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Examiners' Report

Principal Examiner Feedback

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In Further Pure Mathematics F1 (WFM01)

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Introduction

This was a well balanced paper with questions which allowed all candidates to show their knowledge of the specification. Question 1 was a good opening question that could be tackled by almost all candidates, giving them the confidence to proceed with the rest of the paper.

There were instances where candidates did not read the question sufficiently carefully and either did not complete the question or answered an incorrect question. Particular examples of this were questions 3 and 8(d).

Many candidates seemed to be reluctant to factorise complicated expressions preferring instead to multiply out, collect terms and then proceed to factorise the resulting cubic or quartic expression. A small slip in the earlier steps would leave them with an expression which was either very difficult to factorise or would not factorise fully. This was seen in 9(b) and even more frequently in 9(c). Candidates should keep an eye on the result they are hoping to reach in questions like 9(c) – this would help them extract factors at an early stage and so keep their work simple!

Question 1

Candidates knew how to find the determinant of a 2x2 matrix and only carelessness would lead to an incorrect quadratic expression. The roots of their quadratic were found correctly by the vast majority. Most were able to choose the correct region but a significant minority chose to go to the outer values rather than between their roots.

A few sketched the shape of the graph and invariably were able to select the correct region. Relevant sketches should be encouraged for clarification in many circumstances.

Question 2

In part (a) the majority of candidates plotted and labelled the points representing z_1 and z_2 in the correct quadrants. Only a very small minority failed to label their diagram in any way and future candidates need to be clearly taught that this is essential.

In part (b)(i) the majority knew how to find a modulus and arrived correctly at $\sqrt{34}$ however, a few decided that the final answer was going to be an integer and this led to $\sqrt{3^2 + 5^2} = \sqrt{36} = 6$.

In (b)(ii) nearly all candidates multiplied through by z* although a few elected to use -z*. Both approaches usually led to a correct conclusion, although the odd careless error in the numerator or incorrect evaluation of the denominator did lead a few to an incorrect complex number.

A majority obtained a correct expression for their $\arg(z_1/z_2)$ in part (c), and for most candidates this was arctan(±7/6). Sign errors and a lack of an appreciation of where z_1 / z_2 lies on the Argand diagram were the main areas where marks were lost here.
Many candidates found a sketch of the Agand diagram to be of great assistance.

Question 3

In part (a) the vast majority of candidates were able to identify the focus, *S*, as ($\frac{9}{2}$, 0) without difficulty.

Part (b) proved to be more problematic. The vast majority of candidates were able to use the focus-directrix property correctly and identify that *PS* = 9. Those candidates who drew a sketch of the parabola, showing the focus and directrix and the position of the point *P* usually went on to score full marks. A number of candidates worked backwards, using the *x* coordinate of *P* to find its *y* coordinate, and then using Pythagoras to calculate the length of *PS* (even though *P* and *S* had the same *x* coordinate i.e.$PS = \sqrt{(4.5-4.5)^2+(9-0)^2}$)

A substantial minority of candidates had not read the question properly. They assumed that they were asked to calculate the area of triangle *OPS*.A few candidates applied Pythagoras incorrectly (subtracting instead of adding), and some thought that *OP* = 9. Some candidates were reluctant to draw a diagram and to label lengths, which may have cost them marks as "9" was seen as one of their lengths but they did not indicate which.

Question 4

In part (a) it was rare for the second complex root to be incorrect or missing.

In part (b) the determination of the quadratic factor associated with a pair of complex conjugate roots was a well-rehearsed procedure for many candidates, with full marks seen often here.

The existence of a repeated positive real root caused a number of difficulties for some candidates who could thus not handle the algebraic processing techniques required in part (c). Long division was often used and, with unknown coefficients in the quartic function, this often led nowhere. The use of the product of the roots was by far the most successful way to find the repeated root and many candidates used this method. Unfortunately, quite a few candidates selected -3 instead of +3 as their root having not read the question with enough care.
Many candidates correctly determined the values of the constants *A*, *B* and *C* in part (c) although the incorrect use of $x = -3$ for the repeated root resulted in a number of the students not obtaining the required values.

Unfortunately, a significant minority used ($x^2 \pm 9$) which does not have a repeated root.

Question 5

In part (a) the majority of candidates gave a full description of the single transformation represented by the given matrix **P**. Generally, the only lost marks were due to the omission of one of the three elements.

For part (b) most candidates obtained a correct matrix **Q**; errors were generally due to the incorrect positioning of the 0's and 1's in the matrix.

The majority obtained the correct matrix product in part (c); however, a significant minority made the classic mistake of multiplying the matrices in the wrong order.

In part (d) most candidates successfully multiplied their matrix **R** by 3 and the majority knew how to find the required inverse of this for the final answer. Sign errors in finding the determinant caused a minority to err along with a few who were unable to fully transpose their matrix.

The tiny number who decided to let W' be $\begin{pmatrix} a & b \\ c & d \end{pmatrix}$ and then created and solved simultaneous equations found that they had chosen a tortuous route and were rarely fully correct.

Question 6

In part (a) almost every candidate scored B1B1 here by identifying clearly in terms of A the sum and product of the roots of the quadratic. Only a very small number had these the wrong way round.
For parts (b) and (c) most candidates realised they needed to find a sum and product of the given roots and most managed to expand and get both the sum and product in the correct forms, equating their results to $\frac{5}{4}$ and $\frac{\beta}{4}$ respectively. Some candidates made sign slips and lost the A marks; some did not divide the 5 and B by 4 when equating their sum and product, so could only gain the first M mark. A few candidates tried to equate their new sum/product with the sum/product in part (a). A common alternative approach was to form a quadratic equation with the given roots and compare coefficients to find A and B. Several candidates got confused with nomenclature, for example using alpha and beta to denote roots in the second equation and using their answers from (a) to compare the product and sum of roots in the second equation. Successful completion of part (a) did not always lead candidates to a correct approach in part (b) and it was not uncommon for candidates to attempt (unsuccessfully) to answer parts (b) and (c) without reference to their results from (a). For some candidates, it was particularly difficult to follow their work, with alpha and A being mixed up or difficult to decipher. A few candidates, having identified A in part (b), then calculated $\alpha + \beta = \frac{5}{2}$ and $\alpha\beta = 6$ and successfully used these in their solution to part (c).

Question 7

Nearly all candidates were able to tread a well-practiced path in part (a) to obtain the required normal. The differentiation was usually either explicit or implicit, the former being the more common approach, with only a small number using parametric differentiation.

For part (b) most candidates were able to form a correct quadratic equation, usually in x, occasionally in y and a few in t. It was rare to find errors in solving their equation and so the vast majority found correct coordinates for Q.

A few problems did materialise in finding the equation of the tangent to H at Q. A significant minority use the gradient of the tangent at P, which was, of course, not going to lead to the required solution. However, most did find the correct gradient, using the coordinates of Q and this usually led to a fully correct solution, the exceptions being caused by sign errors, giving a constant of zero.

Candidates may well find a sketch useful in situations such as that covered in this part of the question.

Question 8

The error in the final value of the table did not affect candidates' work, although it was sometimes noticed.

Part (a) was almost always completely correct, the most common error being due to rounding -1.2401 to -1.240.A few missed the 1 on -1.2401 (usually stated as -1.2400). Using a calculator's "Table" function was a real advantage.

In part (b) a large majority of candidates were able to identify that the interval [3, 4] contained a root α, using standard phrases such as "*change of sign*" and "*continuous over this interval*" as their explanation. Some referred to the product f(3) x f(4) being negative, which is an acceptable alternative. If the M mark was lost it was typically for failing to mention the sign change. However, very few candidates explained that the interval [1, 2] could be discounted because the function had a discontinuity at $x = \frac{5}{3}$, and therefore lost 1 out of the 2 available marks. A second careful re-reading of the question (i.e. "***explaining your reasoning***") might have alerted candidates that more was required of them from this question than similar previous ones. Some candidates **simply stated the interval with no justification for their choice.**

For part (c) candidates almost always used the interval chosen in part (b). Most were successful in identifying the required interval of length 0.25. Once again, good use of a calculator's "Table" function was a great time saver and a way of avoiding typing errors. The presentation of results in a table was good practice here. Several candidates lost the final mark by failing to identify the correct interval despite having done correct work.

In part (d) most candidates were familiar with the technique and attempted to apply it with the given interval. The most common approach was to use the similar triangles method. Many applied it correctly and arrived at a correct answer. Most realised they needed the modulus of the y-values, but some made sign errors and lost all 3 marks.

Another approach that was quite common was to consider the distances $(1 - x)$ and $(x - 0.5)$ and then use similar triangles. This required them to change the sign of their solutions. Most candidates that took this approach did change the sign, usually however without justifying the change. Those lost the marks as their method was incorrect. Candidates who drew a diagram were the most successful, compared to those who tried to remember a generic formula. Sign errors when calculating distances were commonly seen, but it was also common to see calculation errors such as f(-1) = -4.875 etc. It seemed that having both x values negative confused some candidates who were clearly used to dealing with positive x values. Some candidates ignored the new interval, attempting linear interpolation on their interval from part (b) or part (c).

Question 9

Most candidates were familiar with proof by induction as required in Part (a), although concluding statements indicated that not all really understood what they were doing. The majority of candidates who took the right approach were able to take out a common factor and reach the required form with sufficient working. It was however common to see an incorrect or incomplete attempt at testing the base case, or insufficient working when proceeding with the induction step. A large minority of candidates scored only 4/5 by either not providing sufficient evidence for showing that $n = 1$ was true or by not providing a complete conclusion at the end of their working. Most commonly they failed to state that $\sum_{r=1}^{1} r^3 = 1^3 = 1$, only evaluating the right hand side of the given result for $n = 1$.

In Part (b) most candidates were able to correctly expand $\sum r(r+1)(r-1)$ to $\sum r^3 - \sum r$ and then use standard summation results to reach the required answer scoring full marks here. Too many candidates' instinct is to immediately expand all brackets and only then think about factorisation. This strategy was often successful in this question because candidates were able to use their calculators to find the roots of their resulting polynomial. However factorisation is a much more efficient strategy, with fewer errors occurring. (This was also the case in part (c).)

For Part (c) many candidates were able to carefully handle the algebraic expressions required and factorise/cancel as was needed. Some candidates appeared to be in a rush to remove all the brackets rather than realise that keeping factorised expressions would prove to be easier. This was a far more challenging task than the usual eg $\sum_{r=6}^{23}$ or $\sum_{r=n}^{2n}$ type final part that has been asked in the past. A minority of candidates didn't know how to approach the summation between $r = n$ and $r = 2n$. Many candidates realised they needed to subtract the sum to n - 1 from the sum to $2n$, and most did this correctly. Many candidates worked with the summation of the right hand side to the point where it was fully factorised, before comparing it to the other sum. The majority spotted the factor n on both sides, but many then went on to multiply out both sides and this did not produce a high success rate. A few candidates failed to rule out a negative or zero root alongside their correct answer. Attempts to solve a quartic or cubic using their calculators often led to incorrect solutions.

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