Pearson Edexcel

Examiners' Report
Principal Examiner Feedback

Summer 2022

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

This paper consisted of several questions that were found routine by most candidates and consequently had higher grade boundaries than other papers in this series. Aside from question 2, the modal mark for each question was full marks, though for question 2 it was 6/8. Aside from question 8 (at 22%) the modal mark was achieved by over 37% of candidates for each question.

The most discriminating parts of the paper were questions 2(b) and 8(b), with the rest providing little evidence to separate high grades, and holistic performance across the whole paper being the key factor. The final two questions proved to be, proportional to the mean score, the most demanding, showing they were appropriately placed.

Question 1

This was a question which was well answered by the majority of candidates who had obviously prepared successfully for a question on this topic. The mean score was 4.5/5, with nearly 85% scoring full marks. As such it was a good question to start the exam with and it helped ease candidates into the exam.

There were a large number of fully correct solutions, but the starting limit of 5, rather than 1, did prove problematic for some. A considerable number of candidates started their differences at $r = 1$ rather than $r = 5$. Though, most of these recovered the situation later in the question by subtracting the sum from 1 to 4, a few just gave an answer for a sum from 1 to n. Some attempted the difference but with the wrong indexing, subtracting the sum from 1 to 5 from the sum from 1 to n. Other candidates lost marks by not showing the cancelling process, and these should remember the importance of showing all working when answering a proof question.

Question 2

This was the only question for which the modal score was not full marks, with part (b) providing one of the good discriminating parts on the paper. However part (a) was generally done well, so this was not the most demanding question of the paper, with over 75% scoring 6 or more marks (a little under a quarter achieve full marks).

Part (a) was generally very well approached. The use of a non-algebraic (calculator/graphical) method was rare, with a mix of the algebraic approached used.

Perhaps most candidates started by multiplying both sides by $(x+3)^2$ and factored the cubic, but setting equal to find critical values, or putting the expression over a common denominator were also common approaches. Some did multiply both sides by $(x+3)$ only, usually then missing the critical value at $x = -3$. Even if this was achieved, they would lose the last accuracy mark due to an invalid method. Most achieved all three critical values correctly and converted them into the correct inequalities. Various notations were used and accepted as per the mark scheme.

Fewer candidates scored full marks in part (b), less than 40% scored 7 or more marks. Those that did often did not use efficient methods, but attempted to solve the inequality from scratch again, instead of deducing from the work already done. Often, they opted to separate $x > -3$ from $x < -3$ and attempted to solve the equation again. This often led to extra critical values being found from solving the “negative” equation, which led to no marks unless they spotted these values were all in the permissible set anyway.

Candidates essentially had to realise that all the extra (valid) values less than −3 are solutions, whilst retaining all their given solutions. The most efficient and effective means of doing this, if it was not immediately deduced, was to draw a quick sketch, but few did this. Of those who did identify $x < 6$, many excluded other legitimate values of x, such as the critical values −3 and 4. Of those that did score in this section, $x < 6$ with no other exclusion scored one and few scored both marks by excluding $x = -3$ as well.

Question 3

Candidates generally answered this question well, with 56% obtaining full marks for well executed solutions. The second most common mark was 3, scored by about 15%, who were able to proceed as far as applying $|z| = 3$ but were unable to see where to go thereafter. Those who knew the process usually carried it out well with occasionally slips in accuracy occurring in some cases.

Almost all rearranged to $z =$… with only 6% scoring less than 2 marks. Those who did score less generally made no sensible progress either through non-attempts, or trying to substitute $x + iy$ directly and soon grinding to a halt.

Most achieved a correct rearrangement and knew to apply the modulus. The majority then went on to substitute $w = u + iv$ (or $x+iy$) and many were able to find the modulus of the complex numbers. Most did this by cross multiplying first, but a few made the work harder for themselves by substituting and attempt to use the conjugate to get z in Cartesian form before applying the modulus. This generally went awry with either algebraic error, or giving up before reaching a suitable equation.

For those who did apply the modulus $w = u + iv$ successfully the most common error was to square i, leading to *16 (u2 − v2)*. This and occasional expansion errors led to the coefficients of the squared teams being different and hence not the equation of a circle. Also fairly common among mistakes was forgetting to square the 3 and/or 4. If a valid equation of a circle was achieved, many candidates were fluent at completing the square and there were many fully correct answers.

Question 4

This was another question that candidates seemed well prepared for with 63% achieving full marks, though 10% did not know the how to find an integrating factor and scored no marks as a result.

When things went awry, the major problem for some candidates was their inability to manipulate the logarithmic function successfully while others were careless in omitting the minus sign with the $3\tan x$ term.

Those candidates with an incorrect integrating factor were extremely unlikely to score more than the first two method marks in this question as this invariably led to an almost impossible integral. However, those who did achieve the correct integrating factor generally went on to complete the question successfully. Various forms for the final answer were seen with some dividing by $\cos^3 x$, some dividing by $\sec^{-3} x$ and so on. Omitting a constant of integration was rare.

Part (b) caused few problems for those who had a suitable answer in (a), with the method mark being obtained by almost all candidates who had answer with a constant of integration from (a).

Question 5

Another expected and well-rehearsed question, but with a few slips in accuracy, the score distribution was skewed to the top end, with 48% scoring full marks, 20% 7 out of 8 and 11% achieving 6. The next most common score was zero marks, by 6%, for the few who did not know how to get started at all.

The most common method for part (a), and generally most successful, was to differentiate term by term using the product rule and chain rule and then to rearrange their equation. Slips were more common when attempting to rearrange first (the cube term often being a square), but nevertheless was also generally done well. Many candidates scored full marks here, but there were some that were not comfortable using the product rule and chain rule with an equation that already contained derivatives. Problems were most commonly seen applying the chain rule to $\left(\frac{dy}{dx}\right)^2$ and there were a small number that differentiated $y\frac{d^2y}{dx^2}$ to simply $\frac{d^2y}{dx^2}$ and the product rule not applied at all.

For part (b) most candidates knew what was being asked of them and worked towards a correct power series in *x*. The majority scored B mark for finding the value of the second derivative at $x = 1$, although slips were not uncommon here in incorrect responses. Likewise, the majority also scored the next method mark by attempting to find the value of the third derivative using their answer to part (a). Most then applied the Taylor series correctly. Earlier errors carried forward from part (a) sometimes lost them the final accuracy mark, and in some cases the final mark was also lost by a lack of '$y =$' written or identified in otherwise correct solutions.

Question 6

The questions stepped up in length from this point of the paper, but nevertheless the performance for this question was similar to that for question 5, with around 11% not getting started, but most scoring the top end of 13 (42%), 12 (11%) or 11 (12%) marks out of 13, with low percentages across other score. Those who knew how to start generally knew how to take the question to completion with accuracy errors or forgetting/incorrect method for the triangle impacting the last few marks.

Part (a) was well answered by most candidates. Most candidates were able to deal with the required trigonometric differentiation successfully and progress to the correct quadratic. Both approaches to the differentiation were seen frequently, with the same degree of success. Once started correctly there were very few errors in this part. However, the final mark in part (a) was lost for a minority of candidates through a failure to 'show' that the value of *r* was *6a*, through substitution of their angle. As it was a printed answer, sufficient justification was needed to show it had been genuinely achieved.

It was rare to see $r\cos\theta$ or *r* being differentiated to find the coordinates of the point *A*.

Part (b) proved to be one of the most accessible polar coordinates area questions in recent years, with many candidates able to score at least the first 4 marks for this familiar form of integral. It was clear that most were well practised in this kind of polar area question, and the resulting trigonometry and integration did not present a problem for most. Of the few errors seen in (b) a common one was forgetting to use the $\frac{1}{2}$ in the area formula or integrating incorrectly with sign errors or incorrect reverse chain rule being used.

Of the many candidates who obtained the first 4 marks, most we able to apply the correct limits and proceed to a numerical expression for part of the area. In a few cases, though it was not common, candidates separated this region into separate parts from 0 to $\frac{\pi}{3}$ minus 0 to $\frac{\pi}{6}$. However, a significant number did not realise that the region they had calculated did not define the shaded region and so stopped at the area of the sector. Most candidates who realised that more work had to be done were able to at least achieve the penultimate M mark for a correct attempt at the area of the triangle *AOB*. Common errors here were when substituting the angle $\frac{\pi}{6}$ into the polar equation to find the distance *OB*.

Question 7

Another question that was well rehearsed by many candidates, and certainly part (b) is an expected question, yet proved more challenging than the preceding questions, with 12% failing to score (usually by omission). Still, over a third were able to score full marks with 10 out of 12 also a fairly common score by 13%.

The first part of this question was much better attempted than similar questions in previous years. The most common approach here was the main method in the mark scheme, with differentiation with respect to *x* via the product rule. It was very rare to see candidates resorting to differentiating with respect to *v* or differentiating *v* with respect to *x* and progressing from equation II to equation I.

Of those who successfully obtained a correct or almost correct first derivative, virtually all were able to proceed to a successful attempt, at least, at the second derivative. It was rare to see 'fudging' to arrive at the correct equation after the substitution and most candidates were able to demonstrate the 'show that' successfully. It was clear that candidates were very well prepared for this kind of question, though a minority of candidates treated functions as constants and showed a lack of practice on this expected style of question.

Part (b) was also very successful for most, with many fully correct solutions seen. Common errors here included extracting the incorrect auxiliary equation, $3m^2 + 3m = 0$ seen fairly often, or solving the auxiliary equation incorrectly, or using the wrong form of the CF. There were fewer errors in calculating the particular integral, but it was common for candidates to begin with a quadratic form. For the penultimate mark, some candidates did not label their equation correctly as 'v = ..' and lost a mark carelessly after correct work. The final B1ft mark was achieved by most candidates, and was very typical for this kind of question.

Question 8

Another slightly more challenging question, and a third lengthy question, but only 7% failed to score, with no indication of timing issues shown. Only 22% managed to score full marks, though about 50% scored 12 or more marks of the 14. Part (b) caused the most problems, with many very good attempts at the other parts.

Part (a) was another book work problem in which candidates were generally well versed, and many presented elegant solutions. However, style of proof was lacking for some, with De Moivre's theorem often implied rather than stated explicitly, or sometimes stated incorrectly (losing the B mark), but treated correctly later.

Most took the expected route, though a few did try the alternative, but these usually made little progress beyond the first two marks.

Binomial expansion was very good in both methods, and most showed the necessary substitution and expansion required to gain the final M and A marks when using the main scheme. Occasional slips did, of course, occur, but overall part (a) was successfully carried out.

Part (b) usually started well, with very few of those who attempted it (though some did leave it out) failing to achieve the correct value for sin 5θ. However, the next method, and more so the two accuracy marks, proved more elusive. The method mark was scored by most, but a few neglected to divide by 5 after applying arcsin, or multiplied instead, while others simply stated incorrect values with no indication of the method they used to get them. But the main loss of marks in this part was due to failure to convert back to x values at the end, with many simply stating the values of θ as the answer. A smaller number achieved only some of the correct answers, losing just one mark.

Part (c) fell between parts (a) and (b) in difficulty, better attempted on the whole than (b), but not as successful as (a). Most could see that the answer to (a) needed to be applied in some way, but there was mixed success in the application. Some just tried to integration sin 5θ alone, without evidence of applying the result (guessing it was this) so scored no marks. Others tried incorrect integration methods on the given integral, so also did not get started. However most did arrive at an expression in sin 5θ and sin θ but the coefficient of sin θ was not always correct, particularly after integration, for the accuracy mark, as sign errors or incorrect multiplication by 5 instead of division were not infrequent.

Of those who achieve a suitable expression nearly all went on to apply limits and produce an exact answer, though a few missed the bottom limit (assumed it was 0), and those who had a correct initial integral generally scored all 4 marks for this part.

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