OCR
Oxford Cambridge and RSA

Monday 22 June 2015 – Morning

A2 GCE MATHEMATICS (MEI)

4756/01 Further Methods for Advanced Mathematics (FP2)

QUESTION PAPER

Candidates answer on the Printed Answer Book.

OCR supplied materials:
- Printed Answer Book 4756/01
- MEI Examination Formulae and Tables (MF2)

Other materials required:
- Scientific or graphical calculator

Duration: 1 hour 30 minutes

5104056976

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**. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- 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 bar codes.
- 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

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- 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 **12** 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 (54 marks)

1 **(a)** **(i)** A curve has polar equation $r = 2a\cos\theta + 2b\sin\theta$, where $a > 0$ and $b > 0$.

Show, by considering its cartesian equation, that the curve is a circle which passes through the origin. Find the centre and radius of the circle in terms of a and b. **[5]**

(ii) For the case $a = b = 1$, use integration to show that the region bounded by a minor arc of the circle and the lines $\theta = \frac{\pi}{6}$ and $\theta = \frac{\pi}{3}$ has area $1 + \frac{\pi}{3}$. **[5]**

(b) Given that $f(t) = \ln(1+t)$, obtain expressions for $f'(t)$, $f''(t)$ and $f'''(t)$. Hence show that the Maclaurin series for $\ln(1+t)$ begins

$$t - \frac{t^2}{2} + \frac{t^3}{3} \ldots .$$

Deduce the first two non-zero terms of the Maclaurin series for $\ln\left(\frac{1+t}{1-t}\right)$. **[8]**

2 **(a)** **(i)** By considering $\left(z + \frac{1}{z}\right)^5$, where $z = \cos\theta + j\sin\theta$, show that

$$\cos^5\theta = \tfrac{1}{16}(\cos 5\theta + 5\cos 3\theta + 10\cos\theta).$$ **[5]**

(ii) Use de Moivre's theorem to find an expression for $\cos 5\theta$ in terms of powers of $\cos\theta$. **[5]**

(b) **(i)** Obtain the roots of the equation $w^5 = 4\sqrt{2}$ in the form $re^{j\theta}$. Show the points corresponding to these roots in an Argand diagram. **[4]**

(ii) For each root w, let $v = w\sqrt{2}e^{j\pi/10}$.

Show the points corresponding to the values of v on your Argand diagram.

Find, in simplified form, an equation for which the values of v are the roots. **[4]**

3 This question concerns the matrix $\mathbf{M}$ where $\mathbf{M} = \begin{pmatrix} 5 & -1 & 3 \\ 4 & -3 & -2 \\ 2 & 1 & 4 \end{pmatrix}$.

(i) Obtain the characteristic equation of $\mathbf{M}$.

Find the eigenvalues of $\mathbf{M}$. **[7]**

These eigenvalues are denoted by $\lambda_1, \lambda_2, \lambda_3$, where $\lambda_1 < \lambda_2 < \lambda_3$.

(ii) Verify that an eigenvector corresponding to λ_1 is $\begin{pmatrix} 1 \\ 3 \\ -1 \end{pmatrix}$ and that an eigenvector corresponding to λ_2 is $\begin{pmatrix} 1 \\ 2 \\ -1 \end{pmatrix}$. Find an eigenvector of the form $\begin{pmatrix} a \\ 1 \\ c \end{pmatrix}$ corresponding to λ_3. **[5]**

(iii) Write down a matrix $\mathbf{P}$ and a diagonal matrix $\mathbf{D}$ such that $\mathbf{M} = \mathbf{PDP}^{-1}$. (You are not required to calculate $\mathbf{P}^{-1}$.)

Hence write down an expression for $\mathbf{M}^4$ in terms of $\mathbf{P}$ and a diagonal matrix. You should give the elements of the diagonal matrix explicitly. **[3]**

(iv) Use the Cayley-Hamilton theorem to obtain an expression for $\mathbf{M}^4$ as a linear combination of $\mathbf{M}$ and $\mathbf{M}^2$. **[3]**

Section B (18 marks)

4 **(i)** Starting with the relationship $\cosh^2 t - \sinh^2 t = 1$, deduce a relationship between $\tanh^2 t$ and $\operatorname{sech}^2 t$. **[1]**

You are given that $y = \operatorname{artanh} x$.

(ii) Show that $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{1}{1-x^2}$. **[4]**

(iii) Show, by integrating the result in part (ii), that $y = \frac{1}{2}\ln\left(\frac{1+x}{1-x}\right)$. **[4]**

(iv) Show that $\int_0^{\frac{\sqrt{3}}{6}} \frac{1}{1-3x^2}\,\mathrm{d}x = \frac{1}{\sqrt{3}}\operatorname{artanh}\frac{1}{2}$. Express this answer in logarithmic form. **[4]**

(v) Use integration by parts to find $\int \operatorname{artanh} x \,\mathrm{d}x$, giving your answer in terms of logarithms. **[5]**

END OF QUESTION PAPER

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4756/01 Further Methods for Advanced Mathematics (FP2)

PRINTED ANSWER BOOK

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Other materials required:
- Scientific or graphical calculator

Duration: 1 hour 30 minutes

Candidate forename		Candidate surname	

Centre number						Candidate number				

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Section A (54 Marks)

1 (a) (i)	
1 (a) (ii)	

1(b)	

2 (a) (i)	

2 (a) (ii)

2 (b) (i)
(ii)

3 (i)

3 (ii)	

3 (iii)	
3 (iv)	

Section B (18 Marks)

4 (i)	
4 (ii)	
4 (iii)	

4 (iv)	
4 (v)	

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Annotations and abbreviations

Annotation in scoris	Meaning
✓and ✗	
BOD	Benefit of doubt
FT	Follow through
ISW	Ignore subsequent working
M0, M1	Method mark awarded 0, 1
A0, A1	Accuracy mark awarded 0, 1
B0, B1	Independent mark awarded 0, 1
SC	Special case
^	Omission sign
MR	Misread
Highlighting	
Other abbreviations in mark scheme	**Meaning**
E1	Mark for explaining
U1	Mark for correct units
G1	Mark for a correct feature on a graph
M1 dep*	Method mark dependent on a previous mark, indicated by *
cao	Correct answer only
oe	Or equivalent
rot	Rounded or truncated
soi	Seen or implied
www	Without wrong working

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

a Annotations should be used whenever appropriate during your marking.

The A, M and B annotations must be used on your standardisation scripts for responses that are not awarded either 0 or full marks. It is vital that you annotate standardisation scripts fully to show how the marks have been awarded.

For subsequent marking you must make it clear how you have arrived at the mark you have awarded.

b An element of professional judgement is required in the marking of any written paper. Remember that the mark scheme is designed to assist in marking incorrect solutions. Correct *solutions* leading to correct answers are awarded full marks but work must not be judged on the answer alone, and answers that are given in the question, especially, must be validly obtained; key steps in the working must always be looked at and anything unfamiliar must be investigated thoroughly.

Correct but unfamiliar or unexpected methods are often signalled by a correct result following an *apparently* incorrect method. Such work must be carefully assessed. When a candidate adopts a method which does not correspond to the mark scheme, award marks according to the spirit of the basic scheme; if you are in any doubt whatsoever (especially if several marks or candidates are involved) you should contact your Team Leader.

c The following types of marks are available.

M
A suitable method has been selected and *applied* in a manner which shows that the method is essentially understood. Method marks are not usually lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, eg by substituting the relevant quantities into the formula. In some cases the nature of the errors allowed for the award of an M mark may be specified.

A
Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated Method mark is earned (or implied). Therefore M0 A1 cannot ever be awarded.

B
Mark for a correct result or statement independent of Method marks.

E
A given result is to be established or a result has to be explained. This usually requires more working or explanation than the establishment of an unknown result.

Unless otherwise indicated, marks once gained cannot subsequently be lost, eg wrong working following a correct form of answer is ignored. Sometimes this is reinforced in the mark scheme by the abbreviation isw. However, this would not apply to a case where a candidate passes through the correct answer as part of a wrong argument.

d When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. (The notation 'dep *' is used to indicate that a particular mark is dependent on an earlier, asterisked, mark in the scheme.) Of course, in practice it may happen that when a candidate has once gone wrong in a part of a question, the work from there on is worthless so that no more marks can sensibly be given. On the other hand, when two or more steps are successfully run together by the candidate, the earlier marks are implied and full credit must be given.

e The abbreviation ft implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A and B marks are given for correct work only — differences in notation are of course permitted. A (accuracy) marks are not given for answers obtained from incorrect working. When A or B marks are awarded for work at an intermediate stage of a solution, there may be various alternatives that are equally acceptable. In such cases, exactly what is acceptable will be detailed in the mark scheme rationale. If this is not the case please consult your Team Leader.

Sometimes the answer to one part of a question is used in a later part of the same question. In this case, A marks will often be 'follow through'. In such cases you must ensure that you refer back to the answer of the previous part question even if this is not shown within the image zone. You may find it easier to mark follow through questions candidate-by-candidate rather than question-by-question.

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

g Rules for replaced work

If a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, then examiners should do as the candidate requests.

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

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

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	(a)	(i)	$r^2 = 2ar\cos\theta + 2br\sin\theta$		*(Not yet sufficient for M1)*	
				M1	Using $r^2 = x^2 + y^2$, $r\cos\theta = x$ or $r\sin\theta = y$ in the equation	e.g. $x = (2a\cos\theta + 2b\sin\theta)\cos\theta$
			$x^2 + y^2 = 2ax + 2by$	A1		
			Rearrange to $(x-a)^2 + (y-b)^2 = a^2 + b^2$			
			Circle centre (a, b), radius $\sqrt{(a^2 + b^2)}$	A1A1	*Found, not guessed!*	
			Convincing that it passes through origin	E1		
				[5]		
		(ii)	Show that $\frac{1}{2}r^2 = 2 + 2\sin 2\theta$	M1A1	For r^2 or ½ r^2	Must reach integrable form for M1
			Integrate to $2\theta - \cos 2\theta$	M1A1	Or $2\theta + 2\sin^2\theta$	M1 for integrating $\sin 2\theta$ or $\sin\theta\cos\theta$
			Evaluate between limits get $1 + \frac{\pi}{3}$	E1	Answer given	
				[5]		
	(b)		$f'(t) = (1+t)^{-1}$	B1		
			$f''(t) = -(1+t)^{-2}$	B1		
			$f'''(t) = 2(1+t)^{-3}$	B1	oe, e.g. $2(1+t)/(1+t)^4$	
			$f(0) = 0$, $f'(0) = 1$, $f''(0) = -1$, $f'''(0) = 2$	M1A1	M1 for knowing to put $t = 0$.	M1A0 if $f(0) = 0$ unclear (but E1 can still be given)
			Convincing to series for $\ln(1+t)$	E1	Answer given	
			Use $\ln(1+t) - \ln(1-t)$	M1	or other method	*If x used instead of t, penalise once only*
			Obtain $2t + \dfrac{2t^3}{3} + \ldots$	A1	or B2 if no method shown	
				[8]		
				[18]		

Question			Answer	Marks	Guidance	
2	(a)	(i)	$\left(z+\frac{1}{z}\right)=2\cos\theta$	B1		
			$\left(z+\frac{1}{z}\right)^5=32\cos^5\theta$	B1	Allow 2^5	*Implies previous B1*
			$\left(z+\frac{1}{z}\right)^5=z^5+5z^3+10z+10z^{-1}+5z^{-3}+z^{-5}$ $=2\cos 5\theta+10\cos 3\theta+20\cos\theta$	M1A1	M1 for binomial expansion (unsimplified) including some coefficients	
			(Hence result)	E1 **[5]**	Answer given	
		(ii)	$\cos 5\theta=\text{Re}\left(e^{j5\theta}\right)=\text{Re}\left((c+js)^5\right)$	B1 M1	e.g. $\cos5\theta+j\sin5\theta=(c+js)^5$ Expansion of $(c+js)^5$	OR M1 for finding $\cos3\theta$ in terms of c, s ***and*** using (i)
			$=c^5-10c^3s^2+5cs^4$	A1	Must be explicit expression for $\cos5\theta$	A1 for $\cos3\theta=c^3-3cs^2$ oe A1 for expression for $\cos5\theta$
			Simplify to $16\cos^5\theta-20\cos^3\theta+5\cos\theta$	M1A1 **[5]**		
	(b)	(i)	Roots are $\sqrt{2}\exp(j0, j2\pi/5, j4\pi/5, j6\pi/5, j8\pi/5)$	B1	for $\sqrt{2}$ oe, e.g. $2^{1/2}$, 1.41 *(at least 3 roots needed)*	B0 for $(4\sqrt{2})^{1/5}$
				B1	θ oe, e.g. $-j2\pi/5$, $-j4\pi/5$, $j2\pi$ Allow $\sqrt{2}$ instead of $\sqrt{2}\exp(j0)$	B0 for $(\cos2\pi/5 + j\sin2\pi/5)$ etc
			Argand diagram with points at vertices of a regular pentagon, one vertex at $(\sqrt{2}, 0)$ (FT r, but not $4\sqrt{2}$)	G2 **[4]**	*Some indication of scale required*	Give G1 for any regular pentagon centre O ***or*** for 4 correct points
		(ii)	New points rotated $\pi/10$ from old points. New modulus $\sqrt{2}$ times old modulus	G1 G1	*Must have five points* *Must have five points*	
			$v^5=w^5\left(\sqrt{2}\right)^5 e^{j\pi/2}$	M1	or $(2e^{j\pi/10})^5$ etc	M1A0 for $v^5=32e^{j\pi/2}$
			$=32j$	A1 **[4]** **[18]**	Accept correct answer for both marks	M0 for $v^5=32e^{\pi/2}$ *(with no working)*

Question			Answer	Marks	Guidance	
3		(i)	$\det(\mathbf{M}-\lambda\mathbf{I}) = (5-\lambda)((-3-\lambda)(4-\lambda)+2)$	M1A1	M1 for attempt at $\det(\mathbf{M}-\lambda\mathbf{I})$	
			$+(4(4-\lambda)+4)$	A1	A1 each term correct	
			$+3(4-2(-3-\lambda))$	A1		
			Simplify to $\lambda^3-6\lambda^2-7\lambda=0$	A1	A0 if ' = 0 ' never appears	
			Solve to $\lambda=-1, 0, 7$	M1A1	M1 for eigenvalues are roots of char eqn	
				[7]		
		(ii)		M1	For clear evidence of understanding	e.g. Just finding eigenvector for $\lambda = 7$ would earn M1A0A0B1B1
			Show that $\mathbf{M}(1\ \ 3\ \ -1)^T = (-1\ \ -3\ \ 1)^T$	A1	A1 each calculation	
			Show that $\mathbf{M}(1\ \ 2\ \ -1)^T = (0\ \ 0\ \ 0)^T$	A1		
			Obtain equations			
			$-2a+3c=1$, $2a-c=5$ or equivalent	B1	FT Two correct equations	
			Solve to obtain $(4\ \ 1\ \ 3)^T$	B1	CAO *Accept a = 4, c = 3*	
				[5]		
		(iii)	$P=\begin{pmatrix}1 & 1 & 4\\ 3 & 2 & 1\\ -1 & -1 & 3\end{pmatrix}$ $D=\begin{pmatrix}-1 & 0 & 0\\ 0 & 0 & 0\\ 0 & 0 & 7\end{pmatrix}$	B1B1	FT	*For B2, order must be consistent*
			$\mathbf{M}^4=\mathbf{PD}^4\mathbf{P}^{-1}$ where $\mathbf{D}^4=\text{diag}(1\ \ 0\ \ 2401)$	B1	CAO	
				[3]		
		(iv)	C-H: $\mathbf{M}^3=6\mathbf{M}^2+7\mathbf{M}$	M1		
			$\mathbf{M}^4=6\mathbf{M}^3+7\mathbf{M}^2$	A1	CAO	
			$=6(6\mathbf{M}^2+7\mathbf{M})+7\mathbf{M}^2$			
			$=43\mathbf{M}^2+42\mathbf{M}$	A1	CAO	
				[3]		
				[18]		

Question			Answer	Marks	Guidance	
4	(i)		Divide through by $\cosh^2 t$ to obtain $1 - \tanh^2 t = \text{sech}^2 t$	B1 **[1]**	*No working required*	
	(ii)		$\tanh y = x$ $\text{sech}^2 y\, y' = 1$ oe $y' = 1 / \text{sech}^2 y = 1 / (1 - \tanh^2 y) = 1 / (1 - x^2)$	B1 M1A1 E1 **[4]**	OR M1 for $(\pm)\ \text{sech}^2 y$ Answer given	M1 for $(\text{d}/\text{d}x)(½(\ln(1 + x) - \ln(1 - x)))$ A1A1 for $½(1/(1 + x) + 1/(1 - x))$ E1 for $1 / (1 - x^2)$
	(iii)		$\frac{1}{1-x^2} = \frac{1}{2}\left(\frac{1}{1-x} + \frac{1}{1+x}\right)$ Integrate to $\frac{1}{2}(\ln(1+x) - \ln(1-x)) + c$ Hence $\frac{1}{2}\ln\left(\frac{1+x}{1-x}\right) + c$ Use $x = 0$, $y = 0$ to show $c = 0$	M1A1 B1 B1 **[4]**	 B0 if no ' + c ' Answer given (without c)	*M0 if standard formula for integrating $1 / (a^2 - x^2)$ is used; but B1B1 can still be given*
	(iv)		Substitute $u = \sqrt{3}\,x$ to obtain $\frac{1}{\sqrt{3}}\int_0^{1/2} \frac{1}{1-u^2}\,\text{d}u$ Hence $\frac{1}{\sqrt{3}}\text{artanh}\frac{1}{2}$ Which is $\frac{1}{2\sqrt{3}}\ln 3$	M1 A1 E1 B1 **[4]**	or … $\text{artanh}(x\sqrt{3})$ or $(1/\sqrt{3})\,\text{artanh}(x\sqrt{3})$ Answer given oe, e.g. $(\sqrt{3}/6)\ln 3$, $(1/\sqrt{3})\ln(\sqrt{3})$	

Question			Answer	Marks	Guidance	
	(v)		$\int 1 \times \text{artanh}\, x \, \text{d}x = x \,\text{artanh}\, x - \int \frac{x}{1-x^2} \, \text{d}x$	M1A1		
			Hence $x \,\text{artanh}\, x + \frac{1}{2}\ln(1-x^2) + c$			
			Equals $\frac{1}{2} x \ln\left(\frac{1+x}{1-x}\right) + \frac{1}{2}\ln(1-x^2) + c$	B1B1B1	Third mark is for c	
				[5]		
				[18]		

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PART OF THE CAMBRIDGE ASSESSMENT GROUP

4756 Further Methods for Advanced Mathematics (FP2)

General Comments

Most candidates demonstrated a sound working knowledge of all the topics being examined, and appeared to have sufficient time to complete the paper. When marks were lost, this was very often due to a lack of care rather than a misunderstanding of the concepts. The average marks on all four questions were quite similar but, by a small margin, Q.3 (on matrices) was the best-answered question, and Q.4 (on hyperbolic functions) was the worst.

Comments on Individual Questions

Q.1(a)(i) Many candidates made hardly any progress here; for example, expressing $x = r\cos\theta$ and $y = r\sin\theta$ in terms of θ, followed by some fruitless manipulation, then giving up. Those who started by multiplying the given polar equation by r quickly obtained a suitable cartesian equation from which the centre and radius could be deduced. Very many omitted to mention why the circle passed through the origin; this shows how important it is for candidates to read through the questions very carefully, making sure that they have answered every part.

Q.1(a)(ii) The method for finding the area was well understood, and was very often carried out accurately. A frequent error was to expand $(2\cos\theta + 2\sin\theta)^2$ as $(4\cos^2\theta + 4\cos\theta\sin\theta + 4\sin^2\theta)$. Many candidates used double angle formulae to integrate $\cos^2\theta$ and $\sin^2\theta$, instead of using $\cos^2\theta + \sin^2\theta = 1$ first.

Q.1(b) Most candidates understood the process of finding a Maclaurin series and obtained the given result correctly. As the answer is given on the question paper, full working must be shown, and this included some indication that $f(0) = 0$. In the final part, most candidates used $\ln(1 + t) - \ln(1 - t)$, although many took $\ln(1 - t)$ to be $-f(t)$ instead of $f(-t)$, leading to the common wrong answer of $2t - t^2$.

Q.2(a)(i) This part was well-answered.

Q.2(a)(ii) This was also well-answered, with most candidates using the expected method of expanding $(\cos\theta + j\sin\theta)^5$. An alternative approach, taken by many candidates, was to rearrange the result from part (i) and then express $\cos3\theta$ in terms of $\cos\theta$ and $\cos^3\theta$.

Q.2(b)(i) Most candidates obtained the correct values of w in exponential form. Common errors included taking the argument of the real number $4\sqrt{2}$ to be $\frac{1}{2}\pi$ or π instead of 0, and not simplifying the fifth root of $4\sqrt{2}$ to $\sqrt{2}$. Indicating the five values on an Argand diagram was generally done well, although many diagrams did not include any indication of the scale.

Q.2(b)(ii) The pentagon was usually enlarged and rotated correctly to show the values of v. Many candidates made no attempt to find an equation. Those that did often left $32e^{j\pi/2}$ in their final answer, when this should have been simplified to 32j.

Q.3(i) The expansion of $\det(\mathbf{M} - \lambda\mathbf{I})$ was done extremely well and most candidates obtained the characteristic equation, and the three eigenvalues, correctly.

Q.3(ii) Most candidates understood the concept of eigenvectors and knew how to find them. Some did as intended and verified that the two given eigenvectors worked, but very many found all three by solving equations.

Q.3(iii) This part was very well answered.

Q.3(iv) Most candidates understood the Cayley-Hamilton theorem and were able to obtain $\mathbf{M}^4$. Careless errors such as going from $\mathbf{M}^3 - 6\mathbf{M}^2 - 7\mathbf{M} = \mathbf{0}$ to $\mathbf{M}^4 - 6\mathbf{M}^3 - 7\mathbf{M} = \mathbf{0}$ or $\mathbf{M}^3 = 6\mathbf{M}^2 - 7\mathbf{M}$ were fairly common.

Q.4(i)-(ii) These parts were answered well. Throughout this question, some candidates lost several marks through carelessness such as writing sec where sech was intended, or tanh where artanh was intended.

Q.4(iii) Here candidates were required to use partial fractions to obtain the integral. Two of the four marks were given for including a constant of integration and then showing it to be zero. Very many candidates omitted this essential part of the argument.

Q.4(iv) Most candidates integrated correctly and showed sufficient working to justify the given result. Many did not go on to express the answer in logarithmic form, even though the relevant formula is given in part (iii).

Q.4(v) Most candidates understood how to apply integration by parts to this integral. Common errors in the final answer were failure to write artanh(x) in terms of logaritms, an incorrect sign for the ½ln($1 - x^2$) term, and omission of the arbitrary constant.

GCE Mathematics (MEI)

				Max Mark	a	b	c	d	e	u
4751	01	C1 – MEI Introduction to advanced mathematics (AS)	Raw	72	63	58	53	48	43	0
			UMS	100	80	70	60	50	40	0
4752	01	C2 – MEI Concepts for advanced mathematics (AS)	Raw	72	56	50	44	39	34	0
			UMS	100	80	70	60	50	40	0
4753	01	(C3) MEI Methods for Advanced Mathematics with Coursework: Written Paper	Raw	72	56	51	46	41	36	0
4753	02	(C3) MEI Methods for Advanced Mathematics with Coursework: Coursework	Raw	18	15	13	11	9	8	0
4753	82	(C3) MEI Methods for Advanced Mathematics with Coursework: Carried Forward Coursework Mark	Raw	18	15	13	11	9	8	0
			UMS	100	80	70	60	50	40	0
4754	01	C4 – MEI Applications of advanced mathematics (A2)	Raw	90	74	67	60	54	48	0
			UMS	100	80	70	60	50	40	0
4755	01	FP1 – MEI Further concepts for advanced mathematics (AS)	Raw	72	62	57	53	49	45	0
			UMS	100	80	70	60	50	40	0
4756	01	FP2 – MEI Further methods for advanced mathematics (A2)	Raw	72	65	58	52	46	40	0
			UMS	100	80	70	60	50	40	0
4757	01	FP3 – MEI Further applications of advanced mathematics (A2)	Raw	72	59	52	46	40	34	0
			UMS	100	80	70	60	50	40	0
4758	01	(DE) MEI Differential Equations with Coursework: Written Paper	Raw	72	63	57	51	45	38	0
4758	02	(DE) MEI Differential Equations with Coursework: Coursework	Raw	18	15	13	11	9	8	0
4758	82	(DE) MEI Differential Equations with Coursework: Carried Forward Coursework Mark	Raw	18	15	13	11	9	8	0
			UMS	100	80	70	60	50	40	0
4761	01	M1 – MEI Mechanics 1 (AS)	Raw	72	62	54	46	39	32	0
			UMS	100	80	70	60	50	40	0
4762	01	M2 – MEI Mechanics 2 (A2)	Raw	72	54	47	40	33	27	0
			UMS	100	80	70	60	50	40	0
4763	01	M3 – MEI Mechanics 3 (A2)	Raw	72	64	56	48	41	34	0
			UMS	100	80	70	60	50	40	0
4764	01	M4 – MEI Mechanics 4 (A2)	Raw	72	53	45	38	31	24	0
			UMS	100	80	70	60	50	40	0
4766	01	S1 – MEI Statistics 1 (AS)	Raw	72	61	54	47	41	35	0
			UMS	100	80	70	60	50	40	0
4767	01	S2 – MEI Statistics 2 (A2)	Raw	72	65	60	55	50	46	0
			UMS	100	80	70	60	50	40	0
4768	01	S3 – MEI Statistics 3 (A2)	Raw	72	64	58	52	47	42	0
			UMS	100	80	70	60	50	40	0
4769	01	S4 – MEI Statistics 4 (A2)	Raw	72	56	49	42	35	28	0
			UMS	100	80	70	60	50	40	0
4771	01	D1 – MEI Decision mathematics 1 (AS)	Raw	72	56	51	46	41	37	0
			UMS	100	80	70	60	50	40	0
4772	01	D2 – MEI Decision mathematics 2 (A2)	Raw	72	54	49	44	39	34	0
			UMS	100	80	70	60	50	40	0
4773	01	DC – MEI Decision mathematics computation (A2)	Raw	72	46	40	34	29	24	0
			UMS	100	80	70	60	50	40	0
4776	01	(NM) MEI Numerical Methods with Coursework: Written Paper	Raw	72	56	50	45	40	34	0
4776	02	(NM) MEI Numerical Methods with Coursework: Coursework	Raw	18	14	12	10	8	7	0
4776	82	(NM) MEI Numerical Methods with Coursework: Carried Forward Coursework Mark	Raw	18	14	12	10	8	7	0
			UMS	100	80	70	60	50	40	0
4777	01	NC – MEI 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

GCE Statistics (MEI)											
				Max Mark	a	b	c	d	e	u
G241	01	Statistics 1 MEI (Z1)	Raw	72	61	54	47	41	35	0
			UMS	100	80	70	60	50	40	0
G242	01	Statistics 2 MEI (Z2)	Raw	72	55	48	41	34	27	0
			UMS	100	80	70	60	50	40	0
G243	01	Statistics 3 MEI (Z3)	Raw	72	56	48	41	34	27	0
			UMS	100	80	70	60	50	40	0

GCE Quantitative Methods (MEI)										
				Max Mark	a	b	c	d	e	u
G244	01	Introduction to Quantitative Methods MEI	Raw	72	58	50	43	36	28	0
G244	02	Introduction to Quantitative Methods MEI	Raw	18	14	12	10	8	7	0
			UMS	100	80	70	60	50	40	0
G245	01	Statistics 1 MEI	Raw	72	61	54	47	41	35	0
			UMS	100	80	70	60	50	40	0
G246	01	Decision 1 MEI	Raw	72	56	51	46	41	37	0
			UMS	100	80	70	60	50	40	0