



Oxford Cambridge and RSA

GCE

Mathematics A

H230/02: Pure Mathematics and Mechanics

AS Level

Mark Scheme for June 2022

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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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Text Instructions

1. Annotations and abbreviations

Annotation in scoris	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
Highlighting	
Other abbreviations in mark scheme	Meaning
E1	Mark for explaining a result or establishing a given result
dep*	Mark dependent on a previous mark, indicated by *
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.

2. Subject-specific Marking Instructions for A Level Mathematics A

- a Annotations should be used whenever appropriate during your marking. The A, M and B annotations must be used on your standardisation scripts for responses that are not awarded either 0 or full marks. It is vital that you annotate standardisation scripts fully to show how the marks have been awarded. For subsequent marking you must make it clear how you have arrived at the mark you have awarded.
- 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 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

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.

E

Mark for explaining a result or establishing a given result. This usually requires more working or explanation than the establishment of an unknown result.

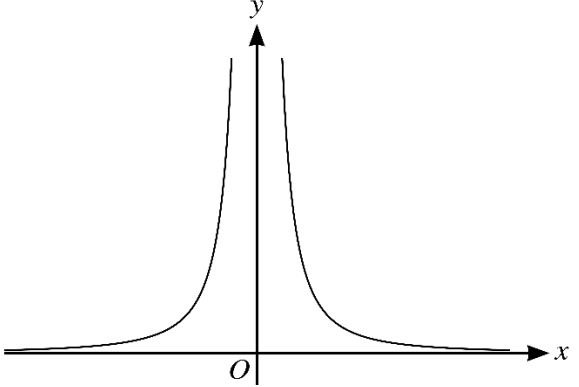
Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored. Sometimes this is reinforced in the mark scheme by the abbreviation isw. However, this would not apply to a case where a candidate passes through the correct answer 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 Unless units are specifically requested, there is no penalty for wrong or missing units as long as the answer is numerically correct and expressed either in SI or in the units of the question. (e.g. lengths will be assumed to be in metres unless in a particular question all the lengths are in km, when this would be assumed to be the unspecified unit.) 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. This rule should be applied to each case. When a value is not given in the paper accept any answer that agrees with the correct value to 2 s.f. Follow through should be used so that only one mark is lost for each distinct accuracy error, except for errors due to premature approximation which should be penalised only once in the examination. There is no penalty for using a wrong value for *g*. E marks will be lost except when results agree to the accuracy required in the question.
- g Rules for replaced work: if a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, then examiners should do as the candidate requests; if there are two or more attempts at a question which have not been crossed out, examiners should mark what appears to be the last (complete) attempt and ignore the others. NB Follow these maths-specific instructions rather than those in the assessor handbook.
- 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 mark in the question. Marks designated as cao may be awarded as long as there are no other errors. E marks are lost unless, by chance, the given results are established by equivalent working. 'Fresh starts' will not affect an earlier decision about a misread. 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, of course, that there is nothing in the wording of the question specifying that analytical methods are required). 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		Critical values of x are 2, -3	B1	1.1	Possibly seen in solution using set notation	±2, ±3 only Curly brackets only With this notation only		
		$\{x : x < -3\} \cup \{x : x > 2\}$	B1ft	2.5	Follow through their two c.v. of x			
			[2]					
2		DR $3x + 1 = 4\sqrt{x}$ $3(\sqrt{x})^2 + 1 = 4\sqrt{x}$ would be enough $3(\sqrt{x})^2 - 4\sqrt{x} + 1 = 0$ $(3\sqrt{x} - 1)(\sqrt{x} - 1) = 0$ $x = 1$ or $x = \frac{1}{9}$	M1*	1.1	Recognise as a quadratic in \sqrt{x}	Condone not = 0		
			A1	1.1	All 3 terms on one side and = 0			
			M1dep*	1.1	Attempt to solve for \sqrt{x}			
			A1	1.1				
		Alternative method $3x + 1 = 4\sqrt{x}$ $(3x + 1)^2 = 16x, 9x^2 + 6x + 1 = 16x$ $9x^2 - 10x + 1 = 0$ $(9x - 1)(x - 1) = 0$ $x = 1$ or $x = \frac{1}{9}$			M1*	1.1	Square both sides	Three terms from squaring bracket, at least 2 correct and = kx with $k = 4$ or 16
					A1	1.1	All 3 terms on one side and = 0	
			M1dep*	1.1	Attempt to solve			
			A1	1.1				
			[4]					

Question		Answer	Marks	AO	Guidance
3		<p>For example, let $x = \pi + 4, y = -\pi + 4$</p> <p>$x + y = (\pi + 4) + (-\pi + 4) = 8$ which is rational (and hence the statement is disproved)</p>	<p>M1</p> <p>A1</p> <p>[2]</p>	<p>2.1</p> <p>2.2a</p>	<p>Choosing x and y such that both are irrational</p> <p>x and y chosen so that $x + y$ is rational. Must comment that answer is rational (oe) (and therefore the statement is disproved.)</p> <p>May not see $x =, y =$</p>

Question		Answer	Marks	AO	Guidance
4		$x^2 + y^2 - 6x + 4y + k = 0$ $\Rightarrow (x-3)^2 - 9 + (y+2)^2 - 4 + k = 0$ $(r^2 =) 9 + 4 - k = 5^2$ $k = -12$	M1* M1dep* A1 [3]	1.1 1.1 1.1	Attempt to complete the square for both x and y terms. Must have $(x \pm 3)^2 + (y \pm 2)^2 + \dots$ Setting up an equation for k correctly using either 5 or 5^2 (e.g., $\sqrt{13-k} = 5$ or $13-k = 25$) cao

Question			Answer	Marks	AO	Guidance
5	(a)	(i)	$y = \frac{k}{x}$ <p>The curve passes through the point $(1, -\frac{1}{2})$ so $k = -\frac{1}{2}$</p> <p>or $y = -\frac{1}{2x}$</p> $y = -\frac{1}{2x} \Rightarrow y' = \frac{1}{2x^2}$	M1 A1 A1ft [3]	2.1 1.1 1.1	Allow any letter, (except x, y) or value, for k Allow this mark for just $-\frac{1}{2x}$ oe Differentiating their $f(x)$ correctly Need to see their value of k substituted Need to see $y' =$ or $f'(x) =$ or $\frac{dy}{dx} =$
5	(a)	(ii)		B1ft [1]	1.1	Excellent curve in 1 st and 2 nd quadrants only: <ul style="list-style-type: none"> • Correct shape, symmetrical, not touching axis • Asymptote clearly the axes • Not finite Allow slight movement away from asymptote at one end but not more
5	(b)		C has no stationary points as indicated by the fact that the curve for the gradient function (seen in part (a)(ii)) does not intersect (or touch) the x -axis	B1 [1]	2.4	Curve in 5(a)(ii) must be of the form $y = \frac{k}{x^2}$ Need to see idea of intersecting, touching, crossing etc x -axis only

Question			Answer	Marks	AO	Guidance
5	(c)		$y = -\frac{1}{2(x+2)}$	M1 A1 [2]	1.1 2.2a	<p>Their $y = f(x)$ with x replaced by $x \pm 2$</p> <p>oe (e.g., $y = -\frac{1}{2x+4}$)</p> <p>May be $y = \frac{k}{x}$</p> <p>Must have $y = \dots$</p>

Question		Answer	Marks	AO	Guidance
6	(a)	$x = 1$	B1 [1]	1.1	cao or (1,0) Need not see $x =$
6	(b)	$\log_2\left(x - \frac{3}{2}\right) = -3$ $x - \frac{3}{2} = 2^{-3}$ $x = 2^{-3} + \frac{3}{2} \Rightarrow x = 1.625$	M1 M1 A1 [3]	1.1 1.1 1.1	Setting $\log_2\left(x - \frac{3}{2}\right) + 3$ equal to zero and isolating $\log_2\left(x - \frac{3}{2}\right)$ term Correctly removing logs cao (o.e. exact answer e.g., $\frac{13}{8}$) After sensible work Need not see $x =$ Condone 1.63
6	(c)	$2\log_2 x = \log_2(x^2)$ seen $\log_2\left(\frac{x^2}{x - \frac{3}{2}}\right) = 3$ $x^2 = 8\left(x - \frac{3}{2}\right) \Rightarrow x^2 - 8x + 12 (= 0)$ $(x - 2)(x - 6) = 0$ Therefore, the x coordinate of C is 2	B1 M1 M1 A1 [4]	1.1 1.1 1.1 2.2a	Using the power law for logarithms Using subtraction or addition law for logarithms Removing logs correctly and re-arranging to a three-term quadratic in x AG so sufficient working must be shown oe, e.g. using $3 = \log_2 8$ etc After sensible work If solving BC then need to see $x = 2$ and $x = 6$ with $x = 2$ chosen as x coordinate

Question		Answer	Marks	AO	Guidance	
6	(d)	y -coordinate of C is 2	B1	1.1	soi	NB x -coordinate of C is 2
		Area = $\frac{1}{2}(1.625-1)(2)$	M1*	3.1a	Correct expression for the area of triangle ABC with their x -coordinate of B from (b) and their y -coordinate	0.625 Need $x = 1$
		0.656 – 0.625	M1dep*	1.1	Difference between their value and 0.656 is calculated	
		Under-estimate by 0.031 (units ²)	A1	3.2b	cao (both numerical value and ‘under-estimate’ required)	Allow 0.026 (comes from $x = 1.63$ in (b)) Allow 4.73% or 3.96%
			[4]			
7	(a)	$\overline{AB} = \overline{OB} - \overline{OA} = (4\mathbf{i} - 3\mathbf{j}) - (2\mathbf{i} + 4\mathbf{j}) = 2\mathbf{i} - 7\mathbf{j}$	M1	2.1	Correct method to find either \overline{AB} or \overline{BA}	
		$\sqrt{53}$ or 53 from $\pm(2\mathbf{i} - 7\mathbf{j})$	A1	1.1	cao	
		$ \overline{OA} = \sqrt{20}, \overline{OB} = 5$	B1	1.1	Correct lengths for OA and OB (or their squares)	
		$\cos AOB = \frac{(\sqrt{20})^2 + 5^2 - (\sqrt{53})^2}{2(\sqrt{20})(5)}$	M1	3.1a	Correct use of cosine rule for their OA, OB and AB	$\cos AOB$ may not be the subject, but substitutions must be correct for their values
		$\cos AOB = \left(\frac{20 + 25 - 53}{10\sqrt{20}}\right) = \frac{4}{5(2\sqrt{5})} = -\frac{2\sqrt{5}}{25}$	A1	2.2a	AG – sufficient working must be shown	Condone this result from calculator without intermediate working.

Question		Answer	Marks	AO	Guidance
			[5]		
7	(b)	$\sin^2 AOB = 1 - \left(-\frac{2\sqrt{5}}{25}\right)^2$ $\sin^2 AOB = \frac{121}{125} \Rightarrow \sin AOB = \frac{11\sqrt{5}}{25}$	M1 A1 [2]	3.1a 1.1	Using the identity $\cos^2 X + \sin^2 X = 1$ with $\cos X = -\frac{2\sqrt{5}}{25}$ Or exact equivalent – justification not required for taking the positive square root
7	(c)	$\text{Area of } OACB = 2 \left(\frac{1}{2} (\sqrt{20})(5) \left(\frac{11\sqrt{5}}{25} \right) \right)$ 22	M1 A1 [2]	3.1a 1.1	Use of $A = ab \sin C$ (or equivalent) with OA and OB and $\sin AOB$ May not use exact values here cao Condone awrt 22.0

Question		Answer	Marks	AO	Guidance
8	(a)	$f(x+h) = a(x+h)^2 + b(x+h)$ $= a(x^2 + 2xh + h^2) + b(x+h)$ $f(x+h) - f(x)$ $= (ax^2 + 2ahx + ah^2 + bx + bh) - (ax^2 + bx)$ $= 2xah + ah^2 + bh$ $\frac{f(x+h) - f(x)}{h} = 2ax + ah + b$ $f'(x) = \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h} = 2ax + b$	M1 A1 A1 A1 [4]	2.1 1.1 1.1 2.2a	Considers $f(x+h)$ and attempts to expand bracket squared Correct simplified expression for $f(x+h) - f(x)$ Correct simplified expression cao – must be explicit that the limit (and not simply $h = 0$) is considered
8	(b)	$\int (ax^2 + bx) dx = \frac{1}{3}ax^3 + \frac{1}{2}bx^2 (+c)$ $\int_1^4 (ax^2 + bx) dx = \left(\frac{64}{3}a + 8b\right) - \left(\frac{1}{3}a + \frac{1}{2}b\right) (= 21a + \frac{15}{2}b)$ $21a + \frac{15}{2}b = 9$ $(f'(4) =) 8a + b = -0.75$ $a = -0.375, b = 2.25$ $y = -0.375x^2 + 2.25x \text{ with } x = 4 \text{ gives } y = 3$ $\text{Equation of tangent: } y - 3 = -0.75(x - 4)$ $0 - 3 = -0.75(k - 4) \Rightarrow k = 8$	M1* M1dep* M1 B1 A1 M1 A1 [7]	2.1 1.1 3.1a 1.1 1.1 1.1 2.2a	Attempt to integrate (with at least one term correct) Correct use of limits $x = 1$ and $x = 4$ in their integrated expression (need not be simplified) Dependent on both previous M marks – setting up an equation in a and b using the area of shaded region Correct equation in a and b BC (oe) Sets up the equation of the tangent at $x = 4$ using 4, -0.75 and their y value at $x = 4$ (dependent on all previous M marks) or for $-\frac{\text{their } y}{k - 4} = -0.75$ Equation of tangent may have y set to 0 and x equal to k

Question		Answer	Marks	AO	Guidance
9		$\mathbf{F} + (3\mathbf{i} + 2\mathbf{j}) = 4(-2\mathbf{i} + 3\mathbf{j})$	M1	3.3	Using $\mathbf{F} = m\mathbf{a}$ with correct number of terms cao – isw if magnitude found
		$\mathbf{F} = 4(-2\mathbf{i} + 3\mathbf{j}) - (3\mathbf{i} + 2\mathbf{j})$	A1	1.1	
		$\Rightarrow \mathbf{F} = -1\mathbf{i} + 10\mathbf{j}$	[2]		
10			M1	3.3	Possible to consider for eg motion up and motion down. In this case: M1 for complete method to find relevant times. A1 All equations correct – need not be simplified $t = 1.0890679\dots$
		$-2 = 3.5t + \frac{1}{2}(-9.8)t^2 (\Rightarrow 4.9t^2 - 3.5t - 2 = 0)$	A1	1.1	
		$t = 1.09$	A1 [3]	1.1 BC (positive root only)	

Question		Answer	Marks	AO	Guidance	
11	(a)	0 (m s ⁻²)	B1 [1]	1.2		
11	(b)	<p>DR</p> $v = t(-t^2 + 11t - 24)$ $\Rightarrow v = -t^3 + 11t^2 - 24t$ $\frac{dv}{dt} = -3t^2 + 22t - 24$ $3t^2 - 22t + 24 = 0$ $(3t - 4)(t - 6) = 0$ <p>From sketch $T > 3$ therefore $T = 6$</p>	B1 M1 M1 M1 A1 [5]	1.1 3.4 1.1 1.1 2.3	<p>Expand and simplify v correctly</p> <p>Differentiate their cubic expression for v correctly</p> <p>Sets their three-term quadratic in t equal to zero</p> <p>Factorises (oe) their three-term quadratic in t</p> <p>Correct value of T with reason for why $T \neq \frac{4}{3}$</p>	<p>Condone this factorisation for $-3t^2 + 22t - 24 = 0$</p> <p>Any working used to determine the required value of T must be accurate</p>
11	(c)	$\int_0^3 v dt \text{ and } \int_3^T v dt$ $\left(-\frac{117}{4}\right) \text{ and } \frac{261}{4}$ $\text{Total distance} = \frac{117}{4} + \frac{261}{4} = 94.5 \text{ (m)}$	M1 A1 A1 [3]	3.1b 1.1 1.1	<p>Need to see attempt at integrals but may be BC</p> <p>cao</p>	Where v is a cubic expression

Question		Answer	Marks	AO	Guidance	
12	(a)	19.6 (N)	B1 [1]	3.4	cao oe (2g)	
12	(b)	$8g - T = 8a$ $T - 6g = 6a$ $a = \frac{1}{8}(8g - T) \Rightarrow T - 6g = \frac{3}{4}(8g - T)$ $(\Rightarrow 4T - 24g = 24g - 3T)$ Magnitude of force exerted on pulley is $2T$ $T = \frac{48}{7}g \Rightarrow F = 134.4 \text{ (N)}$	M1* A1 M1dep* B1 A1 [5]	3.3 1.1 3.4 3.1b 1.1	Attempt at N2L for either P or Q - correct number of terms Correct equations for the motion of P and Q Eliminate a Either stated (anywhere in solution) or if 2(their T) seen Awrt 134(N)	M0 if mass includes g Or if find a first then award this mark for an equation involving T only
12	(c)	$a = 1.4$ $v^2 = 2(1.4)(1.75) (\Rightarrow v^2 = 4.9)$ $0 = (\sqrt{4.9})^2 + 2(-9.8)s (\Rightarrow s = 0.25)$ Total distance travelled by Q is $0.25 + 1.75 = 2 \text{ (m)}$	B1 M1* M1dep* A1 [4]	1.1 3.4 3.4 3.2a	Correct a Using $v^2 = u^2 + 2as$ with $u = 0$ to find speed of Q (or speed squared) after travelling 1.75 Using $v^2 = u^2 + 2as$ with $v = 0$ and $a = \pm g$ cao	$a = \frac{1}{7}g$ Condone awrt 2.0
12	(d)	One factor could be the presence of air resistance	B1 [1]	3.5a	Any correct factor B0 for 'use a more accurate value of g ' If more than one factor given then B1 if all correct. B0 if not.	Friction String is not light String is not inextensible P and Q are not particles Wind speed

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