GCE

Mathematics A

H230/02: Pure Mathematics and Mechanics

AS Level

Mark Scheme for June 2023

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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MARKING INSTRUCTIONS

PREPARATION FOR MARKING
RM ASSESSOR

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM Assessor Online Training*; *OCR Essential Guide to Marking*.

2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are posted on the RM Cambridge Assessment Support Portal http://www.rm.com/support/ca

3. Log-in to RM Assessor and mark the **required number** of practice responses ("scripts") and the **number of required** standardisation responses.

MARKING

1. Mark strictly to the mark scheme.

2. Marks awarded must relate directly to the marking criteria.

3. The schedule of dates is very important. It is essential that you meet the RM Assessor 50% and 100% (traditional 40% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.

4. **Annotations**

Annotation	Meaning
✓and✖	
BOD	Benefit of doubt
FT	Follow through
ISW	Ignore subsequent working
M0, M1	Method mark awarded 0, 1
A0, A1	Accuracy mark awarded 0, 1
B0, B1	Independent mark awarded 0, 1
SC	Special case
^	Omission sign
MR	Misread
BP	Blank Page
Seen	
Highlighting	

Other abbreviations in mark scheme	Meaning
dep*	Mark dependent on a previous mark, indicated by *. The * may be omitted if only one previous M mark
cao	Correct answer only
oe	Or equivalent
rot	Rounded or truncated
soi	Seen or implied
www	Without wrong working
AG	Answer given
awrt	Anything which rounds to
BC	By Calculator
DR	This question included the instruction: In this question you must show detailed reasoning.

5. **Subject Specific Marking Instructions**

a. Annotations must be used during your marking. For a response awarded zero (or full) marks a single appropriate annotation (cross, tick, M0 or ^) is sufficient, but not required.

For responses that are not awarded either 0 or full marks, you must make it clear how you have arrived at the mark you have awarded and all responses must have enough annotation for a reviewer to decide if the mark awarded is correct without having to mark it independently.

It is vital that you annotate standardisation scripts fully to show how the marks have been awarded.

Award NR (No Response)
- if there is nothing written at all in the answer space and no attempt elsewhere in the script
- OR if there is a comment which does not in any way relate to the question (e.g. 'can't do', 'don't know')
- OR if there is a mark (e.g. a dash, a question mark, a picture) which isn't an attempt at the question.

Note: Award 0 marks only for an attempt that earns no credit (including copying out the question).

If a candidate uses the answer space for one question to answer another, for example using the space for 8(b) to answer 8(a), then give benefit of doubt unless it is ambiguous for which part it is intended.

b. An element of professional judgement is required in the marking of any written paper. Remember that the mark scheme is designed to assist in marking incorrect solutions. Correct solutions leading to correct answers are awarded full marks but work must not always be judged on the answer alone, and answers that are given in the question, especially, must be validly obtained; key steps in the working must always be looked at and anything unfamiliar must be investigated thoroughly. Correct but unfamiliar or unexpected methods are often signalled by a correct result following an apparently incorrect method. Such work must be carefully assessed. When a candidate adopts a method which does not correspond to the mark scheme, escalate the question to your Team Leader who will decide on a course of action with the Principal Examiner.

If you are in any doubt whatsoever you should contact your Team Leader.

c. The following types of marks are available.

M
A suitable method has been selected and applied in a manner which shows that the method is essentially understood. Method marks are not usually 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. In some cases the nature of the errors allowed for the award of an M mark may be specified.
A method mark may usually be implied by a correct answer unless the question includes the DR statement, the command words "Determine" or "Show that", or some other indication that the method must be given explicitly.

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). Therefore M0 A1 cannot ever be awarded.

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

Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored. Sometimes this is reinforced in the mark scheme by the abbreviation isw. However, this would not apply to a case where a candidate passes through the correct answer as part of a wrong argument.

d. When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. (The notation 'dep*' is used to indicate that a particular mark is dependent on an earlier, asterisked, mark in the scheme.) Of course, in practice it may happen that when a candidate has once gone wrong in a part of a question, the work from there on is worthless so that no more marks can sensibly be given. On the other hand, when two or more steps are successfully run together by the candidate, the earlier marks are implied and full credit must be given.

e. The abbreviation FT implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A and B marks are given for correct work only – differences in notation are of course permitted. A (accuracy) marks are not given for answers obtained from incorrect working. When A or B marks are awarded for work at an intermediate stage of a solution, there may be various alternatives that are equally acceptable. In such cases, what is acceptable will be detailed in the mark scheme. If this is not the case please, escalate the question to your Team Leader who will decide on a course of action with the Principal Examiner.

Sometimes the answer to one part of a question is used in a later part of the same question. In this case, A marks will often be 'follow through'. In such cases you must ensure that you refer back to the answer of the previous part question even if this is not shown within the image zone. You may find it easier to mark follow through questions candidate-by-candidate rather than question-by-question.

f. We are usually quite flexible about the accuracy to which the final answer is expressed; over-specification is usually only penalised where the scheme explicitly says so.
   - When a value is given in the paper only accept an answer correct to at least as many significant figures as the given value.
   - When a value is not given in the paper accept any answer that agrees with the correct value to 3 s.f. unless a different level of accuracy has been asked for in the question, or the mark scheme specifies an acceptable range.
     NB for Specification B (MEI) the rubric is not specific about the level of accuracy required, so this statement reads "2 s.f".

   Follow through should be used so that only one mark in any question is lost for each distinct accuracy error.
   Candidates using a value of 9.80, 9.81 or 10 for g should usually be penalised for any final accuracy marks which do not agree to the value found with 9.8 which is given in the rubric.

g. Rules for replaced work and multiple attempts:
   - If one attempt is clearly indicated as the one to mark, or only one is left uncrossed out, then mark that attempt and ignore the others.
   - If more than one attempt is left not crossed out, then mark the last attempt unless it only repeats part of the first attempt or is substantially less complete.
   - if a candidate crosses out all of their attempts, the assessor should attempt to mark the crossed out answer(s) as above and award marks appropriately.

h. For a genuine misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain unaltered, mark according to the scheme but following through from the candidate's data. A penalty is then applied; 1 mark is generally appropriate, though this may differ for some units. This is achieved by withholding one A or B mark in the question. Marks designated as cao may be awarded as long as there are no other errors. If a candidate corrects the misread in a later part, do not continue to follow through. Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

i. If a calculator is used, some answers may be obtained with little or no working visible. Allow full marks for correct answers, provided that there is nothing in the wording of the question specifying that analytical methods are required such as the bold "In this question you must show detailed reasoning", or the command words "Show" or "Determine". Where an answer is wrong but there is some evidence of method, allow appropriate method marks. Wrong answers with no supporting method score zero. If in doubt, consult your Team Leader.

j. If in any case the scheme operates with considerable unfairness consult your Team Leader.

Question			Answer	Marks	AO	Guidance	
1			$\Delta = 3^2 - 4(k)(k)$	B1	1.1	Correct discriminant of given quadratic equation (may be implied)	Not given if **just** seen in quadratic formula
			$9 - 4k^2 (< 0)$ leading to two c.v. of k	M1	1.1	Finds two critical values of k from **their** discriminant	**Or** for one correct inequality (may come from only one c.v.)
			$k > \frac{3}{2}$ [or] $k < -\frac{3}{2}$	A1	1.1	oe e.g. set notation $\{k : k < -3/2\} \cup \{k : k > 3/2\}$	
				[3]			

Question	Answer	Marks	AO	Guidance	
2	**DR** $x\sqrt{5}+32=x\sqrt{45}+2x$ $x\left(\sqrt{45}+2-\sqrt{5}\right)=32$	**M1***	**1.1**	Re-arranging and factorising out x	
	$\sqrt{45}=3\sqrt{5}$	**B1**	**1.1**	Replacing $\sqrt{45}=3\sqrt{5}$ (Or $\sqrt{45}\times\sqrt{5}=15$ if multiplying through by $\sqrt{5}$)	Could appear at any point
	$x=\left(\frac{32}{2\sqrt{5}+2}\right)\left(\frac{2\sqrt{5}-2}{2\sqrt{5}-2}\right)$	**M1dep***	**1.1a**	Correct method for rationalising the surd of the denominator with x taking the form $\frac{k_1}{k_2\sqrt{5}+k_3}$ o.e.	
	$x=\frac{32\left(2\sqrt{5}-2\right)}{20-4}=4\sqrt{5}-4$	**A1** **[4]**	**1.1**	cao where $a=4, b=-4$ Need to see some correct working	
	ALTERNATIVE SCHEME $\sqrt{45}=3\sqrt{5}$	**B1**		Replacing $\sqrt{45}=3\sqrt{5}$ (Or $\sqrt{45}\times\sqrt{5}=15$ if multiplying through by $\sqrt{5}$)	Could appear at any point
	$(32-2x)^2=(2\sqrt{5}x)^2\Rightarrow 16x^2+128x-1024(=0)$	**M1***		Rearranging and squaring leading to a 3TQ	
	$x=4\sqrt{5}-4$ only	**M1dep*** **A1** **[4]**		Solve by completing the square or using quadratic formula	

Question			Answer	Marks	AO	Guidance	
3	(a)	(i)	29 (m)	B1 [1]	1.1		
3	(a)	(ii)	1 (m)	B1 [1]	1.1		
3	(b)		$15-14\cos(150k)=1 \Rightarrow \cos(150k)=1$	M1	3.1b	Setting given expression equal to **(a)(ii)** and re-arranging to get $\cos(150k)=...$ **or** for stating $150k=360$	Must substitute/use $t = 150$ for this method mark. May use $t = 75$ with $h = 29$ $150k = 2\pi$, (i.e. using radians) **M1**
			$150k=360 \Rightarrow k=2.4$	A1 [2]	1.1	The correct answer only implies the **M** mark so "k = 2.4" without working is **M1A1**.	
3	(c)		$15-14\cos(kt)=20 \Rightarrow \cos(kt)=-\frac{5}{14}$	M1*	3.1b	Setting given expression equal to 20 to obtain an equation of the form $\cos(kt)=k_1$	Could use inequalities Need $-1 \leqslant k_1 \leqslant 1$
			$t=46.2186....,103.7813$	M1dep*	1.1	Obtaining at least one value of t correctly from their equation above	$2.4t=110.9248...,249.0751...$
			$103.7813... - 46.2186...$ or $150-(2\times 46.2186)$ o.e.	M1	1.1	Subtracting their two positive values of t (**both** obtained correctly from their equation above) or $150-(2\times$ their $t)$	**Dependent on previous two M marks**
			Therefore above 20 m for 57.6 (s)	A1 [4]	3.2a	Must be to 1 decimal place	57.562639… **A0** if using radians.

Question			Answer	Marks	AO	Guidance	
4	(a)		$\left(2+\frac{1}{3}kx\right)^6 = 2^6 + {}^6C_1 2^5\left(\frac{1}{3}kx\right) + {}^6C_2 2^4\left(\frac{1}{3}kx\right)^2 + \ldots$	M1	1.1a	Attempt at least 2 of these terms – products of binomial coefficients and correct powers of 2 and $\frac{1}{3}kx$	Using kx rather than $\frac{1}{3}kx$ mark as **MR -2**
			$64 + 64kx$	A1	1.1		
			$+\frac{80}{3}k^2x^2$	A1	1.1		
				[3]			
4	(b)		$(3-4x)\left(64+64kx+\frac{80}{3}k^2x^2+\ldots\right)$ $= 192 + \ldots + \left(80k^2 - 256k\right)x^2$	M1*	3.1a	Using two terms from the expansion in **(a)** to find the coefficient of x^2	
			$5k^2 - 16k - 12 = 0 \Rightarrow k = \ldots$	M1dep*	2.1	Forming a 3TQ in k	Using $3\times$ their constant term from (a)
			$k = \frac{8+2\sqrt{31}}{5}$	A1	2.2a	**BC** must be positive root **only**	
				[3]			

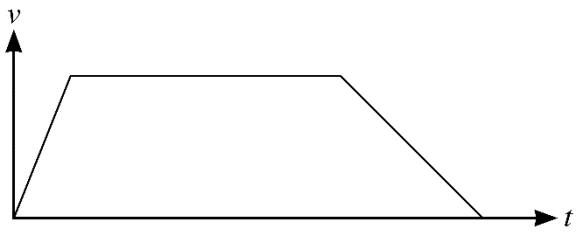
Question			Answer	Marks	AO	Guidance	
5	(a)		scale factor 4	B1	1.1	Allow s.f. or 'factor' but not just 4 or 4 units or 'scale factor 4 units'	Comments MUST refer to a stretch otherwise **B0B0**
			parallel to the *y*-axis	B1	2.5	oe e.g. allow in the *y*-direction, vertically, vertically upwards, vertical stretch, in the vertical direction, positive *y*-direction, parallel to the positive *y*-axis but not just upwards or in/on/about/across/through/along/towards the *y*-axis	If **B0B0** then **SCB1** for re-writing as $(y=)4\left(2^{3x}\right)$
				[2]			
5	(b)		$2^{3x+2}-2^{3x}=36$	B1	1.1	For the correct equation in x	Or $4y_A - y_A = 36 \Rightarrow y_A = 12$
			$2^{3x}=12 \Rightarrow \log\left(2^{3x}\right)=\log 12$	M1	1.1	Simplify to $2^{3x}=k$ where $k>0$ and take logs of both sides (any base)	
			$x=\frac{1}{3}\log_2 12$	A1	1.1	oe, e.g. $x = \log_2(12^{1/3})$	
				[3]			

Question			Answer	Marks	AO	Guidance	
6	(a)		$(AB=)\sqrt{(-3-5)^2+(1-0)^2}$ or $(BC=)\sqrt{(5-9)^2+(0-7)^2}$	M1	1.1	Correct formula for the distance between two points for either AB **or** BC (or these distances squared)	3 out of 4 values correct for either distance
			$AB=BC=\sqrt{65}$	A1	1.1	Correctly showing that $AB = BC$**,** exact values needed	
				[2]			
6	(b)		$(AC=)\sqrt{(-3-9)^2+(1-7)^2}$	M1	2.1	Attempt to find AC (or its square) – 3 out of 4 values correct	Or find gradients of both line segments $m_{AB}=\frac{1-0}{-3-5}$ and $m_{BC}=\frac{7-0}{9-5}$
			$\left(\sqrt{65}\right)^2+\left(\sqrt{65}\right)^2(=130)\neq 180\left(=AC^2\right)$ so angle ABC is not a right angle Or $\cos ABC=-\frac{5}{13}$, which is not =0 therefore angle ABC is not a right angle Or Angle $ABC=112.62...^{o}$ which is not a right angle	A1	2.4	Show correctly that Pythagoras does not hold in triangle ABC Using cosine rule	Or $-\frac{1}{8}\times\frac{7}{4}=\left(-\frac{7}{32}\right)\neq -1$ So angle ABC is not a right angle o.e.
				[2]			
6	(c)		(3, 4)	B1 [1]	1.1		

Question			Answer	Marks	AO	Guidance	
6	(d)		$\frac{y-0}{4-0}=\frac{x-5}{3-5}$	M1	1.1	Correct formula for the equation of the line between B and their midpoint of AC from **(c)**	Or using $y-y_1=m_{BM}(x-x_1)$ Or using $y=m_{BM}x+c$
			$2x+y=10$	A1	1.1	o.e. required form.	
				[2]			
6	(e)		$(x+3)^2+(y-1)^2=65$	B1 B1FT	1.1 1.1	**B1** for correct LHS **B1FT** for their AB^2 on RHS	Must be an equation to gain marks
				[2]			
6	(f)		(1, 8)	B1	2.2a		
				[1]			

Question			Answer	Marks	AO	Guidance	
7	(a)		$\left(\frac{dy}{dx}=\right)8x-10$	B1	1.1	Correct derivative	
			At $\left(\frac{1}{2},3\right): m_T=-6\Rightarrow m_N=\frac{1}{6}$	M1*	1.2	Substitutes $x = 0.5$ into their two-term derivative and using product of gradients is -1	
			$y-3=\frac{1}{6}\left(x-\frac{1}{2}\right)$	M1dep*	1.1	Using $y-3=m\left(x-\frac{1}{2}\right)$ with $m\neq -6$ or their tangent gradient (so must have attempted normal gradient)	Or using $y=mx+c$
			$2x-12y+35=0$	A1	1.1	Must = 0 and integer coefficients	All terms on one side
				[4]			
	(b)		$x \geq 1.25$	B1	1.1		$(y'=0\Rightarrow x=1.25)$
			$y \geq 4x^2-10x+7$	B1	2.2a		
			$2x-12y+35 \geqslant 0$	B1FT	2.2a	o.e. Follow through their **(a)**	**SCB2** if all "correct" (including FT from (a)), but either all strict or a mix of strict and non-strict inequalities used
				[3]			

Question			Answer	Marks	AO	Guidance	
8			**DR**				
				M1*	**2.1**	**M1** for either term integrated correctly	
			$8x^{\frac{1}{2}} + 3x$	**A1**	**1.1**		
			$\left(8a^{\frac{1}{2}} + 3a\right) - (16 + 12) = 7$	**M1dep***	**1.1**	Correct use of correct limits and equating to 7 – allow one substitution error	
			$3a + 8a^{\frac{1}{2}} - 35 = 0$	**M1**	**1.1**	Forming a 3TQ in $a^{\frac{1}{2}}$	Any three-term form (so terms do not need to be on the same side)
			$\left(3a^{\frac{1}{2}} - 7\right)\left(a^{\frac{1}{2}} + 5\right) = 0$	**M1**	**3.1a**	Dependent on all previous **M** marks – correct method for solving for $a^{\frac{1}{2}}$	Or $8a^{\frac{1}{2}} = 35 - 3a$ $9a^2 - 274a + 1225 = 0$ $(9a - 49)(a - 25) = 0$
			$a^{\frac{1}{2}} \neq -5$ as $a^{\frac{1}{2}}$ can't be negative	**A1**	**2.3**	Explicit rejection of -5 No specific justification required	Explicit rejection of $a = 25$ No specific justification required
			$a^{\frac{1}{2}} = \frac{7}{3} \Rightarrow a = \frac{49}{9}$	**A1**	**2.2a**	Correct value only	
				[7]			

Question			Answer	Marks	AO	Guidance	
9	(a)		50 (s)	B1 [1]	3.4		
9	(b)			B1 [1]	1.1	Correct (t, v) graph – no values on axes required	
9	(c)		$\frac{1}{2}(15)(20)+15T+\frac{1}{2}(15)('50')=1950$ or $\frac{1}{2}(20+T+'50'+T)\times 15)=1950$ o.e. 95 (s)	M1 A1 [2]	3.4 1.1	"Correct" equation for finding required time T using their **(a)**	May not be earned until e.g. $\frac{"1425"}{15}$ seen

Question			Answer	Marks	AO	Guidance	
10	(a)		$v=\int(4t-9)\,\mathrm{d}t=2t^2-9t(+c)$	M1*	1.1	Integrate given expression for a with at least one term (unsimplified) correct	+c not required for this first **M** mark
			$(1,2)\Rightarrow 2=2-9+c\therefore c=...$	M1dep*	3.4	Using given conditions to find +c	
			$v=2t^2-9t+9$	A1	1.1	Condone '$v=$' missing.	
				[3]			
10	(b)		$2t^2-9t+9=0\Rightarrow t=...$	M1	3.4	Setting their 3-term quadratic for v, from **(a),** equal to zero and solving for t	
			$(t_1=)\ 1.5,\quad (t_2=)\ 3$	A1	1.1	**BC**	
				[2]			
10	(c)		$\int_0^{1.5}\left(2t^2-9t+9\right)\mathrm{d}t=\frac{45}{8}$	B1FT	3.1b	**BC** – correct value for their $\int_0^{t_1} v\,\mathrm{d}t$	Only **FT** when their 3-term quadratic in **(b)** leads to positive values for t_1 and t_2
			$\int_{1.5}^{3}\left(2t^2-9t+9\right)\mathrm{d}t=-\frac{9}{8}$	B1FT	1.1	**BC –** correct value for their $\int_{t_1}^{t_2} v\,\mathrm{d}t$	
			Total distance travelled is 6.75 (m)	B1	3.2a	cao	
				[3]			

Question			Answer	Marks	AO	Guidance	
11	(a)		$T_1 - 4.5 = 0.6(3.5)$	M1	3.3	N2L for P – correct number of terms and dimensionally consistent – allow sign confusion	
			$T_1 = 6.6\,(\text{N})$	A1	1.1		
				[2]			
11	(b)		For Q: $T_2 + 0.4g - T_1 = 0.4(3.5)$ For R: $mg - T_2 = m(3.5)$	M1 M1 A1	3.3 3.3 1.1	**M1** for N2L for Q and **M1** for N2L for R – correct number of terms and dimensionally consistent – allow sign confusion **A1** for both correct (allow with their tension from **(a)**)	Must be using $a = 3.5$ Or (by considering Q and R together) $(0.4+m)g - T_1 = (0.4+m)\times 3.5$ scores **M2 A1**
			$m = 0.648$	A1	1.1	3sf required (0.6476190…)	$(m = \frac{68}{105})$
				[4]			

Question			Answer	Marks	AO	Guidance	
11	(c)		Before string breaks P moves $0.5(3.5)(0.4)^2\ (=0.28)$	B1	3.4	Correct (unsimplified) expression	
			When string breaks the speed of P is $3.5(0.4)\ (=1.4)$	B1	3.4	Correct (unsimplified) expression	
			For P: $T-4.5=0.6a$ For Q: $0.4g-T=0.4a$	M1* A1	3.3 1.1	**M1** for attempt at N2L for both P and Q after string breaks – correct number of terms and dimensionally consistent- but allow sign confusion	For reference if solved correctly then a is -0.58
			When string breaks P travels a distance s where $0=1.4^2+2(-0.58)s$	M1dep*	3.1b	Use of $v^2=u^2+2as$ with $v=0$ and their values for u and a	**M0** if $a=3.5$ used For reference $s=\frac{49}{29}=1.689655...$
			Total distance is 0.28 + 1.689… = 1.9696… < 2 or Total distance is 0.28 + 1.689… = 1.9696… so P does not reach the pulley	A1 [6]	2.2a	**AG**	
11	(d)		Both P and the pulley are modelled as having negligible size rather than as objects with dimensions and therefore this could account for why P does reach the pulley See Appendix for some allowable responses Identifying a relevant factor is sufficient	B1 [1]	3.5a	An answer that refers to the dimensions of P and/or the pulley	If more than one factor given then **B1** if all are acceptable, **B0** if not.

APPENDIX

Exemplar responses for Q11(d)

Response	Mark
Frictional force may not be constant	**B1**
String not light	**B1**
String not inextensible	**B1**
String may be elastic	**B1**
Elasticity	**B1**
String may be extensible	**B1**
Friction is constant	**B1**
Friction (as a one word answer)	**B1**
Surface being smooth	**B0**
Air resistance	**B0**
Particle may be smooth	**B0**
Frictional force on pulley	**B0**

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