Examiners' Report

Principal Examiner Feedback

Summer 2025

Pearson Edexcel GCE

A Level Further Mathematics (9FM0)

Paper 3A Further Pure Mathematics 1

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Overview

This was fair paper with plenty of accessible marks for mid to high grade students, but which did prove to be a bit more challenging at the lower grade range, with the less prepared candidates struggling with some of the concepts involved on the paper. A couple of the questions did not quite work as intended, with students over thinking what was required in some places and so making things more challenging (cf. question 3(b), 6 (b) and 8(b) in particular). Indeed, question 9 proved to be one of the more accessible questions, but a lot of lower grade candidates had seemingly given up by that point of the paper, missing out on the marks available.

The standard of work was generally good, with most students showing ample working where required, and presenting in a clear way. Exceptions were questions 5(c) and 6(b) where students thought process were often difficult to follow, probably due to confusion in how to tackle the questions, particular 6(b) which caught a few people out as unexpected and students though there was more to it than just evaluating the first few cases.

Individual Question Report

Question 1

A very easy opening to the paper in part (a) turned a lot more challenging by part (c), where students were asked to show two groups are isomorphic, something which has not been tested extensively on previous papers.

Part (a) was answered very well with very few failing to obtain all three marks. Very occasional slips were made, and sometimes the values were not reduced modulo 14, but more likely was a failure to answer the question at all.

There was slightly less success in part (b), though the majority still managed to give the required subgroup successfully. A small number were unsure what a subgroup is, it seems, giving an answer that did not include the identity, 1, e.g. {11,13} was seen a few times. Others included the identity but not the element of order 2 but though any element would suffice.

Part (c) was even less well answered overall, and inconsistent in approach. Candidates largely seemed surprised by the question and did not have a clear approach in their mind, which may be because it is more common for an isomorphism to be asked for than for groups to have to be shown to be isomorphic. Indeed, many simply focussed on finding an isomorphism as the main emphasis, with the reasons why the groups are therefore isomorphic lacking. Those who realised there was a bit more to it often reasoned via the orders of elements but without clear reason why having elements on matching orders would mean they are isomorphic (not something that is true in general).

There was a fair mix of the three alternatives seen of the scheme, as well as variations on these, with probably fewer mentions of cyclic groups or generators, although these were the most likely responses to score full marks, as they were by students who had an appreciation of what isomorphism means and a certain condition – being cyclic of the same order – for it. There were a few errors in identifying correct generators for each, meaning some only score one mark despite having this approach, though. But the reason was usually given.

Those who used element pairing often did not think about the structure but simply paired either be the order of the borders of the table (which score no marks as there were insufficient correct matches) or via elements of the same order with giving due consideration to preserving order, often matching 3 to q but 9 (=3^2) to r and not t (=q^2). Even where correct pairings were given it was rare to see the required justification for the final mark though a few did show this. Group table matching as a whole was seen occasionally, but again quite rare.

For those working out the orders of all the elements, this was more successful in achieving all the correct orders, with only occasional errors made determining orders, but the final justification was again lacking with only very few referring to the order of the group being only 6 and therefore sufficient for same element orders to imply an isomorphism. Couple with this, students using this approach often went on to give an incorrect pairing of the elements anyway, showing the lack of understanding that there is more to it than just pairing up elements by order.

But amongst the many attempts there were also some very confident and coherently expressed reasons given, sometimes showing the isomorphism by a mapping (an extension of the cyclic subgroup reasoning) and occasionally some reasoning by conjugacy classes, and recognising both groups were dihedral. Overall, this question allowed strong candidates to stand out, while also providing a few easy marks in a for less able candidates early on.

Question 2

This was a very straightforward question for the majority that could easily have been first on the paper. Very few had trouble finding the eigenvalues in part (a), although some rejected the eigenvalue 0 and gave only 5. Errors in the expansion were very rare, and non-scorers were mainly those who made no effort to answer the question at all.

Part (b) was also answered well on the whole, though a significant number forgot to normalise their vectors for **P**, which was the most common mistake made, though most scored full marks. Astute candidates were able to state the matrix **D** at the start and secure the B mark early on, but most left stating both matrices until the end.

Setting up the eigenvector equations was done well by most, with very few cases of stating them without any working seen, and once they reached $x = 2y$ or $y = -2x$ most were able to establish the eigenvectors, although the second most common error was to get one (or both) the wrong way up, ie $\begin{pmatrix} 1 \\ 2 \end{pmatrix}$ instead of $\begin{pmatrix} 2 \\ 1 \end{pmatrix}$ for $\lambda = 0$ or similar for $\lambda = 5$.

Most then were able to firm a matrix **P** from their vectors, though as noted some did not normalise first. One surprising factor was the number of candidates who at this point then tried to find **D** by expanding the equation for the diagonalisation process rather than just state it using the theory, and as a result a few managed neither a correct **P** or **D** since the process went wrong without a normalised **P**. But those who knew the theory were able to score the B1ft for a correct **D** even if they neglected to normalise, and the follow through marks gave access to those who had made a slip in one of the eigenvectors to still score four of the give marks available for this part.

Question 3

This was another question that provided both a good source of marks for the low grade students but provided a good discriminator for the high grade students as well with thought needed for how to tackle part (b).

Part (a) was answered very well. A few candidates forgot to square the 2, which was the only significant error noted, algebraically, but these were a minority. The other main reason for loss of a mark here was failure to show sufficient details, missing the "=0" from the final equation being the main such. Occasional slips in the coefficients did happen but most this part led to fully correct responses, and getting the signs wrong between the brackets was seldom seen.

Part (b) was very attainable but did require some thought for how to approach it and there were a number of less able candidates who were not comfortable here. Drawing a diagram was common, which was good to see, and it was evenly split among the two main methods in the approach, whether they considered the discriminant or considered geometry and right-angled triangles. In the latter more considered a trigonometric than the Pythagorean approach. The alternative with differentiation was seen less often but still a reasonably successful approach when used.

However, many responses had a mix of methods before finally settling on one particular route, which sometimes made marking difficult, having to work backwards to see which route was the most complete. Candidates often worked very inefficiently with little clear aim initially, but many showed good persistence and eventually found the correct answer, so this proved a good exercise in problem solving skills, experimenting finding a solution. Notation was generally good and easy to follow, with quite a few choosing to work with c as the intercept of the tangent rather than $-a$, but working clearly enough to be able to solve for a in the end. Overall, this was a good question which was accessible for less able candidates to access, and many possible approaches to problem solving.

Question 4

There were no particular surprises in this question with well-prepared students able to score highly. The induction was done well, and most could solve to find the value for n needed in part (b), though some neglected to find the actual 11-th term.

Part (a) was answered well in the main but with some inconsistency in the low to mid-grade ranges. Most candidates were familiar with the procedure of proof by induction though a significant number seemed less confident by this type with a recurrence relation of order 2. A few wanted to solve the recurrence relation by means of the auxiliary equation and wasted time at the start with this. Some returned to an induction but others did not, preferring to solve by other means and so score no marks.

The first hindrance was in realising that both the cases $n = 1$ and $n = 2$ need to be checked at the start. Those who realise this had little trouble doing so, but there was some who instead only checked $n = 1$, thinking just one case was sufficient, while others instead used u_1 and u_2

to find u_3 and check the closed form works for just $n = 3$, again a false base case since two consecutive cases of agreement need to be checked (e.g. u_1 and u_2 could both fail to work but happen to produce a u_3 that does work).

Tehe next issues was with making the assumption, where again some only state the assumption for $n = k$ rather than for two consecutive cases. Much of the time these then failed to make further progress as they could not see how to bridge from $n = k$ to $n = k + 1$ using the recurrence, though a few did realise they need to go to $n = k + 2$ despite the incorrect assumption so were able to make some progress (though losing the first M and final A as a result). But most did realise the two cases needed to be assumed and made the suitable assumptions. Most went from $n = k$ and $n = k + 1$ to $n = k +2$, but a few did use other starting point, such as from $n = k – 2$, $n = k – 1$ to $n = k$ or $n = k – 1$, $n = k$ to $n = k +1$. Most used k as the variable, but a few used n instead, making the work a bit harder to follow.

The actual manipulation of terms for the inductive step was generally done well, including changing the powers, with candidates working clearly and methodically for the most part. A few slips did occur, or unacceptable jumps to the required form without manipulating the powers first where students could not see how to do it, but overall most were able to bridge the gap between cases, with a variety of approaches seen.

The final conclusion was generally correct though a number did not quite understand the importance of $n = k + 2$ being proved as a result of $n = k$ and $n = k + 1$ being true, especially among those who had not set up the correct base cases or assumption at the start. A few only cited "true for $n = 1$" as a base case, and the usual incorrect "true for $n = k$, $n = k + 1$ and $n = k + 2$" type conclusion without the implication indicated was seen in a few responses. The majority were well trained in giving a formal conclusion at the end, though, with only a small number omitting one entirely.

Part (b) was answered well and being independent of part (a) candidates who were unhappy with how to perform the induction often still did well with this part. The most common error was not understanding that they were required to provide the actual value of u_{11}, with many stopping after establishing that n was 11.

Most were able to set up a suitable inequality or equation using the given closed form and proceed to finding a value for 2^n, or apply a correct logarithmic approach to produce a linear equation in n, though a few less able students were unable to spot the quadratic in 2^n and either used a calculator solve or simply stopped working. Most identified the quadratic in 2^n, but there were also many who took logarithms and applied the laws correctly to form a linear equation, and indeed this approach was often done well. Whichever approach was taken solving for n usually followed without trouble to get to $n = 11$, with mistakes at this stage rare. Some calculated at both $n = 10$ and $n = 11$ to find which was the negative, but many were able to identify it was the $n = 11$ that was needed without substitution – though as noted numerous of these gave no 11-th term and so lost the final A mark. When calculated, the 11-th term was almost always given correctly.

Trial and improvement attempts were occasionally seen, but were not common.

Question 5

This was an inconsistently answered question, with (i) proving most challenging, (ii) proving very straightforward and (iii) producing a very mixed set of response. It is clear that the ideas of “counting” within number theory are still not well understood, but routine procedures such as applying Fermat’s Little Theorem are carried out very well. The leap between performing an algorithm and thinking through a problem can be big and this question therefore was a good discriminator for the paper.

Part (i) was itself a bit mixed in performance, with most able to get started, fewer able to obtain a correct answer for part (a) and only a very small minority achieving a correct answer for (b). Many candidates were not confident working with combinatorics, but most could identify the 26 and the 4 that needed to be multiplied together to get the number of codes for part (a), although a few did have 24 letters in the alphabet rather than 26. The “$10\times9\times8$” or $^{10}P_3$ for the 3 distinct digits was less commonly attained, with $9\times8\times7$ often being given, presumably 0 being discounted at a valid digit. A few tried adding rather than multiplying the values for the three cases, and so scored no marks.

For (i)(b) very few were able to attain the correct answer. The most common thing to do was to multiply the answer to (a) by 5! Thinking that they needed to permute all the possibilities from part (a), not appreciating that the 3 ordered digits were originally chosen from 10, so there were repeats in these permutations from where the same three were chosen in a different order. Only a very few saw that the correct process from (a) to (b) was to multiply by $\frac{5!}{3!}=20$ to discount the repeats. More often where correct answers occurred, they arose from working out from scratch that it was $26\times{}^{10}C_3\times4\times5!$ Many left this part out completely.

Part (ii) was answered very well, with even less able candidates able to score full marks in this part. Most stated Fermat’s Little Theorem initially, a good practice, before applying it to the problem, though a few candidates relied on the result being identified by implication within very brief work. Students should have it stressed that they should make the working clear, as answers only will not necessarily score the marks. After identifying the theorem most correctly adapted the powers and proceeded to simplify to the required residue with mistakes in simplifying being rare.

A few did try approaches by modular arithmetic approaches without using Fermat’s Little Theorem, but these were unable to score marks as they did not follow the demand of the question

Part (iii) was often approached haphazardly, but many were able to find their way to the correct solution, or at least partially correct. Following students work was often a difficult task, with very unclear layout and values appearing all over the place. Very few, after experimenting and finding their answer, went back to present the argument clearly. Again, the importance of making working clear, particular so that partial credit for incorrect answers may be able to be better awarded, should be stressed to students.

In terms of how students approached the problem there were many approaches seen – all those on the mark scheme and variations of them. More students tried direct counting than counting the numbers without 2's first, though the latter were arguably more successful on the whole.

The most common method was considering the numbers in groups of 100, often listing options. E.g. 000's =5, 100's =5, 200's=50, etc and summing the result. Such methods were effective, though less elegant than ones that considered forms of numbers, considering whether the first digit was 2, the second digit was 2 or the first and second digits were 2 and so on. However, these latter approaches were more prone to inclusion of repeats, or exclusion of some valid cases. Such method often scored the B mark on implication as few made it directly clear about the 1 digit numbers, as this was often subsumed in other cases, but it was clear that the majority realised 2 could not be the final digit (in fact there were only 5 choices for the final digit.

Failing to consider multiple 2's in the number was probably the most common error, with the 22x numbers often counted twice in solutions. Omitting possibilities such as the 2 digit numbers (often when counting x2x but excluding the first digit as 0 without considering 2 digit numbers separately) was also fairly common, while a few using the approach of counting no 2's first did not correctly work out the 500 odd numbers to subtract from. Various other mistakes were made as well as these few examples.

There were also several cases of students considering four digit numbers seen, misreading or misinterpreting the "less than 1000".

For a deceptively simple question, this was a good demonstration of the level of complexity involved in counting problems and gave students ample opportunity to flex their problem solving skills.

Question 6

This was a topic which candidates seemed to feel quite comfortable with on the whole, being an expected topic for the paper, and many were fluent in the process required in part (a). Part (b) was, however, often over thought by students with much wild work trying to find closed forms that were not needed.

Part (a) was done well overall, with success found using both main approaches, though the main method the more common. Though many were able to find a successful and succinct route at the first attempt, this question did produce a lot of multiple attempts with some only making suitable progress after several false starts.

With the main method, most candidates got the first two marks without much fuss, though not all were able to spot the way to work with the x^2. Those that did generally completed without trouble to achieve the given result. There were a few who tried this approach but did not apply the chain rule when differentiating u, losing a factor x. These were then unable to make any further progress so score no marks.

With the alternative method, there were more errors seen in the first stage of the process, often a sign error in one of the derivatives when applying parts, but if they succeeded in achieving the first A mark, most were able to finish the question correctly from there. The second M was more easily attainable in this approach as long as a suitable first stage of parts had been achieved.

As well as these two methods the third possibility on the scheme was also seen on a few occasions, although with much more limited success. Often it would arise as an alternative method amongst many attempts when students could not get the main scheme approaches to work. Less able candidates did have trouble making progress with this part at all, which is expected of this topic.

Part (b) tested the candidates' problem solving and often involved much wild working. Many persistently approached this from an algebraic approach, attempting to work from the top end of I_n downward to reach a closed form and reason from there, but these usually ran into trouble. Sometimes they would realise and restart from the bottom end, other times grind to a halt, but it was no uncommon for $n = 4$ to suddenly appear from no clear working, presumably having tried a few cases on the calculator to work it out, despite the comment in the question that a non-calculator was required. However, a few did come up with some well-reasoned answers from the prime factorisation of the value given compared to the closed form– it just happened to be a long-winded unnecessary route in this case.

Those who simply started with the first terms and worked upwards usually obtained the result with little fuss. This meant that some of the less able candidates did better than stronger candidates as they were keener to try a numerical approach rather than algebraic.

It was good to see candidates who did not do well in part (a) persist and do well in part (b). Both parts were discriminating in different ways, with part (a) highlighting stronger candidates' ability to work through the algebra and proof and part (b) giving students an opportunity to show they can step back and think through the most strategic route to a problem.

Question 7

Another number theory question, this again provided some good discrimination and showed students understanding of the methods for solving congruence equations and knowing when solutions do not exist.

Part (i) was the better answered of the two parts, with most realising it was to do with common factors of the 21 and 36. A few only considered the 21 and 11, and so did not score any marks, while some candidates attempted to try to solve it to show the lack of solutions, which was generally less reliable – some found solutions. Those who identified the correct common factor were usually able to relate the reason for no solutions to the 11 not being divisible by 3, but some did not seem certain at this stage and a few unclear answers, often trying to talk about multiplicative inverse, belied this lack of understanding.

Part (ii) was less well done, though often was a case of either fully correct or else little more than the first mark. The most common successful approach was to simplify the given equation to $9y = 48$ (mod 10) directly and the solving from here to get $y = 2$ (mod 10). Most efficiently this was done by spotting $9 \equiv -1 (\text{mod } 10)$, but most students did not spot this directly but derived it using the Bezout's identity to find the multiplicative inverse first, while others tried doubling successively until getting to the solution or similar methods.

Other successful approaches first saw students reduce the equation partially by cancelling some common factors or reducing the right hand side modulo 10 before reducing the modulus to a modulo 10 equation, but these are essentially variations on a theme, and as long as candidates succeeded in reducing the modulus of the equation successfully most went on to the correct final answer, with only a small number making errors in solving the resulting congruence.

However, many did not see that the modulus had a factor 4 in common with both other terms and so never reduced below modulus 40. Though many of these score the first mark for a partial reduction of the equation (both methods in the main scheme were seen frequently to reach this first stage of reduction), no further progress could be made. Indeed, many candidates seemed uncomfortable with congruence equations in general and lacked a clear approach, and there were also a number who were comfortable, but did not seem that confident in presenting their final answer clearly.

The Alternative II in the mark scheme, forming the general equation, was rarely scene in this series, though was successful when used.

Question 8

This question in modelling a satellite was another in which some students hampered themselves part way through by trying to overthink the problem, with many trying far more complicated integration techniques than was necessary. But the general procedures required were shown to be understood, saving that many were confused about the constant needed in front of the integral – whether it need π or 2π.

Part (a) was answered very well, with very few making errors at this stage. Errors made included the mistake of using 60 instead of 30 (taking diameter instead of radius), while some others mixed up x and y, both cases scoring no marks, while some did score the first mark but made an error squaring 30 to given 90 instead of 900.

There was a bit more of a mixed performance in part (b), most notably to do with whether the curve was to be rotated by π or 2π. This was due to the curve in the sketch being above and below the axis, and students not realising the equation $y=\sqrt{90x}$ only represents the part above the axis, so needs rotating by 2π. Many instead rotated by π and only calculated half of the surface area.

The majority of candidates started well by finding $\frac{dy}{dx}$ correctly, following through their answer to (a) in some cases. Both versions in the scheme were seen equally frequently, but the implicit approach was less prone to slips being made.

Again, most attempted the surface area formula, with the proviso about the multiple noted above costing some the first M, but some variations on the formula were seen, for instance $\int y\sqrt{1+\left(\frac{dx}{dy}\right)^2}\,dy$ was used on numerous occasions, which is a correct alternative and gave a suitable integrable function. However, some had versions with x instead of y in front of the square root, and so were incorrect, and these could generally not score any marks as the resulting integral was not of a suitable form. Examiner had to be diligent in checking the equations.

Whichever form was used, substituting into the formula usually followed but not were able to manipulate the integral into a suitable form, and so some stopped at this stage, while others attempted integration by parts or a substitution, often going nowhere - though some and various valid substitutions were used, which again meant examiners needed to be careful to track through work to see if it was successful or not. Even among those who simplified the integral to the point shown in the mark scheme, not all spotted the inverse chain rule integration approach but instead attempted a trigonometric or hyperbolic substitution over thinking the problem. Some of these were correct and reached the correct answer (or half of it if the 2 was missing), but students ought to be watchful for the more direct route, expecting a substitution to be specified if needed. Those who spotted the simpler route were usually successful in attaining a correct follow through integral for their A, or at least a correct form for it – some square rooted the 90 incorrectly to lose the follow through accuracy mark at this stage.

Substitution of limits at the end, providing that a suitable attempt at the surface area integral had been made, gave a bit of access to students even when the integration itself had gone wrong as long as they persisted in reaching that stage, which most did.

Although there were various approaches to the integral taken many did manage to find a value for the surface area, but the most common error was the wrong coefficient at the start, reaching 1600 cm^2 rather than 3100 cm^2, with nearly half of students completing the problem giving this answer.

For the limitation in part (c) most students focussed on the smoothness (or possible lack thereof) of the satellite, and so this part was generally done well. Variations such as stating that the dish may not fit the curve accurately or that the curve may not be exact were also acceptable. However, there were also a significant number who considered instead that the thickness of the dish would be an issue and did not gain the mark since the model is specifically noted as being a model for the inner surface of the dish and not the dish itself, therefore thickness was not relevant. A careful consideration of exactly what the model is for is required in order to identify a limitation.

Question 9

This question was answered well and could easily have come earlier in the paper. It is a familiar and well-rehearsed topic that many could do by a learned procedure without having to think through problem solving topics, and had a high proportion of full mark responses. Timing did not seem to be an issue, as most candidates were able to have a good go at this question.

Those who used the main scheme approach generally made very good progress, with most achieving full marks. The types of errors made, though only infrequently, were an error in rearranging the original equation, neglecting to square the 4 (or 2 if they divide through earlier) when applying the modulus, or minor errors expanding brackets or completing the square.

Where other methods were attempted success levels did drop with the first and second alternatives, which did occur fairly regularly, very unlikely to be taken to completion successfully. A couple did manage to employ the third alternative to make some progress, but again not usually completed and obtaining just the first three marks was common in each alternative route.

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