Pearson Edexcel

Examiners' Report
Principal Examiner Feedback

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In Pure Mathematics P3 (WMA13) Paper 01

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General

The paper was approachable at all grade boundaries, with most students able to make progress with each question while also having some places that differentiated at the higher grades. There did not appear to be any timing problems, with most students attempting every question, even if only partially, though there were some non- or very weak attempts at the paper overall. Question 9, as should be expected, appeared to pose the greatest challenge, particularly part (a), while questions 1-3 were particularly well answered.

Students seemed well prepared for the paper, and it was pleasing to see that errors with signs, rear-ranging and bracket expansion were infrequent compared to some past series. Errors were seen more in comprehension of questions, not giving answers in the required format or not seeing how to progress to the next step.

Routine methods such as differentiation were generally carried out well though some trigonometric work, particular the end of question 6 and question 9(a), did provide a challenge for even some high-grade students. Questions containing logarithms were also answered well with manipulation of the logarithms being carried out well, though the most challenging logarithm question, 4(b), where differentiation was also required did again provide a discriminating part of the paper.

Report on individual questions

Question 1

Given that this was the first question on the paper there were a considerable number of students who simply left it blank or struggled with (a) and consequently often made no progress in (b) (though use of any numbers or letters was allowed for 3 of the marks). The continued fallout of the pandemic was quite possibly the reason for this.

Use of algebraic long division was the most common approach and also the most successful approach to part (a), enabling students to achieve the constants A and B and to spot the common factor in the remainder to achieve full marks. Those who did not achieve full marks by this method usually gained at least two of the four marks simply by writing the quotient of $2x$ within the long division. The method of multiplying through and comparing coefficients was less successful overall due to errors in algebraic manipulation. The grid method was seen only occasionally and was usually well executed.

A good proportion of students also gained full marks for the definite integration in (b), albeit notably fewer than in (a), some failing to spot the form of the second part ($f'(x)/f(x)$) led to a logarithm term, despite that the question asked for an answer in terms of a logarithm. This meant they could not even gain what was, for most, an easy mark for combining logarithmic terms to a single term. In some cases, although students did arrive at a function of the correct form, they had an incorrect k (most often 1/3), and occasionally an extra factor of $(2x+3)$ or similar. Limits were applied correctly in the majority of cases, as was the law for subtracting logs, but about half those who proceeded this far lost the last mark as they failed to apply the power rule for 3ln2 to arrive at ln8 and thus failed to give the answer in the required form.

Question 2

A largely accessible question aside from the difficulties students continue to have understanding ranges and domains. Correctly identifying both ends of the range of $f(x)$ in (a) was executed by only a minority of students, although the majority were able to identify one end. Only a very small number attempted a sketch graph to identify the ends of the range, preferring rather to substitute in the starting end point of the domain to find one end of the range; this probably explains the low success rate. Incorrect answers implied they had not executed this on a graphical calculator either. The lower limit ‘3’ appeared more often than the higher ‘5’, while the inequality signs were not always correctly identified.

The first two marks of part (b) were clearly routine for most students as they set to swapping their x and y and making y the subject. Some students struggled with the algebra (a common error was forgetting to multiply all terms by $(3x + 2)$ during rearrangement) but the majority were successful here. Though many recognised that the range of $f(x)$ was the domain of the inverse function and therefore gained the Bft mark, many others attempted to find a domain from scratch and so acted as if the original domain was ϒ. Also, there were a few who mistook $f^{-1}(x)$ for $f'(x)$.

Most students were able to achieve the correct answer for part (c), a few scored only the method but very few scored neither mark, usually calculating the value of $g(-\pi)$ first and then input this value into the f function. Those who attempted to find the composite expression first were less successful. Common errors in failing to arrive at the correct answer were due to the use of π instead of $-\pi$ (scoring no marks), or by ignoring the modulus sign, leading to ‘6’, or evaluating with the calculator in degrees mode. The use of π is always an indicator that radians are in use.

Question 3

Part (a) was accessible to most students with many gaining full marks or 4/5. Most students realised they needed to apply the product rule to $f(x)$, and many did so successfully. The majority were able to apply the product rule correctly, although a small number incorrectly thought that the derivative was the product of the derivative of $(x - 2)^2$ and the derivative of e^{3x} and so were not then able to make further progress.

Where a correct product rule was applied most students factored or cancelled out the e^{3x} term. The most common approach was then to form a quadratic and attempt to solve this for x, rather than also factor out $(x - 2)$. Apart from a few students who made sign errors or arithmetic slips, most then went on to find a correct value for x. A few students did not answer the question fully and did not attempt to find a value for y, though more lost the final A mark as they gave a rounded decimal answer rather than the exact form.

Part (b) was more challenging for many. Although many were able to write down at least one correct boundary, a substantial number of students lost the A mark for an incorrect strict or loose inequality sign at one of the ends, while others were unable to identify both endpoints or had the direction of inequality incorrect.

Question 4

This question proved to be accessible in part (a), with most correctly able to undo the logarithm, but the performance in part (b) was more mixed. A quarter of the candidature were able to secure full marks, but 2 or 3 marks were also common scores.

In part (a), most students were able to re-arrange the logarithm correctly, although a few just moved the log across as $\log y = 2x + 1$ and so obtained an incorrect result. While the algebra on the paper was generally sound, here there were a number of students who went on to incorrectly simplify as $\frac{10^y - 1}{2}$. Some attempted to rearrange in terms of e^y rather than 10^y with mixed success.

In part (b), the second method mark for applying the reciprocal of derivative was the safest mark for students, with the differentiation itself causing the main issues. Many did know how to correctly differentiate to $10^y\ln 10$ and a common mistake was to differentiate 10^y to 10^{y-1} or to introduce a factor of $\ln y$ instead of $\ln 10$. As noted, most did score the 2nd M mark by taking the reciprocal of their dx/dy to find their dy/dx. Those who were able to do the differentiation usually went on to score full marks, though there were some who did not give a final answer in terms of x and so lost the final mark. Students could be reminded to check the rubric of the question and check that their final answer satisfies any demand for it.

Alternative approaches were allowed for part (b), with implicit differentiation being seen frequently, and usually done well. This may be expected as those using this approach will have studied Core 4. The change of base formula was not widely seen, but there were a number of students who knew how to differentiate the original function directly.

Question 5

There was access into all parts of this question across the candidature, but very few were able to achieve full marks in all parts. The method marks were relatively easy to obtain in all parts, but the accuracy marks more demanding. Indeed, the method in part (a) was the most accessed mark on the paper.

In part (a), the vast majority were able to score the method mark by substituting $t = 1$ and usually achieving a correct value for P. However, many lost the accuracy mark by either omitting the units '£' or not referring to a 'loss'. A small number lost the accuracy due to never actually achieving a value for P before stating the answer, showing only the substitution.

For part (b), again the vast majority attempted to calculate P(6) and P(7) with at least one correct, so scoring the method mark, but even fewer than in part (a) were able to score the accuracy. In a few cases it was due to an error in one of the values, but mostly the loss of the accuracy was due to the lack of a suitable conclusion, with the omission of reference to 'continuity' or 'continuous' being the most common error. This has been the case for the past few series, and it would be advisable for students to be taught to include a reference to continuity as a vital part of the process in this type of question.

Most knew what to do in part (c), though some students made no attempt. Again, the method proved very accessible, but errors in the steps rearranging to the given result caused many to lose accuracy once again. Some students struggled to deal with the change of the log term by changing the sign and using the log power laws while some did not deal with this at all and left their log term as $ln\left(\frac{t+1}{(2t+1)^2}\right)$, and some did not show sufficient steps to justify the accuracy. Students could be reminded that with a given answer, they need to show sufficient working to achieve the printed answer.

Part (d) of this question was generally well answered, with most students scoring full marks here. The routine procedure of calculating values would often be done even when much of the rest of the question was left out. A few did have errors with rounding their calculations, with the most common cause of loss of mark being 6.13 given as the answer for t_6. The answer 6.22 was accepted for the first accuracy mark, sparing the loss of two marks for those consistently rounding too short.

Understanding the context was the main issue in part (e), with a significant number of students misinterpreting the question and taking t to be measured in months. Many lost both marks through not multiplying by 12 at all and leaving their answer as 6.3 years or 6 years, 3 months, or rounding up to 7 "months" as their answer. Those who realised a conversion from years to months was needed were generally successful in carrying out the calculation.

Question 6

This proved to be quite a challenging question for many students and discriminated well. The modal score was full marks, achieved by about a quarter of students, but a score of 3 or 4 was more common. The first three marks were, generally well accessed but how to proceed after applying the quotient rule was a test for student. The B mark for correctly differentiating sin x + cos x, usually within the quotient rule, was scored by the majority and most also applied the quotient rule correctly and so were able to gain the first 3 marks. However, a small number did make errors applying the quotient rule, the most common error in applying being to subtract the numerator the wrong way round. Attempts at the product rule were uncommon, and also rare but not unseen was to multiply through by the denominator and apply implicit differentiation before rearranging to find $\frac{dy}{dx}$.

Even within a successful application of the quotient rule, a few made sign or coefficient errors when multiplying out the brackets, which generally meant they were unable to make further progress—losing the "3" in the cos$x$ term, for instance, meant the Pythagorean identity could not be applied in the numerator. Sign errors in the cos$x$ + sin$x$ derivative sometimes meant a cancelling of (cos$x$ + sin$x$) terms, which again meant no further progress could be made.

There were many students who did not know how to proceed after applying the quotient rule and some just gave up. A few attempted to divide by $\cos^2 x$, but were not able to make any progress. Stronger students realised they needed to apply $\cos^2 x + \sin^2 x = 1$ on both the numerator and/or denominator—those with an error in the numerator could still access the second method mark for work in the denominator. Others were able to expand the denominator and realise multiplication throughout by sec$x$ was needed to achieve the 2sin$x$ term in the denominator, but missed the need to apply the Pythagorean identity.

Those who managed to identify both of the above methods were required were usually able to go on and reach a correct form, and those who did so often attained the correct answer.

Question 7

This proved to be a more accessible question than its placement on the paper suggests, perhaps due to familiarity with the topic and similar style questions on recent papers, with similar performance to the first 3 questions. Aside from this the paper performance did show increasing difficulty as the paper progressed.

Part (a) was answered well by most students. For part (i) a few gave just x = 22/3 or (22/3, 0), but most were able to identify both coordinates correctly. For part (ii) a number of students just stated the value -17 without reference to it being a y value, and no indication of it as the y intercept on the graph and lost the mark because of this. The further detail of (0, -17) or y = -17 or similar was required to show this was the y value.

Again, most students were successful in part (b), most showing the equations before solving, though a few simply stated answers. These may have been read from a graphical calculator, but the marks were allowed as the only part that prohibited a calculator to be used was (d). A few did neglect to solve for the positive and negative options for the modulus and as a result scored no marks for this part of the question.

For part (c) most were able to draw and label a fully correct sketch, realising the graphs intersected at (9, 0). However, some students failed to draw the correct curve but instead drew a straight line, usually through (0, -9). Others drew a V-shape through the 3 correct key points, and a small number drew an inverted parabola. Other incorrect curves included reciprocal or cubic shapes. Tolerance was allowed with the symmetrical aspect of the shape where it was clear symmetry was intended but a slightly skewed curve was drawn with minimum on the y-axis — often this was due to ensuring the graph passed through the correct intersection on the positive x axis having started drawing from the left. A small number of students showed the curve and line intersecting at $x = 17/3$.

Part (d) was the most challenging part of this question, with some discriminating marks as an appreciation of the geometry was needed. Many did not realise that the solution (9, 0) could be stated from the graph in part (c) and proceeded to solve the quadratic equation leading to $x = 9$ and $x = -36$, but often recovered the (9, 0) solution from this. However, for many of these they did not solve the second equation and gave (9, 0) and (−36, their y value) as their answers. Such responses scored only the B mark. Others omitted the (9, 0) solution entirely but found both solutions from the other equation instead.

The first M was generous in allowing the mark for the setting up of the correct equation. This was the minimum that needed to be seen to allow that the solution was not by graphical calculator alone (such answers with no working at all could score at most the B mark). Once a suitable equation was set up, correct roots for the equation could then allow the next marks. Of the students who attempted to solve the correct equation leading to $x = 3$ and $x = 24$, some did not reject $x = 24$ while others failed to proceed to finding a y value, but the majority were successful in solving to find the solution (3, -8) only. But the giving of multiple extra solutions was a common error, losing the last two marks of the question.

Question 8

This question and question 9 provided a challenging end to the paper, and both had modal mark of 0. For this question 16% scored this modal mark, with a wide spread of marks across other scores. Part (a) proved largely accessible as it is a common and expected topic, but parts (b) through to (d) were much more mixed. There were a number of blank responses, possibly indicating this material was not covered by some centres.

In part (a), most students were able to correctly identify that $R = 17$ and set up a suitable equation in either tan α, or in sine or cosine using their R. This is a familiar topic in which students are well drilled and only a small number set up the equation for α incorrectly and 1.081 was achieved by the majority. There were some errors with rounding where students rounded to 3 significant figures instead of 4. Careful heed needs to be paid to the instruction of the question.

The remaining parts were much less successfully tackled. In part (b)(i), the most common error was to use either '41−2×17' or '41 −2×0' for the denominator, while some just state '−17' rather than considering the fractional f(x) as a whole. A small number of students attempted to use differentiation to find a minimum value but mostly without success.

In part (b)(ii), the most common error was to use $x - \alpha = \frac{3\pi}{2}$, following from the error in (i), while others gave $\frac{\pi}{2}$ as the answer. A general lack of understanding in how to minimise a fraction with variable denominator was shown.

Part (c) was moderately more successful due to the follow through mark, with most realising they needed $2 \times \left(their\,\frac{1}{5}\right) - 5$ and successfully calculating it, though many had given up at this stage and offered no answer. However, even with the follow through in part (d), most did not know how to locate the position of the maximum for the given transformation, with most offering a negative value. There were a few good solutions here, but certainly the latter parts of this question were discriminators of the paper.

Question 9

As the last question this was understandably the question that students found most challenging, and possibly attrition played a part with the modal score of zero scored by a quarter of students. These were not all blank responses, though. Most made some kind of attempt at part (a), but many did not progress to the more routine part (b). In this type of question, the result is given in the first part so the second part can be attempted, indeed some did just answer the more straightforward part (b), which when attempted was generally well done.

Proving the given trigonometric identity was a test for the best students. Although the first two method marks were accessible to most, spotting how to proceed was a discriminator. Recognising the need to use the Pythagorean identity and difference of two squares was not commonly seen and in general only one or two marks were commonly awarded in (a), if any. At the other end of the spectrum, the more able students produced some beautifully clear and concise proofs, showing as a factor to be cancelled.

Part (b), when attempted, led to much more success, and is where the majority of marks in this question were scored. Whilst those who made an attempt usually achieved at least the first 4 marks, losing the final A through only providing 2 solutions or incorrectly rounding was common. Answers in radians were rare, and lost the last two marks. A few lost marks due to errors in algebraic manipulation (most commonly through misplacing the 2 on the RHS resulting in the wrong quadratic equation) but overall, the algebraic manipulation was good.

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