Examiners' Report
Principal Examiner Feedback

Summer 2025

Pearson Edexcel International Advanced Level
In Further Pure Mathematics F2 (WFM02) Paper 01

Summer 2025
Publications Code WFM02_01_2506_ER

Overview

This paper was found very accessible, with only the final part of the last question proving to be more challenging than expected. There were access points throughout for all grades with both A and E grade students able to showcase their abilities, but also some discriminating questions to distinguish the grades. This is much in line with recent papers. Presentation was generally fine, with coherent answers for the most part being given, with students showing sufficient working to support the answers in most cases. However, a reliance on calculators for some routine work such as solving quadratics was shown by many.

Individual question reports

Question 1

This should have been a routine opening question, and for the higher grade students that was the case, but in lower grades there was some confusion with regards to the range for the argument, and which quadrant it should be in. Most knew how to apply De Moivre's theorem to find the roots, though a few raised to the 5$^{\text{th}}$ instead of taking a fifth root.

Part (a) was generally well answered by most candidates. The modulus was correctly calculated by the majority with only a few making mistakes. However, some candidates struggled with expressing the argument in the required range. A few did not adhere to the specified range and gave as the answer with argument $\frac{4\pi}{3}$, while others appeared unsure of the method and incorrectly gave the argument $\frac{\pi}{3}$ in the answer, forgetting to check which quadrant the number was in. Few sketched a diagram to help, but those who did were usually successful. A minority of students gave a negative r, but often coupled this with the appropriate argument $\frac{\pi}{3}$ to obtain an expression in the correct form, but it should be noted that r should be positive in exponential form, although this was not specified in the question in this case. Such answers were accepted here, but this is not a guarantee they will be acceptable in future papers.

Part (b) was also handled well by the majority. Most used de Moivre’s theorem and applied it correctly to obtain at least some of the roots, though some slips were made in finding all the roots. However, some who applied this method accurately made errors when calculating the fifth root of the modulus value $4\sqrt{2}$ found previously which affected the overall accuracy of their answers, and since the form was specified, they could not gain full marks. Only a small number of students raised to the fifth instead of taking the fifth root, but it was not uncommon to see only one root calculated, which could score the method mark only if the modulus was correctly simplified.

Encouragingly, only a small number of candidates gave arguments outside the specified range in this part, and cases of errors in the form, such as missing i’s in the index, were rare. Most used the exponential form throughout, but some used the

$r\left(\cos\theta + \mathrm{i}\sin\theta\right)$ forms during working, presumably linking this form specifically to De Moivre’s theorem. If left in this form there were still two marks available in each part.

Question 2

This question proved very accessible to most of the students and was answered well across all grades. Perhaps this would have been a friendlier opening question as such. Most certainly knew the procedure of needing find the third derivative, evaluate the derivatives at $x = 3$ and then apply Taylor’s theorem, though a very small minority failed to do this, instead trying an auxiliary equation approach to try and find the general solution first. Some of these did extensive work to then try and differentiation their result to find the Taylor series, but most such attempts made little progress.

The most common error was in the differentiation of the exponential function in the given equation, though omission of the $\frac{\mathrm{d}y}{\mathrm{d}x}$ when differentiating the $5y^2$ was also common, and other minor slips also seen. There were a few slips in the calculation of f '' (3) and

f ''' (3) but the vast majority of the cohort had a clear understanding of the strategies required to determine a Taylor series, applying a correct formula to gain the final method mark even if errors had been made and much success was achieved. Again, only a small minority applied incorrect series, e.g. by missing the factorial denominators or having a series expansion of x rather than $(x - 3)$ terms.

Question 3

A deceptively simple problem on a complex transformation, students tended to try and make this more complicated than was needed by trying to apply the conjugation approach to realisation of the denominator in part (b). Those who could see the more direct route often scored full marks.

For part (a) the majority of the students knew that the locus was a circle with its centre at the origin, but several did not indicate the radius of 1 in any way, simply drawing a circle that could have any radius. Students should be aware that sketches must give sufficient detail to be able to identify what they are sketching. There were also some straight lines, and a few V-shaped $y = |x - a|$ type graphs drawn.

When it came to part (b) most candidates started correctly, by finding z in terms of w, but then a variety of approaches ensured. Most used $|z| = 1$ as intended, and eventually cross multiplied (though sometimes after trying to simplify the fraction) and then apply moduli to determine the Cartesian equation. Errors in the equation were fairly common meaning that many of these did not reach a suitable equation. Only very few spotted the line was the perpendicular bisector of 9i and $-\text{i}$ to be able to write down the equation directly and a number of those who did used an incorrect midpoint.

The next most common approach was to multiply through by the conjugate of the denominator and try to apply $x^2 + y^2 = 1$. This was much less likely to succeed, often grinding to a halt part way through, as students either failed to extract real and imaginary parts or were unable to factorise the quartic reached after applying the modulus.

Some tried to use either $z = 1$ or $z^2 = 1$ rather than use the modulus, again make little progress. Working with $x + \text{i}y$ from the outset was less common, and again very unlikely to succeed as students were unable to identify the expressions require to simplify the result. Progress to the dM1 was sometimes made, but usually no further. A small number of candidates seemed to think that cartesian equation required use of x and y rather than u and v and so tried to change their correct equation.

Question 4

Differential equations is a very familiar topic in which students often do well in this paper, and this question proved no difference. Perhaps most striking was the ingrained need to find the complementary function before attempting the particular integral that was shown by many students, rather than just showing the particular integral given in the question is one that works.

In part (a), despite sometimes occurring after attempts to find the complementary function first, the majority of the candidates were able to correctly determine, by use of the Product rule, the first and second derivatives of y and proceed to find the value of λ by substituting into the equation and comparing coefficients. A few did make slips either in the derivatives, or during simplification, to either find the wrong value, or arrive at the correct value by incorrect means (e.g. with non-cancelling xe^{3x} terms in the equation), and so forfeit the A mark. But overall, this part was very well done.

In part (b), the familiar routine of forming the associated auxiliary equation and hence determining the general solution of the differential equation was well understood by the vast majority of the cohort. Peculiarly, some who did this at the start of part (a) chose to repeat the whole process again in part (b) rather than just bringing their answer from earlier forward. Very few made errors in solving the auxiliary equation or forgot to combine, though a few did omit the "$y =$…" when giving the final solution.

Part (c) was again generally well answered using the given boundary conditions with the main reason for any loss of marks being due to the incorrect differentiation of the general solution found in part (b) or carrying through from errors in earlier parts.

Question 5

Another expected question, using the method of differences, and the slightly more complicated three-part partial fraction did not cause any significant problems. There was a bit of discrimination at the end of part (c), where not all were able to identify the correct value needed from the context.

In part (a) the correct partial fractions were found successfully by almost all candidates, with none recorded as using the variant two fraction form noted in the scheme.

The method of differences was generally applied well in part (b), although a few candidates made errors, missing the necessary cancellations and failing to identify the correct terms. But the process required was demonstrated by most, and the following procedure to combine to a single fraction was also done very well. Those who extracted the correct terms usually proceeded to the correct answer.

For part (c) most students could set up the appropriate equation or inequality and many reached the correct quadratic equation and solved it, albeit sometimes via a quartic first (i.e. for those who used an inequality and multiplied through by $4(n+1)^2(n+2)^2$ – these sometimes expanded fully before factorising rather than spotting the factors) . However, a significant number did not recognise that n could not be negative and left the solution incomplete, while others tried to give a solution set rather than the smallest value for n. Indeed, giving $n = -7$ as the solution was common here, as was giving such as $n \in (-7, 4)$. A small number of students missed the strict inequality and gave $n = 4$ as the answer.

Question 6

Another well-rehearsed topic, this question was another good source of marks across all grade boundaries, though some did make errors in the integrating factor to hamper progress.

Most of the candidates were able to do part (a) with only a few giving insufficient detail to justify the given result. The derivative at the start was usually correct and proceeding to an expression in $\frac{\mathrm{d}z}{\mathrm{d}x}$ usually followed, after which it is just a case of whether all details were correct in reaching the printed answer. Occasionally an incorrect sign was given in the final answer. A few candidates rearranged the initial equation first to substitute into the chain rule, which also proved an effective means. Very few this year worked in the reverse direction.

For part (b), again most were competent in finding and using the integrating factor, though some incorrectly found an integrating factor of sin x rather than cosec x (either by an initial sign error or by incorrect integration). A few were unable to simplify, at least initially, leaving the integrating factor as an exponential, but were still able to show they knew how to apply it. But if they could not simplify, they usually ceased part way through.

For those with the correct integrating factor, nearly all recognised $\int \frac{1}{\cos^2 x}\,\mathrm{d}x$ as $\int \sec^2 x\,\mathrm{d}x$ and integrated correctly. However, there were a range of algebraic errors in obtaining the expression for y^2, often involving inverting fractions separately, so not all proceeded from a correct initial equation to a correct final equation. Omitting a constant of integration was only rarely seen. Alternative forms of the equation were seen with $y^2 = \frac{\operatorname{cosec} x}{\tan x + c}$ being very common.

As long as students had remembered to include a constant of integration in part (b) then part (c) was mostly a routine operation. However, in finding the value of the constant of integration, a few candidates incorrectly squared the given value of y^2 (thinking it was y), while a considerable number worked through correctly to obtain y^2 at $\frac{\pi}{3}$ but only gave one of the two possible square roots. Various algebraic slips in simplifying or calculating the final value were also made, but the method marks were scored by the majority of students. Very few used incorrect conditions, but substituting a wrong value for x at the end was seen occasionally.

Question 7

This was another good discriminating question across the grades, with most students able to score some marks, but the last three marks in part (b) were taxing, giving a good indicator of higher-grade students.

With two accuracy marks for correct values only, method was not considered in part (a), but nearly all candidates successfully found θ, through some forgot to find r. When found it was usually correct, and two marks was most commonly scored in this part.

For part (b) the majority could perform the required integration correctly but there were various problems with assigning the correct limits to each. Use of the correct area formula was seen in almost all cases, very few omitting the $\frac{1}{2}$, and the application of the double angle identities was also very good. This type of integral is very common, and students seemed well practised in this part of the procedure, with two correct integrals often being seen. Occasional errors in squaring the coefficients were made, but mostly the arithmetic was carried out well. Assigning the correct limits to the integrals, however, proved to be more of a challenge, with the most common error being assigning both integrals limits from 0 to $\frac{\pi}{3}$. In some cases, this led students to try and combine the integrals before carrying out the integration, which unfortunately meant they could not score the accuracy for both integrals correct as no evidence of this was produced. But more often the two were kept separate meaning the accuracy could be given for the integrals with the first of the methods for applying limits. Applying limits (to one or both integrals) did usually follow, but the final method did require correct limits for both, so was quite a demanding mark.

Other common errors were having the integration of curve C_2 with limits from $\frac{\pi}{3}$ to π and having the "correct" limits but assigned to the wrong integrals. In these cases, the integrals were at least kept separate.

There were some minor slips in expanding brackets and in subsequent calculations after generally correct methods had been used, but more often than not the final two marks were lost in this question for an incorrect overall procedure.

A few students approached the problem via segments formulae, but these did not adhere to the "use algebraic integration" demand of the question unless at least one of the areas was found via integration, in which case full marks was possible for a full and correct method.

Question 8

This was found to be the most demanding overall question on the paper, although question 9(b) was the most demanding individual part of any question. Even with the graph given, students had some difficulty in determining which equations led to the critical values and the correct form of the solution sets for each part, and numerous algebraic errors occurred when solving the equations.

In part (a), most of the candidates found the critical values corresponding to where $x > 0$, being the most obvious of the equation, and also usually where $x < 0$, by use of $-x$ for $|x|$. Many did this directly by cross multiplying, but some used the common denominator approach, or multiplying by the square of the denominator, and these were more susceptible to error, often simplifying the equation incorrect, though the method for solving it was usually sound. These methods did have a propensity for introducing extra critical values, ± 4, into the solution.

Despite generally being able to find critical values from the relevant equations, many failed to use these correctly in forming the final solution set of the inequality. Some of the responses had critical values of -4 and 4 appearing which caused problems as they did not fit in with the given sketches of the line and the curve, while others attempted to use all four values found, not realising one was inadmissible. Those who used the diagram, or used their own sketches based on the diagram, had the most success in determining the correct shape and, if the critical values were correct, the correct region. Though even here some tagged a spurious extra $x \neq -4$ to their solution to forfeit the final accuracy. Very few had the wrong type of inequality, since the inequality in the question was strict, so strict inequalities were used.

In part (b), most did not use the given graphs and the reflective properties of modulus graphs to give them an idea of the additional critical values needed and consequently this part was, in general, poorly answered. Numerous different equations were often attempted to be solved, including solving the one from part (a) again from scratch in many cases, and solving the correct equation for part (b) was often stumbled on by trying all the different combinations of positives and negatives by removing the modulus. Some attempts at squaring both sides were made, but due to the additional modulus inside the right-hand side, these usually did not progress far, though correct solutions via this approach were seen.

Those who made good use of the diagram to work out which extra equation was needed were able to produce good solutions, and despite the general poor work, there were nevertheless many correct answers made by the higher-grade students, making this a very good discriminator for the paper.

Question 9

This question provided access to all grades at the start, but only the higher performing students made suitable progress in part (b), with many unable to work out how to proceed.

In part (a) almost all students were able to expand correctly to obtain an expression of the right form for the three imaginary terms, in many cases only giving the imaginary terms as they knew these were the ones that mattered. Those who did not were unable to make any progress, but there is no indication of timing having been an issue, some just did not know the topic.

Most successfully derived the correct expression for sin 5θ in terms of sin θ and cos θ and the majority then applied $\cos^2\theta = 1 - \sin^2\theta$ correctly to reach the required result. However, some made errors when finding $\cos^4\theta$ by simply squaring the two terms in the bracket $(1 - \sin^2\theta)^2$ rather than expanding the square properly to get three terms. Overall, though, this part was well answered with many candidates able to present clear and accurate working in obtaining sin 5θ in the required form and the majority scored full marks for this part.

Part (b) was quite the contrast, and flummoxed many candidates who could not identify how to approach it and in many cases it was left blank. Others tried setting $\theta = \frac{k\pi}{5}$ in the equation, often with specific k values, but without ever realising that $\sin 5\theta = 0$ and so making no progress. Those who realised they needed to set their result from (a) equal to zero generally managed to find solutions, although in many cases it was still not clear they realised what was going on as they often assigned the values found to specific values of k rather than appreciating these were the only possible results for any integer k. However, many of these candidates failed to identify zero as a solution and so did not obtain the complete solution set.

Overall, this part was not well understood by students with very few showing confidence in their solution, and many who did get the correct roots stumbling into them more by chance than true understanding.

Pearson Education Limited. Registered company number 872828
with its registered office at 80 Strand, London, WC2R 0RL, United Kingdom