OCR
Oxford Cambridge and RSA

Monday 14 May 2018 – Afternoon

AS GCE MATHEMATICS (MEI)

4755/01 Further Concepts for Advanced Mathematics (FP1)

QUESTION PAPER

Candidates answer on the Printed Answer Book.

OCR supplied materials:
- Printed Answer Book 4755/01
- MEI Examination Formulae and Tables (MF2)

Other materials required:
- Scientific or graphical calculator

Duration: 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

These instructions are the same on the Printed Answer Book and the Question Paper.
- The Question Paper will be found inside the Printed Answer Book.
- Write your name, centre number and candidate number in the spaces provided on the Printed Answer Book. Please write clearly and in capital letters.
- **Write your answer to each question in the space provided in the Printed Answer Book.** If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the barcodes.
- You are permitted to use a scientific or graphical calculator in this paper.
- Final answers should be given to a degree of accuracy appropriate to the context.

INFORMATION FOR CANDIDATES

This information is the same on the Printed Answer Book and the Question Paper.
- The number of marks is given in brackets **[ ]** at the end of each question or part question on the Question Paper.
- You are advised that an answer may receive **no marks** unless you show sufficient detail of the working to indicate that a correct method is being used.
- The total number of marks for this paper is **72**.
- The Printed Answer Book consists of **16** pages. The Question Paper consists of **4** pages. Any blank pages are indicated.

INSTRUCTION TO EXAMS OFFICER/INVIGILATOR
- Do not send this Question Paper for marking; it should be retained in the centre or recycled. Please contact OCR Copyright should you wish to re-use this document.

Section A (36 marks)

1 The matrices **A** and **B** are given by $\mathbf{A} = \begin{pmatrix} 2 & 2k & -k \\ 0 & 1 & -1 \end{pmatrix}$ and $\mathbf{B} = \begin{pmatrix} 1 & 2 \\ 3 & -3 \\ -2 & 4 \end{pmatrix}$, where k is a constant.

(i) Find, in terms of k, the matrix **AB**. **[2]**

(ii) Find the value of k for which matrix **AB** is singular. **[2]**

2 The quadratic equation $x^2 + px + q = 0$ has roots α and β, where

$$\alpha^2 + \beta^2 = -16,$$
$$\alpha - \beta = 6\text{j}.$$

By considering $(\alpha - \beta)^2$, find the value of $\alpha\beta$. Hence state the value of q and find the possible values of p. **[5]**

3 **(i)** Sketch on an Argand diagram the set of points representing complex numbers z for which

$$|z - (3 + 3\text{j})| = 3.$$ **[2]**

(ii) Find the greatest possible value of $|z|$ for this set of points. **[2]**

(iii) Mark on your Argand diagram the particular point for which $\arg\left(z - (3 + 3\text{j})\right) = \frac{2}{3}\pi$. Find this value of z in the form $a + \text{j}b$. **[3]**

4 **(i)** Use standard series formulae to show that

$$\sum_{r=1}^{n} r(2 + 3r) = \tfrac{1}{2}n(n+1)(2n+3).$$ **[4]**

(ii) Hence find the value of n such that

$$\sum_{r=1}^{4n} r(2 + 3r) = 198n(4n+1).$$ **[3]**

5 You are given that $z = 2 + 5\text{j}$ is a root of the cubic equation $2z^3 - 5z^2 + pz + q = 0$, where p and q are real constants. Find the values of p and q. **[6]**

6 Prove by induction that, for all positive integers n, $\sum_{r=1}^{n} r2^r = 2[1 + (n-1)2^n]$. **[7]**

Section B (36 marks)

7 A curve has equation $y = \dfrac{2x^2 - 5x - 3}{x^2 + x - 2}$.

(i) Find the values of x for which $y = 0$. **[2]**

(ii) Find the equations of the three asymptotes. **[3]**

(iii) Determine whether the curve approaches the horizontal asymptote from above or below for

(A) large positive values of x,

(B) large negative values of x. **[2]**

(iv) Sketch the curve. **[3]**

(v) Solve the inequality $\dfrac{2x^2 - 5x - 3}{x^2 + x - 2} \geqslant 0$. **[3]**

8 You are given that $\dfrac{1}{2r-1} - \dfrac{1}{2r+3} = \dfrac{4}{(2r-1)(2r+3)}$ for all integers r.

(i) Use the method of differences to show that

$$\sum_{r=1}^{n} \frac{1}{(2r-1)(2r+3)} = k - \frac{n+1}{(2n+1)(2n+3)},$$

stating the value of k. **[6]**

(ii) The sum of the infinite series

$$\frac{1}{\big(2(n+1)-1\big)\big(2(n+1)+3\big)} + \frac{1}{\big(2(n+2)-1\big)\big(2(n+2)+3\big)} + \frac{1}{\big(2(n+3)-1\big)\big(2(n+3)+3\big)} + \dots$$

is $\frac{7}{195}$. Show that n satisfies $28n^2 - 139n - 174 = 0$ and hence find the value of n. **[5]**

9 You are given that $\mathbf{M} = \begin{pmatrix} 4 & a \\ -6 & -2 \end{pmatrix}$ and $\mathbf{N} = \begin{pmatrix} -2 & 6 \\ -4a & -14 \end{pmatrix}$, where a is a real constant. Find the possible value(s) of a in each of the following cases.

(i) The point (1, –2) is invariant under the transformation represented by matrix **M**. **[2]**

(ii) $(\mathbf{NM}^{-1})^{-1}\mathbf{NM} = \mathbf{N}$. **[4]**

(iii) A triangle T_1 has an area of 9 square units. The triangle T_1 is transformed to triangle T_2 by the transformation represented by matrix **M**. The area of triangle T_2 is 144 square units. **[6]**

END OF QUESTION PAPER

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Duration: 1 hour 30 minutes

Candidate forename		Candidate surname	

Centre number						Candidate number				

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Section A (36 marks)

1 (i)	
1 (ii)	

2	

3 (i)	
3 (ii)	
3 (iii)	

4 (i)	
4 (ii)	

5

6

Section B (36 marks)

7 (i)	
7 (ii)	
7 (iii)	

7 (iv)	
7 (v)	

8 (i)

8 (ii)	

9 (i)	

9 (ii)	

9 (iii)

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

GCE

Mathematics (MEI)

Unit **4755**: Further Concepts for Advanced Mathematics

Advanced Subsidiary GCE

Mark Scheme for June 2018

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.

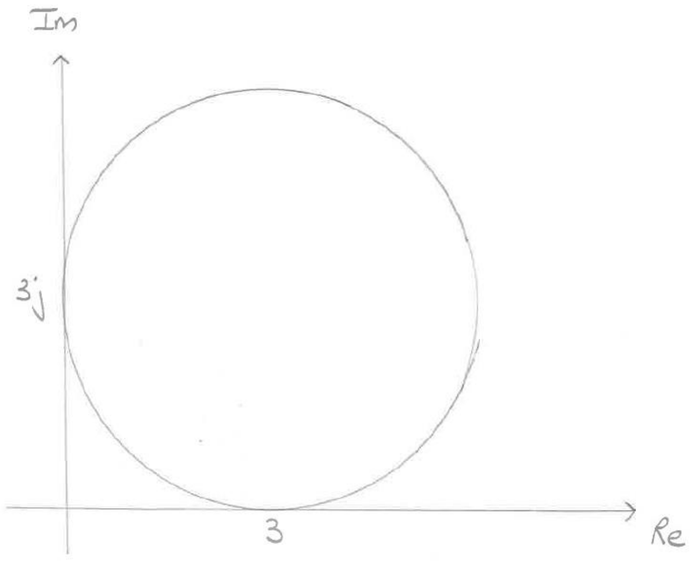
If there are two or more attempts at a question which have not been crossed out, examiners should mark what appears to be the last (complete) attempt and ignore the others.

NB Follow these maths-specific instructions rather than those in the assessor handbook.

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.

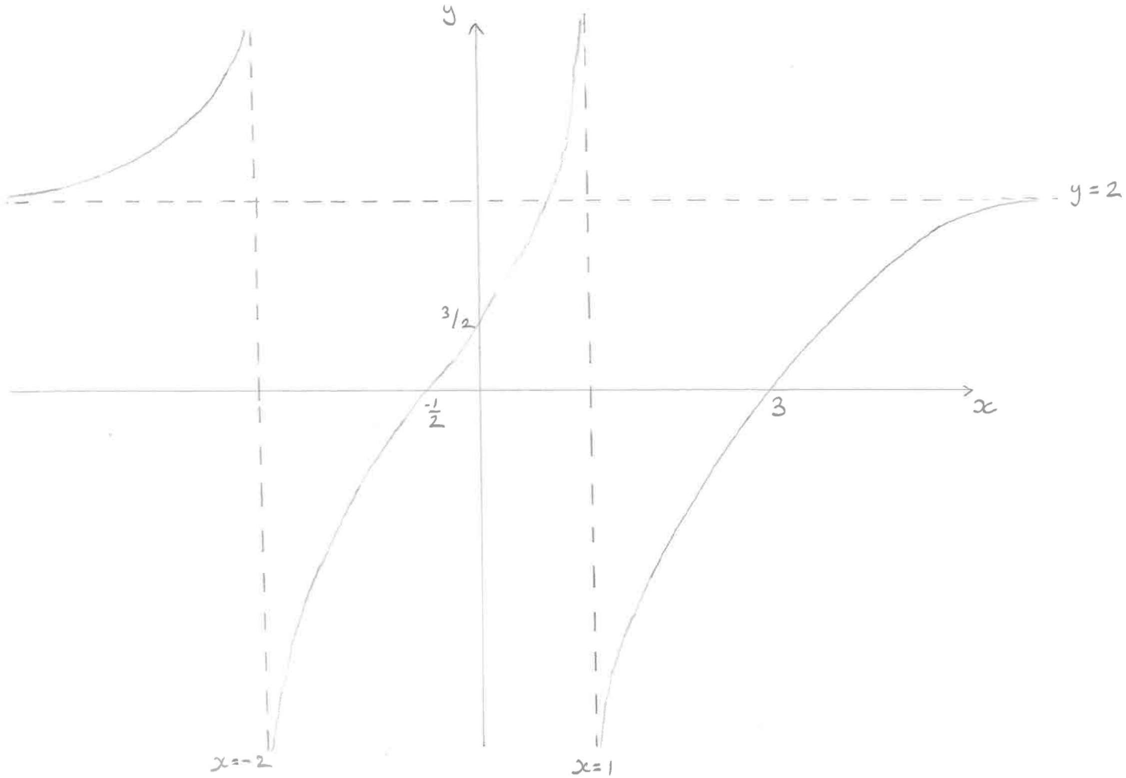
Question		Answer	Marks	Guidance
1	(i)	$\mathbf{AB}=\begin{pmatrix}2 & 2k & -k\\ 0 & 1 & -1\end{pmatrix}\begin{pmatrix}1 & 2\\ 3 & -3\\ -2 & 4\end{pmatrix}=\begin{pmatrix}2+8k & 4-10k\\ 5 & -7\end{pmatrix}$	B1 B1 **[2]**	B1 any two elements correct
1	(ii)	$(2+8k)(-7)-(5)(4-10k)=0$	M1	Attempt at determinant and equate to zero
		$k=-\frac{17}{3}$ o.e.	A1 **[2]**	FT their matrix
2		$(\alpha-\beta)^2=\alpha^2-2\alpha\beta+\beta^2 \Rightarrow (6j)^2=-16-2\alpha\beta$	M1	Expand $(\alpha-\beta)^2$ and substitute given values
		$\alpha\beta=10$	A1	
		$q = 10$	A1	FT their αβ
		$(\alpha+\beta)^2=\alpha^2+2\alpha\beta+\beta^2$ $(\alpha+\beta)^2=-16+20 \Rightarrow \alpha+\beta=L$	M1	Considers expansion of $(\alpha+\beta)^2$, substitutes values and solves for *p* (or other valid method)
		$p=\pm2$	A1 **[5]**	Both answers for *p*, FT their αβ

Question		Answer	Marks	Guidance
3	(i)		B1 B1 **[2]**	Circle Centre $3+3\text{j}$ and radius 3 touching the axes
3	(ii)	$\lvert z\rvert_{\max} = 3+\lvert 3+3\text{j}\rvert$ $= 3+3\sqrt{2}$	M1 A1 **[2]**	3 + attempt at modulus of $\lvert 3+3\text{j}\rvert$
3	(iii)	$\text{Re}\, z = 3-3\sin\dfrac{\pi}{6}$ or $\text{Im}\, z = 3+3\cos\dfrac{\pi}{6}$ $z = \dfrac{3}{2}+\left(\dfrac{3\sqrt{3}}{2}+3\right)\text{j}$	B1 M1 A1 **[3]**	Correctly marking z on Argand diagram, $2\pi/3$ soi on diagram or implied in subsequent working M1 for complete method to find either the real or imaginary part of z

Question		Answer	Marks	Guidance
4	(i)	$\sum_{r=1}^{n} r(2+3r) = 2\sum_{r=1}^{n} r + 3\sum_{r=1}^{n} r^2$	M1	Separate into two sums (may be implied by later working)
		$= 2\left[\frac{n}{2}(n+1)\right] + 3\left[\frac{1}{6}n(n+1)(2n+1)\right]$	M1*	Use of standard results
		$= \frac{1}{2}n(n+1)[2+2n+1]$	M1dep*	Attempt to factorise with either ½ or $n(n + 1)$
		$= \frac{1}{2}n(n+1)(2n+3)$ **(AG)**	E1	cao
			[4]	
4	(ii)	$2n(4n+1)(8n+3)$	B1	Correctly substitutes $4n$ for n in (i)
		$2n(4n+1)(8n+3) = 198n(4n+1) \Rightarrow 8n+3 = 99$	M1	Equate and attempt to solve for n
		$n = 12$	A1	Cao, extra solutions is A0
			[3]	
5		$\sum \text{roots} = (2+5\text{j}) + (2-5\text{j}) + \alpha = \frac{5}{2}$	B1	For using the root $2-5j$
			M1	Attempt at using sum of roots to find real root
		$\alpha = -\frac{3}{2}$	A1	
		$-\frac{q}{2} = (2-5\text{j})(2+5\text{j})\left(-\frac{3}{2}\right)$	M1	Attempt at using product of roots to find q
		$q = 87$		
		$\frac{p}{2} = (2-5\text{j})(2+5\text{j}) + (2+5\text{j})\left(-\frac{3}{2}\right) + \left(-\frac{3}{2}\right)(2-5\text{j})$	M1	Attempt at using $\sum \alpha\beta$ to find p
		$p = 46$	A1	For both p and q cao
		[OR After finding one of p, q substituting a root and solving to find the other]	[M1]	
			[6]	

Question		Answer	Marks	Guidance
		OR		
		$(z-2-5j)(z-2+5j)=z^2-4z+29$	B1 B1	For using 2 – 5*j* For quadratic factor
		$(z^2-4z+29)(az+b)$, $a\neq 1$ or division of cubic by quadratic $a=2, -8+b=-5 \Rightarrow b=3$ or $2z+3$	M1 A1	Quadratic × linear Correct linear factor
		$p=-4b+58, q=29b$ or by inspection of zero remainder	M1	Attempt to equate coefficients and solve for either *p* or *q*
		$p=46, q=87$	A1 **[6]**	Both cao
		OR		
			M1	Attempt to expand both $(2+5\mathrm{j})^2$ and $(2+5\mathrm{j})^3$
		$(2+5\mathrm{j})^2=-21+20\mathrm{j}$	A1	soi
		$(2+5\mathrm{j})^3=-142-65\mathrm{j}$	A1	soi
		$-284-130\mathrm{j}+105-100\mathrm{j}+2p+5p\mathrm{j}+q=0 \Rightarrow 5p=230$ or $2p+q=179$	M1	Substitute and equate either real or imaginary parts
		$p=46$, $q=179-2(46)=87$	M1 A1 **[6]**	Use of other equation Both cao

Question		Answer	Marks	Guidance
6		When $n=1, \sum_{r=1}^{1} r2^r = 1(2^1) = 2$ and $2\left[1+(1-1)2^1\right] = 2(1) = 2$ so true for $n=1$	B1	
		Assume true for $n=k$ that is $\sum_{r=1}^{k} r2^r = 2\left[1+(k-1)2^k\right]$	E1	Assume true for $n=k$
		$\left(\sum_{r=1}^{k+1} r2^r =\right) 2\left[1+(k-1)2^k\right]+(k+1)2^{k+1}$	M1	Add correct term
		$=2\left[1+(k-1)2^k+(k+1)2^k\right]$	M1	Attempt to obtain a factor of 2
		$=2\left[1+(2k)2^k\right]$ $=2\left[1+k2^{k+1}\right]$ $=2\left[1+((k+1)-1)2^{k+1}\right]$	A1	cao with correct simplification
		But this is the given result with $k+1$ replacing k. Therefore if it is true for $n=k$, it is true for $n=k+1$.	E1	Dependent on A1 and first E1
		Since it is true for $n=1$, it is true for $n=1,2,3,...$ and so is true for all positive integers.	E1	Dependent on B1 and second E1
			[7]	
7	(i)	$2x^2-5x-3=0 \Rightarrow (2x+1)(x-3)=0$	M1	Sets numerator equal to zero and attempt to solve
		$x=3$ and $x=-\frac{1}{2}$	A1	
			[2]	
7	(ii)	horizontal asymptote: $y=2$	B1	Allow $y \neq 2$
		$x^2+x-2=0 \Rightarrow (x-1)(x+2)=0$	M1	Sets denominator equal to zero and attempt to solve
		vertical asymptotes: $x=1$ and $x=-2$	A1	A0 if $\neq$ has been used anywhere
			[3]	

Question		Answer	Marks	Guidance
7	(iii)	Some evidence of method needed e.g. substitute in 'large' values or argument involving signs Large positive x, $y \to 2^-$ and large negative x, $y \to 2^+$	M1 A1 **[2]**	
7	(iv)		B1 B1 B1 **[3]**	3 branches correct Asymptotes correct and labelled Intercepts correct and labelled
7	(v)	$x < -2, -\frac{1}{2} \le x < 1, x \ge 3$	B3 **[3]**	One mark for each. Correct inequality signs (B3 then –1 if more than 3 inequalities) SC B1 *y* used instead of *x*

Question		Answer	Marks	Guidance
8	(i)	$\sum_{r=1}^{n}\frac{1}{(2r-1)(2r+3)}=\frac{1}{4}\sum_{r=1}^{n}\frac{1}{2r-1}-\frac{1}{2r+3}$	M1	Use of given result, at least three consecutive terms of the series, ignore ¼
		$=\frac{1}{4}\left[\left(1-\frac{1}{5}\right)+\left(\frac{1}{3}-\frac{1}{7}\right)+\left(\frac{1}{5}-\frac{1}{9}\right)+\ldots+\left(\frac{1}{2n-3}-\frac{1}{2n+1}\right)+\left(\frac{1}{2n-1}-\frac{1}{2n+3}\right)\right]$	A1 A1	First three terms correct Last two terms correct
		$\sum_{r=1}^{n}\frac{1}{(2r-1)(2r+3)}=\frac{1}{4}\left(1+\frac{1}{3}-\frac{1}{2n+1}-\frac{1}{2n+3}\right)$	A1	For reduced terms after cancelling, ignore 1/4
		$=\frac{1}{3}-\frac{1}{4}\left(\frac{(2n+3)+(2n+1)}{(2n+1)(2n+3)}\right)=\frac{1}{3}-\frac{1}{4}\left(\frac{4n+4}{(2n+1)(2n+3)}\right)$	M1	Attempt to combine their algebraic fractions
		$=\frac{1}{3}-\frac{(n+1)}{(2n+1)(2n+3)}$ so $k=\frac{1}{3}$	E1	All correctly done
			[6]	
8	(ii)	Infinite series, $S_\infty = k$	B1	Sum to infinity equals their k soi
		$\frac{n+1}{(2n+1)(2n+3)}=\frac{7}{195}$	M1	Difference of S_∞ and S_n
		$28n^2-139n-174=0$ **AG**	E1	www
		$(28n+29)(n-6)=0$	M1	Attempt to solve quadratic
		$n=6$	A1	Withhold if $n=-29/28$ stated as final answer
			[5]	

Question		Answer	Marks	Guidance
9	(i)	$\begin{pmatrix}4 & a\\ -6 & -2\end{pmatrix}\begin{pmatrix}1\\ -2\end{pmatrix}=\begin{pmatrix}1\\ -2\end{pmatrix}$	M1	$\mathbf{Mx}=\mathbf{x}$ with $\mathbf{x}=\begin{pmatrix}1\\ -2\end{pmatrix}$
		$4-2a=1 \Rightarrow a=\frac{3}{2}$	A1 **[2]**	
9	(ii)	$\left(\mathbf{NM}^{-1}\right)^{-1}=\mathbf{MN}^{-1}$	M1*	Use of $\left(\mathbf{AB}\right)^{-1}=\mathbf{B}^{-1}\mathbf{A}^{-1}$ or premultiply both sides by $\mathbf{NM}^{-1}$
		$\mathbf{M}^2=\mathbf{N}$ or $\mathbf{M}=\mathbf{M}^{-1}\mathbf{N}$	A1	
		$\mathbf{M}^2=\begin{pmatrix}16-6a & 2a\\ -12 & 4-6a\end{pmatrix} \Rightarrow \begin{pmatrix}16-6a & 2a\\ -12 & 4-6a\end{pmatrix}=\begin{pmatrix}-2 & 6\\ -4a & -14\end{pmatrix}$	M1dep*	Forming an equation in a SC B1 Following M0 M0 for $\mathbf{NM}^{-1}$ or $\mathbf{MN}^{-1}$ correct
		$\mathbf{M}^{-1}\mathbf{N}=\frac{1}{6a-8}\begin{pmatrix}4+4a^2 & 14a-12\\ -12-16a & -20\end{pmatrix} \Rightarrow \frac{1}{6a-8}\begin{pmatrix}4+4a^2 & 14a-12\\ -12-16a & -20\end{pmatrix}=\begin{pmatrix}4 & a\\ -6 & -2\end{pmatrix}$		
		$a=3$	A1 **[4]**	
9	(iii)	$\det \mathbf{M}=4(-2)-a(-6)$	M1	Attempt at determinant of $\mathbf{M}$ allow $ad \pm bc$
		$9(6a-8)=144$ o.e.	M1	Sets up one equation with their determinant and correct use of 9 and 144
		$6a-8=16 \Rightarrow a=4$	A1 A1	A correct equation $a=4$
		$9(6a-8)=-144$	M1	Sets up a second equation with their determinant and correct use of 9 and –144
		$6a-8=-16 \Rightarrow a=-\frac{4}{3}$ o.e.	A1 **[6]**	

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AS/A LEVEL GCE

Examiners' report

MATHEMATICS (MEI)

3895-3898, 7895-7898

4755/01 Summer 2018 series

Version 1

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Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates. The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report. A full copy of the question paper can be downloaded from OCR.

Paper 4755/01 series overview

The overall standard this year was high. Very few candidates appeared to be severely challenged by the questions and most were able to complete the examination in the time allowed.

On the whole the concepts of complex numbers, proof by induction and curve sketching were well understood, matrices less so. There was frequently shown to be a poor grasp of the rules of matrix multiplication.

Candidates do well when they automatically write correct expressions both legibly and with careful attention to signs and the need for brackets. Their sketches need to be made with care and full annotation. Calculator use is available but there is still a need to show full working or justification for results.

As usual, algebraic manipulation is not as good as it should be and candidates need to remember what happens to signs when brackets are inserted and negative numbers are involved, skills that should by this stage be well understood and used. Some answers were spoiled by arithmetical slips.

Section A overview

Questions 1, 4, 5 and 6 were on the whole the best answered in this section. The questions that caused candidates the most difficulty were 2, 3(ii) and 3(iii). Question 2 produced an interesting variety of solutions for the finding of *p*.

Question 1(i)

1 The matrices **A** and **B** are given by $\mathbf{A} = \begin{pmatrix} 2 & 2k & -k \\ 0 & 1 & -1 \end{pmatrix}$ and $\mathbf{B} = \begin{pmatrix} 1 & 2 \\ 3 & -3 \\ -2 & 4 \end{pmatrix}$, where k is a constant.

(i) Find, in terms of k, the matrix **AB**. **[2]**

Nearly all candidates began well earning these two marks. There were mistakes involving signs. In working through the second row 3 × 2 and –3 × –4 were seen. Rarely, the product **BA** was found instead of **AB**.

Question 1(ii)

(ii) Find the value of k for which matrix **AB** is singular. **[2]**

The vast majority of candidates understood what was required here and gained the 2 marks. Of the errors the most common was to go from e.g. $6k = -34$ to $k = \frac{17}{3}$, omitting the minus sign. A few candidates thought that the determinant should equal 1. Some confused the determinant with $\frac{1}{\text{determinant}}$, somehow (incorrectly) leading to the correct result.

Question 2

2 The quadratic equation $x^2 + px + q = 0$ has roots α and β, where

$$\alpha^2 + \beta^2 = -16,$$
$$\alpha - \beta = 6\text{j}.$$

By considering $(\alpha - \beta)^2$, find the value of $\alpha\beta$. Hence state the value of q and find the possible values of p. **[5]**

Most candidates earned the 3 marks for finding *αβ* and *q,* although some preferred not to state the value of *αβ* explicitly, rather ignoring the request.

Many were unable to find *p*.

The errors most often seen when finding *αβ* and *q* were:-

- squaring 6j to get –6
- expanding $(\alpha - \beta)^2$ as $\alpha^2 + \beta^2 - \alpha\beta$
- thinking that the product of the roots was –*q*
- writing $(\alpha - \beta)^2 = 0$ and rearranging to get $\alpha\beta = -8$.

Surprisingly many candidates ignored using the obvious expansion of $(\alpha + \beta)^2$ when attempting to find *p*. Errors seen were:-

- assuming that the roots occurred as complex conjugate pairs. This is not stated in the question (compare with question 5 where the coefficients are given to be real).
- misunderstanding the question wording "… possible values of *p*" by looking at the discriminant and starting with $p^2 - 4q > 0$ ....
- solving simultaneous equations by substituting $\alpha = 6\text{j} + \beta$ (or $\beta = 6\text{j} + \alpha$) in $\alpha^2 + \beta^2 = -16$ and ending up with a fourth-order equation. They could usually solve this to find values for α^2 (or β^2) but were unable to proceed. Only two of the four solutions led to the correct value of *αβ*.
- solving simultaneous equations by substituting $\alpha = \frac{10}{\beta}$ (or $\beta = \frac{10}{\alpha}$) in $\alpha - \beta = 6\text{j}$. They would solve the resulting equation using the formula but instead of writing (e.g.) $\alpha = 3\text{j} + 1$ and $3\text{j} - 1$ (which their formula indicated) they would write $\alpha = +3\text{j} + 1$ and $-3\text{j} - 1$ (presumably because they were so accustomed to seeing the complex solutions to quadratic equations as $a \pm b\text{j}$). This was seen many times.

Question 3(i)

3 **(i)** Sketch on an Argand diagram the set of points representing complex numbers z for which

$$|z - (3 + 3\text{j})| = 3.$$ **[2]**

Most candidates earned both marks. Some candidates did not annotate their sketch and so lost a mark.

Question 3(ii)

(ii) Find the greatest possible value of $|z|$ for this set of points. **[2]**

This was reasonably well done. The most common error was for candidates to think that the greatest possible value of $|z|$ occurred when z was at the point 6 + 3j and so $\sqrt{45}$ e was often seen. Some candidates also thought z was at 6 + 6j.

Question 3(iii)

(iii) Mark on your Argand diagram the particular point for which $\arg\left(z-(3+3\text{j})\right)=\frac{2}{3}\pi$. Find this value of z in the form $a+\text{j}b$. **[3]**

Marks were lost by candidates marking z but not indicating the angle $\frac{2}{3}\pi$ on their diagram. The main error was that candidates just used z as $3\left[\cos\left(\frac{2}{3}\pi\right)+\text{j}\sin\left(\frac{2}{3}\pi\right)\right]$ without thinking where the point was. Candidates who found the real part of z to be $\frac{3}{2}$ should have shown explicitly that this came from $3+3\cos\left(\frac{2}{3}\pi\right)$, or equivalently $3-3\cos\left(\frac{1}{3}\pi\right)$.

Question 4(i)

4 **(i)** Use standard series formulae to show that

$$\sum_{r=1}^{n} r(2+3r)=\tfrac{1}{2}n(n+1)(2n+3).$$ **[4]**

Almost all candidates earned 4 marks here, the odd error being in the algebraic manipulation. Some candidates multiplied out and factorised back rather than spotting the common factors and saving time.

Question 4(ii)

(ii) Hence find the value of n such that

$$\sum_{r=1}^{4n} r(2+3r)=198n(4n+1).$$ **[3]**

This question part was also done well. There were two main areas where candidates went astray.

- Some candidates substituted $4n$ in place of n only once i.e. simply multiplied the expression by 4 to give $2n(n+1)(2n+1) = 198n(4n+1)$.
- Some candidates solved correctly but gave either $n = 0$ or $n = -\frac{1}{4}$ (or both) as answers.

Quite a few candidates did not see that the (correct) equation could be factorised/cancelled down to give $8n + 3 = 99$ and instead multiplied the expression out and rearranged. This led to a few errors in the algebraic manipulation.

Question 5

5 You are given that $z = 2 + 5\mathrm{j}$ is a root of the cubic equation $2z^3 - 5z^2 + pz + q = 0$, where p and q are real constants. Find the values of p and q. **[6]**

This question was also well done, with many candidates earning full marks. There were three main methods used, as outlined in the mark scheme and the responses were split fairly equally between the three methods. Some candidates used a mixture of methods.

Those who evaluated $(2 + 5\mathrm{j})^2$ and $(2 + 5\mathrm{j})^3$ were the most prone to making errors in the algebraic manipulation, but almost all gained the 3 method marks.

Those who produced a quadratic factor probably fared best, if only slightly. The two chief sources of error were in the quadratic factor itself, where $z^2 - 4z - 21$, $z^2 - 4z + 9$ and $z^2 - 4z + 25$ were all seen.

The main errors using the sums and product of roots were either the manipulation (especially the sum of the pairs of products), or writing that the sum of the roots was $+\frac{5}{2}$, the sum of the product-pairs was $-\frac{p}{2}$, or that the product of the roots was $\frac{q}{2}$.

Question 6

6 Prove by induction that, for all positive integers n, $\sum_{r=1}^{n} r2^r = 2[1+(n-1)2^n]$. **[7]**

This question topic was encouragingly well answered this year. The majority of candidates were able to work through the inductive process correctly, following closely the argument which has always been advocated in the mark scheme and in these reports.

There are still careless omissions in presentation. Some begin "assume $n = k$" or "$n = k$". Often the $(k + 1)$th term is written as equal to the sum plus this last term. Where sigma appears the notation used often moves k into the general term instead of the limit of summation.

There are still candidates who try to finish off with their own wording, for example "... and so it is true for $n = k$ and for $n = k + 1$". The phrase "$n = k$ is true so $n = k + 1$ is true" also makes its regular appearance.

Clear handwriting is advised to ensure that indices do not become confused with coefficients e.g. 2^{k+1} becoming $2k + 1$ in the following line.

Another source of error came about when candidates multiplied out the whole expression. All the '2's and 'k's caused confusion thus some candidates ended up with $2k^k$ instead of $k2^k$, which was seen fairly often.

Section B overview

Question 7 was by far the most successfully answered question in this section. Question 8(i) required clear presentation which was not always given, and question 8(ii) caused many candidates some difficulty. Parts of question 9 were well answered. Matrix multiplication in question 9(ii) was a very weak area, with incorrect working often leading to an apparently correct result.

Question 7(i)

7 A curve has equation $y = \dfrac{2x^2 - 5x - 3}{x^2 + x - 2}$.

(i) Find the values of x for which $y = 0$. **[2]**

Nearly all candidates gained 2 marks here. Errors, such as factorising incorrectly, e.g. $(2x - 1)(x + 3)$ or equating the denominator to zero, were few and far between.

Question 7(ii)

(ii) Find the equations of the three asymptotes. **[3]**

Again, nearly all candidates gained full marks here. There were the usual errors, writing $x = 1, -2$ instead of $x = 1$ and $x = -2$, or writing $y \to 2$ instead of $y = 2$, and of course factorising as $(x + 1)(x - 2)$.

Question 7(iii)

(iii) Determine whether the curve approaches the horizontal asymptote from above or below for

(A) large positive values of x,

(B) large negative values of x. **[2]**

Candidates need to be aware of what constitutes mathematical justification for this type of question. Unsupported statements such as "when x is large the curve approaches the value 2 from below …." is insufficient. Using a graphical calculator the result can be seen, and the wording of the question is "determine whether…". It should be emphasised to candidates that they need to support their statements by for example choosing a large value of x, substituting this value into the expression and producing an answer before stating the result. Any work shown must be complete and thorough. Very able candidates lost marks here.

Question 7(iv)

(iv) Sketch the curve. **[3]**

Overall this question was answered well. Where a mark was lost it was usually through neglecting to annotate the points where the graph crossed the axis at $x = -\frac{1}{2}$ and at $y = \frac{3}{2}$. This latter point was not part of the previous requests and candidates need to remember that a sketch should show all salient points like this. Some annotations were extremely difficult to read after the scanning process, and on the x-axis '1' in particular had a tendency to disappear into the dashed line which showed the asymptote.

Question 7(v)

(v) Solve the inequality $\dfrac{2x^2-5x-3}{x^2+x-2} \geqslant 0$. **[3]**

Apart from candidates who had gone astray in parts (i) or (ii), the chief errors made were in the inequality signs. Often seen were $x \le -2$, $x > 3$, $-\frac{1}{2} < x < 1$ or $-\frac{1}{2} \le x \le 1$.

8 You are given that $\dfrac{1}{2r-1} - \dfrac{1}{2r+3} = \dfrac{4}{(2r-1)(2r+3)}$ for all integers r.

(i) Use the method of differences to show that

$$\sum_{r=1}^{n} \frac{1}{(2r-1)(2r+3)} = k - \frac{n+1}{(2n+1)(2n+3)},$$

stating the value of k. **[6]**

Question 8(i)

This question was done well providing candidates wrote out a few terms in full. Errors occurred where only the first 2 terms were written out, and/or the last term rather than the final two terms. After cancelling candidates were left with "1" at the beginning, rather than "1 + $\frac{1}{3}$" ,erroneously assuming that all the numerical terms cancelled except for the initial '1'. Also this meant that where only the final term was given only one algebraic term remained, "$-\frac{1}{2n+3}$" instead of "$-\frac{1}{2n+1} - \frac{1}{2n+3}$".

Candidates must take care with signs when inserting brackets as errors of this nature occur each year e.g. the two fractions $-\frac{1}{2n+1} - \frac{1}{2n+3}$ became $-\left[\frac{1}{2n+1} - \frac{1}{2n+3}\right]$. Deriving the final expression which was given, then introduced another error in the working.

The value of k was requested explicitly and should have been clearly stated, not left within the result to be inferred.

Question 8(ii)

(ii) The sum of the infinite series

$$\frac{1}{(2(n+1)-1)(2(n+1)+3)}+\frac{1}{(2(n+2)-1)(2(n+2)+3)}+\frac{1}{(2(n+3)-1)(2(n+3)+3)}+\dots$$

is $\frac{7}{195}$. Show that n satisfies $28n^2-139n-174=0$ and hence find the value of n. **[5]**

Deriving the given equation was poorly done.

Many candidates did not read the question carefully and simply equated their answer in part (i) to $\frac{7}{195}$.

Those that correctly realised that the given series was the difference between the sum to infinity and their answer from part (i) were able to derive the equation.

By writing out terms of the series a few candidates realised that only two fractions from the initial pair of terms remained, which combined to give the correct equation. Sometimes the $\frac{1}{4}$ was forgotten.

Most candidates, whether they were able to derive the required equation or not, were able to solve the quadratic equation given, although a fair number did not reject $n=-\frac{29}{28}$ as an answer and so lost a mark. Ideally either the use of the quadratic formula or the factorisation of the expression should have been shown, even if the figures had been obtained using a calculator.

Question 9(i)

9 You are given that $\mathbf{M}=\begin{pmatrix}4 & a\\-6 & -2\end{pmatrix}$ and $\mathbf{N}=\begin{pmatrix}-2 & 6\\-4a & -14\end{pmatrix}$, where a is a real constant. Find the possible value(s) of a in each of the following cases.

(i) The point (1, –2) is invariant under the transformation represented by matrix **M**. **[2]**

This was done well although some candidates made life hard for themselves by solving $\begin{pmatrix}4 & a\\-6 & -2\end{pmatrix}\begin{pmatrix}x\\y\end{pmatrix}=\begin{pmatrix}1\\-2\end{pmatrix}$ and manipulating the resulting simultaneous equations (often unsuccessfully) eventually inserting $x = 1$ or $y = -2$.

Question 9(ii)

(ii) $(\mathbf{NM}^{-1})^{-1}\mathbf{NM}=\mathbf{N}$. **[4]**

This was very poorly done. There was much 'leapfrogging' of matrices and most candidates showed a complete lack of understanding that matrix multiplication is not commutative. Many candidates derived $M^2 = N$ and then $a = 3$ to no avail, because their first line had been something like $(N^{-1}M)NM = N$ or $NM = N(NM^{-1})$.

Many candidates attempted to evaluate $(NM^{-1})^{-1}NM$ which resulted in a couple of pages of working and only a tiny number succeeded by this method.

Question 9(iii)

(iii) A triangle T_1 has an area of 9 square units. The triangle T_1 is transformed to triangle T_2 by the transformation represented by matrix **M**. The area of triangle T_2 is 144 square units. **[6]**

Most candidates gained the first 4 marks with ease. Only a small minority of candidates realised that the area scale factor might be negative.

There were mistakes made in calculating the determinant of M, with $-8-6a$ often seen. The resulting equation was also sometimes manipulated incorrectly, thus $9(6a-8) = 144$ became $54a-8 = 144$ or $6a-8 = 16$ became $6a = -24$, or similar.

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AS GCE / Advanced GCE / AS GCE Double Award / Advanced GCE Double Award

AS & Advanced GCE Mathematics											
				Max Mark	a	b	c	d	e	u
4721	01	C1 Core mathematics 1 (AS)	Raw	72	61	55	50	45	40	0
			UMS	100	80	70	60	50	40	0
4722	01	C2 Core mathematics 2 (AS)	Raw	72	55	49	43	37	31	0
			UMS	100	80	70	60	50	40	0
4723	01	C3 Core mathematics 3 (A2)	Raw	72	55	48	41	34	28	0
			UMS	100	80	70	60	50	40	0
4724	01	C4 Core mathematics 4 (A2)	Raw	72	54	47	40	34	28	0
			UMS	100	80	70	60	50	40	0
4725	01	FP1 Further pure mathematics 1 (AS)	Raw	72	56	50	45	40	35	0
			UMS	100	80	70	60	50	40	0
4726	01	FP2 Further pure mathematics 2 (A2)	Raw	72	59	53	47	41	35	0
			UMS	100	80	70	60	50	40	0
4727	01	FP3 Further pure mathematics 3 (A2)	Raw	72	47	41	36	31	26	0
			UMS	100	80	70	60	50	40	0
4728	01	M1 Mechanics 1 (AS)	Raw	72	60	51	42	34	26	0
			UMS	100	80	70	60	50	40	0
4729	01	M2 Mechanics 2 (A2)	Raw	72	53	46	39	32	26	0
			UMS	100	80	70	60	50	40	0
4730	01	M3 Mechanics 3 (A2)	Raw	72	50	42	34	27	20	0
			UMS	100	80	70	60	50	40	0
4731	01	M4 Mechanics 4 (A2)	Raw	72	59	53	47	42	37	0
			UMS	100	80	70	60	50	40	0
4732	01	S1 – Probability and statistics 1 (AS)	Raw	72	57	50	43	36	29	0
			UMS	100	80	70	60	50	40	0
4733	01	S2 – Probability and statistics 2 (A2)	Raw	72	56	49	42	35	28	0
			UMS	100	80	70	60	50	40	0
4734	01	S3 – Probability and statistics 3 (A2)	Raw	72	59	50	41	32	24	0
			UMS	100	80	70	60	50	40	0
4735	01	S4 – Probability and statistics 4 (A2)	Raw	72	56	49	42	35	28	0
			UMS	100	80	70	60	50	40	0
4736	01	D1 – Decision mathematics 1 (AS)	Raw	72	55	48	42	36	30	0
			UMS	100	80	70	60	50	40	0
4737	01	D2 – Decision mathematics 2 (A2)	Raw	72	58	53	48	44	40	0
			UMS	100	80	70	60	50	40	0

Oxford Cambridge and RSA

AS & Advanced GCE Mathematics (MEI)

				Max Mark	a	b	c	d	e	u
4751	01	C1 – Introduction to advanced mathematics (AS)	Raw	72	60	55	50	45	40	0
			UMS	100	80	70	60	50	40	0
4752	01	C2 – Concepts for advanced mathematics (AS)	Raw	72	53	47	41	36	31	0
			UMS	100	80	70	60	50	40	0
4753	01	(C3) Methods for Advanced Mathematics (A2): Written Paper	Raw	72	61	56	51	46	40	0
4753	02	(C3) Methods for Advanced Mathematics (A2): Coursework	Raw	18	15	13	11	9	8	0
4753	82	(C3) Methods for Advanced Mathematics (A2): Carried Forward Coursework Mark	Raw	18	15	13	11	9	8	0
			UMS	100	80	70	60	50	40	0
4754	01	C4 – Applications of advanced mathematics (A2)	Raw	90	63	56	49	43	37	0
			UMS	100	80	70	60	50	40	0
4755	01	FP1 – Further concepts for advanced mathematics (AS)	Raw	72	55	51	47	43	40	0
			UMS	100	80	70	60	50	40	0
4756	01	FP2 – Further methods for advanced mathematics (A2)	Raw	72	48	42	36	31	26	0
			UMS	100	80	70	60	50	40	0
4757	01	FP3 – Further applications of advanced mathematics (A2)	Raw	72	63	56	49	42	35	0
			UMS	100	80	70	60	50	40	0
4758	01	(DE) Differential Equations (A2): Written Paper	Raw	72	61	54	48	42	35	0
4758	02	(DE) Differential Equations (A2): Coursework	Raw	18	15	13	11	9	8	0
4758	82	(DE) Differential Equations (A2): Carried Forward Coursework Mark	Raw	18	15	13	11	9	8	0
			UMS	100	80	70	60	50	40	0
4761	01	M1 – Mechanics 1 (AS)	Raw	72	51	44	37	31	25	0
			UMS	100	80	70	60	50	40	0
4762	01	M2 – Mechanics 2 (A2)	Raw	72	59	53	47	41	35	0
			UMS	100	80	70	60	50	40	0
4763	01	M3 – Mechanics 3 (A2)	Raw	72	61	54	48	42	36	0
			UMS	100	80	70	60	50	40	0
4764	01	M4 – Mechanics 4 (A2)	Raw	72	59	51	44	37	30	0
			UMS	100	80	70	60	50	40	0
4766	01	S1 – Statistics 1 (AS)	Raw	72	59	53	47	42	37	0
			UMS	100	80	70	60	50	40	0
4767	01	S2 – Statistics 2 (A2)	Raw	72	54	47	41	35	29	0
			UMS	100	80	70	60	50	40	0
4768	01	S3 – Statistics 3 (A2)	Raw	72	61	54	47	41	35	0
			UMS	100	80	70	60	50	40	0
4769	01	S4 – Statistics 4 (A2)	Raw	72	56	49	42	35	28	0
			UMS	100	80	70	60	50	40	0
4771	01	D1 – Decision mathematics 1 (AS)	Raw	72	50	44	38	32	26	0
			UMS	100	80	70	60	50	40	0
4772	01	D2 – Decision mathematics 2 (A2)	Raw	72	55	51	47	43	39	0
			UMS	100	80	70	60	50	40	0
4773	01	DC – Decision mathematics computation (A2)	Raw	72	46	40	34	29	24	0
			UMS	100	80	70	60	50	40	0
4776	01	(NM) Numerical Methods (AS): Written Paper	Raw	72	57	52	48	44	39	0
4776	02	(NM) Numerical Methods (AS): Coursework	Raw	18	14	12	10	8	7	0
4776	82	(NM) Numerical Methods (AS): Carried Forward Coursework Mark	Raw	18	14	12	10	8	7	0
			UMS	100	80	70	60	50	40	0
4777	01	NC – Numerical computation (A2)	Raw	72	55	47	39	32	25	0
			UMS	100	80	70	60	50	40	0
4798	01	FPT - Further pure mathematics with technology (A2)	Raw	72	57	49	41	33	26	0
			UMS	100	80	70	60	50	40	0

AS GCE Statistics (MEI)

				Max Mark	a	b	c	d	e	u
G241	01	Statistics 1 MEI	Raw	72		No entry in June 2018				
			UMS	100	80	70	60	50	40	0
G242	01	Statistics 2 MEI	Raw	72		No entry in June 2018				
			UMS	100	80	70	60	50	40	0
G243	01	Statistics 3 MEI	Raw	72		No entry in June 2018				
			UMS	100	80	70	60	50	40	0

AS GCE Quantitative Methods (MEI)

				Max Mark	a	b	c	d	e	u
G244	01	Introduction to Quantitative Methods (Written Paper)	Raw	72	58	50	43	36	28	0
G244	02	Introduction to Quantitative Methods (Coursework)	Raw	18	14	12	10	8	7	0
			UMS	100	80	70	60	50	40	0
G245	01	Statistics 1	Raw	72	61	55	49	43	37	0
			UMS	100	80	70	60	50	40	0
G246	01	Decision Mathematics 1	Raw	72	50	44	38	32	26	0
			UMS	100	80	70	60	50	40	0

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Level 3 Certificate Mathematics - Quantitative Methods (MEI)

					Max Mark	a	b	c	d	e	u
G244	A	01	Introduction to Quantitative Methods with Coursework (Written Paper)	Raw	72	58	50	43	36	28	0
G244	A	02	Introduction to Quantitative Methods with Coursework (Coursework)	Raw	18	14	12	10	8	7	0
				UMS	100	80	70	60	50	40	0
				Overall	90	72	62	53	44	35	0

Level 3 Certificate Mathematics - Quantitative Reasoning (MEI)

				Max Mark	a	b	c	d	e	u
H866	01	Introduction to quantitative reasoning	Raw	72	56	49	42	35	28	0
H866	02	Critical maths	Raw	60	44	39	34	29	24	0
		*To create the overall boundaries, component 02 is weighted to give marks out of 72	Overall	144	109	96	83	70	57	0

Level 3 Certificate Mathematics - Quantitative Problem Solving (MEI)

				Max Mark	a	b	c	d	e	u
H867	01	Introduction to quantitative reasoning	Raw	72	56	49	42	35	28	0
H867	02	Statistical problem solving	Raw	60	40	36	32	28	24	0
		*To create the overall boundaries, component 02 is weighted to give marks out of 72	Overall	144	104	92	80	69	57	0

Advanced Free Standing Mathematics Qualification (FSMQ)

				Max Mark	a	b	c	d	e	u
6993	01	Additional Mathematics	Raw	100	56	50	44	38	33	0

Intermediate Free Standing Mathematics Qualification (FSMQ)

				Max Mark	a	b	c	d	e	u
6989	01	Foundations of Advanced Mathematics (MEI)	Raw	40	35	30	25	20	16	0