OCR
Oxford Cambridge and RSA

Tuesday 19 June 2018 – Afternoon

A2 GCE MATHEMATICS (MEI)

4753/01 Methods for Advanced Mathematics (C3)

QUESTION PAPER

Candidates answer on the Printed Answer Book.

OCR supplied materials:
- Printed Answer Book 4753/01
- 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 **8** 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 A point P moves round the curve with equation $3x^2 + 4y^2 = 4$. At time t, P is at the point (x, y), as shown in Fig. 1.

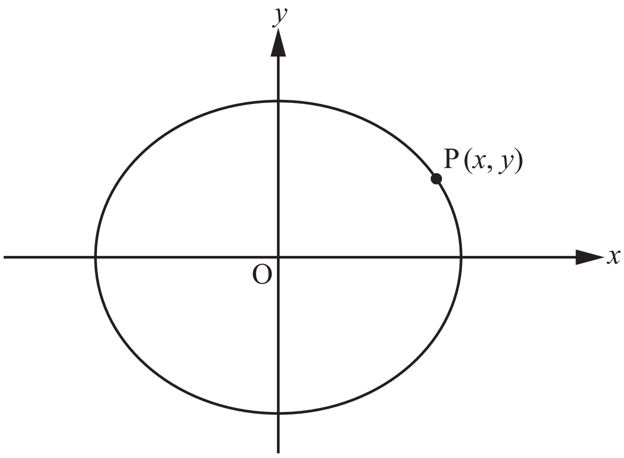

Fig. 1

(i) Find $\frac{\mathrm{d}y}{\mathrm{d}x}$ in terms of x and y. **[2]**

(ii) When P is at the point on the curve with x-coordinate 1 and positive y-coordinate, $\frac{\mathrm{d}x}{\mathrm{d}t} = 4$.

Find $\frac{\mathrm{d}y}{\mathrm{d}t}$ at this point. **[4]**

2 The three functions $\mathrm{f}(x)$, $\mathrm{g}(x)$ and $\mathrm{h}(x)$ are defined as follows:

$$\mathrm{f}(x) = \frac{x}{1-2x^2}, \quad \mathrm{g}(x) = 1 + \sin 2x \quad \text{and} \quad \mathrm{h}(x) = 3\mathrm{e}^{-2x^2}.$$

In the table in the Answer Book, write Yes or No in each space to indicate whether the function is odd, whether it is even, and whether it is periodic. If a function is periodic, state its period. **[4]**

3 The mass of a radioactive material decreases exponentially. Its *half-life* is the time required for the mass of the material to reduce to half its initial value. The half-life of plutonium 241 is 14.4 years.

(i) Write down the percentage of the initial mass of plutonium 241 remaining after 28.8 years. **[1]**

(ii) The mass M grams of plutonium 241 at time t years is given by the equation

$$M = M_0\mathrm{e}^{-kt},$$

where M_0 grams is the initial mass and k is a constant. Find k, giving your answer correct to two significant figures. **[3]**

4 Fig. 4 shows part of the curve with equation $y = e^{-x} \sin 2x$.

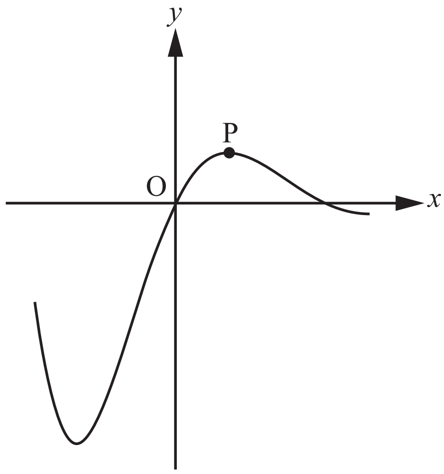

Fig. 4

Find the coordinates of the maximum point P. **[6]**

5 **(i)** On the same axes, sketch the graphs of $y = -|x+1|$ and $y = 2x$. **[3]**

(ii) Solve the equation $-|x+1| = 2x$. **[2]**

6 The function $h(x)$ is such that $h(x) = fg(x)$, where $f(x) = 2x + \frac{1}{2}\pi$ for $x \in \mathbb{R}$ and $g(x) = \arcsin x$ for $-1 \leqslant x \leqslant 1$.

(i) Find $h\left(\frac{1}{2}\right)$, giving your answer as a multiple of π. **[2]**

(ii) Find $h^{-1}(x)$. **[4]**

7 Prove that $n^3 - 3n^2 + 2n$ is divisible by 6 for all positive integers n. **[5]**

Section B (36 marks)

8 Fig. 8 shows the curve with equation $y = \dfrac{2\sqrt{x}}{1+\sqrt{x}}$. The tangent to the curve at P (1, 1) intersects the y-axis at Q.

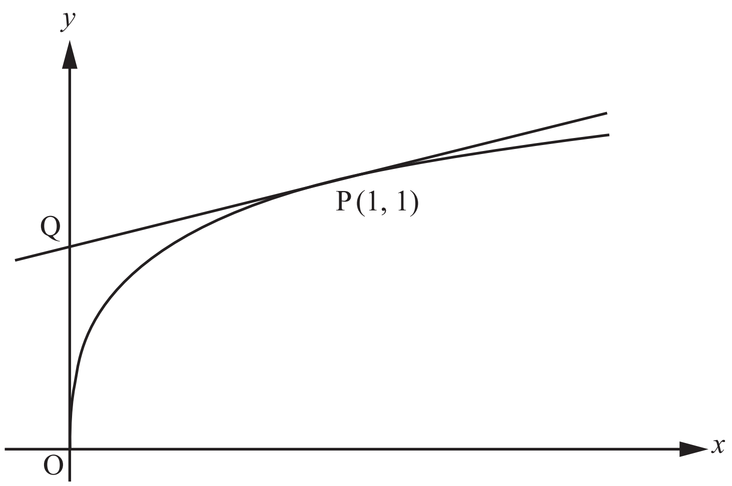

Fig. 8

(i) Show that $\dfrac{\mathrm{d}y}{\mathrm{d}x} = \dfrac{1}{\sqrt{x}(1+\sqrt{x})^2}$.

Hence find the equation of PQ, giving your answer in the form $ax + by + c = 0$, where a, b and c are integers. **[7]**

(ii) Show that the substitution $u = 1 + \sqrt{x}$ transforms $\displaystyle\int \frac{2\sqrt{x}}{1+\sqrt{x}}\mathrm{d}x$ to $\displaystyle\int \frac{4(u-1)^2}{u}\mathrm{d}u$. **[3]**

(iii) Hence find the exact area of the region enclosed by the curve, the y-axis and the line PQ. **[8]**

9 Fig. 9 shows the curves with equations $y = \ln x$ and $y = 2\ln(x-2)$ which intersect at Q. The curve $y = 2\ln(x-2)$ crosses the x-axis at P.

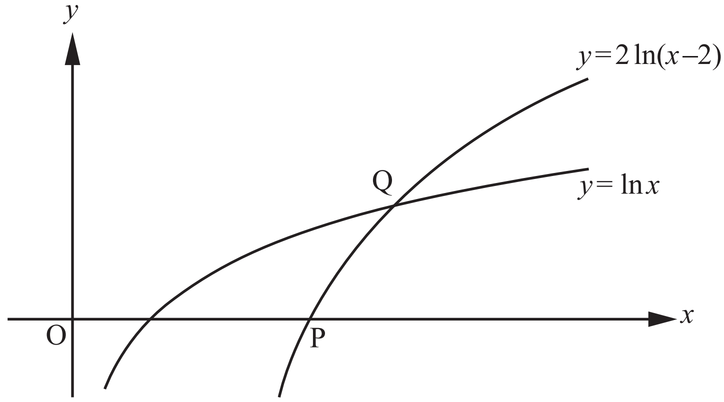

Fig. 9

(i) Describe a sequence of two transformations which maps the curve $y = \ln x$ onto the curve $y = 2\ln(x-2)$. **[3]**

(ii) Find the exact coordinates of P and Q. **[5]**

(iii) Using integration by parts, show that $\int \ln x \, dx = x\ln x - x + c$, where c is an arbitrary constant. **[3]**

(iv) Hence show that the area of the finite region enclosed by the curve $y = \ln x$, the curve $y = 2\ln(x-2)$ and the x-axis is $m\ln 2 + n$, where m and n are integers to be determined. **[7]**

END OF QUESTION PAPER

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A2 GCE MATHEMATICS (MEI)

4753/01 Methods for Advanced Mathematics (C3)

PRINTED ANSWER BOOK

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OCR supplied materials:
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Duration: 1 hour 30 minutes

Candidate forename		Candidate surname	

Centre number						Candidate number				

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Turn over

Section A (36 marks)

1 (i)	
1 (ii)	

2

Function	Odd (Yes/No)	Even (Yes/No)	Periodic (Yes/No): if Yes state the period
$\mathrm{f}(x) = \dfrac{x}{1-2x^2}$			
$\mathrm{g}(x) = 1 + \sin 2x$			
$\mathrm{h}(x) = 3\mathrm{e}^{-2x^2}$			

3 (i)	
3 (ii)	

4

5 (i)	
5 (ii)	

6 (i)	
6 (ii)	

7

Section B (36 marks)

8 (i)

8 (ii)	
8 (iii)	
	(answer space continued on next page)

8 (iii)	**(continued)**

9 (i)	
9 (ii)	

9 (iii)	

9 (iv)	

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).

Oxford Cambridge and RSA

GCE

Mathematics (MEI)

Unit **4753**: Methods for Advanced Mathematics

Advanced GCE

Mark Scheme for June 2018

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

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.

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.

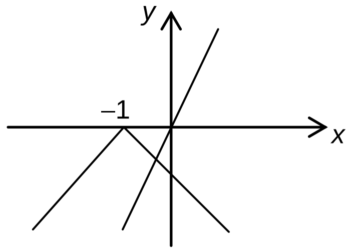
If there are two or more attempts at a question which have not been crossed out, examiners should mark what appears to be the last (complete) attempt and ignore the others.

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)		$3x^2 + 4y^2 = 4 \Rightarrow 6x + 8y\frac{\mathrm{d}y}{\mathrm{d}x} = 0$	M1	$8y\frac{\mathrm{d}y}{\mathrm{d}x}$ seen	or $6x\mathrm{d}x + 8y\mathrm{d}y = 0$
			$\Rightarrow \frac{\mathrm{d}y}{\mathrm{d}x} = -\frac{6x}{8y}$ $[= -\frac{3x}{4y}]$	A1	isw	
			OR			
			$y = \pm\frac{1}{2}(4-3x^2)^{\frac{1}{2}}$			
			$\Rightarrow \frac{dy}{dx} = (\mathrm{m})\frac{3}{2}x(4-3x^2)^{-\frac{1}{2}}$	B1	derivative correct (condone no ±)	
			$= -\frac{6x}{8y}$	B1 [2]	must deal with both signs for 2nd B1	
1	(ii)		When $x = 1$, $y = ½$	B1	o.e. e.g. √¼	or from $\frac{dy}{dx} = -\frac{3}{2}x(4-3x^2)^{-\frac{1}{2}}$ SCB2 but must be correct
			$\frac{\mathrm{d}y}{\mathrm{d}x} = -\frac{3}{2}$	B1	o.e (soi)	
			$\frac{\mathrm{d}y}{\mathrm{d}t} = \frac{\mathrm{d}y}{\mathrm{d}x}.\frac{\mathrm{d}x}{\mathrm{d}t}$	M1	o.e – any correct chain rule	
			$= -\frac{3}{2}\times 4 = -6$	A1cao [4]		
2			f: odd Y, even N, periodic N	B1	all correct	
			g: odd N, even N, periodic Y,	B1	all correct	
			period π	B1	allow 180°	or 0 to π or 180°
			h: odd N, even Y, periodic N	B1 [4]	all correct	
3	(i)		25(%)	B1 [1]	not ¼ or 0.25	
3	(ii)		$½ M_0 = M_0 \mathrm{e}^{-14.4k}$	M1	o.e. (e.g. taking a value for M_0, incl 1)	or $¼ M_0 = M_0 \mathrm{e}^{-28.8k}$ o.e.
			$\Rightarrow -14.4k = \ln(½)$	A1	o.e.	
			$\Rightarrow k = 0.048$ (2 s.f.)	A1cao [3]	mark final answer	

Question			Answer	Marks	Guidance	
4			$y = e^{-x}\sin 2x \Rightarrow \frac{dy}{dx} = e^{-x}.2\cos 2x - e^{-x}\sin 2x$ At P $2e^{-x}\cos 2x - e^{-x}\sin 2x = 0$ $\Rightarrow 2\cos 2x = \sin 2x$, $\tan 2x = 2$ $\Rightarrow [2x = 1.107\ldots]$, $x = 0.554$ $y = 0.514$	M1 A1 M1 M1 A1 A1 [6]	product rule used correct their $\frac{dy}{dx} = 0$ sin/cos = tan used art 0.55, not 31.7° art 0.51	of form $a e^{-x}\cos 2x + b e^{-x}\sin 2x$, where a and b are non-zero integers or squaring and using $\cos^2 2x = 1 - \sin^2 2x$
5	(i)			M1 A1 B1 [3]	$y = -\lvert x + 1\rvert$ correct shape, apex on Ox apex at (–1, 0) indicated on sketch $y = 2x$ steeper gradient through origin, crossing $y = -\lvert x + 1\rvert$ at one point	(inverted 'v')
5	(ii)		$-(x + 1) = 2x$ $\Rightarrow x = -\frac{1}{3}$	M1 A1 [2]	or, from squaring, $4x^2 = x^2 + 2x + 1$ or –0.33 or better, if any additional solution (e.g. $x = 1$) given then A0.	or $x + 1 = -2x$ or $-x - 1 = 2x$ (must resolve the modulus)

Question			Answer	Marks	Guidance	
6	(i)		$g(\frac{1}{2}) = \frac{\pi}{6}$	B1	arcsin ½ = $\frac{\pi}{6}$ soi	condone 30° or 0.523…
			$h(\frac{1}{2}) = \frac{5\pi}{6}$	B1cao [2]	must be exact, allow $0.8\dot{3}\pi$	not 0.83π
6	(ii)		$h(x) = 2\arcsin x + \frac{\pi}{2}$	B1	or $2\sin^{-1} x + \frac{\pi}{2}$	
			$y = 2\arcsin x + \frac{\pi}{2}$ $\quad x \leftrightarrow y$			may interchange x and y at any stage
			$x = 2\arcsin y + \frac{\pi}{2}$	M1	attempt to solve for y	… or x if not yet interchanged
			$\Rightarrow \frac{1}{2}x - \frac{\pi}{4} = \arcsin y$	A1	or $\frac{1}{2}y - \frac{\pi}{4} = \arcsin x$ o.e.	
			$\Rightarrow y = \sin(\frac{1}{2}x - \frac{1}{4}\pi)$ [so $h^{-1}(x) = \sin(\frac{1}{2}x - \frac{1}{4}\pi)$]	A1	oe e.g. $\sin\left(\frac{x-\pi/2}{2}\right)$ mark final answer	
			OR			
			$f^{-1}(x) = ½\,(x - ½\,\pi)$	B1		
			$g^{-1}(x) = \sin x$	B1		
			$h^{-1}(x) = g^{-1}f^{-1}(x)$	M1		
			$= \sin(\frac{1}{2}x - \frac{1}{4}\pi)$	A1 [4]		
7			$n^3 - 3n^2 + 2n = n(n^2 - 3n + 2)$	B1	or, e.g. $(n-1)(n^2-2n)$	
			$= n(n-1)(n-2)$	B1		
			n, $n-1$ and $n-2$ are consecutive integers	B1		
			one must be even, one must be a multiple of 3	B1	divisible by either 2 or 3	condone 'factor' for 'multiple'
			so it is divisible by 6	B1 [5]	both, and conclusion	

Question			Answer	Marks	Guidance	
8	(i)		$\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{(1+x^{\frac{1}{2}})2.\frac{1}{2}x^{-\frac{1}{2}}-2x^{\frac{1}{2}}.\frac{1}{2}x^{-1/2}}{(1+x^{\frac{1}{2}})^2}$	M1 B1 A1	quotient or product rule (see right) allow 1 error (denom correct) derivative of $x^{1/2}=½\,x^{-1/2}$ soi correct expression – condone missing brackets	$(1+x^{\frac{1}{2}})^{-1}.2.\frac{1}{2}x^{-\frac{1}{2}}+2x^{\frac{1}{2}}.(-1)(1+x^{\frac{1}{2}})^{-2}\frac{1}{2}x^{-\frac{1}{2}}$ $=(1+x^{\frac{1}{2}})^{-1}x^{-\frac{1}{2}}-(1+x^{\frac{1}{2}})^{-2}=\frac{(1+x^{\frac{1}{2}})x^{-\frac{1}{2}}-1}{(1+x^{\frac{1}{2}})^2}$
			$=\frac{x^{-\frac{1}{2}}+1-1}{(1+x^{\frac{1}{2}})^2}=\frac{1}{\sqrt{x}(1+\sqrt{x})^2}$ *	A1	or $\frac{1}{x^{\frac{1}{2}}(1+x^{\frac{1}{2}})^2}$ **NB AG**	$=\frac{x^{-\frac{1}{2}}}{(1+x^{\frac{1}{2}})^2}=\frac{1}{\sqrt{x}(1+\sqrt{x})^2}$ *
			When $x=1$, $\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{1}{4}$	B1		
			Equation of tangent is $y-1=\frac{1}{4}(x-1)$	B1ft	or $y=\frac{1}{4}x+c,\ 1=\frac{1}{4}+c,\ c=\frac{3}{4}$	ft their ¼
			$\Rightarrow x-4y+3=0$	B1cao [7]	or $4y-x-3=0$	
8	(ii)		$\frac{\mathrm{d}u}{\mathrm{d}x}=\frac{1}{2}x^{-\frac{1}{2}}$ $x^{\frac{1}{2}}=u-1$	M1	or $\mathrm{d}u=\frac{1}{2}x^{-\frac{1}{2}}[\mathrm{d}x]$	derivative must be correct
			$\int\frac{2\sqrt{x}}{1+\sqrt{x}}\mathrm{d}x=\int\frac{2\sqrt{x}}{1+\sqrt{x}}\frac{1}{\frac{1}{2}x^{-\frac{1}{2}}}\mathrm{d}u$	M1	substituting for dx (must be correct)	
			$=\int\frac{4(u-1)^2}{u}\mathrm{d}u$ *	A1	with convincing working **NB AG**	
				[3]		

Question			Answer	Marks	Guidance	
8	(iii)		Area under curve $=\int_1^2 \frac{4(u-1)^2}{u}\,\mathrm{d}u$	B1	changing limits to 1 and 2	or using these at some stage
			$=\int_1^2 [4u-8+4/u]\,\mathrm{d}u$	M1	expanding and dividing by u	condone one error
			$=\left[2u^2-8u+4\ln u\right]_1^2$ =(8 – 16 + 4ln2) – (2 – 8) = 4ln2 – 2	A1 A1	$\left[2u^2-8u+4\ln u\right]$ o.e.	
			[Q is] (0, ¾) Area under line = $\frac{1}{2}(\frac{3}{4}+1)\times 1$ $=\frac{7}{8}$ or 0.875	B1ft M1 A1cao	soi, or $\int_0^1 \frac{1}{4}(x+3)\,\mathrm{d}x$ $=\frac{1}{4}\left[\frac{1}{2}x^2+3x\right]_0^1$ must correctly ft from their line equation in (i)	ft their line equation or rectangle ± triangle
			or $y=\frac{2\sqrt{x}}{1+\sqrt{x}} \Rightarrow x=\frac{y^2}{(2-y)^2}$ Area between curve and y-axis= $\int_0^1 \frac{y^2}{(2-y)^2}\,\mathrm{d}x$	M1 A1	Finding x in terms of y	
			letting u = 2 – y, $=\left[-4/u-4\ln u-u\right]_1^2$ = 3 – 4ln2	A1 A1cao	$=\left[-4/u-4\ln u-u\right]$ ignore limits	
			Q is (0, ¾) Area under triangle $=\frac{1}{2}\times\frac{1}{4}\times 1$ $=\frac{1}{8}$	B1 B1 A1		
			required area $=2\frac{7}{8}-4\ln 2$	B1cao [8]	o.e., must be exact	$=\frac{23}{8}-4\ln 2$ or $2.875-4\ln 2$

Question			Answer	Marks	Guidance	
9	**(i)**		Translation $\begin{pmatrix}2\\0\end{pmatrix}$	B1	allow 'shift' '+2 in x-direction'	not 'move'
			[One-way] stretch	M1	or 'in y-direction'	transformations can be in either order
			[parallel to] y-axis [scale factor] 2	A1 [3]		
9	**(ii)**		P is (3, 0)	B1	allow $x = 3$	
			Q: $2\ln(x-2) = \ln(x-2)^2$	M1	or $\ln(x-2) = \ln x^{1/2}$…	
			$\Rightarrow \ln x = \ln(x-2)^2$			
			$\Rightarrow x = (x-2)^2$			
			$\Rightarrow x^2 - 5x + 4 = 0$	A1		
			$\Rightarrow x = 4$	A1	NB must be from correct work	
			$y = \ln 4$	A1 [5]	or 2ln 2, must be exact (but can isw)	
9	**(iii)**		let $u = \ln x$, $v' = 1$,	M1		
			$\Rightarrow du/dx = 1/x$, $v = x$			
			$\int \ln x \, dx = x\ln x - \int x.\frac{1}{x} dx$	A1		
			$= x\ln x - \int dx = x\ln x - x + c$ *	A1 [3]	**NB AG** must see $x\ln x - \int [1] dx$	

Question			Answer	Marks	Guidance	
9	(iv)		Area under $y = \ln x$ $= \left[x\ln x - x\right]_1^4$ $= 4\ln 4 - 3$	B1ft B1	ft their 4 or 2.545…isw, if unsupported B0B0	
			Area under $y = 2\ln(x-2)$ is $\int_3^4 2\ln(x-2)\,\mathrm{d}x$ let $u = x-2$, $\mathrm{d}u = \mathrm{d}x$ $= \int_1^2 2\ln u\,\mathrm{d}u$ $= \left[2u\ln u - 2u\right]_1^2$ $= 4\ln 2 - 2$	 M1 A1 A1	 substituting $u = x-2$ $\left[2u\ln u - 2u\right]$ $4\ln 2 - 2$ or 0.772…isw unsupported M0	 or $[2(x-2)\ln(x-2)-2(x-2)]$ B2
			or $\int 2\ln(x-2)\,\mathrm{d}x = 2x\ln(x-2) - \int \frac{2x}{x-2}\,\mathrm{d}x$ * let $u = x-2$, $\int \frac{2x}{x-2}\,\mathrm{d}x = \int \frac{2(u+2)}{u}\,\mathrm{d}u = \int 2+\frac{4}{u}\,\mathrm{d}u$ $= \left[2u + 4\ln u\right]$ $\int_3^4 2\ln(x-2)\,\mathrm{d}x = 8\ln 2 - \left[2u+4\ln u\right]_1^2$ $= 4\ln 2 - 2$	 M1dep A1 A1	 substituting $u = x-2$ dep * or 0.772…isw unsupported M0	 or $\int \frac{2x}{x-2}\,\mathrm{d}x = \int 2+\frac{4}{x-2}\,\mathrm{d}u$ $= \left[2x + 4\ln(x-2)\right]$
			Area is $\int_1^4 \ln x\,\mathrm{d}x - \int_3^4 2\ln(x-2)\,\mathrm{d}x$ $= 4\ln 4 - 3 - 4\ln 2 + 2 = 4\ln 2 - 1$ [so $m = 4$ and $n = -1$]	M1 A1cao [7]	ft their 3 and 4 from part (ii)	could be seen earlier

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Examiners' report

MATHEMATICS (MEI)

3895-3898, 7895-7898

4753/01 Summer 2018 series

Version 1

www.ocr.org.uk/maths

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 4753/01 series overview

This paper proved to be similar in standard to those of recent years, and we saw many excellent scripts. All candidates had sufficient time to complete all the questions. Very few scripts scored fewer than half marks, and a significant percentage scored full marks, suggesting that all the questions were accessible for well-prepared candidates.

It is important in 'show' questions that all the necessary steps are included: sometimes, for example in questions 8(i) and 8(iv), working was missing which was penalised.

Most successful questions	***Least successful questions***
• Q1 (implicit differentiation) • Q3 (exponential decay) • Q4 (product rule for differentiation)	• Q7 (proof) • Q8(iii) integration by substitution • Q9(iv) integration by parts/substitution

Key

AfL Guidance to offer for future teaching and learning practice.

Misconception

Section A overview

Candidates scored heavily on these questions, which proved to be accessible to all but a few. Topics such as linear inequalities (Q5), inverse trigonometric functions (Q6) and proof (Q6) were, in general, better answered than in recent years.

Question 1(i)

1 A point P moves round the curve with equation $3x^2 + 4y^2 = 4$. At time t, P is at the point (x, y), as shown in Fig. 1.

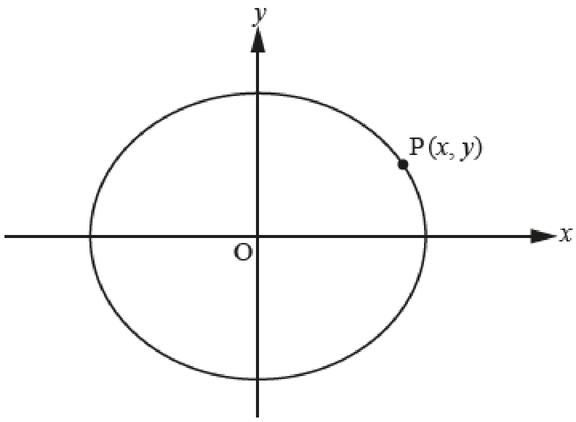

Fig. 1

(i) Find $\frac{dy}{dx}$ in terms of x and y. **[2]**

Virtually all candidates scored 2 marks. Occasional attempts to solve for *y* then differentiate were usually unsuccessful.

Question 1(ii)

(ii) When P is at the point on the curve with x-coordinate 1 and positive y-coordinate, $\frac{dx}{dt} = 4$.

Find $\frac{dy}{dt}$ at this point. **[4]**

All gained M1 for the chain rule. A few neglected to find *y* when *x* = 1 by substituting.

Question 2

2 The three functions $f(x)$, $g(x)$ and $h(x)$ are defined as follows:

$$f(x) = \frac{x}{1-2x^2}, \quad g(x) = 1 + \sin 2x \quad \text{and} \quad h(x) = 3e^{-2x^2}.$$

In the table in the Answer Book, write Yes or No in each space to indicate whether the function is odd, whether it is even, and whether it is periodic. If a function is periodic, state its period. **[4]**

'Periodic' was less well understood than 'odd' and 'even'. Many also stated an incorrect period. A fairly common error was to state that 1 + sin 2*x* is odd (presumably because sin 2*x* is odd). Candidates were required to tick and cross every box – leaving a box blank could mean that they were undecided. Some candidates might have intended a blank entry to mean 'no'; this was not credited marks.

Question 3(i)

3 The mass of a radioactive material decreases exponentially. Its *half-life* is the time required for the mass of the material to reduce to half its initial value. The half-life of plutonium 241 is 14.4 years.

(i) Write down the percentage of the initial mass of plutonium 241 remaining after 28.8 years. **[1]**

A few gave the answer zero here, but most responses were correct.

Question 3(ii)

(ii) The mass M grams of plutonium 241 at time t years is given by the equation

$$M = M_0 \mathrm{e}^{-kt},$$

where M_0 grams is the initial mass and k is a constant. Find k, giving your answer correct to two significant figures. **[3]**

Some used $\frac{1}{4} = \mathrm{e}^{-28.8k}$ instead of $\frac{1}{2} = \mathrm{e}^{-14.4k}$ here, which was of course perfectly acceptable. The logarithm work was generally very well done, and most candidates gained all three marks. Occasionally the answer was incorrectly rounded to 2 significant figures to 0.05.

Question 4

4 Fig. 4 shows part of the curve with equation $y = \mathrm{e}^{-x} \sin 2x$.

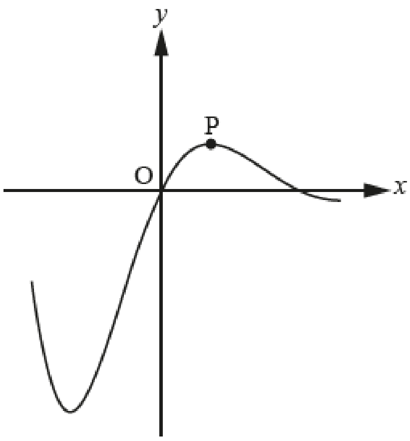

Fig. 4

Find the coordinates of the maximum point P. **[6]**

The product rule was well done here, and the subsequent trigonometric equation using $\frac{\sin}{\cos} = \tan$ was usually successful, although some expanded the sine and cosine of the double angle and then could progress no further.

Question 5(i)

5 (i) On the same axes, sketch the graphs of $y = -|x+1|$ and $y = 2x$. [3]

Candidates who did not label the point (–1, 0) lost a mark. It was also required that the gradient of the $y = 2x$ line to be steeper than the lines of the modulus graph.

Question 5(ii)

(ii) Solve the equation $-|x+1| = 2x$. [2]

Many candidates correctly solved the equation to get $x = -\frac{1}{3}$ and 1, but did not see the point of the sketch in part (i), which rejects the $x = 1$ solution. A few candidates used the squaring method here, occasionally getting $-(x + 1)^2 = 4x^2$.

Another mistake seen in a few scripts was $|x + 1| = |x| + 1$.

Question 6(i)

6 The function $\mathrm{h}(x)$ is such that $\mathrm{h}(x) = \mathrm{fg}(x)$, where $\mathrm{f}(x) = 2x + \frac{1}{2}\pi$ for $x \in \mathbb{R}$ and $\mathrm{g}(x) = \arcsin x$ for $-1 \leqslant x \leqslant 1$.

(i) Find $\mathrm{h}\left(\frac{1}{2}\right)$, giving your answer as a multiple of π. [2]

Question 6(ii)

(ii) Find $\mathrm{h}^{-1}(x)$. [4]

Both parts of this question were very well answered, using $\arcsin\frac{1}{2} = \frac{\pi}{6}$, then inverting the equation to find the inverse function.

Question 7

7 Prove that $n^3 - 3n^2 + 2n$ is divisible by 6 for all positive integers n. [5]

This 'proof' question was more successfully done than others from recent papers. Most candidates factorised correctly and recognised the product of consecutive integers contained one with a factor of 2 and one with a factor of 3, and some minor faults in their reasoning were condoned (for example, some said one was even and another a multiple of 3; others said the 3 consecutive integers contained 'at least' one multiple of 3). Those who did not factorise, however, usually got nowhere, though it is possible to argue that the given expression is even by considering the parity of the individual terms.

Section B overview

Both Section B questions were generally quite well answered, though the longer, more extended parts, required more accurate and sustained work to get to the correct answers.

Some candidates are still approximating answers which are required to be exact.

Question 8(i)

8 Fig. 8 shows the curve with equation $y = \dfrac{2\sqrt{x}}{1+\sqrt{x}}$. The tangent to the curve at P (1, 1) intersects the y-axis at Q.

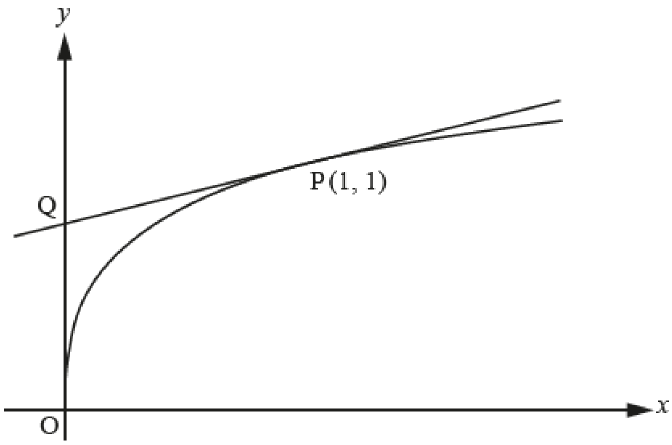

Fig. 8

(i) Show that $\dfrac{dy}{dx} = \dfrac{1}{\sqrt{x}(1+\sqrt{x})^2}$.

Hence find the equation of PQ, giving your answer in the form $ax + by + c = 0$, where a, b and c are integers. **[7]**

This was a pretty straightforward application of the quotient rule, which was usually correctly done. However, many candidates did not show convincingly that their expression simplified to the given answer.

The equation of the tangent was then routine and well done, although a few left the coefficients as fractions.

Question 8(ii)

(ii) Show that the substitution $u = 1 + \sqrt{x}$ transforms $\displaystyle\int \frac{2\sqrt{x}}{1+\sqrt{x}} dx$ to $\displaystyle\int \frac{4(u-1)^2}{u} du$. **[3]**

Some candidates did not show enough work here to be convincing.

It is vital in integration by substitution that 'd*x*' and 'd*u*' are shown as part of the integrand.

Question 8(iii)

(iii) Hence find the exact area of the region enclosed by the curve, the y-axis and the line PQ. **[8]**

This required more extended work. Most candidates calculated the area under the trapezium under PQ, though a minority used the integral of the line equation. When it came to integrating under the curve, most used the transformed integral and changed the limits, but then many did not spot the correct method here, namely expanding and dividing through by *u*. Others made errors with the expansion here. Nevertheless, many managed to navigate the difficulties to get the correct exact expression.

Question 9(i)

9 Fig. 9 shows the curves with equations $y = \ln x$ and $y = 2\ln(x-2)$ which intersect at Q. The curve $y = 2\ln(x-2)$ crosses the x-axis at P.

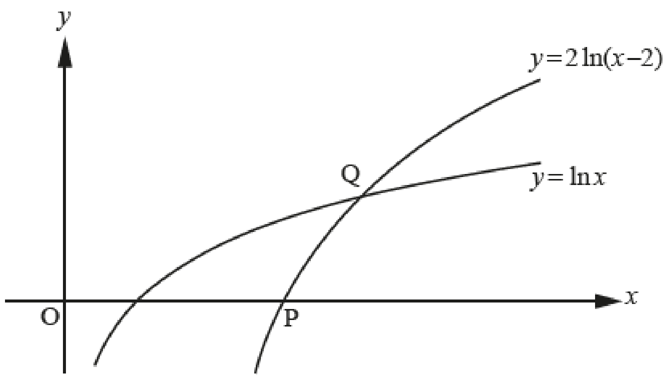

Fig. 9

(i) Describe a sequence of two transformations which maps the curve $y = \ln x$ onto the curve $y = 2\ln(x-2)$. **[3]**

The sequence of transformations was described correctly by most candidates. 'Shift' for translation was allowed, but not 'move'.

Question 9(ii)

(ii) Find the exact coordinates of P and Q. **[5]**

Most found P correctly, but there were a surprising number of incorrect derivations of the *x*-coordinate of Q, most common of which was:

$2\ln(x-2) = \ln x$, so $2(x-2) = x$.

Many of these incorrect methods seemed to lead fortuitously to $x = 4$ but gained no marks.

Question 9(iii)

(iii) Using integration by parts, show that $\int \ln x \, dx = x \ln x - x + c$, where c is an arbitrary constant. **[3]**

This standard application of integration by parts was well done, although candidates were required to resolve the $\frac{x}{x} = 1$ in the resulting integral part.

Question 9(iv)

(iv) Hence show that the area of the finite region enclosed by the curve $y = \ln x$, the curve $y = 2\ln(x-2)$ and the x-axis is $m \ln 2 + n$, where m and n are integers to be determined. **[7]**

Here, the difficulty for many candidates was in dealing with $\int 2\ln(x-2)dx$. Perhaps influenced by the previous part, most candidates applied parts to this but struggled trying to integrate $\frac{x}{(x-2)}$. Only the most competent candidates recognised that substitution was a more appropriate method and saw this work through successfully to the correct final answer.

Candidates need to practice questions where they have to decide which integration method (by parts or by substitution) is most appropriate to use.

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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

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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

Level 3 Certificate, Level 3 Extended Project and FSMQ raw mark grade boundaries June 2018 series

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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