Examiners' Report
Principal Examiner Feedback

Summer 2022

Pearson Edexcel GCE
In Mathematics (9MA0)
Paper 01 Pure Mathematics 1

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General Comments

This is the first set of papers taken by the full cohort of candidates showcasing the improvements made to the accessibility of questions and the exam experience of students.

The improvements were designed to focus on;
1) Helping candidates get off to a good start.
Questions 1 to 5 were short, sharp and familiar. Candidates scored highly evidenced by the mean scores on each of these questions. The number of candidates scoring full marks on each of these questions were;

Question	% of candidates scoring full marks
1	42%
2	69%
3	39%
4	49%
5	34%

2) Providing more restart opportunities
Questions 8(c), 13(ii), 14(b), 15(b) and 16(b) all used results given earlier in the question
3) Unlocking trapped marks assessing standard techniques
For example, in question 5 candidates could show skills in solving simultaneous equations before having to engage with the model
4) Making language more accessible and reducing reading time
Question 15, a 10 mark question, was the longest question on the paper. Each sentence was on its own line. All key points were given using bullet points (see also question 5).

The Advance Information supplied to centres seems to have concentrated the areas of revision of candidates. There were some excellent scripts from high achieving students. Almost all candidates were able to show what they had learned. Timing didn't seem to be an issue. Responses to questions on proof and modelling are showing that centres are getting to grips with aspects of these topics.

Question 1 **(Mean mark 3 out of 4)**
This was an accessible question for virtually all candidates. It asked for the point to which P was mapped, and most candidates gave this as a coordinate pair.
Part (a) was frequently correct; candidates identified the translation and applied it successfully. The attempts at part (b) were less successful. Most solutions used the modulus concept but applied it to both coordinates.
Part (c) was a 3-stage transformation and required the candidates to identify both the transformations and the order in which they were to be applied. This was more of a challenge. In particular, the stretch parallel to the y-axis and final translation were mixed up; those who did, generally received some credit as they obtained $x = 0$.

Question 2 (Mean mark 2.5 out of 3)
This was a familiar and accessible question with most candidates scoring 2 or 3 marks.
The most common and successful approach was via the use of the factor theorem. Following on from setting $f(-2) = 0$, most candidates were able to set up and solve the linear equation in k.
Errors seen resulting in the loss of marks were:

- having $(10k)$ not $(10+k)$ in the linear equation
- expanding $-6(10+k)$ to $\pm 60 \pm k$, or making a sign error on the final stage to get $k=17$
- setting $f(2) = 0$
- expanding the expression before substituting, often leading to sign errors or the loss of the 42

There was a small proportion of candidates who tried to use algebraic division to solve the problem, but most did not score many marks since the working needed here was much more complicated. Often the division was left incomplete, or there was not a linear remainder in k to set equal to zero. Even fewer candidates attempted factorisation by inspection; only a handful of candidates gained marks using this method.

Question 3 (Mean mark 3.5 out of 5)
This question on the geometry of a circle had standard bookwork in part (a) followed by problem solving in part (b). Success in part (b) was usually achieved by candidates who drew a diagram.

In part (a) most candidates scored all three marks. Some candidates made sign errors when completing the square but still obtained some version of $(\pm 5, \pm 8)$. Many candidates were still able to get the correct radius following this slip. A significant minority of candidates obtained a centre of $(5, -4)$ seemingly from square rooting the 16 rather than halving.

In part (b), there was full follow through on the centre and radius, which allowed many candidates to score full marks despite errors in part (a). Candidates who drew a diagram worked out that they need to find the distance of the centre from the origin and add on the radius. One lengthy method involved finding the intersection of the circle with the line through O and C, but this was unlikely to give the requested exact answer, and some candidates gave up at the point where the quadratic had to be solved as it had unpleasant coefficients. A common error was based on simply doubling the radius, either as 26 or finding the length of the vector $(10, -16)$ as $2\sqrt{89}$.

Question 4 (Mean mark 1.9 out of 3)
This was a generously worded question with plenty of guidance to help candidates throughout. As a result, it was generally well attempted, with many candidates scoring full marks.
There were a number of candidates who made no attempt at part (a) despite the guidance to express the given sum as an integral. Where candidates had used the information given in the question the correct answer was relatively easy to deduce. Common errors seen in part (a) were omitting the limits or the dx, and writing dx as δx (although this was condoned).
Candidates who had attempted part (a) generally went on to attempt part (b). Most candidates provided a fully correct solution and gained both marks. Where errors were made, this was usually at the last mark. Common errors seen were;

- incorrectly integrating the expression to $\ln x$ or $\ln 2x$
- differentiating $\frac{2}{x}$ rather than integrating it
- leaving the answer as $2\ln 3$ rather than $\ln 9$

Question 5 **(Mean mark 4.8 out of 6)**

This question involved solving simultaneous equations set within the context of the height of a tree modelled over a number of years. The question was very accessible for many candidates.

In part (a) the majority of candidates gained the first three marks for forming and solving two correct simultaneous equations. Many went to a great deal of effort to solve the simultaneous equations using algebraic methods, whereas some just put the equations into a calculator and wrote down the values of the constants *a* and *b*. Some candidates used the 3 significant figure value of *a* to subsequently find the value of *b*, resulting in finding *b* as 1.94 rather than 1.95 and thus losing the final A mark. A significant number of candidates correctly found the values of the constants *a* and *b*, but then failed to state the equation of the model explicitly anywhere in their answer, losing the final A mark.

In part (b) most candidates realised they had to substitute either $t = 20$ or $h = 7$ into their model and compare the value obtained with the given values. However, some candidates did not know how to evaluate the model with several coming to the wrong conclusion that the model was poor, because it didn't give the exact values for *h* or *t*. There were quite a few candidates who correctly calculated the percentage error as an impressive comparison. It is very important for candidates to give a reason for their answer when the question explicitly demands it.

Question 6 **(Mean mark 2.1 out of 6)**

There was a very mixed response to this question on a cubic function with only one in eight candidates scoring all 6 marks.

Part (a) was for finding the set of values of x for which $f'(x) < 0$. Candidates generally knew what to do and most scored this B mark. Marks were lost when candidates gave the inequality as $2 \leqslant x \leqslant 6$ or else $2 < f'(x) < 6$.

In part (b) the request to give the answer in set notation proved a challenge for many candidates, with many only gaining the M mark for correctly identifying at least one of the correct inequalities. A minority of candidates gained both marks by giving their answer in acceptable set notation but there was widespread misapplication of $\cap$ rather than $\cup$.

Part (c) required the candidates to find the equation of the curve. A very common response, which gained only the first mark, was to give their answer as $y = x(x-6)^2$ without any appreciation of the stretch factor. Candidates who did appreciate that it could be $y = ax(x-6)^2$ could easily use the coordinate (2, 8) to find the value of *a* and hence the equation of the curve. A sizeable minority of otherwise good candidates lost the final mark by incorrectly writing down the equation of the curve as $C = \frac{1}{4}x(x-6)^2$. There were many more time consuming and long winded methods seen here. A significant number of candidates formed the equation of a cubic, i.e. $y = ax^3 + bx^2 + cx + d$ and then attempted to use the points on the curve to find the values of *a, b, c* and *d.* This approach was rarely fully correct with many failing to identify that $d = 0$ or being able to form only 2 equations. A small minority of candidates did attempt to use the turning points at $x = 2$ and $x = 6$ to form the equation $\frac{dy}{dx} = (x-2)(x-6)$ without again, an appreciation of the need for a stretch factor. It was disappointing to see how many candidates got bogged down in pages of algebraic working without noticing that this part of the question was only worth 3 marks.

Question 7 **(Mean mark 1.6 out of 5)**

This question, on two different kinds of proof, proved more demanding than expected. As a result, there were very few completely correct solutions to both parts of this question.

In part (i) candidates were often unable to set up a proof by contradiction using appropriate language, failing to use words such as 'assume', 'there exists' or 'let' . Others simply set up a contradiction such as 'assume p and q are odd' without any reference to pq being even. Many candidates also failed to use different variables for their odd numbers p and q, implying that p and q were either the same odd number, or two consecutive odd numbers such as $2n+1$ and $2n+3$. Candidates who managed to write p and q using different variables were generally able to multiply out pq correctly and write it in the form 2(.....)+1. If this stage was reached, the conclusion was generally correct and an acceptable sentence was written down. A mark of 011 was possible from the mark scheme.

In part (ii) most candidates expanded the left hand side and cancelled terms getting to $2xy < 8x^2$ or equivalent for the method mark. Many then lost the second mark by failing to identify the point at which the inequality reverses, simply writing down $y < 4x$ followed by 'so $y > 4x$'. Other candidates did reverse the inequality at the right point but didn't give an explanation as to why, and so lost the final mark.

Question 8 **(Mean mark 4.1 out of 8)**

This was the second modelling question on the paper. The given equation modelled the speed of a car as it travelled between a pair of traffic lights. Many weaker candidates missed out part (b) and scored marks in the more accessible parts (a) and (c).

Most candidates managed to reach the correct answer of 25 in part (a). A common incorrect answer was 10, possibly from sight of the 10 in the given equation $v = (10 - 0.4t)\ln(t+1)$

The first two marks in part (b) were often achieved by those who attempted it. Using the product rule to find $\frac{\mathrm{d}v}{\mathrm{d}t}$ and then setting this $= 0$ gave them one form of the given equation. The final two marks were only achieved by the best of students. In reality, all that was required was to make t the subject of the formula, but it was beyond most.

Part (c) was the most successful part of the question and familiar to most candidates. Many were able to carry out the iteration process correctly, and write down 7.298 without any problems. In part (c) (ii), the omission of the units, “seconds”, was the most common slip.

Question 9 **(Mean mark 1.9 out of 6)**

This vector question was set within the context of a rhombus. Surprisingly, many candidates were unable to use (or remember) the basic geometric of a rhombus and over 30% did not manage to make any progress.

Part (a) required candidates to show that parallelogram $PQRS$ was a rhombus. Although the requirement to 'show' is becoming more familiar to candidates, a significant number in this case didn't recognise the level of detail expected. So a lack of conclusion, or stating the sides were of length $\sqrt{29}$ without evidence of calculation, led to loss of credit. It was also necessary to conclude that the sides were equal, and not simply find the lengths and leave it to the reader to decide.

A vast array of approaches were in evidence in part (b) to find the area of the rhombus. The easiest and most direct approach was to find $\frac{1}{2}\left|PR\right| \times \left|QS\right|$. A more common method used involved finding the length of one diagonal, followed by the cosine rule to find an internal angle and then use of the formula '$ab \sin C$'. Unfortunately most attempts using this method only scored 3 marks as it was usual for answers to be given as 22.7 rather than the one required,

$\sqrt{517}$. Other methods seen involved use of Heron's formula, the "shoelace" determinant method, scalar product and vector product….. with many successfully used. Students who added a "narrative" – so explaining what they attempted to do – were in a better position to gain credit if they suffered a processing error early in their solution. This has to be considered good practice. The most common incorrect solution, seen many times over was in stating area = $\left|PQ\right|\times\left|PS\right|=\sqrt{29}\times\sqrt{29}=29$

Question 10 (Mean mark 3.8 out of 8)

This was the third modelling question on the paper, this time based around an exponential model. This should have been expected given the Advance Information and candidates performed well on parts (a) and (b). Part (c) was more of a challenge with only higher achieving students scoring all 4 marks.

Part (a) was either answered correctly, or the mark was not awarded because the answer stated was 265 bees not 265,000 bees.

Most candidates recognised the need to differentiate in part (b), and used appropriate notation. Most did this accurately before substituting in t =10 to obtain 18.1. A number of candidates failed to secure the final mark however, for not providing a minimal conclusion relating their answer to 18,000. Common reasons for not achieving full marks were

- failing to use appropriate notation often using $\frac{\mathrm{d}y}{\mathrm{d}x}$ instead of $\frac{\mathrm{d}N}{\mathrm{d}t}$
- failing to recognise the need to use differentiation often subtracting the values of N_b at t =9 and 10 or else t =10 and 11

Part (c) was the most demanding part of the question with many candidates just picking up the first mark for equating the two expressions. Having equated the two expressions, the significance of the negative exponential term seemed to be poorly understood. Very common errors included

- changing the $\mathrm{e}^{-0.05t}$ term to $\mathrm{e}^{0.05t}$ and then solving
- applying 'ln' to each term in the equation to form a linear equation in t
- slips in coefficients with 220 becoming 200

A number of candidates reverted to numerical methods or the use of their calculator to solve the equation rather than solve by algebraic methods. The strongest candidates recognised the quadratic equation in $\mathrm{e}^{0.05t}$ and were able then to solve it correctly, many after making a substitution $x=\mathrm{e}^{0.05t}$.

Question 11 (Mean mark 4.3 out of 7)

This question was based around the intersection of a cubic and a quadratic equation. It proved to be very accessible with many candidates able to make progress in both parts. In fact 30% of all candidates scored full marks on this question.

Part (a) asked candidates to verify that the curves intersect at $x=\frac{1}{2}$. The easiest and most common approach was to substitute $x=\frac{1}{2}$ into both equations, obtain y values of $\frac{41}{4}$ in each and then conclude that the curves did intersect. Candidates using this approach generally scored the method mark, but some lost the accuracy mark either from failing to show full details of the calculations, or from failing to state the conclusion that the curves intersect. Other methods seen included

- setting the equations of the curves equal, rearranging to form a cubic, and then showing that $x = \frac{1}{2}$ satisfied the resulting equation. Again, most gained the method mark, but again some lost the accuracy mark due to a lack of a conclusion.
- setting the equations of the curves equal, rearranging to form a cubic, using the calculator to solve the cubic equation and then writing down the three solutions, indicating that one of the solutions was $x = \frac{1}{2}$. This approach could only achieve the method mark here.

In part (b) most candidates made some progress with weaker students scoring only the first mark for setting up the cubic equation. The majority were then able to divide by either $\left(x - \frac{1}{2}\right)$ or $(2x-1)$ to form a quadratic factor and then equation which could then be solved to find the positive root. Marks lost were usually as a result of

- slips in establishing the cubic equation or else errors in the division
- not giving the exact answer of $-4+\sqrt{33}$ but instead its decimal equivalent
- using a calculator to solve the cubic equation $2x^3 + 15x^2 - 42x + 17 = 0$

Question 12 **(Mean mark 2.8 out of 5)**

This was a very straight forward question on integration by parts with 40% of the candidates scoring full marks. On the reverse side there were also a sizeable number, some 30%, who did not know how to begin and failed to score any marks. Those candidates who knew the method nearly always scored 3, 4 or 5 marks. Reasons for these candidates dropping 1 or 2 marks nearly always centred around

- a failure to integrate the term $\frac{x^4}{4} \times \frac{1}{x}$ correctly, many times to $\frac{x^4}{12}$
- failing to correctly apply the limits, usually achieving $\frac{7}{16}e^8 - \frac{1}{16}$
- achieving a correct answer of $\frac{7}{16}e^8 + \frac{1}{16}$ then inexplicably "simplifying" this to $7e^8 + 1$

Low scoring candidates who attempted the question, usually resorted to integrating each term of the integrand or else having made a good start, disappointingly integrating the $\frac{x^4}{4} \times \frac{1}{x}$ term to $\frac{x^5}{20} \times \ln x$

Question 13 **(Mean mark 3.8 out of 7)**

This question on arithmetic sequences and series proved to be very discriminating. The proof of the sum of an arithmetic sequence is standard, but was not answered well by many candidates. Most candidates however were able to then made progress with the rest of the question, having been given the required formula. Good candidates often did well in this question however, with 17% of the cohort achieving full marks.

In part(i) those who had learned the standard proof for the sum of the first n terms of an arithmetic series often gained full marks. It was however, unusual to see a well set out, fully correct proof. Candidates often failed to write a correct expression for Sn at the start of their proof, or sometimes having an incorrect first or last term or extra terms (most often $a+nd$) within their sum. Other errors included not displaying a sufficient number of terms, not writing $S=$ or $Sn =$, and using commas instead of + sign between the terms.

In part(ii) most realised that they could make headway even if they hadn't attempted part (i). In (ii) (a) many of the candidates used $a=20$, $d = -0.8$ and $Sn = 64$ in the sum formula to score the M mark. Poor notation such as $(n-1)-0.8$ was frequently seen, but candidates usually recovered from this. Following a correct equation most were able to proceed correctly to the given quadratic for the accuracy mark. A common error was where candidates used +0.8 as the common difference rather than -0.8

Part (ii) (b) was generally answered without issues. Almost all candidates managed to get B1 for getting the two values of n, either by factorising or by using a calculator.
Part (ii)(c) was not answered very well with most candidates identifying 10 as the valid solution but not adequately justifying this choice. The reasons provided were often too vague or not related to why 10 was better than 16. More tended to score the mark by explaining that at 16 weeks he would be saving a negative amount rather than using the fact that 10 was the smaller number or that he would have had enough by 10 weeks so would not continue saving until 16 weeks.

<u>Question 14</u> (Mean mark 4.0 out of 8)
This question was another big discriminator. Good candidates found it familiar and accessible with some 25% scoring full marks. Strangely, for candidates who dropped marks, they seemed to be able to do either part (a) or part (b), but not both.
For those candidates who attempted part (a) most recognised the need to use the compound angle expansions. Carelessness with the multiplication by 2, signs and use of the formulas was seen in a small minority of the scripts. Students who attempted to use sin ($A+B$) and cos ($A+B$) with a negative angle B, often introduced sign errors; it is clear that such a method is not to be recommended. Substituting exact numerical values was usually correct, however candidates occasionally fudged their working to get the given answer.
Part (b) could be attempted without having done part (a) and many took up this opportunity. Those who paid attention to the 'hence', deducing that $x = 2\theta + 60$, were very successful in achieving the correct answers, though quite a few only found one solution. For the many students who did not see the link between parts (a) and (b), generally encountered much more complex, longer algebraic manipulation. Such students re-started the question using the compound angle formulae with a combination of other trigonometric identities, but were often not able to reach an equation in one function, or else made numerous slips. If quadratics in tan θ were reached, they were dealt with competently. If the candidate's efforts led to $\tan 2\theta = k$, $k \neq 3\sqrt{3}$ or $\tan (2\theta \pm 60) = 3\sqrt{3}$ they were generally able to use the correct order of operations to solve their equation to find at least one solution.
A fair number of correct answers were seen written down without any correct working. As the question had a warning about the use of calculator technology, these responses gained no marks

<u>Question 15</u> (Mean mark 5.6 out of 10)
This question, based on the minimum surface area of a children's toy proved to be a useful source of marks so late in the paper. In fact 25% of the cohort achieved full marks. Many candidates who could not access part (a) were able to use their skills in differentiation to find an appropriate value for the radius and prove that their value gave a minimum surface area.

Unsurprisingly, part (a) was the most demanding part of this question. The key was to find an expression (using the volume of 240 cm^3) for h in terms of r. Unfortunately some solutions featured the volume of a sphere, which proved a costly error, from which there was no return. Candidates produced their formula for surface area in a variety of ways – sometimes leaving it to the last line to substitute in the value for the angle, occasionally replacing 0.8 by 4/5. As with other "show" questions, sufficient detail has to be written to convince the reader that progress is genuine.

Part (b) well generally well done. Many candidates scored full marks for reaching either $\sqrt[3]{1050}$ or 10.2. Occasionally some candidates mistakenly wrote down $\sqrt{1050}$ and subsequently simplified their answer to $5\sqrt{42}$. Very few candidates who attempted this part failed to score marks. The main reason for this was usually an inability to differentiate $\frac{1680}{r}$ which usually became $\frac{1680}{1}$ or $1680 \ln r$

Most candidates were able to find the second derivative correctly in part (c). How it should be used was confused in much of the work seen. Common reasons for a loss of marks here were;

- candidates solving the equation $\frac{\mathrm{d}^2 S}{\mathrm{d}r^2} = 0$
- use of incorrect notation including $\frac{\mathrm{d}^2 S}{\mathrm{d}r^2}$ and $\frac{\mathrm{d}^2 y}{\mathrm{d}x^2}$
- incomplete solutions with calculations or conclusions missing

<u>Question 16</u> (Mean mark 1.9 out of 9)

The final question on the paper proved to be a challenge for many candidates and there were several blank responses seen. It is possible that this was due to time management. Some candidates attempted unsuccessfully to change to a Cartesian equation, suggesting that possibly parametric integration had not been covered.

In part (a), candidates who recognised the need to use parametric integration were usually able to differentiate correctly to find $\frac{\mathrm{d}x}{\mathrm{d}t}$, multiply this by y and then use the double angle formulae to find an acceptable expression for $y\frac{\mathrm{d}x}{\mathrm{d}t}$. It was common for candidates to score the first two marks. The next two marks were more elusive, and it was common to see candidates perform a lot of onerous manipulation without making any significant progress. Those who were most likely to be successful were the ones who had an expression in terms of $\sin^2 2t$ and then spotting the need to use the double angle formula to form a term in cos 4t. For many candidates the mark for the upper limit was all that was achieved in part (a). However, some failed to achieve it as they left it as 4 (value for x not t) or 45 (degrees).

It was good to see students who were unsuccessful at part (a) still attempting part (b), and in some cases scoring full marks. Most candidates were able to integrate the first two terms correctly, but a significant proportion were unable to integrate the third term to get an expression in $\sin^3 t$. The majority of correct solutions came from the use of the reverse chain rule for the final term. Those who attempted to use integration by substitution or by parts were usually unsuccessful. Candidates who had successfully completed the integration often went on to score full marks.

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