Examiners' Report
Principal Examiner Feedback

Summer 2022

Pearson Edexcel GCE
AL Further Mathematics (9FM0)
Paper 02 Core Pure Mathematics

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Question 1

This question was generally well answered by most candidates and was a gentle lead into the entire paper.

Part (a) (i) Those who drew diagrams to support understanding and working out were often rewarded with full marks. Some struggled to convey their thoughts mathematically, resorting to words rather than using notation (or just writing out the correct answer). While a few were incorrect in having $\tan^{-1}\left(\frac{3}{-3}\right)$ or says that the 3 should be – 3 not specify which 3, the vast majority got the mark eventually.

Part (a) (ii) This was the poorest of the 3 parts. Many got the answer but there was a significant minority who incorrectly wrote $\arg(z_1 - z_2)$, but then recovered to get the correct answer in part (b) showing they understood the idea, if not how to write it mathematically. The most common error for part (b) was missing negative signs, or not actually using the answer they got in part (a) to answer the question.

Question 2

This question on a model involving matrices was generally well-answered, but there was less success in part (b).
In part (a), a small number of students neglected to define variables or did so in a cursory fashion (e.g., "$C = x$"). Most, however, were able to produce a set of equations and these were often correct although there were incorrect multipliers seen for the percentage increases and decrease. "$H – C$ = 370" rather than "$C – H$ = 370" was occasionally seen. 1110 was sometimes misread as 1100. Some tried to eliminate variables as they constructed the equations – this generally led to correct answers but tended to cause problems in part (b).
In part (b) most set up a matrix equation although some merely solved their set of linear simultaneous equations. The matrix equations tended to be correct for their equations and most knew that an inverse had to be obtained to solve for the variables. It was unfortunate to see manual attempts at matrix inversion – teachers and students are reminded that unless the question directs otherwise, it is expected that a matrix whose elements are fully numerical then a calculator can be used. A small number left their answer (sometimes unrounded) as a column vector instead of putting their values in context.

Question 3

Part (a) was generally well answered. However, when testing n = 1, some missed out by not demonstrating fully the substitution of 1 into the original matrix before simplifying it to 2.
The assumption step was done well, as was setting up the matrix multiplication to find $\mathbf{M}^{k+1}$. Most achieved the correct answer to the multiplication, but a noticeable minority jumped straight to the answer without sufficient intermediate working. All steps in candidates working should be included to convince the examiner that they have achieved the result successfully.
The final conclusion was generally well done although a few had not learned the phrases "**IF** true when $n = k$ **THEN** it is also true for $n = k$+1.
Candidates are reminded that in the specification appendix 2: Notation ,the set of natural numbers $\mathbb{N}$ is defined as $\{1, 2, 3, ...\}$

Part (b) This was well answered by the majority of candidates, a good number still remembered that det $\mathbf{M}^n$ was the area scale factor and solved the required index equation.

The errors with (b) included using the square root of the determinant whilst a notable minority were unable to link them at all. A significant number of candidates failed to get a determinant.
Part (c) Candidates who successfully found a value for *n* then went on to find a value for *a* successfully with only a very few making arithmetic slips. The most common mistakes were not setting their matrix multiplication equal to $\begin{pmatrix} 123 \\ -2 \end{pmatrix}$.

Question 4
This complex number question saw a mixed response with part (b) proving fairly discriminating in particular. Most knew the sensible way forward in part (a) with the wide variety of viable alternatives rarely seen. However, having converted to $a + \mathrm{i}b$ form and adding, many students did not show their method to obtain the modulus and/or the argument, this is a show question.
In part (b), students who produced a reasonable sketch usually went on to score all the marks. Most sketches seen were realistic with the half-line in the correct place. It was anticipated that simple right-angled trigonometry or Pythagoras would be the most likely ways forward from here. Most who opted for this were successful. Algebraic approaches were more mixed in quality. Those who chose to find the distance of the point of intersection of the two relevant lines to the origin were often correct but those embarking on a circuitous route requiring minimisation tended to fall short.

Question 5

Generally, well answered and part (a) was done well with and students appearing confident with this. After writing as $x = \sin y$ methodology was split between implicit differentiation and working out $\frac{\mathrm{d}x}{\mathrm{d}y}$ but both were equally successful. Candidates used the identity $\sin^2 y + \cos^2 y = 1$ to replace $\cos y = \sqrt{1 - \sin^2 y}$ and then show the required derivative.

Part (b) was less well answered. A big minority substituted e^x directly for x and only scored 1 out of 3 for this part, and many forgot to multiply by the derivative of the denominator because they did not use the chain rule. There were the occasional answers of $\frac{\mathrm{e}^x}{\sqrt{1+x^2}}$ which showed they had thought of the chain rule but were sloppy in their execution. Some had not got e^{2x} on the denominator while those that did had not multiplied by e^x.
Although only a brief statement that e^x could never equal zero, was required, some missed out on the final mark by neglecting the conclusion, i.e. therefore there were "no stationary points".

Question 6
There were a lot of fully correct responses here throughout all three question parts. It was rare to see incorrect formulae for the sum, pair sum and product in terms of the coefficients of the cubic and slips with the required identities were also not common. A few algebraic errors were evident, particularly with obtaining the value of *q* in part (b).
Part (c) was slightly less well done although the standard method of multiplying out the brackets was usually correct. However, the "– 1" was occasionally lost. This was also true in the alternative where some students stopped when they had obtained the constant instead of going on to divide it by – 4.

Question 7

Part (a) was well answered, with the majority of students showing sufficient evidence of their working Students who did best on this question, tended to simplify $x = r\cos\theta = (1+\tan\theta)$ to $x = \cos\theta + \sin\theta$ before differentiating as it enabled quite simple differentiation without having to use reciprocal functions. Those who did not, gave themselves a harder differentiation to perform followed by a harder trig equation to solve. A noticeable number of candidates incorrectly attempted to find $\frac{\mathrm{d}y}{\mathrm{d}\theta}$ and so attained no marks for part a.
On rare occasions some candidates tried to over complicate the trig identities and used double angle formulae but were unable to progress due to the complicated process they had begun.

Part (b) was not well answered in its entirety. Candidates correctly applied the formula to find the area bounded by a polar curve with the majority using the identity $\tan^2\theta = 1-\sec^2\theta$ to integrate $\tan^2\theta$. A few used the substitution $u = \tan\theta$, mostly with success. Aside from careless errors most were able to integrate correctly and having done so, substituted the limits, which in the main were the correct values of $\pi/4$ and 0.
There was much confusion about which area bounded by the polar equation actually gave. Candidates who drew on the diagram generally realised that they need to subtract area bounded by the curve from the area of the triangle. There was much bluffing to try and get the answer as ln2 appeared in the integral, changing signs in their working to match the given answer and so changing a correct integral to incorrect, resulting in loss of marks.

Question 8

This question on a vector model was well-answered although completely correct solutions across all question parts were not that common.
Most knew how to use the scalar product to set up an equation in part (a) although the acute angle between the flight paths was used on occasion. Most solved their equation correctly but many responses did not identify that it was the negative value of a that was required.
Part (b) was very well done on the whole. Most knew to equate the components of the two lines and the correct coordinates of the nest were widely seen. However, a significant number did not perform an appropriate check on the consistency of their equations.
In part (c), using the result in formula book was the most common approach but a few did succumb to errors in substitution or had the wrong sign of the constant from the plane equation. Finding the length of the line from the nest to the ground in the direction of the normal to the plane was not common and led to confusion for many who tried it. Parallel plane approaches were generally numerically correct but often involved sign errors when combining the two values.
The mark in part (d) was not widely scored. Many said “reliable” or “unreliable” based on their assessment of the reasonableness of the actual distance found in part (c). However, the best students did identify an appropriate reason, usually that the model was unreliable due to its assumptions that birds fly in a straight line or that the ground was being modelled as a plane or the nest will not be a particle. Candidates are reminded to reread the question and look where the modelling takes place.

Question 9

This proved a demanding question for many candidates

In part (a)(i), a good attempt was made by many, using the chain rule and product rules but there were a few slips (even though they sometimes recovered from them). Some gained no credit because the square on the sinh$x$ term for the second derivative was missing. Missing x's were also quite common as a cause of dropped marks. The identity $\cosh^2 x - \sinh^2 x = 1$ was well remembered well by most with a few sign slips.

Part (a)(ii) proved a challenge, there were many alternatives approaches possible and students didn't need to simplify to get the marks. Some replaced $n\cosh^2 x$ with ny^2 which made it easier to differentiate. A few changed hyperbolic functions into exponential functions and used this to differentiate. The complexity of the 3rd and 4th differentials put many off and those who attempted it often made slips with a term or got themselves very confused with multiple attempts.
It was very common for candidates to make a slip, meaning that only a minority of candidates were able to produce a completely correct expression for the 4th differential.

Part (b) many students struggled or did not fully attempt this part as they had got into a muddle in part (a). They need to then evaluate it at $x = 0$ and simplify was often the final straw and only the best reached the final answer. There were one or two who showed great understanding and made it look straightforward, but they were a small group.
The most common mistakes seen were not showing the method for evaluating the derivatives at $x = 0$ and just making up values.
The complexity of the differentiation in this question left many unable to demonstrate any ability they may have at Maclaurin.