Examiners' Report/
Principal Examiner Feedback

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Pearson Edexcel International A Level
Further Pure Mathematics F1
(WFM01/01)

Paper 01

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Further Pure Mathematics F1 (WFM01)

General Introduction

This paper was a good test of candidates' knowledge and understanding of the F1 specification. There was plenty of opportunity throughout the paper for grade E candidates to demonstrate their skills. There were some testing questions involving coordinate systems and induction that allowed the paper to discriminate well across the higher ability levels.

In summary, Q1(a), Q1(b), Q2, Q4(c), Q5, Q6(a) and Q7 were a good source of marks for the average candidate, mainly testing standard ideas and techniques; and Q1(c), Q3, Q4(a), Q4(b) and Q9 were discriminating at the higher grades. Q6(b) and Q8(b) proved to be the most challenging questions on the paper.

Question 1

This question discriminated well with about 47% of candidates gaining full marks.

Part (a) was almost always done correctly. A few candidates, however, made arithmetic slips or evaluated i^2 incorrectly.

In part (b), the majority of candidates, by showing their working clearly, provided a fully correct method of evaluating $\frac{z}{w^*}$ to give $\frac{5}{2}-\frac{1}{2}\mathrm{i}$. A few candidates instead tried to evaluate $\frac{z}{w}$ but the main loss of marks in part (b) was through failing to give the final answer in the form $a+b\mathrm{i}$.

Part (c) was done well by only a minority of candidates. The majority were unable to apply Pythagoras' Theorem correctly to find the magnitude of the expression $|z+k|$. Various incorrect methods were seen such as simplifying $|3+2i+k|=\sqrt{53}$ to give either $(3+k)^2-4=53$ or $9+4+k^2=53$. Among those who applied Pythagoras' Theorem correctly there were some who were unable to solve the quadratic equation obtained. A few completed the square but took only the positive root. Others rejected the negative root for no clear reason.

Question 2

This question proved accessible for the vast majority of candidates, with about 60% of candidates scoring full marks.

In part (a), most candidates correctly evaluated the values of $\mathrm{f}(1.6)$ and $\mathrm{f}(1.7)$ with the majority also able to draw the appropriate conclusion. A few candidates, however, did not refer to a change of sign.

In part (b), there was a significant minority of candidates who were unable to differentiate either $-\frac{3}{\sqrt{x}}$ or $-\frac{4}{3x^2}$ correctly. Many candidates applied the Newton-Raphson procedure correctly and gave their final answer correct to 3 decimal places. A noticeable number of candidates incorrectly rounded their answer to 1.673 and so lost the final accuracy mark. A few candidates used interval bisection whilst others wasted their time by performing a second iteration of the Newton-Raphson procedure.

Question 3

This question discriminated well with about 31% of candidates gaining full marks and about 56% gaining at least 9 of the 11 marks available. It was disappointing to see a small number of the candidates, losing a substantial number of marks by ignoring the instruction "Without solving the equation, …". These candidates solved the equation $x^2 - 2x + 3 = 0$ to give α, β as $1 \pm \sqrt{2}\,\mathrm{i}$ and applied these roots in their solution to this question.

In part (a), those candidates who took on board the instruction usually completed this part with a great deal of success. Most of the errors were seen in part (iii) with poor algebraic processing skills being demonstrated in the evaluation of $\alpha^3 + \beta^3$.

In part (b), many candidates correctly answered part (i). In part (ii), the requirement to find the sum and the product of the roots was identified by the majority of the candidates and many went on to find the quadratic equation in the required form. Most of the errors made in this part were in evaluating the product of the roots, with errors in signs and bracketed terms resulting in some marks being lost.

Question 4

This question discriminated well with about 20% of candidates gaining full marks and about 45% gaining at least 7 of the 8 marks available.

A significant number of candidates struggled to gain full marks in part (a), although most of them recognised that a rotation was involved, although not always stating the centre of rotation. There was a fairly even spread between those candidates correctly stating 225° anticlockwise and 135° clockwise. Errors in this part included candidates incorrectly stating the sense of the rotation or stating an incorrect angle of rotation.

In part (b), a significant number of candidates struggled to find the correct answer, $n = 8$. Candidates obtained the correct answer by either raising the matrix **A** to a variety of successive powers until reaching the identity matrix or multiplying the angle of rotation by integers until they had a multiple of 360°. Incorrect answers included zero, $\sqrt{2}$ and $\frac{1}{\sqrt{2}}$, among the more plausible values of 2, 4 and 6.

In part (c), many candidates found the matrix **B** by correctly applying $\mathbf{CA}^{-1}$, although a significant number attempted to find $\mathbf{A}^{-1}\mathbf{C}$ after writing down the incorrect matrix equation $\mathbf{C} = \mathbf{AB}$. A minority of candidates correctly wrote down $\mathbf{C} = \mathbf{BA}$ and used $\mathbf{B} = \begin{pmatrix} a & b \\ c & d \end{pmatrix}$ to find the elements *a*, *b*, *c* and *d* by solving simultaneous equations. Calculation errors and arithmetic errors sometimes led to a loss of marks in this part.

Question 5

This was a well-answered question with 57% of the candidates gaining full marks.

In part (a), almost all candidates substituted the standard formula for $\sum_{r=1}^{n} r^3$ and $\sum_{r=1}^{n} r$ correctly into $\sum_{r=1}^{n} 8r^3 - 3r$. Candidates who then directly factorised out $\frac{1}{2}n(n+1)$ were usually more successful in obtaining the correct answer. Some candidates who multiplied out their expression struggled in their attempts to factorise $2n^4 + 4n^3 + \frac{1}{2}n^2 - \frac{3}{2}n$.

In part (b), there were many good solutions, and the majority of candidates gained full marks. Most candidates realised that they needed to substitute both $n = 10$ and $n = 4$ into both $\frac{1}{2}n(n+1)(2n+3)(2n-1)$ and $\frac{k}{6}n(n+1)(2n+1)$. Some candidates, however, substituted $n = 5$ and so lost 3 out of the 4 marks available in part (b). A small minority of candidates split up the given expression in part (b) into separate terms and applied the standard formulae. This method was slightly less successful, as arithmetic errors were more likely.

Question 6

This question discriminated well with about 27% of candidates gaining full marks and about 77% gaining at least 6 of the 9 marks available.

In part (a), candidates used a variety of methods to find $\frac{\mathrm{d}y}{\mathrm{d}x}$. Most candidates wrote y in terms of x and were able to differentiate and find $\frac{\mathrm{d}y}{\mathrm{d}x}$ in terms of p correctly. Some candidates used implicit differentiation or the chain rule with the parametric equations. Most candidates were then successful in finding the equation of the normal and obtained the given result in part (a). A number of candidates did not use a calculus method to find $\frac{\mathrm{d}y}{\mathrm{d}x} = -\frac{1}{p^2}$, and so lost marks in part (a).

Part (b) proved to be more challenging for many candidates, although there were some excellent, and fully correct solutions. Most candidates made some progress by correctly substituting $y = \frac{c^2}{x}$ or $x = \frac{c^2}{y}$ into the given equation. Many then proceeded to form a three-term quadratic equation. Some candidates were then unable to make further progress. Of those that attempted to solve the quadratic, most used the quadratic formula. In many cases the algebra became cumbersome and many made algebraic errors and were unable to find a correct coordinate. The majority of the candidates who obtained full marks in part (b) usually did so by applying a method of factorisation.

Question 7

This question proved to be the most accessible question on the paper with about 69% of candidates gaining full marks.

In part (a), almost all candidates were able to write down the complex conjugate root $3-2\mathrm{i}$. Most candidates went on to use the conjugate pair to identify a quadratic factor. It was very common to then see algebraic long division to establish the other quadratic factor, although some candidates compared coefficients or used inspection. Those candidates who had got this far usually solved their $x^2+3x-10=0$ to find the final 2 roots, although some made errors in trying to solve $x^2+3x-10=0$.

Most candidates correctly plotted $3+2\mathrm{i}$, $3-2\mathrm{i}$, -5 and 2 on an Argand diagram, although some did not show a scale. A minority plotted -5 and 2 on the imaginary axis. Those who had incorrectly solved the equation in (a) found their roots a little more difficult to plot on their Argand diagram. A small minority made no attempt at part (b).

Question 8

This was the most demanding question on the paper with about 20% of candidates gaining full marks and about 61% gaining at least 4 of the 8 marks available.

Part (a) was generally done well with some succinct solutions seen. The majority of candidates found the correct gradient of *l*. Many of them used this to write down a correct equation for the line *l*, which they manipulated to give the required equation. A small minority attempted to differentiate $y^2=4ax$ and so made no progress in part (a).

Part (b) proved to be the most challenging question on the paper, and there were relatively few fully correct solutions. Many candidates gained some credit for finding either the *y*-coordinate of *C* or for finding the height of triangle *OCS*.

Many candidates attempted to equate the area of triangle *OSC* to 3 times the area of triangle *OSB*. A significant number of candidates struggled to manipulate their equation into an equation of the form $\lambda a = \mu q$, and so were unable to make any further progress. A few candidates applied a method of similar triangles to achieve the result $5a=3q$. Those candidates who achieved $5a=3q$ or $a=\frac{3}{5}q$ were usually able to write down an correct expression for the area of triangle *OBC* and usually manipulated it to obtain the required result of $\frac{6}{5}qr$.

Question 9

This question proved to be a good discriminator with about 35% of candidates scoring full marks.

Many candidates started this question by proving the result was true for $n=1$. There were then varying approaches to the induction with $\mathrm{f}(k+1)-\mathrm{f}(k)$ being the most popular. There were also other valid methods that met with varying degrees of success, such as attempts to find $\mathrm{f}(k+1)-n\mathrm{f}(k)$ with a suitable value for *n* or attempts to find $\mathrm{f}(k+1)$ directly. Although the majority of candidates were able to write down a correct expression for either $\mathrm{f}(k+1)-\mathrm{f}(k)$ or

$f(k+1)$, a significant number could not manipulate their expression to a correct result for $f(k+1)$ of either $4(4^{k+1}+5^{2k-1})+21(4^{k+1})$ or $25(4^{k+1}+5^{2k-1})-21(4^{k+1})$ or equivalent. Some candidates did not bring all parts of their proof together to give a full conclusion. An example of a minimum acceptable conclusion, following on from completely correct work, would be 'if the result is true for $n=k$ then it has been shown to be true for $n=k+1$ and as it was shown true for $n=1$ then the result is true for all positive integers'.

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