OCR
Oxford Cambridge and RSA

GCE

Mathematics (MEI)

Unit **4751**: Introduction to Advanced Mathematics (C1)

Advanced Subsidiary GCE

Mark Scheme for June 2017

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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.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

Annotations and abbreviations

Annotation in scoris	Meaning
BP	Blank Page – this annotation **must** be used on all blank pages within an answer booklet (structured or unstructured) and on each page of an additional object where there is no candidate response.
✓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.

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.

Question			Answer	Marks	Guidance	
1			correct ruled line of intercept (0, 1) and gradient −2 drawn on grid, extending at least from (−1.5, 4) to (2, −3), as per the circles on the overlay, tol. 1mm horizontally (ie half a square on the grid)	2 **[2]**	**M1** for correct line but eg not extending into 4th quadrant or **M1** for line with correct gradient but wrong intercept or **M1** for line with correct intercept and gradient negative but not −2 or **M1** for correct plots but line not ruled	NB page 12 shown in this image must be annotated as BP if blank. Highlight (to indicate seen) in q1 image of page 12 if just rough work crossed out. If a qn number is shown and relevant work seen, highlight the qn no in the q1 image then use full response view to link page 12 to relevant question; also put a highlight by the image in the correct qn space to remind you there is extra work to look at.
2	(i)		$\frac{3}{4}$ oe	3 **[3]**	**B2** for $\frac{3}{a}$ or $\frac{c}{4}$ or $\pm\frac{3}{4}$ or **M2** for $\left(\frac{4}{3}\right)^{-1}$ or $\left(\frac{9}{16}\right)^{\frac{1}{2}}$ or $\sqrt{\frac{9}{16}}$ or **M1** for $\frac{1}{\left(1\frac{7}{9}\right)^{\frac{1}{2}}}$ or $\left(\frac{16}{9}\right)^{-\frac{1}{2}}$ or $\frac{4}{3}$	isw wrong conversion to decimals
2	(ii)		$12x^{15}y^{-4}$ or $\frac{12x^{15}}{y^4}$	2 **[2]**	**B1** for two elements correct if B0, allow **M1** for expanded numerator = $6^3x^{15}y^6$ or $216x^{15}y^6$	
3			$6 - x > 5x - 15$	M1		the first two Ms may be earned with an equation or wrong inequality

Question			Answer	Marks	Guidance	
			$21 > 6x$ or $-6x > -21$ oe or ft	M1	for correctly collecting x terms on one side and number terms on the other and simplifying	ft wrong first step
			$x < \frac{21}{6}$ or $\frac{21}{6} > x$ oe isw or ft	M1	ft their ax [inequality] b, where $b \neq 0$ and $a \neq 0$ or ± 1	award 3 marks only if correct answer obtained after equations or inequalities are used with no errors
				[3]		
4			$2(4 + 2y) + 5y = 5$ oe in x or $2x - 4y = 8$ oe	M1	for subst to eliminate one variable; condone one error; or for multn or divn of one or both eqns to get a pair of coeffts the same, condoning one error	
			$9y = -3$ or $9x = 30$ oe	M1	for collecting terms and simplifying; condoning one error ft or for appropriate addn or subtn to eliminate a variable, condoning an error in one term; if subtracting, condone eg x instead of 0 if no other errors	
			$\left(\frac{30}{9}, -\frac{3}{9}\right)$ oe isw	A2	or $x = 30/9$, $y = -3/9$ oe isw eg $x = 10/3$, $y = -1/3$ allow **A1** for each coordinate	
				[4]		
5	**(i)**		[centre] $(-2, 3)$ [radius] $\sqrt{5}$	B1 B1	**B0 for** $\pm\sqrt{5}$	
				[2]		
5	**(ii)**		$5x + y = -7$ or $y = -5x - 7$ or $5x + y + 7 = 0$	2	**M1** for $5x + y = k$, $k \neq 4$ or for gradient of parallel line $= -5$ or for answer $-5x - 7$	if wrong centre in 5(i), can earn just M1
				[2]		

Question			Answer	Marks	Guidance	
6					each M1 is for a correct, constructive step following through correctly from previous step	
			$r^2 = \dfrac{V}{a+b}$	M1	for squaring both sides	
			$r^2(a+b) = V$ or $r^2a + r^2b = V$	M1	for multiplying both sides by denominator for this and all subsequent Ms, ft for equiv difficulty	allow candidates to combine two or three stages in one working statement eg award first two Ms for $r^2(a+b) = V$ seen as first step
			$r^2b = V - r^2a$ or $a + b = \dfrac{V}{r^2}$	M1	for getting *b* term on one side, other terms on other side	3rd and 4th M1s may be earned in opposite order, as in second answer for these M1s
			$b = \dfrac{V - r^2a}{r^2}$ or $b = \dfrac{V}{r^2} - a$ as final answer	M1 **[4]**	for dividing by coefficient of *b* award 4 marks only if working is fully correct, with at least one interim step. allow **SC2** if there is no working, just the correct answer	where rhs has two terms in the numerator, the division line must clearly extend under both terms
7	(i)		$\dfrac{29 - 11\sqrt{7}}{2}$ isw	3 **[3]**	**B1** for each element; condone written as two separate fractions if 0, allow **M1** for three terms correct in $15 - 5\sqrt{7} - 6\sqrt{7} + 14$ or for attempt to multiply both denominator and numerator by $3 - \sqrt{7}$	
7	(ii)		$13\sqrt{2}$	2 **[2]**	**M1** for $\dfrac{12}{\sqrt{2}} = 6\sqrt{2}$ soi or for $\sqrt{98} = 7\sqrt{2}$ soi or for $\dfrac{12+14}{\sqrt{2}}$ oe	

Question			Answer	Marks	Guidance	
8			$a^5 = 32$	B1	must have evidence that they have considered the constant term	NB examiners must use annotation in this part; a tick where each mark is earned is sufficient
			$a = 2$	B1	**B0** for $a = \pm 2$, but allow them to gain all marks for b if earned	
			$10a^2b^3$ [$= -1080$]	B1	may include x^3 on both sides, or $(bx)^3$ on left and x^3 on right; may have subst their a^2; condone poor notation with inconsistent xs.	B0 for eg $10a^2bx^3 = -1080x^3$
			$4b^3 = -108$ oe	B1	for subst $a = 2$ in $10a^2b^3 = -1080$ oe	B0 for $4b^3 = -108x^3$ etc
			$b = -3$	B1	if 0 in qn, allow **B1** for 1 5 10 10 5 1 row of Pascal's triangle seen or for ${}^5C_3 = 10$	those trialling factors of -108: Allow up to 3 marks (B0,B1,B1 if earned,B0,B1) for reaching $a = 2$ and $b = -3$ with trialling unless explicit reference to 32 in checking, in which case award up to full marks (in effect explicit reference showing their solution fits both constraints triggers 1st and 4th B1s)
				[5]		

9			n $n+1$ $n+2$ soi	B1	may be earned later	
			$(n+2)^2 - n^2$ soi	M1	allow ft for next three marks for other general consecutive integers eg $n-1$ n $n+1$ for other integers in terms of n (eg $2n, 2n+1, 2n+2$ or $2n+1, 2n+3, 2n+5$) allow ft for this M1 only	allow $n^2 - (n+2)^2$ for M1 then A0 for negative answer; may still earn last B1
			$4n + 4$ obtained with at least one interim step shown	A1		
			$4(n + 1)$ or $\frac{4n+4}{4} = n+1$	B1 **[4]**	may be obtained independently	B0 for $n+1 \times 4$
10	**(i)**		$AB^2 = 5^2 + 5^2 = 50$	B1	oe with AB; may go straight from correct unsimplified form to 50 with no interim working (applies to both marks), but for 2 marks any interim working must be correct	for 2 marks to be awarded, notation used must be fully correct. Penalise only one mark if squares and square roots eg 50 and $\sqrt{50}$ confused, or brackets used incorrectly or AB and BC missing, etc, but working is otherwise correct
			$BC^2 = 7^2 + 1^2 = 50$	B1 **[2]**	oe with BC	

10	**(ii)**		grad AC = $\frac{-1-3}{5-3}\left[=-2\right]$ oe isw grad perp = ½ or ft from their grad AC or finding gradient of their BF $y+2=their\,\frac{1}{2}(x+2)$ or $-2=their\,\frac{1}{2}(-2)+c$ oe $y=\frac{1}{2}x-1$ isw	B1 M1 M1 A1 **[4]**	or midpt F of AC = $\left(\frac{5+3}{2},\frac{3-1}{2}\right)$ may be seen in eqn of perp or using coords of their F; no ft for using their grad AC for this allow both M1s for eqn of line through B and their F	must be a changed gradient related to grad AC, or be their grad BF, to score this M1
10	**(iii)**		(10, 4)	2 **[2]**	**B1** for each coordinate or **M1** for use of $\overrightarrow{AD}=\overrightarrow{BC}$, $\overrightarrow{CD}=\overrightarrow{BA}$ or $\overrightarrow{BF}=\overrightarrow{FD}$ or for correct method for intersection of (ii) line and line through A parallel to BC [$y=3+\frac{1}{7}(x-3)$ oe or $y=\frac{1}{7}x+\frac{18}{7}$ oe if correct] or line through C parallel to BA [$y = x - 6$ if correct] allow **SC1** for (-4 , 2) for ADBC found, or (0 , -6) for ABDC found [both parallelograms, not rhombi]	NB more complicated methods exist using simultaneous equations and eg grad BD = ½ and $AD^2 = BC^2$

10	**(iv)**		grad AD = $\frac{4-3}{10-3}$ or $\frac{1}{7}$ or ft relevant D from attempt at ABCD	M1	however, if D = (0, −6), or (−4, 2) or other attempt at ABDC or ADBC in (iii), or other attempt where one or both coords of D are less than the corresponding coords of (8, 3.8) award only **SC1** in (iv) for showing by diagram or coordinates that E is obviously outside the rhombus ABDC eg since its *x*-coordinate is greater than the *x*-coordinate of all the vertices (or similarly *y*-coordinates)	some are working with CD only, not AD. Give M0 but allow SC1 for showing that CD is $y = x - 6$ and then finding on CD when $y = 3.8$, $x = 9.8$ or when $x = 8$, $y = 2$; allow ft from wrong but relevant D – see 'however' in previous column
			so when $x = 8$, y-coord. on AD = $3+\frac{1}{7}\times(8-3)$ or ft	M1	or use of $y-3=\frac{1}{7}(8-3)$ oe or **M1** for $3.8-3=\frac{1}{7}(x-3)$ oe, after correct method for finding eqn of AD using coords of A and D – need not be simplified [AD is $y=3+\frac{1}{7}(x-3)$ oe or $y=\frac{1}{7}x+\frac{18}{7}$ oe if correct]	may use coords of their D not A in eqn i.e. M1 for substituting one coord of E in their equation for AD after correct method seen for AD, or AD correct; condone substituting both coords of E
			= $3\frac{5}{7}$ or 3.7…	A1	or on AD when $y = 3.8$, $x = 8.6$ no ft from wrong D	
			conclusion E is outside rhombus, with $3\frac{5}{7}$ shown to be less than 3.8 if not seen earlier, if y used	A1	no ft from wrong D	
			or	**or**		

			grad AD = $\frac{4-3}{10-3}\left[=\frac{1}{7}\right]$ or ft their D	M1		similarly may find line through E parallel to AD (M1 for gradient of AD as in first method and M1 for eqn $y=\frac{1}{7}x+(3.8-\frac{8}{7})$ oe and compare with eqn of AD $y=3+\frac{1}{7}(x-3)$ oe: A1 for showing $3.8-\frac{8}{7}>\frac{18}{7}$, A1 for conclusion E is outside rhombus
			grad AE = $\frac{0.8}{5}$ [=0.16]	M1	or allow M1, for DE used, dep on first M1, for grad DE = $\frac{0.2}{2}[=0.1]$, no ft from wrong D	the SC for working with CD rather than AD is also available if they use gradients – allow SC1 if they find grad CD = 1, and grad CE = 4.8/3 or 1.6 or grad DE $\frac{0.2}{2}[=0.1]$
			grad. AE shown to be greater than grad AD eg 0.16 > 0.14… or grad DE shown to be less than grad AD eg 0.1 < 0.014…	A1	no ft from wrong D;	
			conclusion E is outside rhombus	A1 **[4]**	no ft from wrong D	

11	**(i)**		graph of cubic correct way up	B1	**B0** if stops at *x*-axis	must not have any ruled sections; no curving back; condone slight 'flicking out' at ends but not approaching a turning point; allow max on *y*-axis or in 1st or 2nd quadrants; condone some 'doubling' or 'feathering' (deleted work still may show in scans)
			crossing *x*-axis at –5, 1.5 and 2	B1	on graph or nearby; may be in coordinate form mark intent for intersections with both axes	allow if no graph, but marked on *x*-axis condone intercepts for *x* and / or *y* given as reversed coordinates
			crossing *y*-axis at 30	B1 **[3]**	or $x = 0$, $y = 30$ seen if consistent with graph drawn	allow if no graph, but eg B0 for graph with intn on *y*-axis nowhere near their indicated 30

11	**(ii)**		roots of g(x) = 0 are -8, -1.5, -1	M1	or [g(x) =] (x + 1)(2x + 3)(x + 8) oe, condoning error in one bracket	NB examiners must use annotation in this part; a tick where each mark is earned is sufficient
			correct expansion of two of their two-term factors	M1	dep on attempt on f($x \pm 3$) attempted; may be 3 or 4 terms	condone lack of brackets if correct expansions as if they were there [for reference re ft: if correct, f(x – 3) = (x + 2)(2x – 9)(x – 5); allow ft if two of these brackets correct]
			correct expansion and completion to given answer, $2x^3 + 21x^2 + 43x + 24$	A1	must be working for this step before given answer backwards working: allow M1 for obtaining a correct linear × a quadratic factor of given g(x) and M1 for obtaining all 3 linear factors and A1 for justifying that these are the correct factors from using the translated roots	or for direct expansion of all three correct factors, allow M1 for $2x^3 + 16x^2 + 2x^2 + 3x^2 + 24x + 16x + 3x + 30$, condoning an error in one term, and A1 if no error for completion by then stating given answer
		or		**or**		
			finding f(x) = $2x^3 + 3x^2 - 29x + 30$ and substituting (x + 3) or (x – 3) for x	M1	condoning one error; condone omission of 'f(x) =' or 'y = '	f(x) may appear in (i) but no credit unless result is used in (ii)
			correct expansion for $(x + 3)^3$ and $(x + 3)^2$	M1		
			correct expansion and completion to given answer, $2x^3 + 21x^2 + 43x + 24$	A1 **[3]**		

11	**(iii)**		$-16 + 84 - 86 + 24 = 6$ or $-16 + 84 - 86 + 24 - 6 = 0$	B1	or **B1** for the correct division of $g(x) - 6$ by $(x + 2)$ or for the quadratic factor found by inspection, and, for either of these, the conclusion that no remainder means that $g(-2) = 6$ oe or **B1** for correct division of $g(x)$ by $(x + 2)$ with remainder 6 and the conclusion that $g(-2) = 6$ oe	NB examiners must use annotation in this part; a tick where each mark is earned is sufficient
			need roots of] $2x^3 + 21x^2 + 43x + 18 = 0$ soi	B1	or clear working with $g(x)$ and remainder of 6 found when divided by $(x + 2)$ or $g(x) = (x + 2)(2x^2 + 17x + 9) + 6$ clearly stated at some point	
			attempt at division by $(x + 2)$ as far as $2x^3 + 4x^2$ in working	M1	or inspection with at least two terms of three–term quadratic factor correct;	allow working with $g(x) = 0$ for this M1
			correctly obtaining $2x^2 + 17x + 9$	A1	if working with $g(x) = 0$ must show remainder of 6 eg in working	
			$\frac{-17 \pm \sqrt{17^2 - 4 \times 2 \times 9}}{2 \times 2}$	M1	condone one error in quadratic formula or completing square; **M0** for incorrect quadratic 'factor'	
			$\frac{-17 \pm \sqrt{217}}{4}$ oe isw	A1 **[6]**		

12	**(i)**		$\left(x+\frac{1}{2}\right)^2+2\frac{3}{4}$ oe	3	**B1** for $m = ½$ oe **B2** for $p=2\frac{3}{4}$ oe or **M1** for $3 -$ their m^2	Ignore '=0' M0 if $m = 0$
			min $y = 2\frac{3}{4}$ oe or ft, isw or showing that if $y = 0$, their $\left(x+\frac{1}{2}\right)^2$ is negative, so no real roots [or no solution]	B1 **[4]**	ft their p, provided $p > 0$; ignore x value of min pt stated, even if wrong ft **B0** if only say tp rather than min, though need not justify min	B0 if explanation not 'hence' eg using $b^2 - 4ac$ on $x^2 + x + 3 = 0$ condone B1 for min pt = $2\frac{3}{4}$
12	**(ii)**		$x^2-4x-12[=0]$	M1	condone one error; for equating and simplifying to solvable form	rearranging to zero not required if they go on to complete the square
			$(x-6)(x+2)[=0]$	M1	for factors giving at least two terms correct, ft, or for subst in formula with at most one error ft	similarly for attempt at completing square
			$x = 6$ or -2	A1	allow **A1** for coords with x values 6 and -2 but wrong y values	
			$y = 45$ or 5	A1 **[4]**	or **A1** each for (6, 45) and $(-2, 5)$	

12	**(iii)**		$x^2 - 4x - (9+k)[=0]$	M1	condone one error, but must include k **M0** if not all on one side of equation, unless completing the square	Eg allow M1 for $y = x^2 - 4x - (9+k)$ or for $x^2 - 4x(-9-k)[=0]$ for completing the square method: eg $(x-2)^2 - 4 = 9 + k$ earns M1 and the second A1, which is likely to be earned before the first A1
			$b^2 - 4ac < 0$ oe soi	A1	may be earned near end with correct inequality sign used there	allow '$b^2 - 4ac$ is negative' oe; 0 for just 'discriminant < 0' unless implied by later work; A0 for $\sqrt{b^2 - 4ac} < 0$; for completing the square, allow A1 for $4 + 9 + k < 0$ oe
			$16 + 4 \times (9 + k)$ (< 0) oe or ft	A1	for correct substitution ft into $b^2 - 4ac$; brackets / signs must be correct; allow recovery from eg wrong bracket earlier but **A0** if recovery line contains additional error(s)	can be earned with equality or wrong inequality, or in formula (ignore rest of formula); for completing the square method, will see $4 + 9 + k$ oe, or on opposite sides of an inequality/ equation eg $9 + k < -4$ M0 for trials of values of k in $b^2 - 4ac$
			$k < -13$ www	A1 **[4]**	**A0** for just $k < -52/4$	

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