0.1^2)}$ (= 298.496..)	B1		
		M1		For using $\mu = F/R$
	Coefficient is 0.0335	A1	5	

(ii)	[The component of weight (30 N) is greater than the frictional force (10 N)]	M1		For comparing the weight component parallel to the plane and the frictional force or for using Newton's Second Law and finding the acceleration
	Box does not remain in equilibrium	A1	2	
5 (i)		B1		The sketch requires three straight line segments with +ve, zero and –ve slopes in order, which together with a segment of the t axis form a trapezium.
		M1		For using v = at for T_1 or u = –at for T_3
	$T_1 = V \div 0.3$, $T_3 = V$	A1	3	
(ii)	$[S = \frac{1}{2} T_1V + T_2V + \frac{1}{2} T_3V]$	M1		For using the area property for the distance travelled
		M1		For substituting for T_1, T_2 and T_3 in terms of V
	$S = 552V - V\ \{0.5(T_1 + T_3)\}$ $= 552V - 13V^2/6$	A1		
	$13V^2 - 3312V + 72000=0$	B1		AG
	V = 24	B1	5	
6 (i)	[144000/v – 4800 = 12500a]	M1		For using DF = P/v and Newton's 2nd law at A or at B
	Acceleration at A is 0.336 ms^{-2}	A1		
	The speed at B 24 ms^{-1}	A1	3	AG
(ii)	WD by DF = 5800 × 500 &			
	WD against res'ce = 4800 × 500	B1		
	Loss in KE = ½12500($24^2 - 16^2$)	B1		
		M1		For using WD by DF = PE gain – KE loss + WD against res'ce
	5800x500 = 12500gh – ½12500($24^2 - 16^2$) + 4800 × 500	A1		
	Height of C is 20 m	A1	5	

	(ii) Alternative			
	$[16^2 = 24^2 + 2 \times 500a]$	M1		For using $v^2 = u^2 + 2as$
	$a = -0.32$ ms^{-2}	A1		
		M1		For using Newton's second law
	$5800 - 4800 - 12500g \times (h \div 500) = 12500(-0.32)$	A1		
	Height of C is 20 m	A1	5	
7 (i)	$[s = k_1t^2/2 - 0.005t^3/3 + (C)]$	M1		For using $s = \int v dt$
	$[k_1(60^2/2) - 0.005(60^3/3) = 540]$	DM1		For using limits 0 and 60 and equating to 540
	$k_1 = 0.5$	A1		
	$0.5 \times 60 - 0.005 \times 60^2 = k_2 \div \sqrt{60}$	M1		For using $v_1(60) = v_2(60)$
	$k_2 = 12\sqrt{60}$	A1	5	AG
(ii)		M1		For using $s = 540 + 12\sqrt{60}\int_{60}^{t} (t^{-1/2})dt$
	$[s = 540 + 12\sqrt{60}(2\sqrt{t} - 2\sqrt{60}) =]$ $24\sqrt{(60t)} - 900$	A1	2	Accept any other correct form for s if it is used in **(iii)**
(iii)	$[24\sqrt{(60t)} - 900 = 1260]$	M1		For solving s(t) = 1260 for t
	t = 135	A1		
	$v = 12\sqrt{60} \div \sqrt{135} \rightarrow$ speed is 8 ms^{-1}	B1	3	

CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2013 series

9709 MATHEMATICS

9709/42 Paper 4, maximum raw mark 50

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1	Applying T cos β = W sin α Tension is 2.5 N	M1 A1 A1	 3	For resolving forces parallel to the line of greatest slope T (24/25) = 5.1 (8/17) or T cos 16.26 = 5.1 sin 28.07
First Alternative Marking Scheme				
	Applying R cos α + T sin (α + β) = W and R sin α = T cos (α + β) Tension is 2.5 N	M1 A1 A1	 3	For resolving forces vertically or horizontally R cos 28.07 + T sin 44.33 = 5.1 and R sin 28.07 = T cos 44.33
Second Alternative Marking Scheme				
	Applying T / sin α = 5.1 / sin (90 + β) Tension is 2.5 N	M1 A1 A1	 3	Using Triangle of forces T / sin 28.07 = 5.1 / sin 106.26

2	Gain in KE = ½ 25 × 3^2 or WD by pulling force = 220 × 15 cos α WD by pulling force = 220 × 15 cos α or Gain in KE = ½ 25 × 3^2 [3300 cos α = 112.5 + 3000] α = 19.4	M1 A1 B1 M1 A1	 5	For using KE = ½ m v^2 or WD = F d cos α For using WD by pulling force = KE gain + WD against resistance

3 (i)		M1		For using F = P/v and Newton's 2nd law with a = 0
	100/4 – 4k = 0 → k = 6.25	A1	2	AG
(ii)		M1		For using Newton's 2nd law with a = 0 uphill → 3 term equation
	100/v – 70g × 0.05 – 6.25v = 0	A1		
	$[6.25v^2 + 35v – 100 = 0]$ or $[v^2 + 5.6v – 16 = 0]$	M1		For solving a 3-term quadratic for v
	Maximum speed is 2.08 $ms^{–1}$	A1	4	

4		M1		For resolving three forces parallel to the plane
	0.6g sin α = F + P cos α	A1		Value of α used or values of sin α and cos α used
		M1		For resolving three forces perpendicular to the plane
	R = 0.6g cos α + P sin α	A1		Value of α used or values of sin α and cos α used
		M1		For using F = μR
	0.6g sin α – P cos α = 0.4 (0.6g cos α + P sin α)	A1		Value of α used or values of sin α and cos α used
	6(12/13) – P(5/13) = 2.4(5/13) + 0.4P(12/13)	M1		For solving the resultant equation for P
	P = 6.12	A1	8	

Alternative Marking Scheme

		M1		For resolving three forces vertically
	W = R cos α + F sin α	A1		Value of α used or values of sin α and cos α used
		M1		For resolving three forces horizontally
	P = R sin α – F cos α	A1		Value of α used or values of sin α and cos α used
		M1		For using F = μR in both equations
	0.6g = R(5/13) + 0.4R(12/13) and P = R(12/13) – 0.4R(5/13)	A1		Value of α used or values of sin α and cos α used
	78 = R(5 + 4.8) and 13P = R(12 – 2) → 13P = (78 ÷ 9.8) × 10	M1		For finding R and substituting into an expression for P
	P = 6.12	A1	8	

5 **(i)**	$[s = t^2/2 - 0.1t^3/3]$	M1*		For integrating to find s for $0 \leqslant t \leqslant 5$
	$[s_1 = 25/2 - 0.1 \times 125/3]$	DM1*		For obtaining s_1 by using limits 0 to 5 or having zero for constant of integration (can be implied) and substituting t = 5
	$s_1 = 8.33$	A1	3	
(ii)			M1	For using s = v(5) × (45 – 5) for $5 \leqslant t \leqslant 45$
	$s_2 = 2.5 \times 40$	A1		
	$[s = 9t^2/2 - 0.1t^3/3 - 200t$ for $45 \leqslant t \leqslant 50]$	M1		For integrating to find s for $45 \leqslant t \leqslant 50$ and implying the use of limits 45 and 50 or equivalent via constant of integration
	$s_3 = [9(50)^2 / 2 - 0.1(50)^3 / 3 - 200(50)] - [9(45)^2 / 2 - 0.1(45)^3 / 3 - 200(45)]$ [= 8.33]	A1		For applying the limits at 45 and 50 correctly or equivalent via constant of integration

Alternative mark scheme for previous 2 marks				
	Recognising the symmetry of the velocity distribution due to the correspondence of the points (0,0) → (50,0) and (5,2.5) → (45,2.5)	(M1)		
	Complete the idea of symmetry with one further property and hence State $s_3 = s_1 = 8.33$	(A1)		Property is any one of a(0) = – a(50) a(5) = a(45) v(2.5) = v(47.5) oe
	Distance from O to A is 117m	A1		
	Average speed is 2.33 ms^{-1}	B1ft	6	ft answer for total distance

6 (i)		M1		For applying Newton's 2nd law to A or B
	T – 0.4g = 0.4a or 1.6g – T = 1.6a	A1		
	1.6g – T = 1.6a or T – 0.4g = 0.4a or 1.6g – 0.4g = (1.6 + 0.4)a	B1		
	T = 6.4	A1		
	Work done by tension is 7.68 J	B1ft	5	
Alternative mark scheme for 6 (i)				
		M1		For applying Newton's 2nd law to A or B
	T – 0.4g = 0.4a or 1.6g – T = 1.6a	A1		
	1.6g – T = 1.6a or T – 0.4g = 0.4a or 1.6g – 0.4g = (1.6 + 0.4)a	B1		
	WD by T = initial PE – final KE = 1.6 × g × 1.2 – ½ × 1.6 × 14.4	M1		For finding v^2 and applying Work/Energy equation to B
	WD by T = 19.2 – 11.52 = 7.68	A1	5	

6 (ii)	[1.6 × 10 × 1.2 = ½ 1.6 v^2 + 7.68]	M1		For using PE loss = KE gain + WD by T to find v^2
	v^2 = 14.4	A1		
	14.4 = 2 × 10 × h h = 0.72 H = 2 × 1.2 + h	M1		For using PCE for A's motion after B reaches the ground or $0 = u^2 - 2gh$ and H = 2 × 1.2 + h
	Greatest height is 3.12 m	A1	4	
First Alternative Marking Scheme for 6 (ii)				
	[v^2 = 2 × 6 × 1.2]	M1		For using v^2 = 2as to find v^2
	v^2 = 14.4	A1		
	14.4 = 2 × 10 × h h = 0.72 H = 2 × 1.2 + h	M1		For using PCE for A's motion after B reaches the ground or $0 = u^2 - 2gh$ and H = 2 × 1.2 + h
	Greatest height is 3.12 m	A1	4	
Second Alternative Marking Scheme for 6 (ii)				
	WD by T = Increase in PE 7.68 = 0.4 × g × s	M1		For applying WD by T to particle A's complete motion
	s = 1.92	A1		
	H = 1.2 + s	M1		For adding 1.2 to s
	H = 1.2 +1.92 = 3.12 Height = 3.12 m	A1	4	

7 (i)	[s = ½ 5 × 0.4 + 19 × 0.4 + ½ 4 × 0.4] Distance = 9.4	M1 A1	 2	For using the area property for distance
(ii)	Acceleration is 0.08 ms^{-2} Deceleration is 0.1ms^{-2}	B1 B1	 2	
(iii)	[T – (800 + 100) g = (800 +100)a] T – 900g = 900a T = 9072 N in 1st stage T = 9000 N in 2nd stage T = 8910 N in 3rd stage	M1 A1 A1	 3	For applying Newton's 2nd law to the elevator and box
(iv)	[R – 100g = 100a] R = 1008 N R = 990 N	M1 A1 A1	 3	For applying Newton's 2nd law to the box For obtaining the greatest value of the force on the box For obtaining the least value of the force on the box

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1	[$T\cos\alpha = mg$]	M1		For resolving forces vertically
	Tension is 3.4 N	A1		
	[$F = T\sin\alpha$]	M1		For resolving forces horizontally
	$F = 1.6$	A1	4	
2	**(i)** [WD = $30 \times 20 \times 0.6 + 40 \times 20 \times 0.8$]	M1		For using WD = $Fd\cos\theta$
	Work done is 1000 J	A1	2	
	(ii)	M1		For applying $F = \mu W$ and Newton's 2nd law with $a = 0$
	$30 \times 0.6 + 40 \times 0.8 - 0.625W = 0$	A1		
	Weight is 80 N	A1	3	
3	**(i)**	M1		For applying Newton's 2nd law to the bicycle/cyclist
	$F - 780 \times (36 \div 325) - 32 = 78 \times (-0.2)$	A2		(A2 for all correct, A1 for one error, A0 for more than one error)
	$F = 103$ (102.8 exact)	A1	4	
	(ii) [$0 = 7^2 + 2(-0.2)s$]	M1		For using $0 = u^2 + 2as$
	Distance is 122.5 m (accept 122 or 123)	A1	2	
4	**(i)** [$-\mu mg = ma$]	M1		For using Newton's 2nd law, $F = \mu R$ and $R = mg$
	Decelerations of P and Q are $2\ \text{ms}^{-2}$ and $2.5\ \text{ms}^{-2}$.	A1	2	
	(ii)	M1		For using $s = ut + \frac{1}{2}at^2$ and $s_P = s_Q + 5$
	$8t - t^2 = 3t - 1.25t^2 + 5$	A1		
	$t = \sqrt{120} - 10$ (=0.95445…)	A1		
		M1		For using $v = u + at$ for both P and Q
	Speed of P = $6.09\ \text{ms}^{-1}$, speed of Q = $0.614\ \text{ms}^{-1}$	A1	5	

5	(i)	Gain in PE $=15000g \times 16$	B1		
		WD against resistance = 1800×1440	B1		
			M1		For using:– WD by driving force = Gain in PE + WD against resistance
		Work done is $4.99\text{x}10^6$ J	A1	4	
	(ii)		M1		For using :– WD by engine = Increase in KE + WD against resistance
		$5030\,000 = \frac{1}{2}\,15\,000(24^2 - 15^2) + 1600d$	A1		
		Distance is 1500 m	A1	3	
6	(i)		M1		For applying Newton's 2nd law to A or to B
		$T - 0.3g = 0.3a$ or $0.7g - T = 0.7a$	A1		
		$0.7g - T = 0.7a$ or $T - 0.3g = 0.3a$ or $0.7g - 0.3g = (0.7 + 0.3)a$	B1		
		Tension is 4.2 N	A1	4	
	(ii)	$a = 4$	B1		May be scored in **(i)**
		$s_{taut} = 1.6^2/(2 \times 4)$ $(= 0.32)$	B1		
		$[(0.52 + 0.32) = -1.6t + 5t^2]$	M1		For using $s = ut + \frac{1}{2}gt^2$
		$[(t - 0.6)(5t + 1.4) = 0]$	M1		For solving the resultant quadratic equation.
		Time taken is 0.6 s	A1	5	

Alternative Marking Scheme for the last three marks

		$0^2 = 1.6^2 - 2gs_{up}$, $t_{up} = 2s_{up}/(1.6 + 0)$ $(= 0.16)$	M1		For using kinematic formulae to find t_{up}
		$0.52 + s_{taut} + s_{up} = 0 + \frac{1}{2}gt_{down}^2$ $(t_{down} = 0.44)$	M1		For using kinematic formulae to find t_{down}
		Time taken $= t_{up} + t_{down} = 0.6$ s	B1		

7	**(i)**	M1		For integrating 0.6t and using v(0) = 0 (may be implied by absence of constant of integration)
	$v(t) = 0.3t^2$	A1		
		M1		For integrating v(t) and using s(0) = 0 (may be implied by absence of constant of integration)
	$s(t) = 0.1t^3$	A1		
	Velocity is $30\,ms^{-1}$ and displacement is 100 m	A1	5	
	(ii)	M1		For integrating –0.4t and using v(10) = 30
	$v(t) = -0.2t^2 + 50$	A1		
	At A, $-0.2t^2 + 50 = 0 \Rightarrow t = \sqrt{250}$	B1		
		M1		For integrating v(t) and using s(10) = 100
	$s(t) = -t^3/15 + 50t - 1000/3$	A1		
		M1		For finding $s(\sqrt{250})$
	Distance OA is 194 m	A1	7	

CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the May/June 2013 series

9709 MATHEMATICS

9709/43 Paper 4, maximum raw mark 50

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1	[(W / g) a = W sin α – 0.02 W cos α]	M1		For using Newton's second law
	a = (sin 14° – 0.02 cos 14°) g (= 2.225 …)	A1		
	$[v^2 = 8^2 + 2 \times 2.225 \ldots \times 50]$	M1		For using $v^2 = u^2 + 2as$
	Speed is 16.9 m s^{-1}	A1	[4]	
Alternative Scheme				
1	WD against friction = 0.02 W cos α × 50	B1		
	PE loss = W × 50 sin α	B1		
		M1		For using Gain in KE = Loss in PE – WD against friction
	Speed is 16.9 m s^{-1}	A1	[4]	
2 (i)		M1		PE loss = B's loss – A's gain
	Loss of PE = 2g × 3.24 – 1.6 g (3.24 × 0.8)	A1		
	Loss is 23.328 J.	A1	[3]	AG
(ii)	½ (1.6 + 2) v^2 = 23.328	B1		
	Speed is 3.6 m s^{-1}	B1	[2]	
				SR (max 1/2) for using Newton's second law and $v^2 = u^2 + 2as$ 2 g – T = 2 a and T – 1.6g × 0.8 = 1.6a a = 2 $v^2 = 2 \times 2 \times 3.24$ v = 3.6 B1
3		M1		For using DF = P / v
		M1		For using Newton's 2nd law for both speeds / accelerations
	1000 P / 14 – R = 800 x 1.4 and 1000 P / 25 – R = 800 x 0.33	A1		
		M1		For solving for P
	P = 27.2	A1		
	R = 825	B1	[6]	Accept 825.5

4	(i)		M1		For integrating a (t) to obtain v (t)
		V (t) = 1.5 t + 0.006 t^2	A1		Constant of integration zero or absent
		[0.006 t^2 + 1.5 t - 90 = 0 ➔ t^2 + 250t – 15000 = 0] ➔ (t – 50) (t + 300) = 0]	DM1		For using v (t) = 90 and solving for t (dependent on integration)
		Leaves the ground when t = 50	A1	[4]	
	(ii)		M1		For integrating v (t) and using limits 0 to candidate's answer for part (i)
		s = 0.75 t^2 + 0.002 t^3	A1ft		ft if there is a non-zero constant of integration C in part (i) s = 0.75 t^2 + 0.002 t^3 + C t
		Distance is 2125 m	A1ft	[3]	Accept 2120 or 2130 ft t from part (i) in 0.75 t^2 + 0.002 t^3
5	(i)	[T = 2 x 1.7 – 2 x 0.7] [for P 17 t – 5 t^2 = 0 and for Q 7 t = 5 t^2 = 0]	M1		T = 2 x time to max. height for P – 2 x time to max. height for Q or For using T = time for P to return to ground – time for Q to return to ground
		T = 2	A1	[2]	SR (max 1/2) for candidates who find difference in time to maximum height T = 1.7 – 0.7 = 1 B1
	(ii)		M1		For using $h_P – h_Q$ = 5 and s = u t – 5 t^2 for both P and Q
		17(t + 2) – 5(t + 2)^2 – (7t – 5t^2) = 5 or 17t – 5t^2 – 7(t - 2) + 5(t – 2)^2 = 5			
			A1	ft	ft T from part (i)
		t = 0.9 or t = 2.9	A1		
			M1		For using v = u – 10 t for P and Q

	$v_P = 17 - 10(0.9 + 2)$, $v_Q = 7 - 10 \times 0.9$ → Magnitudes are 12 m s^{-1} & 2 m s^{-1}	A1	ft	ft using t_P and $t_P - T$ or using t_Q and $t_Q + T$
	The direction for both is vertically downwards	A1	[6]	
6 (i)		M1		For resolving the applied forces on the box in the *x*-direction or the *y*-direction.
	$100 \cos 30^o + 120 \cos 60^o - F \cos\alpha = 136$ ($F \cos \alpha = 10.6025 \ldots$) or $100 \sin 30^o - 120 \sin 60^o + F \sin \alpha = 0$ ($F \sin \alpha = 53.9230 \ldots$)	A1		
	$100 \sin 30^o - 120 \sin 60^o + F \sin \alpha = 0$ ($F \sin \alpha = 53.9230 \ldots$) or $100 \cos 30^o + 120 \cos 60^o - F \cos \alpha = 136$ ($F \cos \alpha = 10.6025 \ldots$)	B1		
		M1		for using $F^2 = (F \cos \alpha)^2 + (F \sin \alpha)$ or $\tan \alpha = F \sin \alpha \div F \cos \alpha$
	F = 55.0 or α = 78.9	A1		
	α = 78.9 or F = 55.0	B1	[6]	
(ii)	Magnitude is 136 N	B1		
	R = 40 g	B1		
	Coefficient is 0.34	B1	[3]	

7	**(i)**		M1		For applying Newton's 2nd law to A or to B
		T – (2 / 7) 1.26 g = 1.26 a or 0.9 g - T = 0.9 a	A1		
		0.9g – T = 0.9 a or T – (2 / 7) 1.26 g = 1.26 a or 0.9 g – (2 / 7) 1.26 g = (0.9 + 1.26) a	B1		
		Acceleration is 2.5 m s^{-2}	B1		AG
		Tension is 6.75 N	A1	[5]	
	(ii)	[$v^2 = 2 \times (2.5) \times 0.45$]	M1		For using $v^2 = 2ah$
		Speed is 1.5 m s^{-1}	A1	[2]	
	(iii)	[– (2 / 7) 1.26 g = 1.26 a]	M1		For applying Newton's 2nd law to A
		a = – 20 / 7	A1		
		[$v^2 = 2.25 + 2(-20/7)(0.03)$]	M1		For using $v^2 = v_B^2 + 2as$
		Speed is 1.44 m s^{-1}	A1	[4]	

CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the May/June 2013 series

9709 MATHEMATICS

9709/42 Paper 4, maximum raw mark 50

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1	(i)	[24 = μ30]	M1		For using R = W, F = T and F = μR
		Coefficient is 0.8	A1	[2]	
	(ii)		M1		For resolving forces vertically and using F = μR
		$F = 0.8(30 - 25\sin 30^\circ)$ (=14)	A1		
		$[25 \cos 30^\circ - F = (30 \div g)a]$	M1		For using of Newton's 2nd law
		Acceleration is 2.55 ms^{-2}	A1	[4]	
2	(i)		M1		For using work done by pulling force = increase in KE – decrease in PE + WD by resistance
		$1150 = ½\ 16 \times 10^2 - 16g(50 \times 0.05)$ + WD by resistance	A1		
		WD by resistance = 750 J	A1	[3]	
	(ii)	1150 = increase in KE + 16 g(50 × 0.05) + 750	M1		For WD by pulling force = KE gain + PE gain + WD by resistance
		KE gain = 0 → speed at top = speed at bottom	A1	[2]	AG
3			M1		For resolving forces acting on P horizontally or vertically
		$T_A \times (40/50) + T_B \times (40/104) = 21$ or $T_A \times (30/50) = T_B \times (96/104)$	A1		
		$T_A \times (30/50) = T_B \times (96/104)$ or $T_A \times (40/50) + T_B \times (40/104) = 21$	B1		
		Solve for T_A and T_B	M1		Solving for both
		Tension in AP is 20 N and tension in BP is 13 N	A1	[5]	Both $T_A = 20$ and $T_B = 13$
		First Alternative Marking Scheme			
3			M1		For using the sine rule in the triangle of forces
		21/sin 75.75 (or 75.7 or 75.8) = T_A/sin 67.4 (or T_B/sin 36.9)	A1		
		21/sin 75.75 (or 75.7 or 75.8) = T_B/sin 36.9 (or T_A/sin 67.4) or T_B/sin 36.9 = 20/sin 67.4	B1		
		Solve for T_A and T_B	M1		Solving for both

	Tension in AP is 20N and tension in BP is 13N	A1	[5]	Both $T_A = 20$ and $T_B = 13$
	Second Alternative Marking Scheme			
3		M1		For using Lami's Rule
	$21/\sin 104.3 = T_A/\sin 112.6$ (or $T_B/\sin 143.1$)	A1		
	$21/\sin 104.3 = T_B/\sin 143.1$ (or $T_A/\sin 112.6$) or $T_B/\sin 143.1 = 20/\sin 112.6$ or $T_A/\sin 112.6 = 13/\sin 143.1$	B1		
	Solve for T_A and T_B	M1		For using the equations to find T_A and T_B
	Tension in AP is 20 N and tension in BP is 13 N	A1	[5]	Both $T_A = 20$ and $T_B = 13$
4 (i)	$a = (16 \div 65)g$	B1		
	$[8^2 = 2(16 \div 65)gS]$	M1		For using $v^2 = 2as$ to find S
	$S = 13$	A1		
	$[v^2 = 2(16 \div 65)g \times 6.5$ or $v^2 \div 8^2 = ½]$	M1		For using $v^2 = 2a(½S)$ or $v^2 \propto s$
	Speed is 5.66 ms^{-1}	A1	[5]	
(ii)	$[s = ½ a \times (64 \div 4a^2)$ or $s \div 13 = (½)^2]$	M1		For using $8 = 0 + aT$ and $s = ½a(T/2)^2$ or $s \propto t^2$
	Distance is 3.25 m	A1	[2]	
	Alternative Marking Scheme			
4 (i)	$[½ m v^2 = mgh$ and $S = h \div \sin \alpha$	M1		For using KE gain = PE loss
	$S = (8^2 \div 20) \div (16 \div 65)$	A1		Or AEF
	$S = 13$	A1		
	$½ m v^2 = mg(½\ 13 \times (16/65))$	M1		Or AEF
	Speed is 5.66 ms^{-1}	A1	[5]	
(ii)		M1		For eliminating at^2 from $s = ½at^2$ and $13 = ½a(2t)^2$
	Distance is 3.25 m	A1	[2]	
5 (i)	Driving force = 1000P/25	B1		

			M1		For using Newton's 2nd law
		$1000P/25 - 600 = 1000 \times 0.2$	A1		
		$P = 20$	A1	[4]	
	(ii)		M1		For using Newton's 2nd law with $a = 0$
		$20000/v_{max} - 600 = 0$	A1ft		ft for their P in (i)
		Steady speed is 33.3 ms^{-1}	A1	[3]	
6	**(i)**	For sketch of single valued, continuous graph consisting of 3 straight line segments with $+^{ve}$, then $-^{ve}$, then $+^{ve}$ slope	B1		
		Sketch appears to show $v(0) = 0$ and $v(8) > v(26) > v(20)$	B1	[2]	
	(ii)	For shading the triangle from $t = 0$ to $t = 8$, the trapezium from $t = 8$ to $t = 20$ and the trapezium from $t = 20$ to a value of t seen to be between 20 and 26	B1	[1]	
	(iii)		M1		For using area property to find s(20)
		$s(20) = ½(8 \times 8) + ½(8 + 2) \times 12$ (= 92)	A1		
			M1		For using the gradient property to find acceleration in 3rd phase
		$a = (6.5 - 2)/6$ (= 0.75)	A1		
		$[s(t) = 92 + 2(t - 20) + 0.375(t - 20)^2$	M1		
		Displacement is $0.375t^2 - 13t + 202$ metres	A1	[6]	
		Alternative Marking Scheme for final 2 marks of Q6			
		$[v(t) = 2 + 0.75(t - 20)$ $s(t) = 0.375t^2 - 13t + A$ where $92 = 0.375 \times 400 - 13 \times 20 + A]$	M1		For finding v(t), integrating and using s(20) = 92
		Displacement is $0.375t^2 - 13t + 202$ metres	A1		
6	**(iii)**	**First Alternative Marking Scheme for part (iii) of Q6**			
		$a = (6.5 - 2) / (26 - 20) = 0.75$	B1		
		$v = 0.75t$ (+ C1)	M1		Integrating
		$v = 0.75t - 13$	A1		Using $v(20) = 2$ or $v(26) = 6.5$

	$s(20) = 92$ or $s(26) = 117.5$	B1		Using area in diagram
	$s = 0.375t^2 - 13t (+ C_2)$	M1		Integrating
	$s = 0.375t^2 - 13t + 202$	A1	[6]	Using s(20) or s(26) to find $C_2 = 202$
6 (iii)	**Second Alternative Marking Scheme for part (iii) of Q6**			
	s = 0.375t2 – 13t + 202			Given
	$v = 0.75t - 13$	M1		Differentiating
	$a = 0.75$	M1		Differentiating
	$a = (6.5–2)/(26–20) = 0.75$	B1		Check agreement from graph
	$v(20) = 0.75(20) - 13 = 2$ or $v(26) = 0.75(26) - 13 = 6.5$	B1		Check v agrees at a point between t = 20 and t = 26
	Show $s(20) = 92$ or $s(26) = 117.5$	B1		Using area under graph
	$s(20) = 0.375(20)^2 - 13(20) + 202 = 92$ or $s(26) = 0.375(26)^2 - 13(26) + 202 = 117.5$	B1		Check s agrees at a point between t = 20 and t = 26
7 (i)		M1		For applying Newton's 2nd law to A or B
	$T - 0.26g(16÷65) = 0.26a$ or $0.52g - T = 0.52a$	A1		
	For $\{0.52g - T = 0.52a$ or $T - 0.26g(16 ÷ 65) = 0.26a\}$ or $0.52g - 0.26g(16 ÷ 65) = (0.52 + 0.26)a$	B1		
	Acceleration is $5.85\ ms^{-2}$	B1		
	Tension is 2.16 N	A1	[5]	
(ii)	$[v^2 = 2 × (76/13) × 0.6]$	M1		For using $v^2 = 2as$
	Speed is $2.65\ ms^{-1}$	A1		
	$0 = 91.2/13 - 2(160/65)s$	M1		For using $0 = v_B^2 - 2(g \sin\alpha)s$
	S = 57/40 (= 1.425)	A1		
	[AP = 2.5 – 0.6 – 1.425]	M1		For using AP = 2.5 – 0.6 – s
	Distance AP is 0.475 m	A1	[6]	

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MARK SCHEME for the May/June 2013 series

9709 MATHEMATICS

9709/41 Paper 4, maximum raw mark 50

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 will not enter into discussions about these mark schemes.

Cambridge is publishing the mark schemes for the May/June 2013 series for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level components and some Ordinary Level components.

Mark Scheme Notes

Marks are of the following three types:

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.

- 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 (or dep*) 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.

- The symbol √ 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 and B marks are not given for fortuitously "correct" answers or results obtained from incorrect working.

- Note: B2 or A2 means that the candidate can earn 2 or 0.
  B2/1/0 means that the candidate can earn anything from 0 to 2.

  The marks indicated in the scheme may not be subdivided. If there is genuine doubt whether a candidate has earned a mark, allow the candidate the benefit of the doubt. Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored.

- Wrong or missing units in an answer should not lead to the loss of a mark unless the scheme specifically indicates otherwise.

- For a numerical answer, allow the A or B mark if a value is obtained which is correct to 3 s.f., or which would be correct to 3 s.f. if rounded (1 d.p. in the case of an angle). As stated above, an A or B mark is not given if a correct numerical answer arises fortuitously from incorrect working. For Mechanics questions, allow A or B marks for correct answers which arise from taking *g* equal to 9.8 or 9.81 instead of 10.

The following abbreviations may be used in a mark scheme or used on the scripts:

AEF Any Equivalent Form (of answer is equally acceptable)

AG Answer Given on the question paper (so extra checking is needed to ensure that the detailed working leading to the result is valid)

BOD Benefit of Doubt (allowed when the validity of a solution may not be absolutely clear)

CAO Correct Answer Only (emphasising that no "follow through" from a previous error is allowed)

CWO Correct Working Only – often written by a 'fortuitous' answer

ISW Ignore Subsequent Working

MR Misread

PA Premature Approximation (resulting in basically correct work that is insufficiently accurate)

SOS See Other Solution (the candidate makes a better attempt at the same question)

SR Special Ruling (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)

<u>Penalties</u>

MR –1 A penalty of MR –1 is deducted from A or B marks when the data of a question or part question are genuinely misread and the object and difficulty of the question remain unaltered. In this case all A and B marks then become "follow through √" marks. MR is not applied when the candidate misreads his own figures – this is regarded as an error in accuracy. An MR –2 penalty may be applied in particular cases if agreed at the coordination meeting.

PA –1 This is deducted from A or B marks in the case of premature approximation. The PA –1 penalty is usually discussed at the meeting.

1	**(i)**	Less than	B1		
		F = 1.25W so W< F	B1	[2]	
	(ii)	[P – 60 × 1.25 = 6 × 4]	M1		For applying Newton's second law.
		P = 99	A1	[2]	
2		Increase in PE = 1250 × 10 × 600 sin2.5°	B1		
		Decrease in KE = ½ 1250($30^2 – v_{top}^2$)	B1		
		WD against resistance = 400 × 600	B1		
		[562500 – $625v_{top}^2$ = 327145 + 240000 – 450000]	M1		For using WD by DF = Increase in PE – decrease in KE + WD against resistance
		Speed is 26.7 ms^{-1}	A1	[5]	
Special Ruling for candidates who assume, without justification, that the driving force (DF) is constant (maximum mark 4).					
		[DF – Weight component – Resistance = Mass × Accel'n]	M1		For applying Newton's second law.
		750 – 545 – 400 = 1250a	A1		
		$v^2 = 30^2 + 2 \times (-0.156) \times 600$	B1ft		ft value of a
		Speed is 26.7 ms^{-1}	B1	[4]	
3	**(i)**		M1		For using $0 = u^2 – 2gs$
		$u^2 = 2 \times 10 \times 45$; speed is 30$ms^{-1}$	A1	[2]	
	(ii)	[$40 = 30t – 5t^2$ ➔ t = 2, 4]			For using $s = ut – ½ gt^2$ with s = 40, u = 30 and T = $t_2 – t_1$ or $s = ut + ½ gt^2$ s = 5, u = 0 and T = 2t
		[$5 = ½ 10t^2$ ➔ t = 1]	M1		
		Time above the ground is 2 s	A1ft	[2]	
Special Ruling for candidates who assume, without justification, that the length of time required is that of the upward movement only. (maximum mark 1).					
	(ii)	$5 = ½ 10t^2$ ➔ t = 1, the length of time required is 1 s	B1	B1	
	(iii)	Max. height above top of cliff = ½ g(17 ÷ 4) (= 21.25)	B1		
		[$0 = V^2 – 2g(40 + 21.25)$]	M1		For using $0 = u^2 – 2gs$
		Speed is 35 ms^{-1}	A1	[3]	

Alternative Marking Scheme for (iii)

	(iii)		M1		For using $40 = Vt - 5t^2$ ➔ $t_2 - t_1 =$ ½ $(V/5 + \sqrt{(V^2/25 - 32)}) -$ ½ $(V/5 - \sqrt{(V^2/25 - 32)})$
		$17 = V^2/25 - 32$	A1		
		Speed is 35 ms^{-1}	A1	[3]	
4	(i)	DF = 1500 000/37.5 (= 40 000)	B1		
		[DF – R = ma]	M1		For using Newton's second law
		DF – 30 000 = 400 000a	A1		
		Acceleration is 0.025 ms^{-2}	A1	[4]	
	(ii)	[1500 000/v – 30 000 = 0]	M1		For using Newton's 2nd law with a = 0
		Steady speed is 50 ms^{-1}	A1	[2]	
5	(i)	R = 2.6 × (12 ÷ 13) (= 2.4)	B1		
		[F = 0.2 × 2.4]	M1		For using F = μR
		[T – 2.6(5 ÷ 13) – F = 0.26a, 5.4 – T = 0.54a]	M1		For applying Newton's 2nd law to A or to B.
		For any two of T – 1 – 0.48 = 0.26a, 5.4 – T = 0.54a or (5.4 – 1 – 0.48) = (0.54 + 0.26)a	A1		
		Acceleration is 4.9 ms^{-2}	B1		
		Tension is 2.75 N (2.754 exact)	A1	[6]	
	(ii)	[s = ½ 4.9 × 0.4^2]	M1		For using s = ½ at^2
		Distance is 0.392 m	A1	[2]	
6	(i)		M1		For resolving forces in the *x* and *y* directions (or for sketching a marked triangle of forces)
		Fcosθ = 2.5 × 24 ÷ 25 + 2.6 × 5 ÷ 13	A1		(= 3.4)
		Fsinθ = 2.6 × 12 ÷ 13 – 2.5 × 7 ÷ 25	A1		(= 1.7)
			M1		For using $F^2 = (F\cos\theta)^2 + (F\sin\theta)^2$ to find F or tanθ = Fsinθ ÷ Fcosθ to find θ
		For F = 3.80 N or tanθ = 0.5	A1		
		For tanθ = 0.5 or F = 3.80 N	B1	[6]	

	(ii)	[3.80 = 0.5a]	M1		For using Newton's 2nd law with the magnitude of the resultant force equal to the value of F found.
		Acceleration is 7.60 ms^{-2}	A1ft		ft value of F found in (i)
		Direction is 26.6° clockwise from +ve *x*-axis.	B1ft	[3]	ft value of tanθ found in (i)
7	**(i)**	[$0.0000117(1200t^2 - 12t^3) = 0$]	M1		For differentiating and solving ds/dt = 0
		$1200t^2 = 12t^3 \Rightarrow t = 0, 100$	A1		Accept just t = 100, if it is used to find distance AB.
		Distance AB = 1170 m	A1	[3]	
	(ii)		M1		For differentiating again and solving $d^2s/dt^2 = 0$
		$2400t - 36t^2 = 0 \Rightarrow t = 0, 200/3$	A1		Accept just t = 200/3, if it is used to find v_{max}.
		[$v_{max} = 0.0000117\{1200(200/3)^2 - 12(200/3)^3\}$]	M1		For substituting into v(t)
		Maximum speed is 20.8 ms^{-1}	A1	[4]	
	(iii)	At A a(t) = 0	B1		
		At B a(t) = $0.0000117(2400 \times 100 - 36 \times 100^2) = -1.40$ ms^{-2} (–1.404 exact)	B1	[2]	
	(iv)	Sketch has v increasing from 0 to maximum and decreasing to 0, with maximum closer to t = 100 than t = 0.	B1		
		Sketch has zero gradient at t = 0 and inflexion closer to t = 0 than t = 100.	B1	[2]	