

Mathematics (MEI)

Advanced Subsidiary GCE

Unit **4751**: Introduction to Advanced Mathematics

Mark Scheme for June 2013

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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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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
U1	Mark for correct units
G1	Mark for a correct feature on a graph
M1 dep*	Method 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

Subject-specific Marking Instructions for GCE Mathematics (MEI) Pure strand

- 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, award marks according to the spirit of the basic scheme; if you are in any doubt whatsoever (especially if several marks or candidates are involved) 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, eg 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

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, eg 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, exactly what is acceptable will be detailed in the mark scheme rationale. If this is not the case please consult your Team Leader.

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. Wrong or missing units in an answer should not lead to the loss of a mark unless the scheme specifically indicates otherwise. Candidates are expected to give numerical answers to an appropriate degree of accuracy, with 3 significant figures often being the norm. Small variations in the degree of accuracy to which an answer is given (e.g. 2 or 4 significant figures where 3 is expected) should not normally be penalised, while answers which are grossly over- or under-specified should normally result in the loss of a mark. The situation regarding any particular cases where the accuracy of the answer may be a marking issue should be detailed in the mark scheme rationale. If in doubt, contact your Team Leader.

- 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.

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- 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.

Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

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Question		Answer	Marks	Guidance
1		$y = -0.5x + 3$ oe www isw	3 [3]	B2 for $2y = -x + 6$ oe or M1 for gradient = $-\frac{1}{2}$ oe seen or used and M1 for $y - 1 = \textit{their } m(x - 4)$ for 3 marks must be in form $y = ax + b$ or M1 for $y = \textit{their } mx + c$ and (4, 1) substituted
2		substitution to eliminate one variable simplification to $ax = b$ or $ax - b = 0$ form, or equivalent for y (0.7, 0.1) oe or $x = 0.7, y = 0.1$ oe isw	M1 M1 A2 [4]	or multiplication to make one pair of coefficients the same; condone one error in either method or appropriate subtraction / addition; condone one error in either method A1 each independent of first M1
3	(i)	25	2 [2]	M1 for $\left(\frac{10}{2}\right)^2$ or $\left(\frac{1}{0.2}\right)^2$ oe soi or for $\frac{1}{0.04}$ oe ie M1 for one of the two powers used correctly M0 for just $\frac{1}{0.4}$ with no other working
3	(ii)	$8a^9$	3 [3]	B2 for 8 or M1 for $16^{\frac{1}{4}} = 2$ soi and B1 for a^9 ignore \pm eg M1 for 2^3 ; M0 for just 2

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6		-2560 www	4	<p>B3 for 2560 from correct term (NB coefficient of x^4 is 2560)</p> <p>or B3 for neg answer following $10 \times 4 \times -64$ and then an error in multiplication</p> <p>or M2 for $10 \times 2^2 \times (-4)^3$ oe; must have multn signs or be followed by a clear attempt at multn;</p> <p>or M1 for $2^2 \times (-4)^3$ oe (condone missing brackets) or for 10 used or for 1 5 10 10 5 1 seen</p> <p>for those who find the coefft of x^2 instead: allow M1 for 10 used or for 1 5 10 10 5 1 seen ; and a further SC1 if they get 1280, similarly for finding coefficient of x^4 as 2560</p>	<p>ignore terms for other powers; condone x^3 included;</p> <p>but eg $10 \times 4 \times -64 = 40 - 64 = -24$ gets M2 only</p> <p>condone missing brackets eg allow M2 for $10 \times 2^2 \times -4x^3$</p> <p>5C_3 or factorial notation is not sufficient but accept $\frac{5 \times 4 \times 3 \times 2 \times 1}{2 \times 1 \times 3 \times 2 \times 1}$ oe</p> <p>10 may be unsimplified, as above</p> <p>M1 only for eg 10, 2^2 and $-4x^3$ seen in table with no multn signs or evidence of attempt at multn</p> <p>[lack of neg sign in the x^2 or x^4 terms means that these are easier and so not eligible for just a 1 mark MR penalty]</p>
7	(i)	$5^{3.5}$ oe or $k = 7/2$ oe	2 [2]	M1 for $125 = 5^3$ or $\sqrt{5} = 5^{\frac{1}{2}}$ soi	M0 for just answer of 5^3 with no reference to 125

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7	(ii)	<p>attempting to multiply numerator and denominator of fraction by $1 + 2\sqrt{5}$</p> <p>denominator = -19 soi</p> <p>$8 + 3\sqrt{5}$</p>	<p>M1</p> <p>M1</p> <p>A1</p> <p>[3]</p>	<p>must be obtained correctly, but independent of first M1</p>	<p>some cand's are incorporating the $10 + 7\sqrt{5}$ into the fraction. The M1s are available even if this is done wrongly or if $10 + 7\sqrt{5}$ is also multiplied by $1 + 2\sqrt{5}$</p> <p>eg M1 for denominator of 19 with a minus sign in front of whole expression or with attempt to change signs in numerator</p>
8		<p>$3(x - 2)^2 - 7$ isw or $a = 3, b = 2, c = 7$ www</p> <p>-7 or ft</p>	<p>4</p> <p>B1</p> <p>[5]</p>	<p>B1 each for $a = 3, b = 2$ oe</p> <p>and B2 for $c = 7$ oe</p> <p>or M1 for $[-]\frac{7}{3}$ or for $5 - \text{their } a(\text{their } b)^2$</p> <p>or for $\frac{5}{3} - (\text{their } b)^2$ soi</p> <p>B0 for $(2, -7)$</p>	<p>condone omission of square symbol; ignore '='</p> <p>may be implied by their answer</p> <p>may be obtained by starting again eg with calculus</p>
9	(i)	<p>$3n$ isw</p>	<p>1</p> <p>[1]</p>	<p>accept equivalent general explanation</p>	

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9	(ii)	<p>at least one of $(n - 1)^2$ and $(n + 1)^2$ correctly expanded</p> <p>$3n^2 + 2$</p> <p>comment eg $3n^2$ is always a multiple of 3 so remainder after dividing by 3 is always 2</p>	<p>M1</p> <p>B1</p> <p>B1</p> <p>[3]</p>	<p>must be seen</p> <p>dep on previous B1</p> <p>B0 for just saying that 2 is not divisible by 3 – must comment on $3n^2$ term as well</p> <p>allow B1 for $\frac{3n^2 + 2}{3} = n^2 + \frac{2}{3}$</p>	<p>M0 for just $n^2 + 1 + n^2 + n^2 + 1$</p> <p>accept even if no expansions / wrong expansions seen</p> <p>SC: $n, n + 1, n + 2$ used similarly can obtain first M1, and allow final B1 for similar comment on $3n^2 + 6n + 5$</p>
10	(i)	<p>[radius =] $\sqrt{20}$ or $2\sqrt{5}$ isw</p> <p>[centre =] (3, 2)</p>	<p>B1</p> <p>B1</p> <p>[2]</p>	<p>B0 for $\pm\sqrt{20}$ oe</p>	<p>condone lack of brackets with coordinates, here and in other questions</p>

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10	(ii)	<p>substitution of $x = 0$ or $y = 0$ into circle equation</p> <p>$(x - 7)(x + 1) [=0]$</p> <p>$(7, 0)$ and $(-1, 0)$ isw</p> <p>$[y =] \frac{4 \pm \sqrt{(-4)^2 - 4 \times 1 \times (-7)}}{2}$ oe</p> <p>$(0, 2 \pm \sqrt{11})$ or $(0, \frac{4 \pm \sqrt{44}}{2})$ isw</p>	<p>M1</p> <p>M1</p> <p>A1</p> <p>M1</p> <p>A1</p> <p>[5]</p>	<p>or use of Pythagoras with radius and a coordinate of the centre eg $20 - 2^2$ or $h^2 + 3^2 = 20$ ft their centre and/or radius</p> <p>no ft from wrong quadratic; for factors giving two terms correct, or formula or completing square used with at most one error</p> <p>accept $x = 7$ or -1 (both required)</p> <p>no ft from wrong quadratic; for formula or completing square used with at most one error</p> <p>accept $y = \frac{4 \pm \sqrt{44}}{2}$ oe isw</p>	<p>equation may be expanded first, and may include an error</p> <p>bod intent</p> <p>allow M1 for $(x - 3)^2 = 20$ and/or $(y - 2)^2 = 20$</p> <p>completing square attempt must reach at least $(x - a)^2 = b$</p> <p>following use of Pythagoras allow M1 for attempt to add 3 to $[\pm]4$</p> <p>completing square attempt must reach at least $(y - a)^2 = b$</p> <p>following use of Pythagoras allow M1 for attempt to add 2 to $[\pm]\sqrt{11}$</p> <p>annotation is required if part marks are earned in this part: putting a tick for each mark earned is sufficient</p>
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10	(iii)		<p>show both A and B are on circle</p> <p>(4, 5)</p> <p>$\sqrt{10}$</p>	<p>B1</p> <p>B2</p> <p>B2</p> <p>[5]</p>	<p>explicit substitution in circle equation and at least one stage of interim working required oe</p> <p>B1 each or M1 for $\left(\frac{7+1}{2}, \frac{6+4}{2}\right)$</p> <p>from correct midpoint and centre used; B1 for $\pm\sqrt{10}$</p> <p>M1 for $(4-3)^2 + (5-2)^2$ or $1^2 + 3^2$ or ft their centre and/or midpoint, or for the square root of this</p>	<p>or clear use of Pythagoras to show AC and BC each = $\sqrt{20}$</p> <p>may be a longer method finding length of $\frac{1}{2}$ AB and using Pythag. with radius;</p> <p>no ft if one coord of midpoint is same as that of centre so that distance formula/Pythag is not required eg centre correct and midpt (3, -1)</p> <p>annotation is required if part marks are earned in this part: putting a tick for each mark earned is sufficient</p>
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11	(i)		<p>sketch of cubic the right way up, with two tps and clearly crossing the x axis in 3 places</p> <p>crossing/reaching the x-axis at -4, -2 and 1.5</p> <p>intersection of y-axis at -24</p>	<p>B1</p> <p>B1</p> <p>B1</p> <p>[3]</p>	<p>intersections must be shown correctly labelled or worked out nearby; mark intent</p>	<p>no section to be ruled; no curving back; condone slight 'flicking out' at ends but not approaching another turning point; condone some doubling (eg erased curves may continue to show); accept min tp on y-axis or in 3rd or 4th quadrant; curve must clearly extend beyond the x axis at both 'ends'</p> <p>accept curve crossing axis halfway between 1 and 2 if $3/2$ not marked</p> <p>NB to find -24 some are expanding $f(x)$ here, which gains M1 in iiiA. If this is done, put a yellow line here and by (iii)A to alert you; this image appears again there</p>
11	(ii)		<p>-2, 0 and $7/2$ oe isw or ft their intersections</p>	<p>2</p> <p>[2]</p>	<p>B1 for 2 correct or ft or for $(-2, 0)$ $(0, 0)$ and $(3.5, 0)$ or M1 for $(x + 2)x(2x - 7)$ oe or SC1 for -6, -4 and $-1/2$ oe</p>	

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11	(iii)	(A)	<p>correct expansion of product of 2 brackets of $f(x)$</p> <p>correct expansion of quadratic and linear and completion to given answer</p>	<p>M1</p> <p>A1</p> <p>[2]</p>	<p>need not be simplified; condone lack of brackets for M1</p> <p>or allow M1 for expansion of all 3 brackets, showing all terms, with at most one error: $2x^3 + 4x^2 + 8x^2 - 3x^2 + 16x - 12x - 6x - 24$</p> <p>for correct completion if all 3 brackets already expanded, with some reference to show why -24 changes to -9</p>	<p>eg $2x^2 + 5x - 12$ or $2x^2 + x - 6$ or $x^2 + 6x + 8$</p> <p>may be seen in (i) – allow the M1; the part (i) work appears at the foot of the image for (iii)A, so mark this rather than in (i)</p> <p>condone lack of brackets if they have gone on to expand correctly; condone ‘+15’ appearing at some stage</p> <p>NB answer given; mark the whole process</p>
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11	(iii)	(B)	<p>$g(1) = 2 + 9 - 2 - 9 [=0]$</p> <p>attempt at division by $(x - 1)$ as far as $2x^3 - 2x^2$ in working</p> <p>correctly obtaining $2x^2 + 11x + 9$</p> <p>factorising a correct quadratic factor</p> <p>$(2x + 9)(x + 1)(x - 1)$ isw</p>	<p>B1</p> <p>M1</p> <p>A1</p> <p>M1</p> <p>A1</p> <p>[5]</p>	<p>allow this mark for $(x - 1)$ shown to be a factor and a statement that this means that $x = 1$ is a root [of $g(x) = 0$] oe</p> <p>or inspection with at least two terms of quadratic factor correct</p> <p>allow B2 for another linear factor found by the factor theorem</p> <p>for factors giving two terms correct; eg allow M1 for factorising $2x^2 + 7x - 9$ after division by $x + 1$</p> <p>allow $2(x + 9/2)(x + 1)(x - 1)$ oe; dependent on 2nd M1 only; condone omission of first factor found; ignore '= 0' seen</p>	<p>B0 for just $g(1) = 2(1)^3 + 9(1)^2 - 2(1) - 9 [=0]$</p> <p>M0 for division by $x + 1$ after $g(1) = 0$ unless further working such as $g(-1) = 0$ shown, but this can go on to gain last M1A1</p> <p>NB mixture of methods may be seen in this part – mark equivalently eg three uses of factor theorem, or two uses plus inspection to get last factor;</p> <p>allow M1 for $(x + 1)(x + 18/4)$ oe after -1 and $-18/4$ oe correctly found by formula</p> <p>SC alternative method for last 4 marks: allow first M1A1 for $(2x + 9)(x^2 - 1)$ and then second M1A1 for full factorisation</p>
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12	(i)	$y = 2x + 3$ drawn accurately (-1.6 to -1.7, -0.2 to -0.3) (2.1 to 2.2, 7.2 to 7.4)	M1 B1 B1 [3]	at least as far as intersecting curve twice intersections may be in form $x = \dots, y = \dots$	ruled straight line and within 2mm of (2, 7) and (-1, 1) if marking by parts and you see work relevant to (ii), put a yellow line here and in (ii) to alert you to look
12	(ii)	$\frac{1}{x-2} = 2x + 3$ $1 = (2x + 3)(x - 2)$ $1 = 2x^2 - x - 6$ oe $\frac{1 \pm \sqrt{1^2 - 4 \times 2 \times -7}}{2 \times 2}$ oe $\frac{1 \pm \sqrt{57}}{4}$ isw	M1 M1 A1 M1 A1 [5]	or attempt at elimination of x by rearrangement and substitution condone lack of brackets for correct expansion; need not be simplified; NB A0 for $2x^2 - x - 7 = 0$ without expansion seen [given answer] use of formula or completing square on given equation, with at most one error isw eg coordinates; after completing square, accept $\frac{1}{4} \pm \sqrt{\frac{57}{16}}$ or better	may be seen in (i) – allow marks; the part (i) work appears at the foot of the image for (ii) so show marks there rather than in (i) implies first M1 if that step not seen implies second M1 if that step not seen after $\frac{1}{x-2} = 2x + 3$ seen completing square attempt must reach at least [2] $(x - a)^2 = b$ or $(2x - c)^2 = d$ stage oe with at most one error

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12	(iii)	$\frac{1}{x-2} = -x+k$ <p>and attempt at rearrangement</p> $x^2 - (k+2)x + 2k + 1 [= 0]$ $b^2 - 4ac = 0$ <p>oe seen or used</p> <p>[k =] 0 or 4 as final answer, both required</p>	<p>M1</p> <p>M1</p> <p>M1</p> <p>A1</p> <p>[4]</p>	<p>for simplifying and rearranging to zero; condone one error; collection of x terms with bracket not required</p> <p>SC1 for 0 and 4 found if 3rd M1 not earned (may or may not have earned first two Ms)</p>	<p>eg M1 bod for $x^2 - (k+2)x + 2k$ or M1 for $x^2 - 2kx + 2k + 1 [= 0]$</p> <p>= 0 may not be seen, but may be implied by their final values of k</p> <p>eg obtained graphically or using calculus and/or final answer given as a range</p>
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Appendix: revised tolerances for modified papers for visually impaired candidates (graph in 12(i) with 6mm squares)

12	(i)		$y = 2x + 3$ drawn accurately	M1	at least as far as intersecting curve twice	ruled straight line and within 3 mm of (2, 7) and (-1, 1)
			(-1.6 to -1.8, -0.2 to -0.3)	B1	intersections may be in form $x = \dots, y = \dots$	
			(2.1 to 2.3, 7.1 to 7.4)	B1		
			[3]			
						if marking by parts and you see work relevant to (ii), put a yellow line here and in (ii) to alert you to look

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