OCR
RECOGNISING ACHIEVEMENT

Friday 20 January 2012 – Afternoon

AS GCE MATHEMATICS (MEI)

4755 Further Concepts for Advanced Mathematics (FP1)

QUESTION PAPER

Candidates answer on the Printed Answer Book.

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

Other materials required:
- Scientific or graphical calculator

Duration: 1 hour 30 minutes

4733170112

INSTRUCTIONS TO CANDIDATES

These instructions are the same on the Printed Answer Book and the Question Paper.

- The Question Paper will be found in the centre of 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

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.

Turn over

Section A (36 marks)

1 You are given that $\mathbf{A} = \begin{pmatrix} 2 & -1 & 1 \\ 0 & p & -4 \end{pmatrix}$ and $\mathbf{B} = \begin{pmatrix} 0 & q \\ 2 & -2 \\ 1 & -3 \end{pmatrix}$.

(i) Find **AB**. **[3]**

(ii) Hence prove that matrix multiplication is not commutative. **[2]**

2 Find the values of A, B, C and D in the identity $2x^3 - 3 \equiv (x + 3)(Ax^2 + Bx + C) + D$. **[5]**

3 Given that $z = 6$ is a root of the cubic equation $z^3 - 10z^2 + 37z + p = 0$, find the value of p and the other roots. **[6]**

4 Using the standard summation formulae, find $\sum_{r=1}^{n} r^2(r-1)$. Give your answer in a fully factorised form. **[6]**

5 The equation $z^3 - 5z^2 + 3z - 4 = 0$ has roots α, β and γ. Find the cubic equation whose roots are $\frac{\alpha}{2} + 1$, $\frac{\beta}{2} + 1$, $\frac{\gamma}{2} + 1$, expressing your answer in a form with integer coefficients. **[6]**

6 Prove by induction that $\sum_{r=1}^{n} r3^{r-1} = \frac{1}{4}[3^n(2n-1) + 1]$. **[8]**

Section B (36 marks)

7 A curve has equation $y = \dfrac{(x+1)(2x-1)}{x^2 - 3}$.

(i) Find the coordinates of the points where the curve crosses the axes. **[2]**

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

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

(A) large positive values of x,

(B) large negative values of x. **[3]**

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

(v) Solve the inequality $\dfrac{(x+1)(2x-1)}{x^2 - 3} < 2$. **[3]**

8 **(i)** Sketch on an Argand diagram the locus, C, of points for which $|z-4|=3$. **[3]**

(ii) By drawing appropriate lines through the origin, indicate on your Argand diagram the point A on the locus C where $\arg z$ has its maximum value. Indicate also the point B on the locus C where $\arg z$ has its minimum value. **[2]**

(iii) Given that $\arg z = \alpha$ at A and $\arg z = \beta$ at B, indicate on your Argand diagram the set of points for which $\beta \leqslant \arg z \leqslant \alpha$ and $|z-4| \geqslant 3$. **[2]**

(iv) Calculate the value of α and the value of β. **[3]**

9 The matrix $\mathbf{R}$ is $\begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix}$.

(i) Explain in terms of transformations why $\mathbf{R}^4 = \mathbf{I}$. **[3]**

(ii) Describe the transformation represented by $\mathbf{R}^{-1}$ and write down the matrix $\mathbf{R}^{-1}$. **[2]**

(iii) $\mathbf{S}$ is the matrix representing rotation through 60° anticlockwise about the origin. Find $\mathbf{S}$. **[2]**

(iv) Write down the smallest positive integers m and n such that $\mathbf{S}^m = \mathbf{R}^n$, explaining your answer in terms of transformations. **[2]**

(v) Find $\mathbf{RS}$ and explain in terms of transformations why $\mathbf{RS} = \mathbf{SR}$. **[3]**

THERE ARE NO QUESTIONS WRITTEN ON THIS PAGE

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AS GCE MATHEMATICS (MEI)

4755 Further Concepts for Advanced Mathematics (FP1)

PRINTED ANSWER BOOK

Candidates answer on this Printed Answer Book.

OCR supplied materials:
- Question Paper 4755 (inserted)
- MEI Examination Formulae and Tables (MF2)

Other materials required:
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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

4

(answer space continued overleaf)

4	**(continued)**
5	

5	(continued)

6

6	**(continued)**

Section B (36 marks)

7 (i)	
7 (ii)	

7 (iii) (*A*)	
7 (iii) (*B*)	

7 (iv)	
7 (v)	

8 (i) (ii) & (iii)	
8 (iv)	

9 (i)	
9 (ii)	

9 (iii)	
9 (iv)	

9 (v)	

GCE

Mathematics (MEI)

Advanced Subsidiary GCE

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

Mark Scheme for January 2012

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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

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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.

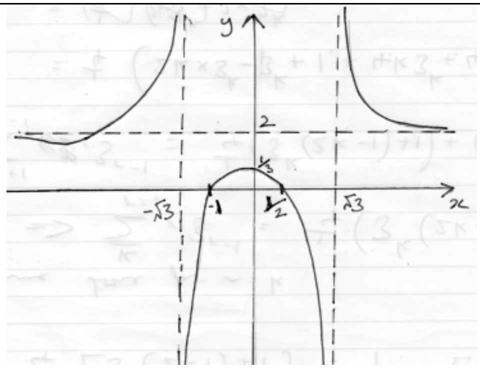
Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

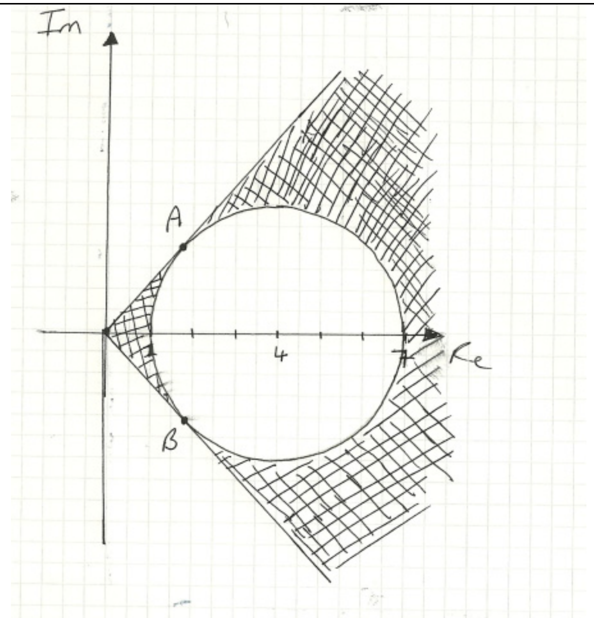
Question			Answer	Marks	Guidance
1	(i)		$\mathbf{AB}=\begin{pmatrix}2 & -1 & 1\\ 0 & p & -4\end{pmatrix}\begin{pmatrix}0 & q\\ 2 & -2\\ 1 & -3\end{pmatrix}=\begin{pmatrix}-1 & 2q-1\\ 2p-4 & -2p+12\end{pmatrix}$	M1 A2 **[3]**	Attempt to multiply in correct order Correct and simplified -1 each error
1	(ii)		$\mathbf{BA}=\begin{pmatrix}0 & q\\ 2 & -2\\ 1 & -3\end{pmatrix}\begin{pmatrix}2 & -1 & 1\\ 0 & p & -4\end{pmatrix}=\begin{pmatrix}* & * & *\\ * & * & *\\ * & * & *\end{pmatrix}$ $\mathbf{BA}\neq\mathbf{AB}$ hence not commutative	M1 A1 **[2]**	Valid method to compare products Reason for conclusion stated
2			$2x^3-3\equiv(x+3)(Ax^2+Bx+C)+D$ $B=-6,\ C=18,\ D=-57$	B1 M1 A3 **[5]**	$A = 2$ Evidence of comparing coefficients or other valid method (may be implied) 1 mark each for B, C and D, c.a.o.
3			$6^3-10\times6^2+37\times6+p=0$ $\Rightarrow p=-78$ $z^3-10z^2+37z-78=(z-6)(z^2-4z+13)$ $z=\dfrac{4\pm\sqrt{16-52}}{2}=2\pm3\mathrm{j}$ So other roots are $2+3\mathrm{j}$ and $2-3\mathrm{j}$	M1 A1 M1 A1 M1 A1 **[6]**	Substituting in 6, or other valid method cao Valid attempt to factorise Correct quadratic factor Valid method for solution of their 3 term quadratic One mark for both cao

Question			Answer	Marks	Guidance
4			$\sum_{r=1}^{n} r^2(r-1)=\sum_{r=1}^{n} r^3-\sum_{r=1}^{n} r^2$	M1*	Attempt to split into two summations.
			$=\frac{1}{4}n^2(n+1)^2-\frac{1}{6}n(n+1)(2n+1)$	M1 A1	Attempt to use at least one standard result appropriately Correct
			$=\frac{1}{12}n(n+1)(3n^2-n-2)$, oe or $\frac{1}{12}n(n-1)(3n^2+5n+2)$, oe	M1 dep *	Attempt to factorise using either $n(n-1)$ or $n(n+1)$
			$=\frac{1}{12}n(n+1)(n-1)(3n+2)$	A2 **[6]**	All correct SC A1 correct but $(3kn+2k)/12k$ seen

Question	Answer	Marks	Guidance
5	$\omega = \frac{z}{2} + 1 \Rightarrow z = 2(\omega - 1)$	B1	Substitution
	$(2(\omega-1))^3 - 5(2(\omega-1))^2 + 3(2(\omega-1)) - 4 = 0$	M1	Substitute their expression for z into cubic and attempt to expand
	$\Rightarrow 4\omega^3 - 22\omega^2 + 35\omega - 19 = 0$	A4	Minus 1 each error (allow integer multiples)
		[6]	
	OR	OR	
	$\alpha + \beta + \gamma = 5$ $\alpha\beta + \alpha\gamma + \beta\gamma = 3$ $\alpha\beta\gamma = 4$	B1	Correct sums and products of roots
	Let new roots be k, l, m then		
	$k + l + m = \frac{1}{2}(\alpha+\beta+\gamma) + 3 = \frac{11}{2} = \frac{-B}{A}$ $kl + km + lm = \frac{1}{4}(\alpha\beta + \alpha\gamma + \beta\gamma) +$ $(\alpha+\beta+\gamma) + 3 = \frac{35}{4} = \frac{C}{A}$ $klm = \frac{1}{8}\alpha\beta\gamma + \frac{1}{4}(\alpha\beta + \beta\gamma + \beta\gamma)$ $+\frac{1}{2}(\alpha+\beta+\gamma) + 1 = \frac{19}{4} = \frac{-D}{A}$	M1	Attempt to use root relations of original equation to find all three sums and products of roots in related equation
	$\Rightarrow \omega^3 - \frac{11}{2}\omega^2 + \frac{35}{4}\omega - \frac{19}{4} = 0$		(*)
	$\Rightarrow 4\omega^3 - 22\omega^2 + 35\omega - 19 = 0$	A4	SC (*) A3 Minus 1 each error (allow integer multiples)
		[6]	

Question			Answer	Marks	Guidance
6			When $n = 1$, $\sum_{r=1}^{n} r3^{r-1} = 1\times 3^0 = 1$		
			and $\frac{1}{4}\left[3^n(2n-1)+1\right] = \frac{1}{4}\left[3\times(2-1)+1\right] = 1$, so true for $n = 1$	B1	
			Assume $\sum_{r=1}^{k} r3^{r-1} = \frac{1}{4}\left[3^k(2k-1)+1\right]$	E1	Assuming true for k
			$\sum_{r=1}^{k+1} r3^{r-1} = \frac{1}{4}\left[3^k(2k-1)+1\right]+(k+1)3^{k+1-1}$	M1*	Adding $(k+1)$th term (incorrect expressions on LHS lose final E1)
			$= \frac{1}{4}\left[3^k(2k-1)+1+4(k+1)3^k\right]$	M1 dep*	Attempt to obtain factor of $\frac{1}{4}$
			$= \frac{1}{4}\left[3^k(2k-1+4(k+1))+1\right]$	M1dep*	For $\left[3^k(ak+b)+c\right]$ $c \neq 0$
			$= \frac{1}{4}\left[3^k(6k+3)+1\right]$		
			$= \frac{1}{4}\left[3^{k+1}(2k+1)+1\right]$	A1	
			$= \frac{1}{4}\left[3^{k+1}(2(k+1)-1)+1\right]$		Or target seen
			Therefore if true for $n = k$ it is also true for $n = k+1$. Since it is true for $k = 1$, it is true for all positive integers.	E1 E1 **[8]**	Dependent on A1 and previous E1 Dependent on B1 and previous E1
7	(i)		$(-1,\ 0)$, $(\frac{1}{2},\ 0)$ $(0,\ \frac{1}{3})$	B1 B1 **[2]**	Both x-intercepts y-intercept
7	(ii)		$x = -\sqrt{3},\ x = \sqrt{3},\ y = 2$	B1,B1,B1* **[3]**	

Question			Answer	Marks	Guidance
7	(iii)		Evidence of method needed e.g. evaluation for 'large' values or convincing algebraic argument (*A*)Large positive x, $y \to 2^+$ so from above (*B*) Large negative x, $y \to 2^-$ so from below	M1 A1 dep* A1 dep* **[3]**	 Allow if $y = 2$ indicated but not explicit in (ii) SC B1 dep* Correct (*A*) and (*B*) following M0
7	(iv)			B1 B1 B1 **[3]**	Correct asymptotes shown and labelled Correct central branch with intercepts labelled Correct shape. Allow asymptotes at $x = \pm 3$ and $y = k$, $k > 0$. asymptotic behaviour shown with clear minimum in the LH branch.
7	(v)		$(x+1)(2x-1) = 2(x^2 - 3)$ $x = -5$ $x < -5$ or $-\sqrt{3} < x < \sqrt{3}$	M1 B1 B1 **[3]**	Finding where curve cuts $y = 2$ (or valid solution of an inequality)

Question			Answer	Marks	Guidance
8	(i)			B3 **[3]**	Circle, B1; centre 4, B1; radius 3 with evidence of scale B1;
8	(ii)			B1 B1 **[2]**	Tangent OA Tangent OB
8	(iii)			B1 B1 **[2]**	Region outside their circle indicated Correct region shown
8	(iv)		$\alpha = \arcsin\frac{3}{4}$ $\alpha = 0.848$ $\beta = -0.848$	M1 A2 ft **[3]**	Valid method ft their tangents if circle centred on any axis One for each; accept 48.6° and –48.6° A1 max if $\alpha < \beta$
9	(i)		**R** represents a rotation through 90° $\mathbf{R}^4$ represents 4 successive rotations through 90°, making 360°, which is a full turn, which is equivalent to the identity	B1 B1 E1 **[3]**	4 successive rotations Interpretation of $\mathbf{R}^4$ and **I** required
9	(ii)		$\mathbf{R}^{-1}$ represents a rotation of 90° clockwise about the origin. $\mathbf{R}^{-1} = \begin{pmatrix} 0 & 1 \\ -1 & 0 \end{pmatrix}$	B1 B1 **[2]**	Rotation, angle, centre and sense

Question			Answer	Marks	Guidance
9	(iii)		$\mathbf{S}=\begin{pmatrix}\frac{1}{2} & -\frac{\sqrt{3}}{2}\\ \frac{\sqrt{3}}{2} & \frac{1}{2}\end{pmatrix}$	B2 **[2]**	One mark for each correct column (allow 3sf)
9	(iv)		$m = 3$ $n = 2$ $\mathbf{S}^3=\mathbf{R}^2$ because both represent a rotation through 180°	B1 E1 **[2]**	$m = 3$ and $n = 2$
9	(v)		$\mathbf{RS}=\begin{pmatrix}0 & -1\\ 1 & 0\end{pmatrix}\begin{pmatrix}\frac{1}{2} & -\frac{\sqrt{3}}{2}\\ \frac{\sqrt{3}}{2} & \frac{1}{2}\end{pmatrix}=\begin{pmatrix}-\frac{\sqrt{3}}{2} & -\frac{1}{2}\\ \frac{1}{2} & -\frac{\sqrt{3}}{2}\end{pmatrix}$ $\mathbf{RS}=\mathbf{SR}$ because $\mathbf{RS}$ represents a 60° rotation anticlockwise about the origin followed by a 90° rotation anticlockwise about the origin, making a total rotation of 150° anticlockwise about the origin. $\mathbf{SR}$ represents these two rotations in the opposite order, but the net effect is still a rotation of 150° anticlockwise about the origin.	M1 A1ft E1 **[3]**	ft their **S** -1 each error Convincing explanation, correct, no ft

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4755 Further Concepts for Advanced Mathematics (FP1)

General Comments

The paper appeared to be largely accessible, with many good scores obtained from high quality responses. There did appear to be a surprising number of misreads this session, especially in the early questions. Notation was not always conventional and this could be unhelpful to the candidate. In particular the careful use of brackets is recommended. Candidates need to ensure that all diagrams are clear and in pencil, with minimal alterations; where such are needed they should be thoroughly erased. It seemed that there were more occasions this time where responses were put in the wrong space in the answer book. This is understandable for a candidate in full flow, but extremely unhelpful for the examiner.

Comments on Individual Questions

1 (i) This was usually well done, except for not uncommon misreadings of the figures, and sometimes of q, in **A** or **B**.

1 (ii) The majority of candidates chose to multiply out **BA** in full. Some candidates failed to produce a 3x3 matrix. The chief error was to claim that **BA** did not exist. Not many chose the economical route of considering the resulting order of a (3 by 2) matrix multiplying a (2 by 3) matrix, which saved a lot of work.

2 This was usually well done, with most candidates scoring full marks. Errors in finding D (as 57, or −51, sometimes 51) were the most common.

3 This question was also done well. Substitution to find p was the favourite starting point, but many candidates chose to find the linear and quadratic factors first, either by inspection, long division, or matching coefficients. There were some mistakes in finding the roots of the quadratic equation, often caused by careless notation.

4 This was well done by many. However, some candidates tried to treat $\sum r^2(r-1)$ as $(\sum r^2)(\sum r-1)$, scoring no marks. Those that did not begin by taking out the factors n and $(n+1)$ often failed satisfactorily to complete the factorisation of their quartic in n. Another error which occurred was to write down the summation initially as $\sum r^2 - \sum r$, for which it was possible to score a maximum of 3 marks.

5 Most candidates chose to use the relationships $\sum\alpha$, $\sum\alpha\beta$ and $\alpha\beta\gamma$, then the sums and products of the new roots. This could lead to mistakes in the resulting expansions and substitutions. The more successful used the substitution $w = 2(z - 1)$ and achieved the required result more quickly, especially if they were conversant with the cubic expansion. This method could also lead to the error of using $w = 2z - 1$.

6 This type of question always differentiates between candidates. Some know the words but not always their logical sequence nor the meaning of some of their phrases. This particular question challenged the algebraic manipulation of many and not a few fudged their work to the result that they knew was wanted. It was apparent that many problems here would have been alleviated by a rigorous approach to using brackets. It was not that uncommon to see $4\text{x}3^k$ turn into 12^k.

7 (i) Many did not write conventional co-ordinates, and are fortunate that the scheme allows $x = 0$, $y = 1/3$ etc.

7 (ii) The examiners want to see three distinct equations here. Most candidates found $y = 2$, and only a few gave $x = 3$ and $x = -3$.

7 (iii) For this question the mark scheme is necessarily sketchy, as many substitutions could be used. It is important that evaluations of the numerical expressions are given to demonstrate the conclusions about the approaches to the asymptotes. The conclusions are wanted in words. An algebraic argument was not a popular choice, and, where attempted, was insufficiently thorough.

7 (iv) Many clear, well presented graphs were seen. Some were carelessly drawn or had incomplete annotation. Some were wrong, particularly in the left hand branch. Alterations can be difficult to decipher and need careful erasing.

7 (v) This was not well answered on the whole. The best solved an equation to find the value of x where $y = 2$. As an inequality this should only be solved by multiplying by $(x^2 – 3)$ if there is an argument to explain that this expression is positive. Some candidates forgot the part of the graph in $-\sqrt{3} < x < \sqrt{3}$.

8 (i) Well answered by most candidates, with circles placed in more or less the right place and with sufficient annotation on the diagram to see what was intended. The most common error was to see the centre at −4 on the real axis.

8 (ii) Many candidates correctly placed A and B on the tangents from O. A small minority got them muddled up. A frequently seen mistake was to place A and B at the top and bottom of the circle. Some candidates put A and B on the real axis, forgetting that in these positions both had arguments of zero.

8 (iii) Shading began to obscure some of the earlier notation. This part was often not well answered. Most often that part of the locus to the right of the circle was forgotten. Some candidates shaded inside the circle, contravening the condition $|z - 4| \geq 3$.

8 (iv) Not all those who managed to place A and B correctly were able to complete this section successfully. The geometry of the diagram was not appreciated, leading to the wrong trigonometric function being used. Many candidates guessed that $\pi/4$ was the answer. Those who had A and B wrongly positioned could not score. A high proportion of candidates did not attempt a solution.

9 (i) Quite a number of candidates ignored the wording of this question and simply showed by evaluation that $\mathbf{R}^4$ was **I**. A surprisingly high proportion of candidates thought that **R** represented a reflection. Those who correctly identified both the rotation and the full turn did not always make explicit that this was equivalent to the identity transformation, as represented by **I**. There were several instances of confusion between matrices and the images of objects, making the explanation less than coherent.

9 (ii) The matrix was usually correct, apart from those who believed the determinant of **R** was −1. The transformation was often correct, but the description frequently left out the centre of the rotation. Those who had the direction wrong in (i), where this was condoned, were penalised here. It was surprising that some candidates gave the correct transformation in this section having described **R** as representing a reflection in part (i).

9 (iii) Overall this was quite well done. Some candidates simply substituted the number 60 for θ in the given formula which scored no marks. It was interesting that quite a few thought of 60 as 2/3 of 90, whence **S** became (2/3)**R**.

9 (iv) Those that attempted this question mostly answered it very well, with excellent explanation. Reflections, however, could not score.

9 (v) With credit available for the correct use of an incorrect **S** many candidates earned the first two marks. A small minority evaluated **SR** instead of **RS**. The final explanation was for correct transformations only, and a few candidates were perceptive enough to realise that all rotations were commutative. Claiming this for "transformations", however, was not sufficient, nor correct.