GCE

Further Mathematics B MEI

Y414/01: Numerical Methods

AS Level

Mark Scheme for June 2025

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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.

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 available in RM Assessor

3. Log-in to RM Assessor and mark the **required number** of practice responses ("scripts") and the **required number** of 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. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the RM Assessor messaging system.

5. **Crossed-Out Responses**
   Where a candidate has crossed out a response and provided a clear alternative then the crossed-out response is not marked. Where no alternative response has been provided, examiners may give candidates the benefit of the doubt and mark the crossed-out response where legible.

Rubric Error Responses – Optional Questions
Where candidates have a choice of question across a whole paper or a whole section and have provided more answers than required, then all responses are marked and the highest mark allowable within the rubric is given. Enter a mark for each question answered into RM Assessor, which will select the highest mark from those awarded. *(The underlying assumption is that the candidate has penalised themselves by attempting more questions than necessary in the time allowed.)*

Multiple-Choice Question Responses
When a multiple-choice question has only a single, correct response and a candidate provides two responses (even if one of these responses is correct), then no mark should be awarded (as it is not possible to determine which was the first response selected by the candidate).
When a question requires candidates to select more than one option/multiple options, then local marking arrangements need to ensure consistency of approach.

Contradictory Responses
When a candidate provides contradictory responses, then no mark should be awarded, even if one of the answers is correct.

Short Answer Questions (requiring only a list by way of a response, usually worth only one mark per response)
Where candidates are required to provide a set number of short answer responses then only the set number of responses should be marked. The response space should be marked from left to right on each line and then line by line until the required number of responses have been considered. The remaining responses should not then be marked. Examiners will have to apply judgement as to whether a 'second response' on a line is a development of the 'first response', rather than a separate, discrete response. *(The underlying assumption is that the candidate is attempting to hedge their bets and therefore getting undue benefit rather than engaging with the question and giving the most relevant/correct responses.)*

Short Answer Questions (requiring a more developed response, worth two or more marks)
If the candidates are required to provide a description of, say, three items or factors and four items or factors are provided, then mark on a similar basis – that is downwards (as it is unlikely in this situation that a candidate will provide more than one response in each section of the response space).

Longer Answer Questions (requiring a developed response)
Where candidates have provided two (or more) responses to a medium or high tariff question which only required a single (developed) response and not crossed out the first response, then only the first response should be marked. Examiners will need to apply professional judgement as to whether the second (or a subsequent) response is a 'new start' or simply a poorly expressed continuation of the first response.

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there, then add the annotation 'SEEN' to confirm that the work has been seen and mark any responses using the annotations in section 11.

7. There is a NR (**No Response**) option. Award NR (No Response):

   - if there is nothing written at all in the answer space
   - 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) which is not an attempt at the question.

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

8. The RM Assessor **comments box** is used by your Team Leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**

9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. For answers marked by levels of response: Not applicable in F501
    To determine the level – start at the highest level and work down until you reach the level that matches the answer
    To determine the mark within the level, consider the following

Descriptor	Award mark
On the borderline of this level and the one below	At bottom of level
Just enough achievement on balance for this level	Above bottom and either below middle or at middle of level (depending on number of marks available)
Meets the criteria but with some slight inconsistency	Above middle and either below top of level or at middle of level (depending on number of marks available)
Consistently meets the criteria for this level	At top of level

11. **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.

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. 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” 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.

<table>
<tr><th colspan="2">Question</th><th>Answer</th><th>Marks</th><th>AO</th><th>Guidance</th></tr>
<tr><td>1</td><td>(a)</td><td>=(A2 + C2)/2</td><td>B1
[1]</td><td>1.1</td><td>Accept =(1/2)*(C2+A2) oe in correct notation</td></tr>
<tr><td>1</td><td>(b)</td><td>=IF(F2<0,C2,E2) or =IF(F2>0,E2,C2)</td><td>B1
[1]</td><td>1.1</td><td></td></tr>
<tr><td>1</td><td>(c)</td><td><table><tr><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td><td>F</td></tr><tr><td>2.75</td><td>-0.16987</td><td>2.8125</td><td>0.303839</td><td>2.78125</td><td>0.06008…</td></tr></table></td><td>B1

B1

[2]</td><td>1.1

1.1</td><td>Columns A,B,C and D correct

Columns E and F correct
(0.06008(1) to at least 4sf, do not penalise if over-specified)</td></tr>
<tr><td>1</td><td>(d)</td><td>2.75 < root < 2.78125 (since there is a change of sign over this interval)

So root is 2.8 to 1 dp</td><td>

B1
[1]</td><td>

2.2a</td><td>Do not allow reference to 2.8125
Allow ‘it is between 2.75 and 2.78125’</td></tr>
</table>

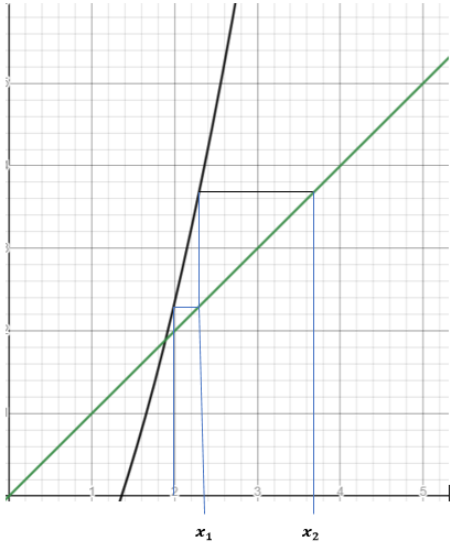
Question		Answer	Marks	AO	Guidance
2		$\frac{(x-2)(x-3)}{(-1-2)(-1-3)} \times -3.39$ $+ \frac{(x--1)(x-3)}{(2--1)(2-3)} \times 0.18 + \frac{(x--1)(x-2)}{(3--1)(3-2)} \times 0.45$	**M1**	**1.1**	correct formula; allow sign errors and/or one substitution error allow if terms given separately provided summation implied later
			A1	**1.1**	all substitutions correct
			A1	**1.1**	two of three terms correct; condone wrong variable and omission of $y =$ for this mark.
		$y = -0.23x^2 + 1.42x - 1.74$	**A1**	**1.1**	all three terms correct and must see $y =$ either here or in earlier correct working
			[4]		

Question		Answer	Marks	AO	Guidance
3	(a)	$\frac{3.141-\pi}{\pi}$	M1	1.1	allow **M1** for $\frac{\pi-3.141}{\pi}$ or ± 0.0001886 ... rot to 2 or more sf May be implied by A1
		$-0.000\,188\,6$ ...	A1 [2]	1.1	-0.0001886474967 or $-1.886 \ldots \times 10^{-4}$ rot to 2sf or better
3	(b)	$\frac{3.142-\pi}{\pi}$	M1	1.1	allow **M1** for $\frac{\pi-3.142}{\pi}$ or ± 0.0001296 ... rot to 2 or more sf May be implied by A1
		$0.000\,129\,6$ ...	A1 [2]	1.1	0.00012966238947 or $1.296 \ldots \times 10^{-4}$ rot to 2sf or better
3	(c)	The student is wrong, [the values will be different because] the order of the operations is different	B1 [1]	2.3	Or equivalent explanation (allow explanations that describe or show how the calculations might be different provided they do not rely on **evaluating** those calculations). Allow e.g.: • "No because the order of operations is different" Condone 'order of calculations' for 'order of operations' Allow answers based on the two expressions provided that they are compared with both mentioned e.g.: • Incorrect because $\pi^2 - 5 \neq (\pi - 5)^2$ • Incorrect because $-10\pi + 25 \neq -5$ ISW any attempts to evaluate either calculation but do not allow answers that just evaluate both and state they are not equal.

Question		Answer	Marks	AO	Guidance
4	(a)	forward difference (method)	B1 [1]	1.2	Condone 'forward difference approximation'
4	(b)	0.22	B1	1.1	
		The spreadsheet **stores** values to a **greater precision** than they are **displayed**	B1	2.4	Condone 'greater accuracy' but not 'exact' or 'actual' Condone 'shown' for 'displayed'
		The spreadsheet **uses** the **stored** values for cells H5 and G5, (not the displayed values), to calculate the approximation (in G10)	B1 [3]	2.4	For this mark, the explanation must be given in context e.g. referring to cells H5 and G5 or 'the approximation to $f'(2)$' Condone reference to 'row 5' instead of cell references Allow the converse i.e. '**using** the displayed values for cells H5 and G5 gives a different result than the spreadsheet calculates using the **stored** values'
4	(c)	0.217 seems justified as the two approximations agree to this precision	B1 [1]	2.2b	Allow e.g. "G10 and H10 agree to this precision" Allow "both approximations" but not just "both values" Allow 0.21709 and 0.21661 agree to this Condone "estimates" for "approximations"
4	(d)	$\pm 0.1 \times '0.217'$	M1	1.1	FT their 0.217 for this mark
		-0.0217	A1 [2]	1.1	Allow 0.0217 SC**B1** for ± 0.0217 unsupported (as question is 'Determine')
4	(e)	As h decreases, approximations (to $f'(2)$) increase **oe** (so the answer to part **(e)** is likely to be) an **under-estimate**	B1 [1]	3.5a	Allow either 'approximations' or '$f'(2)$' Must refer to h decreasing (or 'getting smaller' etc.) Allow 'as h increases, approximations decrease…'

Question		Answer	Marks	AO	Guidance
5	(a)	3.1×10^{-5} or 0.000 031	B1 [1]	1.1	
5	(b)	0.89377295 because S_{128} and S_{64} agree to this precision	B1 [1]	2.2b	Allow H28 and H29 Allow 'the best/last two **Simpson's** estimates agree/are the same'
5	(c)	= (4*G23 – G22)/3	M1 A1 [2]	1.1 1.1	Correct form of expression e.g. $\frac{4T_{2n}-T_n}{3}$; allow slips such as omission of =, omission of * Condone 4*G4-G3 or 4*G3-G2 or 4*G24-G23 All correct Allow =(1/3)*(4*G23-G22)
5	(d)(i)	the ratios seem to be **converging** [to 0.063] which is approximately $\frac{1}{16}$ suggesting (the method is) **fourth order** in this case	B1 B1 [2]	2.2b 2.4	allow eg entries are tending to / approaching 0.063… condone 0.0625 do **not** allow eg ratios are constant / (approximately) equal Must refer to a value (but allow 0.063, 0.0625 or $\frac{1}{2^4} = \frac{1}{16}$) for this mark. Condone 'fourth order convergence'

Question		Answer	Marks	AO	Guidance
5	(d)(ii)	which is usual since Simpson's rule is (generally) a fourth order (method)	B1FT [1]	2.2a	Allow 'usual because Simpson's rule generally has this order' dep. on B1 for 'fourth order' in part **(d)(i)** FT their answer to **(d)(i)** e.g. if in **(d)(i)** conclude 'hence is first order' then B1 for 'unusual since Simpson's rule is is generally fourth order' (must quote the correct fact about Simpson's rule and conclude appropriately)

Question		Answer	Marks	AO	Guidance
6	(a)	the calculation in cell L4 is not valid because $\ln(-1)$ does not exist	B1 [1]	2.4	Must identify $\ln(-1)$ as the term in the function that will cause this error Do not allow just 'you can't compute this value' Allow 'you can't ln a negative number' Allow '$\ln(-1)$ is imaginary' or '$\ln(-1) = i\pi$'
6	(b)		B1 [1]	1.1	Must see at least: • $x_0 = 2$ (used, may not be labelled) • $x_1 \in [2.2,2.5]$ • $x_2 \in [3,4.5]$ With at least two 'right-angles' of the staircase marked. Condone x-values marked on or above the graph with correct notation i.e. x_0, x_1, x_2 ISW any further iterations
6	(c)	(may not be used) because $g'(\alpha) > 1$	B1 [1]	2.4	allow eg because at the **point** of intersection with $y = x$ the **gradient** of **g**(x) is greater than the gradient of $y = x$ (Must mention gradient, g, and a point – which could be α) Condone $g'(x) > 1$ at or near α (or 'the root')

Question		Answer	Marks	AO	Guidance
6	(d)	r x_r [0 1] 1 1.656 2 1.87295936282 3 1.88976041648 4 1.88987225010 5 1.88987241780 [6 1.88987241805]	**M1***	**1.1**	x_1 and x_2 rot to 3 dp or more
			M1 dep*	**1.1**	Two consecutive iterates x_n and x_{n+1} rot to 7dp or more for $n \geq 4$ (allow 1.889 872 4(1)…) Or for e.g. x_4 seen to 6dp **and** 6dp accuracy verified by change of sign.
		$\alpha = 1.889\,872$ **cao**	**A1** **[3]**	**1.1**	Dep on both method marks.

<table>
<tr><th>Question</th><th></th><th>Answer</th><th>Marks</th><th>AO</th><th>Guidance</th></tr>
<tr><td>7</td><td>(a)</td><td>
<table>
<tr><td>t</td><td>T</td><td>ΔT</td><td>$\Delta^2 T$</td></tr>
<tr><td>5</td><td>78.5</td><td></td><td></td></tr>
<tr><td></td><td></td><td>–10.4</td><td></td></tr>
<tr><td>10</td><td>68.1</td><td></td><td>1</td></tr>
<tr><td></td><td></td><td>–9.4</td><td></td></tr>
<tr><td>15</td><td>58.7</td><td></td><td>1</td></tr>
<tr><td></td><td></td><td>–8.4</td><td></td></tr>
<tr><td>20</td><td>50.3</td><td></td><td></td></tr>
</table>
second differences are constant, which suggests a quadratic (model) is appropriate</td><td>M1

A1*

A1 dep*

[3]</td><td>3.1b

1.1

3.2a</td><td>attempt at difference table

all correct (allow transposed table or other formats provided correct values seen)
Condone omission of t column
Condone omission of (or different) column headings

Or third differences are 0.
Must refer to second differences or $\Delta^2 T$ etc.
Allow ‘equal’ or ‘unchanging’
Must conclude but could just be ‘yes’</td></tr>
<tr><td>7</td><td>(b)</td><td>$78.5 + (-10.4) \times \frac{t-5}{5\times 1!} + (1) \times \frac{(t-5)(t-10)}{5^2 \times 2!}$

$[T =]\ 0.02t^2 - 2.38t + 89.9$

$T = 0.02t^2 - 2.38t + 89.9$</td><td>M1*

A1

M1 dep*

A1

[4]</td><td>3.3

1.1

1.1

1.1</td><td>allow use of other variable, allow omission of T; allow sign errors and/or one substitution error
all correct

At least two simplified coefficients correct; allow omission of T and other variable instead of t

all correct; must see $T =$ here or in earlier correct working</td></tr>
<tr><td>7</td><td>(c)(i)</td><td>19.1[°C]</td><td>B1FT

[1]</td><td>3.4</td><td>FT their polynomial with $t = 60$ substituted (must be from Newton’s interpolating polynomial)</td></tr>
<tr><td>7</td><td>(c)(ii)</td><td>37.7[°C]</td><td>B1FT

[1]</td><td>1.1</td><td>FT their polynomial with $t = 90$ substituted (must be from Newton’s interpolating polynomial)</td></tr>
</table>

Question		Answer	Marks	AO	Guidance
7	(c)(iii)	The model predicts that the **temperature** starts to **rise** after reaching room temperature **oe**	**B1** **[1]**	**3.2b**	or: (after t=59.5) the model predicts an increase in temperature, which is unlikely to be realistic; Allow e.g.: • "the **temperature** starts to **increase** after some time" • "the **temperature** starts to **rise** after it has cooled [which is impossible]" • "the **tea** starts to **warm up** again which does not happen" Condone "the temperature should be constant once room temperature is reached" **oe** Must be in context e.g. mentioning tea / temperature (i.e. do not allow just 'the gradient is positive') Do not allow references to negative temperature

Question		Answer	Marks	AO	Guidance
8	(a)	$\frac{0.71101-1.41421}{1.3-0.5}$ **oe**	**M1**	**1.1**	Must see at least $\frac{f(1.3)-f(0.5)}{0.8}$
		–0.879	**A1**	**1.1**	ISW
			[2]		SC**B1** for -0.879 unsupported (as question is 'Determine')
8	(b)	$A \pm d \times \frac{r}{1-r}$	**M1***	**3.1a**	Extrapolation where: • A is an approximation to $f'(0.9)$ from **Table 8.2**, • d is the associated difference and • $r = 0.25$ or one of the ratios from **Table 8.2** Condone $A \pm d \times \frac{1}{1-r}$ or $A \pm d \times r$
		$A \pm d \times \frac{r}{1-r}$	**M1 dep***	**3.1a**	Extrapolation to **infinity** with $0.24993 \leq r \leq 0.25$ Condone $A \pm d \times \frac{1}{1-r}$
		$-0.983525 + (-0.000301) \times \frac{r}{1-r}$	**A1**	**1.1**	$0.24993 \leq r \leq 0.25$
		–0.98362533… to –0.9836252959	**A1**	**1.1**	if **A0A0** allow **SCB1** for awrt –0.9836002 from partial extrapolation
		–0.9836 (probable) or –0.98363 (possible) since extrapolation greatly improves accuracy	**A1**	**3.2a**	allow –0.984 seems certain by comparison of extrapolated value with -0.983525 (or 'best approximation from table' oe). Dep on all previous marks.
			[5]		

Question		Answer	Marks	AO	Guidance
9	(a)	**DR** $\left[\frac{dy}{dx} =\right] 0.8x^3 + 0.8$	**B1**	**1.1**	soi (may be embedded) May be implied by $4x^3 + 4$
		$[x_{n+1} =]x_n - \frac{0.2x_n^4+0.8x_n-0.2}{0.8x_n^3+0.8}$	**B1FT**	**2.5**	$x - \frac{f(x)}{\text{their } f'(x)}$ all correct, condone omission of subscripts oe: may see $x_{n+1} = x_n - \frac{x_n^4+4x_n-1}{4x_n^3+4}$ or $(1) - \frac{0.2(1)^4+0.8(1)-0.2}{0.8(1)^3+0.8}$
		r x_r [0 1] 1 0.5 2 0.263888888889 3 0.249060160472	**M1**	**2.1**	x_1, x_2 correct (for their iterative formula) rot to 4dp or more
		4 0.249038376442 5 0.249038376398 [6 0.249038376398]	**A1**	**1.1**	x_4, x_5 or any two further consecutive iterates x_n and x_{n+1} for $n \geq 4$ rot to 7dp or more. OR allow eg x_4 seen to 6dp **and** 6dp accuracy verified by change of sign
		0.249038	**A1**	**2.2a**	Correct answer to 6dp fully justified by correct iterates to 7dp or a change of sign. Dependent on M1A1. **A0** if not fully justified by iterates
			[5]		

Question		Answer	Marks	AO	Guidance
9	(b)(i)	**DR** the ratios are decreasing	**B1**	**1.1**	allow eg values getting smaller eg entries decreasing in size do **not** allow eg ratios not converging to a constant eg entries converging to zero
		so (order of convergence) is **higher** than **first order** **or (**convergence is) **faster** than **first order oe**	**B1** **[2]**	**2.2b**	**B0** if answer spoiled; condone eg order is faster than first order eg convergence is higher than first order do **not** allow eg second order eg better / greater / bigger / more than first order Do not allow eg suggests second order convergence ISW if **B0B0** allow **SC1** for values not converging to a constant so convergence is not first order **oe**
	(b)(ii)	**DR** This is usual since (convergence of) Newton-Raphson (approximations) is generally second order **oe**	**B1FT** **[1]**	**2.2a**	FT their reasoning from (b)(i) e.g. if in (b)(i) conclude 'hence is first order' then B1 for 'unusual since Newton-Raphson is generally second order' (must quote the correct fact about N-R and conclude appropriately) Condone incorrect use of 'method'

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