GCE

Mathematics B (MEI)

H630/01: Pure Mathematics and Mechanics

Advanced Subsidiary GCE

Mark Scheme for November 2020

Oxford Cambridge and RSA Examinations

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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.

Text Instructions

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
E	Explanation mark 1
SC	Special case
^	Omission sign
MR	Misread
BP	Blank page
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 *. The * may be omitted if only 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 indicates that the instruction **In this question you must show detailed reasoning** appears in the question.

Subject-specific Marking Instructions for AS Level Mathematics B (MEI)

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.

E
A given result is to be established or a result has to be explained. 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.
- When a value is **not given** in the paper accept any answer that agrees with the correct value to **2 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 A the rubric specifies 3 s.f. as standard, so this statement reads "3 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.

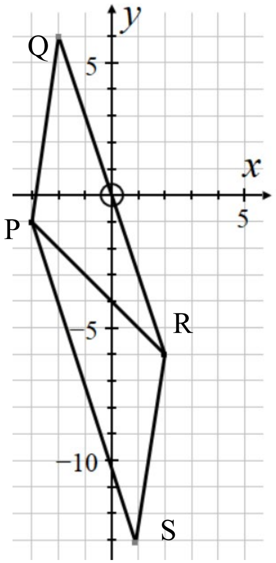
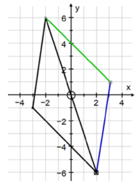
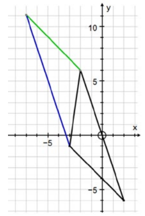
h For a genuine misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain unaltered, mark according to the scheme but following through from the candidate's data. A penalty is then applied; 1 mark is generally appropriate, though this may differ for some 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. E marks are lost unless, by chance, the given results are established by equivalent working. 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" and "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	AOs	Guidance	
1			When $n=2$, $2^2+2\times 2+10$ $(=18)$ which is not odd So the statement must be false (counterexample)	M1 A1 [2]	2.1 2.2a	Use of $n = 2$ seen Complete argument must include a clear conclusion that statement false	

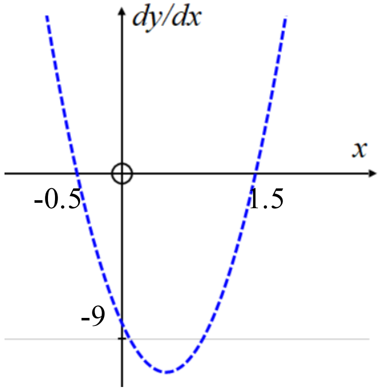
Question			Answer	Marks	AOs	Guidance	
2			Cosine rule in triangle ABC $AC^2=5^2+6^2-2\times 5\times 6\cos 60°=31$ Sine rule in triangle ACD $\frac{AD}{\sin 60°}=\frac{AC}{\sin 45°}$ $AD=\frac{\sqrt{3}}{2}\times\sqrt{31}\times\sqrt{2}=\frac{1}{2}\sqrt{186}$	M1 A1 M1 A1 [4]	1.1a 1.1 1.1a 1.1	attempt to use the cosine rule Need not be evaluated soi Using their AC (not AC^2 in sine rule) oe. Must be surd form FT their AC	

Question			Answer	Marks	AOs	Guidance	
3	(a)		$\left\lvert\overrightarrow{PQ}\right\rvert = \sqrt{1^2+7^2} = \sqrt{50}$ $\overrightarrow{PR} = (\mathbf{i}+7\mathbf{j})+(4\mathbf{i}-12\mathbf{j}) = 5\mathbf{i}-5\mathbf{j}$ $\left\lvert\overrightarrow{PR}\right\rvert = \sqrt{5^2+5^2} = \sqrt{50}$ So the triangle is isosceles	B1 M1 A1 [3]	1.1a 1.1a 2.2a	Allow for PQ^2 Attempt to add vectors Must deduce the triangle is isosceles from correct working	Allow finding $\overrightarrow{RP} = -5\mathbf{i}+5\mathbf{j}$
3	(b)		PQRS parallelogram so $\overrightarrow{PS} = \overrightarrow{QR} = 4\mathbf{i}-12\mathbf{j}$ Position vector $\overrightarrow{OS} = \overrightarrow{OP}+\overrightarrow{PS} = (-3\mathbf{i}-\mathbf{j})+(4\mathbf{i}-12\mathbf{j}) = \mathbf{i}-13\mathbf{j}$ 	M1 A1 [2]	3.1a 1.1	Using the properties of the parallelogram cao	SPECIAL CASES Allow **SC1** for correct answer for either PQSR or PSQR If PQSR used, then $\overrightarrow{OS} = 3\mathbf{i}+\mathbf{j}$  If PSQR used, then $\overrightarrow{OS} = -7\mathbf{i}+11\mathbf{j}$ 

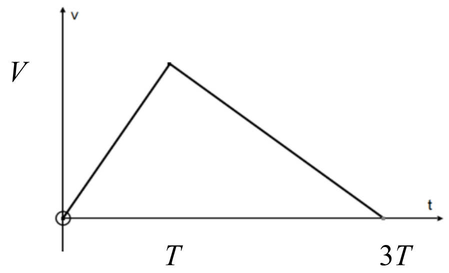
Question			Answer	Marks	AOs	Guidance	
4	(a)		weight $\begin{pmatrix} 0 \\ -1.5g \end{pmatrix}$	B1	1.2	Allow seen or implied by correct answer	
			Equilibrium equation $\begin{pmatrix} 0 \\ -1.5g \end{pmatrix} + \begin{pmatrix} 4 \\ -2 \end{pmatrix} + \mathbf{F}_2 = \mathbf{0}$	M1	1.1a	FT their weight. Allow sign errors	
			$\mathbf{F}_2 = \begin{pmatrix} -4 \\ 2+1.5g \end{pmatrix} = \begin{pmatrix} -4 \\ 16.7 \end{pmatrix}$ N	A1 [3]	1.1	must be vector allow **i-j** form	
4	(b)		Newton's second law $\begin{pmatrix} 0 \\ -1.5g \end{pmatrix} + \begin{pmatrix} 4 \\ -2 \end{pmatrix} + \begin{pmatrix} 2 \\ 20 \end{pmatrix} = m\mathbf{a}$	M1	1.1a	Addition of vectors. Allow if weight missing but other two forces and acceleration seen in equation	Allow wrong weight only if given as a vector
			$\mathbf{a} = \frac{1}{1.5}\begin{pmatrix} 6 \\ 3.3 \end{pmatrix} = \begin{pmatrix} 4 \\ 2.2 \end{pmatrix}$ m s^{-2}	A1 [2]	1.1 [2]	Must be vector; any correct form.	

5	(a)		2 | 1.414 214 | 0.414 214 | 0.414 214	B1 [1]	1.1a	cao Must be to 6 dp	Condone truncated to 6 dp (1.414213 etc.)
5	(b)		The limit of the sequence of gradients as h tends to zero is the gradient of (the tangent to) the curve. (The sequence of gradients tends to 0.5.)	B1 [1]	2.4	Must communicate the idea of a **limit as *h* tends to zero** but need not be expressed in that way	Do not allow "as h decreases, gradient increases" without "towards 0.5" or "towards a limit" or "towards the gradient of the curve/tangent"
5	(c)		$\frac{dy}{dx} = \frac{1}{2}x^{-\frac{1}{2}}$	M1	1.1a	Differentiating	
			When $x = 1$, $\frac{dy}{dx} = \frac{1}{2} \times 1^{-\frac{1}{2}} = \frac{1}{2}$	A1 [2]	1.1		

Question			Answer	Marks	AOs	Guidance	
6	(a)		$v = t^3 - 5t^2 = 0$ $t^2(t-5) = 0$	M1	1.1a	**DR** Attempt to solve $v = 0$	Allow M1 for at least one root found by substitution
			So at rest when $t = 0$ or 5 s	A1 [2]	1.1	Both roots and no others	
6	(b)		There is a change of direction when $t = 5$ $\int_0^5 (t^3 - 5t^2)\,dt = \left[\frac{t^4}{4} - \frac{5t^2}{3}\right]_0^5 = -\frac{625}{12}$	M1 M1	3.4 3.4	**DR** Considering signed areas either side of $t = 5$ s. Algebraic integration seen attempted	SPECIAL CASE $\int_0^6 (t^3 - 5t^2)\,dt$ $= \left[\frac{t^4}{4} - \frac{5t^2}{3}\right]_0^6 = -36$ **SCM1** for algebraic integration seen attempted **SCA1** for –36 m seen or distance 36 given
			$\int_5^6 (t^3 - 5t^2)\,dt = \frac{193}{12}$ Total distance $\frac{625+193}{12} = \frac{409}{6} = 68.2$ m	A1 [3]	1.1	Correct to at least 2 sf	

Question			Answer	Marks	AOs	Guidance	
7	(a)		$\frac{dy}{dx} = 12x^2 - 12x - 9$	M1	1.1a	**DR** Attempt to differentiate seen	
			When $\frac{dy}{dx} = 12x^2 - 12x - 9 = 0$	M1 (dep)	1.1a	Attempt to solve their $\frac{dy}{dx} = 0$	
			$3(2x+1)(2x-3) = 0$ so $x = -0.5, \quad 1.5$	A1	1.1a	Both values seen – may be indicated on the graph	
				B1 [4]	1.1	Correct shape through $(0, -9)$	SC For cubic graph of the function drawn with M0M0A0 allow SC1 for correct shape with minimum when $x =$ 1.5, and maximum when $x =$ -0.5
7	(b)		Min point of gradient function when $\frac{d^2y}{dx^2} = 24x - 12 = 0$ so $x = \frac{1}{2}$	M1	3.1a	**DR** Attempt to find the vertex (including completing the square or symmetry argument)	
			Gradient is decreasing for $\left\{x : x < \frac{1}{2}\right\}$	A1 [2]	2.5	Inequality correctly formed and expressed as a set. Allow either $<$ or $\leq$	

Question			Answer	Marks	AOs	Guidance	
8			EITHER Midpoint AB is (3, 1)	B1	3.1a	Seen or implied	
			Gradient of AB is $\frac{4-(-2)}{7-(-1)}\left(=\frac{6}{8}=\frac{3}{4}\right)$	M1	3.1a	Must be correct way up – allow one slip	
			Gradient of perpendicular $-\frac{4}{3}$	M1	1.1a	negative reciprocal FT their gradient of AB	Allow this M1 for showing the perpendicular to the given line is $\frac{1}{2}$.
			Equation of perpendicular bisector $y-1=-\frac{4}{3}(x-3)$	M1	1.1a	FT their gradient. Condone A or B used instead of M. Do not allow if their gradient of AB used.	
			Solve the simultaneous equations $4x+3y=15$ $2x+y=k$	M1	1.1a	Attempt to eliminate one variable	
			$y=15-2k$, $x=\frac{1}{2}(3k-15)$	A1	1.1	cao	
			giving P $\left(\frac{1}{2}(3k-15),15-2k\right)$	A1 [7]	1.1	cao	
			OR P is of the form $(x,k-2x)$	B1		Seen or implied	
			and is equidistant from A and B $(x+1)^2+(y+2)^2=(x-7)^2+(y-4)^2$	M1 M1		Finding at least one distance Equating distances	
			$(x+1)^2+(k-2x+2)^2=(x-7)^2+(k-2x-4)^2$	M1		Substituting for y	
			$-8x+1=60-12k$	M1		Attempt to simplify	
			So $x=\frac{1}{2}(3k-15)$ and $y=15-2k$	A1		cao	
			P is $\left(\frac{1}{2}(3k-15),15-2k\right)$	A1 [7]		cao	

Question			Answer	Marks	AOs	Guidance	
9	(a)			B1 B1 [2]	1.1a 1.1a	Two line segments starting and ending on the x-axis T and $3T$ seen on t-axis	Instead of $3T$, allow for $2T$ shown on the horizontal axis for the second phase
9	(b)		Acceleration phase $\frac{V}{T}=2.5$ Area under graph $\frac{1}{2}\times V\times 3T=240$ Solving simultaneously $\frac{3}{2}(2.5T)T=240 \Rightarrow T^2=64$ So $T=8$ and $V=20$	B1 B1 M1 A1 [4]	3.4 3.4 1.1a 1.1	soi May be sum of two areas soi Attempt to eliminate one variable correct pair of answers	$\frac{1}{2}VT+VT=240$
			OR Acceleration phase using $v=u+at$ $V=2.5\times T$ First phase has distance $240\div 3=80\text{ m}$ Using $s=80, u=0, a=2.5$ $80=\frac{1}{2}\times 2.5T^2$ giving $T=8$ and $V=20$	B1 M1 B1 A1		May be final step using $T=8$ award if seen Using *suvat* equation(s) leading to a value for t with $s=80$ correct pair of answers	

Question			Answer	Marks	AOs	Guidance	
10	(a)		Acceleration due to gravity is not a constant but depends on location in the universe.	B1 [1]	3.5b	Allow any sensible comment that g might be different on the moon	
10	(b)		Using $s=2,\quad u=0,\quad t=1.6$ and $s=ut+\frac{1}{2}at^2$ Downwards as the positive direction $2=\frac{1}{2}\times 1.6^2 a$ giving $[a=1.5625]$ which 1.6 m s^{-2} to 2 sf	M1 A1 [2]	3.3 1.1	Allow any sign convention Allow -1.6 m s^{-2} if upwards is clearly indicated as positive. Must be 2 significant figures.	
10	(c)		Using $u=15,\quad v=0,\quad a=-1.6$ and $v^2=u^2+2as$ Upwards as the positive direction $0=15^2-2\times 1.6s$ $s=70.3$ m	M1 A1 [2]	3.4 1.1	Use of *suvat* equation(s) leading to a value for s. Allow sign errors Must follow from correct working and if negative, explained.	Allow answers in the range 70 to 72.2

Question			Answer	Marks	AOs	Guidance	
11	(a)		The argument is not correct. $x<16$ includes negative values for x for which $x^{\frac{1}{2}}$ does not exist so the statement does not imply that $x^{\frac{1}{2}}<4$.	**E1** **[1]**	**2.3**	**DR** Allow that x must be positive	Allow the correct solution $0 \le x < 16$ or $0 < x < 16$ without further explanation
11	(b)		EITHER Take logs of both sides $x\log\left(\frac{1}{2}\right)<\log 4$ Giving $x>\frac{\log 4}{\log\left(\frac{1}{2}\right)}$ [since $\log\left(\frac{1}{2}\right)$ is negative] $x>-2$	**M1** **B1** **A1** **[3]**	**2.1** **1.1a** **2.1**	**DR** Use of laws of logs must be seen Allow equivalent with natural logs Award for the boundary value even if only evaluated. Correct inequality.	
			OR Solve $\left(\frac{1}{2}\right)^x=4$ by taking logs base $\frac{1}{2}$ $\log_{\frac{1}{2}}(4)=-2$ Test value – eg when $x=0$ $\left(\frac{1}{2}\right)^0=1<4$ So $x>-2$	**M1** **B1** **A1** **[3]**		**DR** Using log base $\frac{1}{2}$ Award for the boundary value even if only seen as part of an equation or incorrect inequality Correct inequality.	

Question			Answer	Marks	AOs	Guidance	
11	(c)		Using laws of logs $\log_2(x+8)^2 - \log_2(x+6) = 3$	M1	3.1a	**DR** At least one correct use of laws of logs	
			$\log_2 \dfrac{(x+8)^2}{(x+6)} = 3$				
			$\dfrac{(x+8)^2}{(x+6)} = 2^3$	M1	3.1a	Clearing logs to obtain 2^3 or 8 seen in an equation	
			$(x+8)^2 = 8(x+6)$	A1	1.1	Correct quadratic	
			$x^2 + 8x + 16 = 0$ Discriminant is $8^2 - 4\times1\times16 = 0$	M1	2.1	Attempt to find the discriminant of their quadratic (allow one slip)	Allow M1 for an attempt to solve their quadratic
			so there is only one solution	A1 [5]	2.2a	Correct argument from zero discriminant or repeated root $x = -4$ found	

Question			Answer	Marks	AOs	Guidance	
12	(a)		$\frac{\mathrm{d}y}{\mathrm{d}x}=2x-2x^{-3}$	M1	3.1a	Attempt to differentiate	
			At $\left(2,\frac{17}{4}\right)$ gradient $=2\times2-2\times2^{-3}=\frac{15}{4}$	A1	1.1	Correct value in any form	
			Equation of the tangent $y-\frac{17}{4}=\frac{15}{4}(x-2)$	M1	3.1a	Using their gradient to find the equation of the tangent	
			$y=\frac{15}{4}x-\frac{13}{4}$				
			Crosses x-axis when $y=0$, $x=\frac{13}{15}$	A1	1.1	Allow 0.867 or better	
			Crosses y-axis when $x=0$, $y=-\frac{13}{4}$	A1	1.1	any form	
			Area of triangle $\frac{1}{2}\times\frac{13}{15}\times\frac{13}{4}=\frac{169}{120}$ [below the axis]	A1 [6]	1.1	FT their values but must be exact. Accept positive or negative value	Note Area 1.41 gets 5/6 marks
12	(b)		At a stationary point $\frac{\mathrm{d}y}{\mathrm{d}x}=2x-2x^{-3}=0$	M1	1.1a	Equating their derivative to zero and attempting to solve	Allow for evaluating gradient at appropriate points either side. Arguing point is minimum from their gradients [incl sketch]
			$x^4=1$ giving $x=\pm1$ so there are only two stationary points	A1	1.1	Finding both roots and no others	
			$\frac{\mathrm{d}^2y}{\mathrm{d}x^2}=2+6x^{-4}$	M1	1.1a	Differentiating their $\frac{\mathrm{d}y}{\mathrm{d}x}$	
			When $x=1$, $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}=2+6\times1^4[=8]>0$ so minimum point	M1	2.1	Evaluating at (at least one of) their stationary point(s)	
			When $x=-1$, $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}=2+6\times(-1)^4[=8]>0$ so also minimum point	A1	2.1	Argues that both points are minimum from correct working. Allow arguing that second derivative is positive everywhere or a symmetry argument	
			The two stationary points are both minimum points so there is no maximum point.	E1 [6]	2.2a	Deduces that there are no maximum points.	

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