OXFORD
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AQA EXAMINATIONS

INTERNATIONAL A-LEVEL MATHEMATICS

Mark scheme

Mechanics Unit 2

Specimen

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Principal Examiners have prepared these mark schemes for specimen papers. These mark schemes have not, therefore, been through the normal process of standardising that would take place for live papers.

Key to mark scheme abbreviations

M	Mark is for method
m	Mark is dependent on one or more M marks and is for method
A	Mark is dependent on M or m marks and is for accuracy
B	Mark is independent of M or m marks and is for method and accuracy
E	Mark is for explanation
√ **or ft**	Follow through from previous incorrect result
CAO	Correct answer only
CSO	Correct solution only
AWFW	Anything which falls within
AWRT	Anything which rounds to
ACF	Any correct form
AG	Answer given
SC	Special case
oe	Or equivalent
A2, 1	2 or 1 (or 0) accuracy marks
–*x* EE	Deduct x marks for each error
NMS	No method shown
PI	Possibly implied
SCA	Substantially correct approach
sf	Significant figure(s)
dp	Decimal place(s)

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No method shown

Where the question specifically requires a particular method to be used, we must usually see evidence of use of this method.

Where the answer can be reasonably obtained without showing working and it is very unlikely that the correct answer can be obtained by using an incorrect method, we must award **full marks**. However, the obvious penalty to candidates showing no working is that incorrect answers, however close, earn **no marks**.

Where a question asks the candidate to state or write down a result, no method need be shown for full marks.

Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

Otherwise we require evidence of a correct method for any marks to be awarded.

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Q	Answer	Marks	Comments
1(a)	KE = $\frac{1}{2} \times 58 \times 2^2$	M1	M1 Correct fully substituted expression for KE
	= 116 J	A1	A1 CAO
1(b)	Change in PE: $mgh = 58 \times 9.8 \times 7$	M1	M1 Expression for PE with 58 and 9.8 or 9.81 with 6 or 7 for the height (or 11 and 4, 11 and 5 or 10 and 4)
	= 3978.8	A1	A1 Accept 3980 or 3970 or 3978 or 3979 or 3978.8 Accept 3982 or 3983 or 3980
	KE = 3978.8 + 116 J = 4094.8 J	M1	M1 Adding their two previous answers
	Speed of Kim is $\sqrt{\frac{4094.8}{\frac{1}{2} \times 58}}$ = 11.88 m s^{-1}	m1	dM1 Seeing expression for v (not v^2), dependent on second M1
	= 11.9 m s^{-1}	A1	A1 Accept 11.88 or 11.8 or 11.9 Accept 11.88 or 11.8 or 11.9 or AWRT 11.89 from $g = 9.81$. Obtaining $v = \sqrt{u^2 + 2gh}$ followed by incorrect substitution M0M1M1, unless h is 6 or 7, which is M1M1M1 11.0 (from $h = 6$) M1M1M1 $v = \sqrt{2^2 + 2 \times g \times 7}$ M1M1M1 $= \sqrt{141.2}$ A1 = 11.9 A1 $v = \sqrt{24 + 14g}$ M1M1M1A1 = 11.9 A1 $v = \sqrt{2^2 + 12g}$ M1M1M1
	Total	**7**	

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Q	Answer	Marks	Comments
2(a)(i)	Moments about AB $1.6 \times 4 + 0.4 \times 8 = 2 \times x$ $x = 4.8$	M1A1	M1 for 2 terms correct
	Distance is 4.8 cm	A1	
2(a)(ii)	Moments about AD: $1.6 \times 6 + 0.4 \times 12 = 2 \times y$ $y = 7.2$	M1A1	M1 for 2 terms correct
	Distance is 7.2 cm	A1	SC2 + SC2 for **(a)(i)** and **(a)(ii)** reversed
2(b)	Moments about A: $1.6g \times 6 + 0.4g \times 12 = 12 \times T_B$	M1A1	M1 for 1 side of equation Or using above: moments about A $12 \times T_B = 7.2 \times 2g$ (ft for M marks)
	$T_B = 1.2g = 11.8$ N	A1	
	Resolve vertically: $T_A + T_B = 2g$	M1	
	$T_A = 0.8g = 7.84$ N	A1	1.2 and 0.8 is zero marks If 11.8 and 7.8 as final answer, must lose 1 mark somewhere
	Total	**11**	

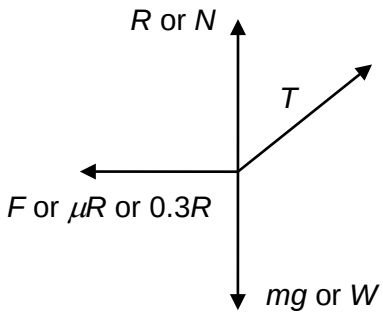
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Q	Answer	Marks	Comments
3(a)	$\mathbf{a} = \frac{dv}{dt}$ $\mathbf{a} = -8e^{-2t}\mathbf{i} + (6 - 6t)\mathbf{j}$	M1 A1 A1	M1 Differentiating with either of the two components correct. Do not need to see **i** or **j**. A1 Correct **i** component. A1 Correct **j** component.
3(b)(i)	Using $\mathbf{F} = m\mathbf{a}$ $\mathbf{F} = 5 \times \{-8e^{-2t}\mathbf{i} + (6 - 6t)\mathbf{j}\}$ $= -40e^{-2t}\mathbf{i} + (30 - 30t)\mathbf{j}$	M1 A1	M1 Multiplying their acceleration by 5, even if not a vector. A1 Correct expression.
3(b)(ii)	Magnitude of **F** is $\{(-40)^2 + (30)^2\}^{\frac{1}{2}}$	M1	M1 Finding magnitude from two non-zero terms. Must add terms and square root. Condone $\{(40)^2 + (30)^2\}^{\frac{1}{2}}$
	$= 50$	A1	A1 Correct answer only In this part, condone lack of negative signs in expression for force in **(b)(i)**
3(c)	When **F** acts due west, **j** component is zero $30 - 30t = 0$	M1	M1 Putting **j** component equal to zero
	$t = 1$	A1	A1: Correct time.
3(d)	$\mathbf{r} = -2e^{-2t}\mathbf{i} + (3t^2 - t^3)\mathbf{j} + \mathbf{c}$	M1 A1 A1	M1 Integration with either of the two components correct. Do not need to see **i** or **j**. A1 Correct **i** component A1 Correct **j** component Condone lack of + **c**
	When $t = 0$, $\mathbf{r} = 6\mathbf{i} + 5\mathbf{j}$ $\therefore$ $\mathbf{c} = 8\mathbf{i} + 5\mathbf{j}$	m1	m1 Finding **c** using $6\mathbf{i} + 5\mathbf{j}$ and $e^0 = 1$
	$\therefore$ $\mathbf{r} = (8 - 2e^{-2t})\mathbf{i} + (5 + 3t^2 - t^3)\mathbf{j}$	A1	A1 Correct position vector.
	Total	**14**	

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Q	Answer	Marks	Comments
4	Force acting against gravity is $mg\sin\theta$ Force acting against gravity and resistance is $mg\sin\theta + 8000$	M1	Condone $\cos\theta$ or -1 for M marks
	$= 1500 \times g \times \sin\theta + 8000$ $= 8588$ N or 8590 N	A1	
	Using power = force × velocity $= 8588 \times 22$	m1	
	$= 188\,936$ W	A1	
	$= 189$ kW	A1	Accept 188.9 or 188
	Total	**5**	

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Q	Answer	Marks	Comments
5(a)		B1	B1 Diagram with **exactly four** forces showing arrow heads and labelled If components are also shown and they use a different style, eg dashed lines, they can be ignored Note Award mark if forces drawn on the diagram in the question Note Do not accept 8 kg for the weight Note Accept μR or $0.3R$ for F
5(b)	$R + T\sin30° = 8 \times 9.8$	M1	M1 Resolving vertically to obtain a three term equation, with R, T sin or cos(30° or 60°) and 8g oe
	$(R =)\ 78.4 - T\sin30°$	A1	A1 Correct equation
	$(R =)\ 78.4 - 0.5T$	A1	A1 Correct expression for R Accept $(R =)\ 8g - T\sin30°$ Note if using g = 9.81 accept $R = 78.48 - 0.5T$ or $R = 78.5 - 0.5T$
5(c)	**Alternative method 1**		
	$T\cos30° - F = 8 \times 0.05$	M1 A1	M1 Horizontal equation of motion with F, T sin or cos(30° or 60°) and 8×0.05 oe A1 Correct equation
	$F = 0.3(78.4 - T\sin30°)$ $T\cos30° - 0.3(78.4 - T\sin30°) = 0.4$	M1 A1	M1 Using $F = 0.3R$ with their R from part (b), provided it includes a term in T A1 Correct expression for friction
	$T = \dfrac{23.52 + 0.4}{\cos30^\circ + 0.3\sin30^\circ} = 23.5$ N	m1 A1	m1 Solving for T Must see $(\cos 30° \pm 0.3\sin30°)$ or similar in the denominator. (Dependent on both previous M marks) A1 Correct T Accept 23.6 or AWRT 23.5

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Q	Answer	Marks	Comments
5(c)	**Alternative method 2**		
	$T\cos30° - F = 8 \times 0.05$	M1 A1	M1 Horizontal equation of motion with F, T sin or cos(30° or 60°) and 8×0.05 oe A1 Correct equation
	$T\cos30° - 0.3R = 8 \times 0.05$ $R + T\sin30° = 8 \times 9.8$	M1 A1	M1 Using $F = 0.3R$ A1 Two correct equations involving only T and R
	Solving simultaneously gives $T = 23.5$	m1 A1	m1 Solving for T A1 Correct T Accept 23.6 or AWRT 23.5 Note using g = 9.81 gives 23.6, also accept 23.5
	Total	**10**	

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Q	Answer	Marks	Comments
6(a)	For particle *B*, tension in string = 2.1g N Resolve horizontally for particle *A*	B1	
	$m\omega^2 r = T$	M1	or $m_1\omega^2 r = m_2 g$ or $\frac{m_1 v^2}{r} = m_2 g$
	$1.4\omega^2 \times 0.3 = 2.1g$ $\omega^2 = 49$	A1	
	Angular velocity is 7 rad/sec	A1	
6(b)	Using $v = r\omega$ speed = 0.3 × 7	M1	
	$= 2.1 \text{ m s}^{-1}$	A1	Part (b) marks can be awarded in (a)
6(c)	Time taken is $2\pi / \omega$	M1	or $\frac{2\pi}{2.1}$
	$= \frac{2\pi}{7} = 0.898$ sec	A1	Accept $\frac{2\pi}{7}$ (0.895 M1A0)
	Total	**8**	

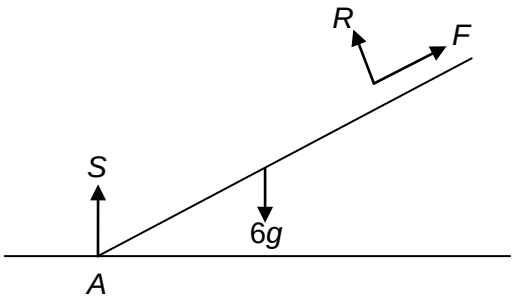
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Q	Answer	Marks	Comments
7(a)	**Alternative method 1**		
	$12\sin30°t - 4.9t = -0.5$ $4.9t^2 - 12\sin30°t - 0.5 = 0$	M1A1A1	M1 Three term equation for vertical motion, with $\pm g, \pm 0.5$ (or ± 1 and ± 1.5) and $12\sin30°t$ or $12\cos30°t$ A1 Correct terms. (one must be equivalent to ± 0.5) A1 Correct signs
	$t = 1.30281\ldots$ or $-0.078323\ldots$ $t = 1.30$ seconds (to 3sf) AG	m1A1	m1 Solving the quadratic to find t Must see use of quadratic equation formula or can be implied by seeing 1.303 or 1.302 or similar A1 Correct time from correct working Must see more than 3 significant figures in their working before the final answer or two correct solutions to the quadratic (eg 1.3 and -0.08) Accept 1.3
	Alternative method 2		
	time up = 0.6122	M1A1	M1 Adding time up to time down having used a quadratic. A1 0.6122
	time down = 0.6122 + 0.0783 = 0.6905	m1A1	m1 Finding time down with a quadratic A1 0.6905
	total time = 0.6122 + 0.6905 = 1.30 (to 3sf)	A1	A1 Correct answer Accept 1.3
	Alternative method 3		
	$-6.767 = 12\sin30° - gt$	M1A1A1	M1 Forms an equation to find t having found v first A1 Correct terms A1 Correct signs
	$t = \frac{12\sin30° \times 6.767}{g} = 1.30281 = 1.30$ (to 3sf)	m1A1	m1: Solving for t A1 Correct time from correct working. Must see more than 3 significant figures in candidate's working before the final answer. Accept 1.3

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Q	Answer	Marks	Comments
7(b)	$12\cos30° \times 1.303 = 13.5$ m	M1A1	M1 Finding horizontal displacement using 1.30 (or better) and $12\cos30°$ Do not allow $12\sin30°$ A1 Correct distance. AWRT 13.5.
7(c)	$v_y = 12\sin30° - 9.8 \times 1.3028$ (= 6.767)	M1A1	M1 Finding vertical component of velocity or velocity squared at impact. Must include $12\cos30°$ or $12\cos30$ and $\pm g$ A1 Correct expression for vertical component. May have 1.3 or 1.30 instead of 1.3028 (Accept +6.767 or similar)
	$v = \sqrt{(12\cos30^\circ)^2 + (-6.767)^2}$ $= 12.4\ \text{ms}^{-1}$	m1A1	m1 Finding speed from two components. May use 6.74. A1 Correct speed. Allow 12.3 or AWRT 12.4. Note using $g = 9.81$ still gives 12.4
7(d)	$\tan\theta = \dfrac{6.767}{12\cos30^\circ}$ $\theta = 33.1°$ **or** $\sin\theta = \dfrac{6.767}{12.4}$ $\theta = 33.1°$ **or** $\cos\theta = \dfrac{10.4}{12.4}$ $\theta = 33.1°$	M1	M1 Trigonometric equation to find angle Can only be those shown opposite or described below For tan, fraction can be inverted For sin, 10.4 can be used instead of 6.767 For cos, 6.767 can be used instead of 10.4 Can use their values from part (c) (eg 6.74 or 6.77)
		A1ft	A1ft Correct angle Accept AWRT 33° Follow though vertical component or final speed from part (c)
	Total	**8**	

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Q	Answer	Marks	Comments
8(a)		B2	B1 for S and $6g$ (in correct place) B1 for R and F or combined vertical force at C
8(b)	Moments about C:		
	$3 \times S \times \cos 20° = 6g \times 1 \times \cos 20°$	M1A1	M1 2 terms, 1 term correct
	$S = 19.6$ N or $2g$	A1	R, F not correct 0 marks in (c)(i) and (c)(ii)
8(c)(i)	Moments about A $2 \times 6g \times \cos 20° = R \times 3$	M1A1	**Or** Moments about mid-point of rod: $2 \times S \times \cos 20° = P \times 1 \times \cos 20°$
	$R = 36.8$ N (or resolving, $R = 6g\cos 20° - S\cos 20°$ $= 4g\cos 20°$)	A1	$P = 39.2$ N or $4g$ (or resolving vertically $P = 4g$)
8(c)(ii)	Resolve parallel to AB: $S\cos 70° + F = 6g\cos 70°$ $F = 4g\cos 70°$	M1	$R = P \times \cos 20°$ M1 A1 $= 36.8$ N A1 $F = P \times \sin 20°$ M1
	$= 13.4$ N (or $F = 6g\sin 20° - S\sin 20° = 4g\sin 20°$)	A1	$= 13.4$ N A1
8(d)	Using $F = \mu R$: $13.4 = \mu \times 36.8$	M1	M1 their (c)(ii) = μ their (c)(i)
	$\mu = 0.364$ or $\tan 20°$	A1ft	(condone $\geq$)
	Total	**12**	

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