

4725/01

ADVANCED SUBSIDIARY GCE MATHEMATICS

Further Pure Mathematics 1

MONDAY 2 JUNE 2008

Morning Time: 1 hour 30 minutes

Additional materials: Answer Booklet (8 pages) List of Formulae (MF1)

INSTRUCTIONS TO CANDIDATES

- Write your name in capital letters, your Centre Number and Candidate Number in the spaces provided on the Answer Booklet.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Answer **all** the questions.
- Give non-exact numerical answers correct to 3 significant figures unless a different degree of accuracy is specified in the question or is clearly appropriate.
- You are permitted to use a graphical calculator in this paper.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [] at the end of each question or part question.
- The total number of marks for this paper is 72.
- You are reminded of the need for clear presentation in your answers.

This document consists of 4 printed pages.

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1 The matrix **A** is given by $\mathbf{A} = \begin{pmatrix} 4 & 1 \\ 5 & 2 \end{pmatrix}$ and **I** is the 2 × 2 identity matrix. Find (i) $\mathbf{A} - 3\mathbf{I}$, (ii) $\mathbf{A} - 3\mathbf{I}$,

- (ii) A^{-1} . [2]
- 2 The complex number 3 + 4i is denoted by *a*.

(i) Find |a| and $\arg a$. [2]

- (ii) Sketch on a single Argand diagram the loci given by
 - (a) |z-a| = |a|, [2]
 - **(b)** $\arg(z-3) = \arg a.$ [3]

3 (i) Show that
$$\frac{1}{r!} - \frac{1}{(r+1)!} = \frac{r}{(r+1)!}$$
 [2]

(ii) Hence find an expression, in terms of *n*, for

$$\frac{1}{2!} + \frac{2}{3!} + \frac{3}{4!} + \dots + \frac{n}{(n+1)!}.$$
[4]

[2]

4 The matrix **A** is given by $\mathbf{A} = \begin{pmatrix} 3 & 1 \\ 0 & 1 \end{pmatrix}$. Prove by induction that, for $n \ge 1$,

$$\mathbf{A}^{n} = \begin{pmatrix} 3^{n} & \frac{1}{2}(3^{n} - 1) \\ 0 & 1 \end{pmatrix}.$$
 [6]

5 Find
$$\sum_{r=1}^{n} r^2(r-1)$$
, expressing your answer in a fully factorised form. [6]

- 6 The cubic equation $x^3 + ax^2 + bx + c = 0$, where a, b and c are real, has roots (3 + i) and 2.
 - (i) Write down the other root of the equation. [1]
 - (ii) Find the values of a, b and c. [6]

7 Describe fully the geometrical transformation represented by each of the following matrices:

(i)
$$\begin{pmatrix} 6 & 0 \\ 0 & 6 \end{pmatrix}$$
, [1]

$$(\mathbf{i}\mathbf{i}) \begin{pmatrix} 0 & 1\\ 1 & 0 \end{pmatrix},$$
 [2]

$$(\mathbf{iii}) \begin{pmatrix} 1 & 0\\ 0 & 6 \end{pmatrix},$$

$$[2]$$

$$(iv) \begin{pmatrix} 0.8 & 0.6 \\ -0.6 & 0.8 \end{pmatrix}.$$
 [2]

8 The quadratic equation $x^2 + kx + 2k = 0$, where k is a non-zero constant, has roots α and β . Find a quadratic equation with roots $\frac{\alpha}{\beta}$ and $\frac{\beta}{\alpha}$. [7]

9 (i) Use an algebraic method to find the square roots of the complex number 5 + 12i. [5] (ii) Find (3 - 2i)². [2]

(iii) Hence solve the quartic equation $x^4 - 10x^2 + 169 = 0.$ [4]

10 The matrix **A** is given by $\mathbf{A} = \begin{pmatrix} a & 8 & 10 \\ 2 & 1 & 2 \\ 4 & 3 & 6 \end{pmatrix}$. The matrix **B** is such that $\mathbf{AB} = \begin{pmatrix} a & 6 & 1 \\ 1 & 1 & 0 \\ 1 & 3 & 0 \end{pmatrix}$.

- (i) Show that AB is non-singular.[2](ii) Find $(AB)^{-1}$.[4]
- (iii) Find \mathbf{B}^{-1} . [5]

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1 (i) $\begin{pmatrix} 1 & 1 \\ 5 & -1 \end{pmatrix}$	 B1 Two elements correct B1 All four elements correct
(ii) EITHER $\frac{1}{3}\begin{pmatrix} 2 & -1 \\ -5 & 4 \end{pmatrix}$ OR	 B1 Both diagonals correct B1 Divide by determinant 2 B1 Solve sim. eqns. 1st column correct B1 2nd column correct
2 (i) 5 0.927 or 53.1° (ii)(a) (b) $A(3, 4)$ O	 B1 Correct modulus B1 Correct argument, any equivalent form 2 B1 Circle centre A (3, 4) B1 Through O, allow if centre is (4, 3) 2 B1 Half line with +ve slope B1 Starting at (3, 0) B1 Parallel to OA, (implied by correct arg shown) 3
3 (i) $\frac{r}{(r+1)!}$	M1 Common denominator of $(r + 1)!$ or $r!(r + 1)!$ A1 Obtain given answer correctly
(ii) $1 - \frac{1}{(n+1)!}$	 M1 Express terms as differences using (i) A1 At least 1st two and last term correct M1 Show pairs cancelling A1 Correct answer a.e.f.
4	B1Establish result is true, for $n = 1$ (or 2 or 3)M1Attempt to multiply A and A ⁿ , or vice versaM1Correct process for matrix multiplicationA1Obtain 3^{n+1} , 0 and 1A1Obtain $\frac{1}{2}(3^{n+1} - 1)$ A1Statement of Induction conclusion, only if 5 marks earned, but may be in body of working6

5			M1 M1	Express as difference of two series Use standard results
		$\frac{1}{4}n^2(n+1)^2 - \frac{1}{6}n(n+1)(2n+1)$	A1	Correct unsimplified answer
			M1	Attempt to factorise
			Al	At least factor of $n(n + 1)$
		$\frac{1}{12}n(n+1)(3n+2)(n-1)$	A1	Obtain correct answer
		12	6	
6	(i)	3 – i	B1	Conjugate stated
	(ii)	EITHER	M1	Use sum of roots
			A1	Obtain correct answer
			M1	Use sum of pairs of roots
			A1	Obtain correct answer
			M1	Use product of roots
		a = -8, b = 22, c = -20	A1	Obtain correct answers
		OR	<u>0</u> M1	Attempt to find a quadratic factor
		OK .	M11 A 1	Obtain correct factor
			M1	Expand linear and quadratic factors
		a = -8, b = 22, c = -20	A1A1	IA1 Obtain correct answers
			M1	Substitute 1 imaginary & the real root into ean
			M1	Equate real and imaginary parts
			M1	Attempt to solve 3 eqns.
		a = -8, b = 22, c = -20	A1A1	IA1 Obtain correct answers
7	(i)		B1 1	Enlargement (centre <i>O</i>) scale factor 6
	(ii)		B1	Reflection
			B1	Mirror line is $y = x$
			2	
	(iii)		B1	Stretch in <i>y</i> direction
	. /		B1	Scale factor 6, must be a stretch
			2	<i>`</i>
	(iv)			Rotation
	(11)		B1 B1	36.9° clockwise or equivalent
			2	sets stock the of equivalent

$\alpha\beta = 2k$ B1State or use correct value $\frac{\alpha}{\beta} + \frac{\beta}{\alpha} = \frac{(\alpha + \beta)^2 - 2\alpha\beta}{\alpha\beta}$ A1Attempt to express sum of new roots in terms of $\alpha + \beta$. $\alpha\beta$ $\frac{\alpha}{\beta} + \frac{\beta}{\alpha} = \frac{1}{2}(k-4)$ A1Obtain correct expression $\alpha'\beta' = 1$ B1Correct product of new roots seen $x^2 - \frac{1}{2}(k-4)x+1=0$ B1ftObtain correct answer a.e.f. $\frac{\alpha}{\beta} + \frac{\beta}{\alpha} = \frac{1}{2}(k-4)x+1=0$ B1ftObtain correct answer, must be an eqn. $\boxed{7}$ A1Obtain correct answer, must be an eqn. $\frac{\alpha}{2} + \frac{1}{2}(k-4)x+1=0$ B1ftObtain correct answer, must be an eqn. $\boxed{7}$ A1Obtain correct answerA1Obtain correct answerA1 $\boxed{8}$ A1Obtain correct answer $\boxed{9}$ (i)M1 $\underbrace{1} + 2i$ M1 $\underbrace{1} + 2i$ M1 $\underbrace{2} + (3 + 2i)$ M1 $\underbrace{3} + 2i$ M1 $\underbrace{3} + 2i$ M1 $\underbrace{4} + 2i$ M1 $\underbrace{3} + 2i$ M1 $\underbrace{4} + 2i$ M1 $\underbrace{3} + 2i$	8	$\alpha + \beta = -k$	B1	State or use correct value
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A1Obtain correct answers as complex nos. 5 5 (ii) $5-12i$ 5 $1000000000000000000000000000000000000$		$\pm (3 + 2i)$	M1	Solve a 3 term quadratic & obtain x or y
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		$x = \pm (3 \pm 2i)$	A1A1	Each pair of correct answers a.e.f.
			4	•

10 (i)	M1	Find value of det AB
	A1	Correct value 2 seen
	2	
(ii)	M1	Show correct process for adjoint entries
	A1	Obtain at least 4 correct entries in adjoint
	B1	Divide by their determinant
$(0 \ 3 \ -1)$		-
$(\mathbf{AB})^{-1} = \frac{1}{2} \begin{bmatrix} 0 & -1 & 1 \end{bmatrix}$	A1	Obtain completely correct answer
$^{2}(2 \ 6-3a \ a-6)$		
	4	
(iii) EITHER	M1	State or imply $(\mathbf{AB})^{-1} = \mathbf{B}^{-1}\mathbf{A}^{-1}$
	A1	Obtain $\mathbf{B}^{-1} = (\mathbf{A}\mathbf{B})^{-1} \times \mathbf{A}$
	M1	Correct multiplication process seen
	A1	Obtain three correct elements
$\begin{pmatrix} 1 & 0 & 0 \end{pmatrix}$		
$\mathbf{B}^{-1} = \begin{vmatrix} 1 & 1 & 2 \end{vmatrix}$	A1	All elements correct
$\begin{pmatrix} -6 & 2 & -2 \end{pmatrix}$		
		Attenuet to Condictory of CD
OK	MI	Attempt to find elements of B
	Al	All correct

- M1 Correct process for B
- A1 3 elements correct
- A1 All elements correct