Examiners' Report
Principal Examiner Feedback

Summer 2024

Pearson Edexcel GCE
In Further Mathematics (8FM0)
Paper 01 Core Pure Mathematics

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Report on Individual Questions

Question 1

This question was generally well-answered and showed an improvement in previous years regarding candidates' understanding of the methods.

In part a) a significant majority of candidates reached the correct value following a correct identity and evaluation of the sum and pair sum. The most common error seen was for candidates to simply square their sum (rather than forming an identity as required), which lost them all marks (unless they used the correct pair sum in a later part, which many did), or losing the coefficient of 2 on their pair sum term. It was pleasing to note that very few candidates used $-\frac{3}{2}$ for the value of the sum.

Again, part b) was answered well with the modal outcome being 3/3; again, the majority of candidates formed a correct identity (either writing the numerator as 3 x pair sum or writing the overall as 3 x (pair sum/products) with relatively similar frequency) and substituting in the correct values. There were occasional slips where candidates formed an incorrect identity (generally losing the 3), though some candidates showed weaker fundamentals in the algebraic manipulation, some resulting in 3 x sum / product and others 'adding' the denominators and attempting to use the reciprocal of their sum of roots in some capacity – a surprising error at this level.

Finally, part c) was the more challenging part but again candidates did well, with a majority scoring either 2 or 3 marks here. Expanding the given identity to form an identity using all three of their values was by far the most common approach, and the majority scored at least two marks in this way (commonly making sign slips only to lose the A mark e.g. 193/2 being a common answer). Some candidates sadly, whilst attempting this approach, lost the product term entirely and unfortunately scored no marks whilst demonstrating a correct approach but without the requisite algebraic skills required at this level.
Attempts using linear transformations were infrequently seen (only a handful in part b), with a few more in c) – again, often candidates scored only the one mark in part c) via this method, often simply failing to find their transformed functions product having correctly expanded the necessary terms (-2 and 207).
Overall, this was a very accessible start to the paper with the vast majority of candidates able to achieve some marks, and a majority scoring very well.

Question 2

Part a) was often answered incorrectly and candidates failed to check their value worked consistently, common incorrect answers included $\pm 30^{\circ}$ and 150°.

Part b) was attempted by most students who recognised the need for αk to be divisible exactly by 360, it was common to see attempts involving trial and error or calculator use. The odd attempt at finding the LCM of α and 360 was seen which were generally successful in finding a value of *k* however not the lowest. Many students who got 30^0 and 150^0 in part a) were able to calculate *k*, scoring M1A0.

Part c) was very well answered with the large majority achieving this mark. It was pleasing to see candidates that although maybe couldn't access a) and b) continued to read through the question and pick up marks here.

Part d) was a show that question and whilst many candidates appreciated the need for matrix multiplication and furthermore understood the necessary order many failed to show evidence of matrix multiplication which was not sufficient. Those who did show their working generally did so correctly and were able to proceed to the correct answer. Some students left their answer as a vector which was condoned in this question.

Candidates who drew a sketch were more successful in part e and f than those who didn't. It was common to see both the cosine rule and scalar product used in part e), most candidates who selected a correct method were able to proceed to the final answer. Numerical and sign errors were more common when using the cosine rule and calculating $|\mathbf{AB}|$.

Part f) was generally well done although some candidates selected the wrong side and used *AB* in place of *OA* or *OB*, again a sketch helped with this. A small number of candidates failed to round to the required level of accuracy in e) and f) losing the final mark.

Question 3

In part (a), the vast majority of the candidates correctly substituted the standard summation formulae into the expanded expression and obtained the final required factorised expression. Occasionally this involved the factorisation of the cubic function $3n^3 + 10n^2 + 9n + 2$ and the use of the calculator to achieve this was acceptable.

In part (b), the majority of the cohort identified the need to subtract the sum to *k* terms from the sum to 3*k* terms and confidently dealt with the associated algebraic demands. Taking out a common factor of at least $k(k+1)$, as given in the question, was the most common approach here but expanding the expression into a quartic and then factorising was also seen.

In part (c), many of the candidates used the answer found in part (b) to obtain a correct value for *k* with the cancellation of the $k(k+1)$ being a common approach to achieve this. A number of the candidates struggled with the algebraic demands in this part and obtained quartic functions of n that they could not then process.

Question 4

In part (a), the vast majority of the cohort correctly found one of the terms on the leading diagonal of the product and was able to deduce that $c = 1$.

In part (b), many of the candidates did not recognise the link between finding the value of *k* and the part (a) and thus found the determinant of **A** and equated it to zero to find *k.*

In part (c), as in the above, very few of the candidates identified how the result in part (a) could be used to write down the inverse matrix $\mathbf{A}^{-1}$ and thus proceeded with the well-rehearsed routine of using minors, cofactors and transposes.

In part (d), the vast majority of the candidates converted the given system of equations into a matrix equation and then used their inverse matrix to correctly solve for *x*, *y* and *z.* Any marks lost here were mainly due to sign errors.

Question 5

In part (a), the vast majority of the candidates correctly found the centre and radius of the given circle with any loss of mark being for sign errors on the centre coordinates or an incorrect radius of $\sqrt{10}$.

In part (b), nearly all of the cohort drew a correct circle with the inside shaded.

In part (c), the majority of the cohort recognised the point on the circle at which the maximum value of $|z|$ occurs and thus found the correct distance of 23. Although the vast majority of candidates added the radius to the distance from the origin to the centre of the circle, some candidates found the coordinates of the required point on the circle which, although involving more work, is a perfectly acceptable method.

In part (d), many of the cohort identified the need to find the area of a minor segment. Within this, a correct angle was found at the centre of the circle, from which a segment area was found. Any errors here were mainly in finding a required angle which often resulted in the loss of the two accuracy marks.

Question 6

In part (a), the vast majority of the candidates correctly formed the vector equation of the line representing the pipe P_1 with any loss of marks being mainly due to the equation not having r as the subject.

In part (b), nearly all of the cohort recognised the need to equate the k component of r to zero and hence find the **i** and **j** components.

In part (c), there was much success in finding the acute angle between the pipes with the use of the scalar product being the most common method in this procedure.

In part (d), many of the candidates found this part the most demanding on the entire paper and struggled to make much progress. The need to find a general vector which connects the two pipes was identified by many of the cohort but then some went on to find inappropriate scalar products and thus lost both method and accuracy marks. A pleasing number of candidates did find the correct scalar products and went on to find the required shortest distance, even though the calculations did involve non-routine fractions such as $\frac{7}{118}$ and $\frac{131}{236}$. A few of the cohort found the distance using a method, outside of the specification, involving vector products which was perfectly acceptable here.

Question 7

Many candidates displayed a good understanding of the required steps need for proof by induction. In both questions many students lost the final mark for incomplete conclusions, particularly for failing to state it was true for **positive integers *n*** or for not referring to the dependency of $n = k$ on $n = k + 1$.

In part i) although candidates knew they were required to use $n = 1$, some did not show enough evidence that they had substituted into both the LHS and RHS simply stating $= \frac{1}{2}$, this was not sufficient for B1. Candidates need to show the substitution that $n = 1$. Almost all candidates were able to state the assumption. When considering $n = k + 1$ most candidates were aware of the need to add the next term, and where they correctly started $\frac{k}{k+1} + \frac{1}{(k+1)(k+2)}$ they were usually able to find a common denominator to add the terms. Some candidates failed to show the final required line $\frac{k+1}{(k+1)+1}$ or previously stated they were aiming to get $\frac{k+1}{k+2}$ and thus lost the accuracy marks. A small minority of candidates attempted to add the 1st term to the kth term and could not progress any further. Pleasingly hardly any algebraic or bracketing errors were seen.

In part ii) the first mark was almost always scored with students able to substitute in $n=1$ to get 725. There were lots of different methods used to consider $n=k+1$, the most successful were either using $\mathrm{f}(k+1)=3^2\left(3^{2k+4}\right)-2^2\left(2^{2k}\right)$ and splitting the terms up to get $9\mathrm{f}(k)$ or $4\mathrm{f}(k)$ or those who used the assumption to form $3^{2k+4}-2^{2k}=5m$ then rearranged to get $3^{2k+4}=\ldots$ or $2^{2k}=\ldots$ and substituted. There were also many attempts at $\mathrm{f}(k+1)\pm m\mathrm{f}(k)$ but some candidates using this method failed to isolate the $\mathrm{f}(k+1)$ term at the end leading to A0. The indices work proved challenging for the majority of candidates and various incorrect methods of factorising were seen in an attempt to find a factor of 5.

Question 8

Considering this was the final question on the paper it was pleasing to see that most candidates were able to access this question and made good progress towards a solution, understanding the method needed for the volume of revolution. The main errors were with the algebraic expansion of x^2 rather than the integration.

In part a) most candidates successfully found k. Where errors occurred, they were through using the point (0.4, 4.5) or forgetting to square root y before finding k. A minority of candidates showed some misunderstanding of roots, erroneously attempting the 'negative' root of 4; however, the MS did not repeatedly penalise these students as they were still able to complete the full question correctly for their k with only the final accuracy mark in part b) not available to them.

Whilst many made a good attempt in part b) the expansion of x^2 threw up two main errors: using +0.1 instead of – 0.1 to create the second term; and, creating a term in $y^{\frac{3}{2}}$ instead of $y^{\frac{5}{2}}$. The latter was the most common error. A significant minority only achieved 2 terms when incorrectly finding x^2, just squaring each term.
There was some use of calculator instead of algebraic integration, but this was rare. On the whole, integration was good. The volume of the cylinder was often missed or incorrectly calculated occasionally an attempt was made which resulted in area leading to three marks being lost due not to being able to sum the two **volumes**. Where the volume of the cylinder was attempted both use of integration and use of formula were seen in equal measures. The loss or omission of π in the calculation was extremely rare however the requirement of "exact value" was often ignored to lose the final A mark. A small number of candidates tried to integrate the curve between 0 and 4.5 solely, misunderstanding the model provided. These candidates were still able to score 4/7 though often they lost further marks along the way.

For parts c) and d) most candidates knew what was expected to achieve this mark, following through on any incorrect answer in part b) to achieve the B1 in d).
Part c) was generally well-answered with most candidates commenting on a limitation such as the potential for the glass not to be smooth or the curve not to be an exact fit to the ornament's shape. However, a significant minority failed to note that the ornament was solid, making comments relating to 'thickness' of glass. The most common error in part d) was to calculate the

percentage error relative to their model not the true volume. However, many candidates are still not correctly interpreting the ‘trigger word’ “evaluate”, failing to appraise the model in terms of good/bad and thus losing this mark despite having correct information to work from.

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