Examiners' Report
Principal Examiner Feedback

Summer 2019

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

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Introduction

This was the first 9MA01 paper under the new specification which tested the full cohort of students. The paper had many straightforward and accessible questions as well as more demanding ones that stretched the most able of students. Accessible questions and parts of questions included 1, 3, 4a, 5ab, 6, 8a and 12ab. The performance of candidates on topics that were new to the specification were mixed. For example Q7, the exponential model, was well attempted but Q10, the proof, was not. Generally students had difficulty on questions that demanded an explanation. This is something that will improve over the lifetime of the specification as both students and teachers adjust to these new demands.

Question 1 (Mean Mark 2.6 out of 3)

This proved to be a very suitable start to the paper. Most candidates used the factor theorem and produced an equation in a by setting f (-3) = 0. Most could then solve their linear equation in a to find its value. Candidates who used this method generally went on to score full marks. Common mistakes tended to be arithmetic or sign errors, for example not cubing (-3) accurately in the first term.
Other methods were seen but were generally less efficient and not as effective. Those candidates that started with $(x+3)(ax^2+bx+c)$ and equated coefficients were generally successful, however those candidates that tried to solve this problem using long division generally made errors and did not score highly. It was rare to see students scoring zero on this question.

Question 2 (Mean Mark 2.5 out of 5)

This question proved to be more challenging for a number of candidates although many were still able to score full marks.
In part (a) it was important for candidates to pay attention to the scale of the graph. Most candidates who did draw a straight-line graph were able to make the link between one point of intersection and one real root to the equation, however, a significant minority of these were unable to construct the correct straight-line graph with enough accuracy to gain both marks for this part of the question.
In part (b) almost all candidates were able to write down the small angle approximation for $\cos x$ even if they were unable to use it in order to answer the question. Most candidates did substitute correctly into the equation in order to gain a quadratic equation, although some did contain a mixture of variables. Sign errors sometimes occurred at this stage and the weakest candidates were unable to deal correctly with resulting fractions in order to simplify the equation. Many candidates appear to be using calculators in order to solve quadratics and in this question, this usually resulted in full marks. The final mark was lost by some candidates who correctly solved the quadratic equation but gave both roots as their final answer.

Question 3 (Mean Mark 2.8 out of 5)

This was an accessible question for most students, but the second half of part (a) did discriminate at all levels. In part (a) students generally recognised the need to use the quotient or product rule and were successful at differentiating for the first 2 marks. The most common mistake was forgetting to square the denominator, with incorrect order of terms in the numerator being less common. Students should also be reminded to quote a formula before attempting to use it, as they may still gain method marks for this, even if there are slips in its application. Omission of brackets in terms in the numerator was also common, but often recovered in working. However, it would benefit students to be careful in the use of brackets.
Having achieved a derivative, attempting to simplify to the required form proved difficult for many students. Many did not realise that they could factorise the $(x+1)$ out early and instead expanded fully, simplified then factorised again to cancel in the last step. This wasted valuable time and it was during this process that errors usually occurred.

The alternative method of simplifying the fraction before differentiating was less common, with usually poor attempts at partial fractions being applied leading to error. Those who successfully simplified the fraction almost always went to achieve the correct answer.
Nearly all students who were correct in part (a) achieved the mark for part (b), including many who had failed to cancel the (x+1). Indeed, there were many cases where a correct answer to part (b) was seen following incorrect work in (a), presumably due to the use of a calculator to plot and inspect the graph.

<u>Question 4 (Mean Mark 3.3 out of 6)</u>

The vast majority of candidates did well in part (a), securing most or all of the marks available. They appreciated the need to rewrite the expression with a negative power and dealt confidently with the factorisation. The binomial expansion itself was also correctly executed and careful working ensured that there were relatively few slips in powers or signage.
Common errors included

- bracketing errors seen with $-\frac{x^2}{4}$ in the third term rather than $\left(-\frac{x}{4}\right)^2$
- failing to correctly combine the factored out $4^{-\frac{1}{2}}$ with the expansion $\left(1+\frac{x}{8}+\frac{3x^2}{128}\right)$

Part (b) caused more difficulty. In part (i), many candidates appeared to realise that the question was linked to the range of valid x values and the correct answer, $x=-14$, was selected most often. To gain this mark however, the correct answer and a valid reason needed to be given. Examples of valid reasons were "the expansion is only valid for $|x|<4$", "the expansion is not valid for $x=-14$ as $|-14|>4$".
In part (ii), only a small proportion of the candidates realised that the expansion is more accurate for values of x closest to 0. Many resorted to using the three values given and comparing the results to the exact value of $\sqrt{2}$ or else stating that the answer was 2 as it was the closest value to $\sqrt{2}$.

<u>Question 5 (Mean Mark 6.3 out of 10)</u>

This question on completing the square and the quadratic function was accessible to all, especially the first 6 marks. Part (c) was more demanding but there were some excellent responses here.
Part (a) was very straightforward and many students were able to write down the answer without any difficulty. Although errors were rare, one common incorrect answer was $2(x+1)^2+8$.
Part (b) was equally straightforward, even for candidates who did not achieve the correct result in part (a). Many used the form $a(x+b)^2+c$ or their graphical calculators to produce accurate and well drawn curves. Marks were lost here when candidates drew V shaped curves or had incorrectly placed turning points.
As stated earlier, part (c) was a lot more demanding. Rather strangely part (i) was found more accessible than part (ii). Many candidates sketched the new curve and compared the positions of the turning points noting that $(-1,7)$ had "moved" to $(1,3)$. Disappointingly a rather sizeable majority could only describe this "movement" as a "transformation" rather than "translation" . Fewer students could use the form $\mathrm{h}(x)=\frac{21}{2(x+1)^2+7}$ to find the range of the function. Many resorted to substituting $x=0$ producing a range with $y=\frac{21}{9}$ as one of the limits. Common incorrect answers for the range of h scoring one mark were $\mathrm{h}(x)\geqslant 3$ or $0<\mathrm{f}(x)\leqslant 3$.

Question 6 (Mean Mark 4.4 out of 8)

This was generally a well attempted question with most candidates able to score over half of the marks.
In part (a) the correct identities were well known and efficiently used in order to obtain an equation in one function. Almost all candidates who reached this stage were then able to proceed to find at least one correct angle. It was clear from the graphs and diagrams sketched by most candidates that they had been taught to look for all angles in the required range and many were able to give all four of the angles needed. Only a minority of candidates identified $0, \pm 180$ as solutions to the equations. Most candidates divided through by $\sin\theta$ or $\cos\theta$ and failed to identify any of these values.
In part (b) a significant number used $2x - 50 = \theta$ rather than $x - 25 = \theta$. Of those who used one of their solutions to part (a), the majority then proceeded to the correct answer, although a significant number did not give the smallest positive solution to the equation. This was usually due to the fact that they used their smallest positive solution to part (a) (i.e. 18.4) in the equation, not realising that they needed to use – 18.4.

Question 7 (Mean Mark 4.2 out of 7)

It was pleasing to see that most candidates attempted to form an exponential model using a suitable equation. This is one of the new topics in the specification and candidates who didn't gain any marks on this question, generally did so because they did not attempt it, or that they tried to use a non-exponential model.

In part (a) $V = Ar^t$ or $V = Ae^{kt}$ were the most popular types of correct models that candidates opted for. However, some methods were often muddled or poorly shown, but many candidates who used a correct model were able to proceed to obtain correct values for their constants. Those candidates who used the model $V = Ae^{kt}$ frequently gave the constant *k* as a log and errors sometimes occurred with the sign of this constant. Errors in calculating constants with the model $V = Ar^t$ often occurred when candidates used $V = Ar^{t-1}$ instead.

In part (b) candidates who correctly answered part (a) usually understood that for this section they needed to substitute $t = 10$ into their model, and most were able to do this. Many candidates then proceeded to make a sensible comparison of the value gained by their model with the actual value in order to comment on the model's reliability (sometimes calculating and commenting on % error). The final mark, however, was frequently lost because answers were too vague, without a clear comparison or assessment of reliability being made. Some candidates appeared to think that a model was only acceptable if it gave the exact real value.

Most candidates who attempted part (c) understood which of their two constants would need to be altered, although marks were lost either because the answer given just said the constant needed to be changed or because they wrongly identified whether the constant needed to be decreased/increased. This was more of a difficulty for those candidates who had used the model $V = Ae^{kt}$, because candidates were often dealing with negative constants and/or constants given as logs so the phrases used were not always mathematically correct. An example was often useful to convey what the candidate meant where there was ambiguity. Candidates who had gone with model $V = Ar^t$ were less likely to make an error in judging whether their constant should increase or decrease.

Question 8 (Mean Mark 4.9 out of 10)

The first six marks in this question relating the definite integral with the area under the curve were straightforward. Only the best candidates were able to access the last four with many struggling to explain the significance of the root 5.442.

Most students gained all 4 marks in part (a). Some unnecessarily complicated their proof by attempting integration by parts but in the main, all calculations were accurately performed.
As with all proofs, part (b) proved to be very discriminating. Many candidates picked up the first mark for setting $\frac{1}{4}b^4 - \frac{2}{3}b^3 - 4b^2 = \pm\frac{20}{3}$ but there was much confusion as to the sign of $\frac{20}{3}$ on the right hand side.
Most students attempted to proceed by the method shown in the scheme. It should be noted that division by $b^2 + 4b + 4$ was much easier and faster than dividing by $(b+2)$ twice.
Fully correct solutions to (b) were rare with many picking up 2 out of the 4 marks.
In part (c) many candidates realised that 5.442 was to the right of 4 on the *x*- axis and shaded an appropriate area, scoring one mark. Full explanations as to its significance were rare and confined to the best candidates. Any suitable statement that alluded to the fact that the area above the curve is equal to the area below the curve (between -2 and 5.442) was acceptable.

Question 9 (Mean Mark 2.6 out of 5)

There were many good attempts to this question, though complete answers to part (b) were achieved only by the very best.

In part (a) most students gained the B mark by writing $\log a - \log b = \log\left(\frac{a}{b}\right)$, though a few did attempt to rearrange first and used other equivalents. Students who gained this mark generally were successful at 'undoing' the logs and making *a* the subject. Students who failed to recognise the logarithmic rule for subtraction or addition often made no progress with the question.
Part (b) was more challenging with many only scoring the first mark. Many students focused solely on the exclusion of $b = 1$ from the denominator and paid no heed to the condition that $a > 0$. Few students were able to provide a full explanation including that as $a > 0$, $\frac{b^2}{b-1} > 0$ and so $b > 1$.
Most candidates knew that the denominator of a fraction cannot be zero, though few of them used the words "undefined" or "infinity" in their answers, but would more often refer to 'math error' or 'can't didide by 0'.

Question 10 (Mean Mark 1.7 out of 6)

The idea of proof is another new one in this updated specification. It was not well known and a disproportionate number of blank or barely started solutions indicated a lack of expertise in this topic.
Candidates who scored full marks for part (i) most often did so via algebraic proof, letting n=2m (for even numbers) and then n=2m+1 (for odd numbers), although several candidates missed out on the final accuracy mark as they failed to insert a conclusion for all *n*. Weaker candidates tried to use $m + 1$ instead of $2m + 1$ to represent odd numbers. Also many candidates only considered either odd or even numbers, but not both.
Candidates who set out to use proof via contradiction tended to score few marks as they did not show an understanding of how to use that method of proof. Proofs via logic were rare and tended to appear as part of a mix of different methods where the candidates seemed to be unclear of the best way to proceed. Some candidates seemed to think that using random numbers to show that the expression is not divisible by 4 amounted to proof (receiving 0 marks). Students need more practice on this style of proof.

In part (ii) more candidates approached the problem algebraically than graphically. They were generally able to set up the two equations / inequalities required, but errors often occurred in their use of algebra when attempting to solve them. Some candidates only set up one of the two required inequalities. Many students attempted the question by just substituting numbers in to the expression, with most of these deducing that the statement was always true. Where candidates drew a graph, they often did not describe why their graph indicated that the statement is sometimes true. Many graphs showed a line and a V shape but some were incorrect in the relative positioning of these shapes.

Question 11 (Mean Mark 3.1 out of 7)

Overall very good attempts to this question were spoiled by a lack in accuracy .

Part (a) was routine for most and candidates were thorough in showing their method. The most frequent and concise method involved calculations of the form $24+6\times1.05+6\times1.05^2$. Occasionally the work was overcomplicated by converting to seconds though the end result was generally satisfactory.

Part (b) was found to be challenging with some candidates choosing not to answer. The most straightforward way was to use some values and spot the patterns. This is a skill taught at GCSE yet seemed forgotten to many.

	Time taken	
5th kilometre	6×1.05^1	Using the pattern on the left the time taken for the r th kilometre would be $6\times1.05^{r-4}$
6th kilometre	6×1.05^2	
7th kilometre	6×1.05^3	

Although most candidates knew that for part (c) they needed to sum a sequence of terms, errors were frequent and many. A sizeable minority lacked any appreciation of the model and resorted to the calculation $\frac{6\left(1.05^{20}-1\right)}{1.05-1}$. The majority of errors however were mainly due to a failure to link up the correct values for *a* and *n* in the formula for a geometric series. The most common of these was to use the strategy 24 + $\frac{6\left(1.05^{16}-1\right)}{1.05-1}$, forgetting that the geometric sequence in this case should start at 6.3 instead of 6.

It is often a good idea in such a question to write out the first few terms to gain an appreciation of the model and how the sequence is formed. (See below)

Km	1st	2nd	3rd	4th	5th	6th	7th		20th
Time	6	6	6	6	6×1.05	6×1.05^2	6×1.05^3		6×1.05^{16}

From here it should be a fairly straightforward task to write down $24+\frac{6.3\left(1.05^{16}-1\right)}{1.05-1}$

Question 12 (Mean Mark 4.1 out of 10)

This question discriminated well between students of all abilities with part (a) and (b) more accessible to students compared to part (c) and (d).

In part (a) most students were successful at using the product rule and setting $\mathrm{d}y/\mathrm{d}x$ equal to 0 (though the latter was implied rather than being explicit in many cases). Missing the −0.25 factor when differentiating the $e^{(-0.25x)}$ was fairly common, but the differentiation was mostly correctly carried out. A few students failed to use the product rule correctly, instead multiplying the derivatives of each term, but these were in the minority.

Having attempt the derivative the majority did set the result equal to zero (possibly implied) and proceeded to cancel the exponentials. Reasoning for the cancellation was usually not given, but in this instance there was no requirement for such reasoning. However it might be well noted that such explanations may be required under the new specification. Many students lost the final accuracy mark as they did not state or show division by cos x. Students need to be clear that in a 'show that' question all steps need to be shown.

Part (b) was the most successfully answered part of the question. Students realised that the graph of $|f(x)|$ should be above the x-axis. Where students did not gain full credit, this was usually due to poor drawing of loops (not decreasing heights, or rounding at the cusps). A few students chose to draw over the original figure which made it difficult in many cases to determine which pieces formed their graph. They would be well advised to sketch separate graphs in similar questions.

There was less success in part (c). Attempts at this part were varied, with a sizeable proportion not making the connection with part (a) at all and attempting to find the value of $H(t)$ at $\pi/2$ or some other value, or failing to substitute into $H(t)$ at all. Many solved tan $x = 4$ to find the acute angle but did not then look for the further solution which was needed for the height between the first and second bounces and so achieved only the first mark. Also, use of degrees instead of radians was a common error, but this was allowed the first method mark. The magnitude of their resulting answer should have alerted them to the fact that something had gone very wrong.

Part (d) was another part with a varied array of answers. Common incorrect responses referred to negative time, and the times between each bounce would be longer or that the ball would not bounce forever. Many students gave a rote answer of "the effect of air resistance has not been taken into account" or "energy loss" or similar vague reasons rather than relate to the context of the question. Since the model may have taken air resistance into account (the contributing factors to the model were not listed in the question), such an answer was unacceptable.

Question 13 (Mean Mark 5.5 out of 11)

Only the strongest candidates scored all 11 marks here, with the majority losing at least 1 mark, usually the first mark in (a) or the last mark in (b).

In part (a) (i) many candidates realised that $x = 2$ was linked to establishing that $q = 4$ but they found difficulty explaining this by referencing the asymptote, or the denominator being zero.
Almost all candidates provided good explanations in (a)(ii) even when they had provided inadequate explanations on part (i)

In part (b) the vast majority of students knew they had to use partial fractions to attempt the question with many achieving the correct expression and correct integration. The most common error was in simplifying the final logarithmic expression with many candidates leaving some of their answers in terms of ln (3/4) or ln (4/3) for example. It was uncommon therefore to see a fully correct solution in the required form.

Question 14 (Mean Mark 2.4 out of 7)

A number of candidates did not attempt this question. Whether this was due to lack of understanding or time constraints is unknown.

Part (a) was generally well done with a surprising proportion using implicit differentiation. A good number who found $\frac{dy}{dx}$ correctly failed to substitute in $y = 0$ to find the value of $\frac{dy}{dx}$ at the origin. Candidates who tried to expand sin2y using the double angle formulae and then differentiating using the product rule often went wrong.

The small angle approximation in (b) part (i) was also well handled. Most settled for the form $x = 8y$ although some rearranged to y = . Marks were generally lost when $\sin 2y$ was replaced by 2θ instead of 2y. Many candidates failed to see the link between (a) and (b)(i) even though they had both answers correct. They were unable to see that the gradients were the same or else failed to explain themselves coherently.

Only a small percentage of candidates were able to secure full marks for part (c) and it was not uncommon to see the whole question left unanswered. This type of question was common on Core 3 and usually well answered.

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