Examiners' Report
Principal Examiner Feedback

Summer 2023

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

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Question 1

The vast majority of candidates obtained, by equating positional elements, four equations connecting x, y, z and k and then solved them simultaneously to find the required values. A number of candidates did not use the value of k and thus obtained the incorrect equations $x - 3z = 1$ and $z - 3y = 1$ resulting in a loss of marks. However, many candidates scored full marks on this question and found it a good start to the paper.

Question 2

In part (a), much success was achieved in finding the values of a and b with the two main methods, namely forming a quadratic function using the two complex roots or the use of the sum and pair sum, being used equally by the cohort. Occasionally, Alternative 2 was seen but the inability to give the associated simultaneous equations in a and b resulted in a loss of marks. The error, in Alternative 1, in making the product of roots = +175 was seen quite often and thus produced incorrect values for a and b.

In part (b), the majority of candidates correctly plotted the complex numbers $-3 + 4\text{i}$ and $-3 - 4\text{i}$. However, a significant minority, having obtained an incorrect real root, lost the 2$^{\text{nd}}$ B mark in this part.

In part (c), many candidates recognised the need to subtract 2 from the roots found previously but there were many candidates who incorrectly added 2 to the roots and thus lacked confidence in the transformation required in dealing with the function $\text{f}(z + 2)$.

Question 3

Nearly all candidates made some attempt at this question.

In part (a), the first B mark was almost always given for rotation, most did also achieve the second B, though some added extra information eg 'around origin' or gave an incorrect description e.g. 'z-plane', '$x = 0$' so lost the second B mark.

In part (b), this was generally correct and explained using all examples in the scheme.

In part (c), many gained this mark. Where it was lost this was either due to occasional errors in multiplication or, more often, giving the answers to 3sf rather than exact figures as requested. A few just stated the matrices in the correct order but did not proceed to multiply.

Question 4

This question enabled all students to access some part of the question whilst also providing challenge to the more able.

In (i) part (a), this was generally answered very well with the majority of candidates achieving full marks. The common errors that did occur were usually either the incorrect denominator $25 - \text{i}^2 = 24$ or students not giving the answer in the correct form. Occasionally we saw some state the correct answer but without the working to demonstrate their understanding and thus, lost marks.

In (i) part (b), most candidates realised that they could use trial and error, there were lots of students who calculated this by hand instead of using the calculator. Frequent incorrect answers were $n = 0$ which almost satisfies the demand of the question except it is not a positive integer, or $n = 2$.

(ii) This proved a very challenging question for most students. Many blank or no scoring attempts were seen however a good number of students were able to gain the first mark from either $|z| = 3$ or $a^2 + b^2 = 9$ and whilst it was certainly less common for them to able to deal with the argument correctly some did go on to achieve the second M for a valid attempt to find the complex number, with an incorrect argument generally leading to $a = \frac{3}{2}$ and $b = \frac{3\sqrt{3}}{2}$. For those who did manage to correctly identify the modulus and argument they nearly always went on to achieve a correct answer, with the occasional loss of sign on the real part.
Other incorrect attempts involved attempts at expanding $z^{10} = (a + b\text{i})^{10}$

Question 5

In part (a), the majority of candidates used the correct volume of revolution formula, taken around the *y*-axis, to set up and process the associated integration. The main errors seem in this part were either the use of an incorrect upper limit on the integration, usually √2, or taking the revolution around the *x*-axis. However, many of the cohort obtained the correct mass of 5700 kg.
In parts (b) and (c), many of the candidates gave valid comments relating to the limitation and evaluation of the model and thus obtained the two available marks. Any marks lost here were mainly due to references to density or an incorrect calculation of errors.

Question 6

This was another good question with the first three parts being accessed by the majority with part (d) providing a good level of challenge.

In part (a), this was generally well answered with most candidates using the dot product. They were able to show the answer was equal to zero, although a minority of candidates failed to conclude that the lines were perpendicular or in fact incorrectly concluded parallel. Some failed to show full use of dot product, instead just stating = 0 and therefore gained no marks despite correct conclusion.

In part (b), this part was also well answered although some candidates left their answer as a scalar equation, other errors were to attempt the Cartesian equation of a line. Those who proceeded to a cartesian equation most likely did so correctly with either achieving $x + 2y - 3z = 2$ or $x + 2y - 3z - 2 = 0$

In part (c), those who obtained both marks in (b) typically also obtained the mark here, it was pleasing to see that most gave a minimal conclusion, though that was not necessary for this mark.

In part (d), this part was less well answered. Several candidates obtained the first mark for finding the coordinates of *B* but were unable to then use the distance between points in terms of their parameter. There were several numerical errors which led to an incorrect quadratic equation. It was very common for candidates to only find the positive root of their quadratic equation and therefore find the wrong coordinate. Some candidates used the Alternative approach finding the length of *AX* then *XB*. They were not always certain how to then proceed and compare to find μ. For those successful candidates the main scheme proved most popular, occasionally candidates rewrote their three expressions in terms of *p* in place of μ which proved to be equally as effective.

Question 7

In part (a), the first part of this question was well done overall, with the best solutions coming from candidates who drew a scale drawing of the perpendicular bisector required. It was necessary for equal scales on both axes to ensure that the y-intercept was negative. Quite a few went to the trouble of calculating the exact equation of the line and then drew it correctly, not required for the marks in this case. Shading the correct side of the line caused a few more difficulties with some not knowing how to decide which side to shade. Occasionally the shading was bounded which cost them the final mark.

In part (b), using the argument to find the gradient of each line proved quite challenging for some in this part of the question. If the correct Cartesian equations of both lines were found, then a correct solution for *w* usually followed. M0A0A0M1M1A0 was a fairly common mark trait as the demand of the final Ms was simply simultaneously equating their two lines and solving to reach *w*. Some very good diagrams allowed some candidates to use basic trigonometry to reach the correct complex number from a very neat geometric approach, although this was not seen often it was usually correct providing the real length had been dealt with correctly. It is clear that not all students have a sound enough understanding of what the argument of a complex number actually represents.

Question 8

In part (a), a standard question that was very well answered though there were some unavoidable errors when expanding $(2r-1)^2$, most frequently with the r^2 term. The majority of candidates knew their sum formulae and where there was an error it was generally incorrectly stating $\sum_{r=1}^{n} 1 = 1$ which resulted in the last 3 marks being lost. It was pleasing to see that there were very few mistakes in the algebra and even more pleasing to see that those candidates that did make errors and corrected themselves generally knew to do so on all lines of their working so as not to lose the final A.

In part (b), this was a more challenging question, due to the necessity to realise that they had the sum of *n* odd integers already, so the limits had to be considered with more care. Still, a good number of candidates got it right. The mistakes with the limits were mainly of 2 types:
1 - limits at 101 and 999 - they could gain the method mark here as long as they split their sum correctly into $\sum_{r=1}^{999}(2r-1)^2 - \sum_{r=1}^{100}(2r-1)^2$
2 - attempt at halving the number of three digit numbers and using this at the top limit.
Further to the struggle with limits there were a few blank scripts on this part of the question and others thought about the limits but then failed to use part (a).

Question 9

In part (i), the vast majority of the candidates expanded along the first row to find the determinant of the matrix **P** and much success was achieved. The most common error was not applying the change of sign rule which resulted in the loss of the first two marks at least. For those responses that had found the correct determinant, the proof of the non-singularity of **P** proved demanding and although the use of either the discriminant or completing the square were well identified methods, many solutions did not include all of the necessary details and thus fully complete solutions did not often appear. This is a show questions and candidates are remined that they do need to show the reasoning clearly. Just saying no real roots is insufficient they need to show why it has no real roots.

In part (ii), the vast majority of the candidates correctly found the coordinates of *A*' and *B*' and then equated the distance between them to √58 to form the required quadratic equation. The occasional sign error or incorrect expansions were the main reasons here as to why marks were lost but much success was achieved in this part and many of the cohort scored full marks.

Question 10

In part (i), the vast majority of the candidates correctly expressed *z* as a function of *w* and then substituted it into the given quartic equation. In general the expansions of $\left(\frac{w+1}{3}\right)^4$ and $\left(\frac{w+1}{3}\right)^3$ were handled well and the most common error was not multiplying the – 30 term by 81 when rearranging the equation into the requested form.

In part (ii), many of the candidates were able to form the two required equations in α and β using the sum and product of the roots of the given equation and then went on to solve for α and β. The equating of the product of roots to $+\frac{81}{4}$ instead of $-\frac{81}{4}$ was a fairly common error but was condoned for the method mark. The way in which the given roots were labelled did cause confusion with some of the cohort with the root 2α being incorrectly taken as β, presumably from the fact that students often think of the three roots as being labelled α, β and γ.

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