Pearson Edexcel

Examiners' Report
Principal Examiner Feedback

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In Pure Mathematics P3 (WMA13) Paper 01

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Examiners Report

General

This paper proved to be a good test of candidates' ability on the WMA13 content and plenty of opportunity was provided for them to demonstrate what they had learnt. Marks were available to candidates of all abilities. The questions that proved to be the most challenging were 8 and 9.

Presentation was generally good and candidates often showed sufficient working to make their methods clear. In some cases candidates did not show sufficient working to justify their answers such as in question 8(c). A calculator warning was provided in this question as well as an instruction to show all stages of working. It is worth stressing here the importance of adhering to the calculator warnings given in the paper and it was clear that some candidates resorted to using a calculator in this part of the question.

Despite it being highlighted in every appropriate series, students often lost a mark in question 2(a) for not making a reference to the continuity of the function when showing that a root exists in a particular interval.

Question 1

This was a straightforward question on transformations which was generally done well by most candidates. Partial understanding of the transformations, however, led to some candidates failing to gain full credit, typically making an error of (–8, –3) or (–8, –6) in part (a). In part (b) a common error was to subtract 1 from the x coordinate to give (–5, –9) and in part (c) the most common error was to change the sign of both the x and y coordinates, to give (4, 3). Some candidates used poor notation, e.g. missing out the brackets, but marks were awarded if the intention was clear.

Question 2

A familiar and accessible question meant that this was answered well by the majority of candidates. It was common for well-prepared candidates to score at least five out of the six available marks. As is often the case with similar questions in previous series, candidates commonly lost a mark due to a failure to refer to continuity in part (a). Others knew to mention continuity, but misconceptions were apparent when candidates concluded with erroneous statements such as 'a change of sign, hence f(x) is continuous', or 'the interval is continuous' or ‘the sign changes continuously’. In a minority of cases, candidates stopped after evaluating f(2) and f(3) and made no consideration of the signs. This meant that they were unable to access the method mark in this part.

In part (b), most candidates used a direct approach and were often successful although some made sign errors when rearranging. This was often recovered in part (c) although surprisingly some candidates persevered with their own incorrect iteration formula. It was rare to see candidates attempting to work backwards and these approaches were generally less successful and incomplete, lacking a concluding statement. Candidates should take care to show all steps of their working in a ‘show that’ question. Some candidates showed too little working and did not show the key intermediate step of isolating the x^3 term prior to taking the cube root. Other candidates accidentally wrote square roots rather than cube roots or had notation that was sometimes ambiguous as to whether the root encompassed the entire fraction or just the numerator.

Part (c) was usually attempted successfully. It is always advisable for candidates to write out the iteration formula with values substituted in to avoid loss of the method mark if values are subsequently entered into a calculator incorrectly. Errors in substitution seemed to sometimes arise due to using a square root rather than a cube root. It was worrying however, to see candidates in some cases spending valuable exam time setting out the calculation for each iteration in part (c)(ii) when this work can, and should, be easily carried out on a calculator. A common error in part (c)(ii) was an error in rounding or premature rounding of intermediate steps which often led to a final answer of 2.1564. Perhaps surprisingly, a few candidates did not seem to understand what they were being asked to do in part (c)(ii) and performed only one or two extra iterations so halting the process too soon.

<u>Question 3</u>

This question was very accessible, with a large number of candidates gaining full marks.

Part (a) was answered accurately by most candidates. A significant majority successfully identified either $a = 10^{1.04}$ or $b = 10^{0.38}$ or, more commonly, both, which gained them the first two marks. A number of rounding errors were seen, both in terms of incorrect rounding or insufficient accuracy given to meet the requirements of the question, which meant candidates lost the final mark. Other candidates failed to earn the final mark because they did not go on to write down the equation once they had found the values.

Part (b) was completed very well, with the vast majority of candidates able to write down a correct equation and attempt to find a value for t, with very few rounding errors seen. Those who chose to solve $\log_{10} 45000 = 1.04 + 0.38T$ tended to make fewer errors than those who chose to solve $45000 = "10.96" \times "2.399"^t$. It was pleasing to see it being successfully attempted by several candidates who had been unable to achieve an answer to part (a) but had recognized that they could still continue with the question.

Candidates used a variety of approaches to answer part (c). It was common for both marks to be earned, with the candidates using $t = 12$ to find a value for D being the most successful. Some interpretation issues arose, with candidates declaring that the charity would not achieve its aim because the model did not show exactly £350,000 at the end of 12 months. Some did not recognise that exceeding this target also qualified as achieving it. Those who compared $1.04 + 0.38x12$ with $\log_{10} 350\ 000$ sometimes had trouble interpreting their findings.

Question 4

Candidates found some parts of this question more accessible than others, with the two most challenging marks being the final mark in part (b) and the final mark in part (c).

Many candidates answered part (a) well and it was pleasing to see that very few lost marks for failing to show sufficient working to achieve the given result. Those who used a common denominator of $(3x - 5)(x + 4)$ to combine the fractions tended to earn all 3 marks. Candidates who factorised $2x^2 - 32$ often gave a very concise solution, but these candidates sometimes lost the factor of 2, writing $(x - 4)(x + 4)$ as the numerator before cancelling the $(x + 4)$, however they still scored the first two marks for an acceptable strategy. A few candidates simply cross-multiplied their denominators immediately without looking to factorise or simplify first, and this made the task more challenging, although some were still successful. There were instances of seeing factorisation which had clearly come from using the calculator to find roots, so the bracket $\left(x - \frac{5}{3}\right)$ occurred without a factor of 3 to balance it. This caused problems when seeking the common denominator. There were some candidates who probably knew what needed to be done but still lost the final mark for not showing sufficient steps for a proof question, but this was reasonably rare and on the whole candidates produced sufficient working.

In part (b), most candidates used the quotient rule successfully to differentiate $\mathrm{f}(x)$, earning 2 marks for correct (unsimplified) differentiation. Some errors were made simplifying their $\mathrm{f}'(x)$, usually by failing to multiply both terms in the bracket by 2. Not all candidates appeared to be confident about what was expected of them to fully justify that $\mathrm{f}(x)$ was decreasing, so the final mark was only gained by a minority. Many either made no comment at all on the derivative found, or simply stated the expression was negative without justifying this claim by consideration of the squared denominator. Others did not proceed to a conclusion such as ‘hence the function is decreasing’ or similar. It also appeared that a number of candidates either did not see or did not understand the instruction ‘using calculus’ and so proceeded to demonstrate a decrease in f(x) between particular values of x.

In part (c), most candidates knew what was expected and were able to go on to score the first two marks, successfully rearranging the function and remembering to give the final inverse in terms of x. However, there were a number of errors in rearranging seen, including: rearranging to $y = 3 + \ln x$ instead of $y = 3 + 2\ln x$, incorrect order of rearrangement, leaving the inverse function in terms of y, or writing the inverse as $\mathrm{f}^{-1}(x) = \ldots$ It was pleasing to see a good proportion of candidates showing an awareness that they were required to write down a domain, but the fully correct domain of $x \geq 3$ was not often seen, with some candidates making statements about $g^{-1}(x)$ instead of x.

Candidates seemed to find part (d) more accessible and, irrespective of how they performed on the earlier parts, made good progress here. Most started with the equation $3 + 2\ln\left(\frac{2a}{3a-5}\right) = 5$ followed by fully correct work to reach an expression for a in terms of e. The most common early errors were to form $fg(a)$ instead of $gf(a)$, or to expand the $\ln\left(\frac{2a}{3a-5}\right)$ as a subtraction before taking its inverse. A number of candidates unfortunately omitted the coefficient of 2 with the $\ln x$, but were still able to score the method marks. If candidates made a good start, the final marks were most often lost due to: errors with the rearranging steps, failing to give the answer in the required form, or for writing $\sqrt{e^2}$ instead of e, although e^1 was accepted for this mark. A significant minority were evidently uncomfortable working in terms of e and resorted to decimals which cost them the second two marks at least.

Question 5

In general, this question was well answered with part (a) providing little difficulty. Again, (b) was achieved by most, and the answer was usually given as a decimal. Some gave the answer exactly in terms of $\ln\left(\frac{3}{4}\right)$. A few rounded the answer to 0.006, giving the answer to 3 decimal places rather than to 3 significant figures. Some of these had given a correct exact value before rounding, so were able to achieve full marks in (b). Unfortunately if the rounded value was used in part (c) they did not score the accuracy mark. An incorrect answer of 6.39 was occasionally seen in part (b) - perhaps a misread from the standard form given on the calculator.

In part (c) most candidates realised they had to differentiate and did this correctly to obtain $-BAe^{-Bt}$. Some lost the negative sign in the index, achieving $\ldots e^{BT}$, which lost them the method mark. A few differentiated incorrectly and reached the form $\ldots te^{-Bt}$, scoring no marks. Those who did not differentiate and found an average rate of change also scored no marks. There was a clear separation between those who understood that they needed to differentiate and those who thought that it was a simple case of substitution. A typical incorrect answer here was 17.89. However, those who carried out the differentiation did reasonably well, although some lost the accuracy mark from the use of incorrect values of B. Moreover, the question required an answer to four significant figures. Many showed poor understanding of what this meant, giving an answer of –0.050, which was a shame after having done everything else correctly. Some missed out the negative sign, and if they did not mention that the rate of change was decreasing they too lost the accuracy mark.

The reasons given in (d) were quite varied, fairly evenly split between the two approaches given in the mark scheme. Some clear explanations of why the temperature could not reach 5 degrees were seen by either explaining that the lower limit was 10 or by trying to solve the equation and explaining that the log of a negative number could not be found. Common incorrect answers were to give the minimum value as 8 or 18. Incorrect or ambiguous statements, such as ‘the maximum temperature is 10 or ‘logs can’t be negative’ were not given this mark.

Question 6

There was a limited number of fully correct solutions to this question. In part (a), the modal mark was 0. Little reference was made to the diagram and although the majority of candidates understood that they were looking for when $y = 0$, but incorrectly gave $\pi/2$ rather than $3\pi/2$ as the specific point required.

Part (b) was generally very well answered, with a significant number of candidates scoring all four marks here. The product rule was generally performed accurately. A reasonable majority of candidates scored the first two marks, though some at this point made errors in factorising, or simply lost the coefficient of the sin x term. Those who factored out $e^{3\sin x}$, or divided through by it, were generally successful in reaching the correct answer in an acceptable form. The most common form of the answer was $6\sin^2 x + 2\sin x - 6 = 0$ rather than $3\sin^2 x + \sin x - 3 = 0$. A small number of candidates lost the last mark for not understanding/using the fact that $e^{3\sin x} = 0$ has no solutions to reduce to the quadratic required.

In part (c), a great number of candidates were unable to round correctly, seemingly not understanding the difference between decimal places and significant figures. Very few candidates did not achieve a 3 term quadratic in sin x and the majority who did were able to solve their quadratic for sin x and proceed to a value for x. It was very common for the graph not to be used to identify the required turning point, with the incorrect value for x being chosen. A few interpreted the solution to their equation as being the value for x rather than for sin x, thereby losing both marks in this part. A few solutions using $\pi - 1.01055$ lost the final mark by rounding the answer to 2.13. A few candidates wasted time calculating a y-value.

Question 7

In part (a), the most successful attempts at finding $\frac{dy}{dx}$ arose from the correct application of the chain rule with an unexpanded denominator. Those who expanded the denominator, either correctly or with numerical errors ($9 \times 3 = 18$ was a surprisingly common error) were also often able to use the chain rule to differentiate correctly but usually failed to simplify their derivative fully and so lost the accuracy mark. Some candidates attempted to apply either the quotient rule or the product rule to obtain $\frac{dy}{dx}$ but were frequently unable to apply the technique correctly. Often incorrect attempts involved differentiating a constant to obtain another constant and so ultimately obtained an expression with linear terms on the numerator. This was a costly error as it usually meant marks in part (b) were not available. For other candidates, sign errors were not uncommon, and this also proved to be a critical problem in some cases as it led to equations with no real solutions in part (b), although when this occurred a ‘solution’ was often obtained nonetheless following a strategic manipulation of signs. A small minority of candidates attempted integration in part (a) rather than differentiation.

In general, for candidates who had achieved $\frac{\mathrm{d}y}{\mathrm{d}x}$ in an acceptable form, either simplified or unsimplified, part (b) proved to be quite accessible. The majority of candidates understood that they needed to set their derivative from part (a) equal to -12 and proceed to a solution for k. Some candidates solved the equation in a more long-winded way than necessary, multiplying out the squared bracket rather than rearranging to the form $(3x - k)^2 = A$ and then taking square roots. The more laboured approach was more prone to sign errors and arithmetical slips which prevented the correct values for k being obtained. An unsimplified derivative from part (b) certainly led to a quadratic with more unwieldy coefficients in part (b) but this was often handled with success.

In part (c) most candidates were clear about the method required to find the equation of the normal and were able to begin correctly by using their value of k to find the value of y at P. Some candidates had incorrect values of k from part (b) or chose the wrong value for k here but were nonetheless able to access method marks. Unfortunately, some candidates neglected to use $x = 1$ at P or incorrectly used the value of k either as the gradient of the normal or as the value of y at P. Others forgot to take the negative reciprocal of the gradient to find the normal gradient using ± 12 instead and some candidates did not realise the significance of the given gradient instead substituting for x = 1 and k in their $\frac{\mathrm{d}y}{\mathrm{d}x}$ to achieve a value for the gradient. Finally, there were occasional errors made in rearranging the equation of the normal to the required form and some did not have integer coefficients as requested.

Independently of work completed in earlier parts, many candidates were able to make good attempts at the integration in part (d) and were often able to obtain a correct form of the integral in terms of k, with most recognising that a natural log was required. For many candidates, $\ln(3x - k)$ or equivalent forms such as $\ln(27 - 9k)$ term were correctly obtained and the correct coefficient was also often successfully achieved. In some cases, though there was some confusion about the coefficient of the ln term due to errors in integrating by inspection. The vast majority of candidates recognised the need to substitute and subtract the limits of $x = 3$ and $x = 1$, to achieve a simplified expression of the required form. Some candidates used a substitution to complete the integration commonly with success but occasionally did not correctly transform the limits before substituting. Some candidates had difficulty simplifying the log terms and, in some cases, those who had incorrect values of k from earlier parts of the question stated ‘ln10’ here when it clearly did not follow from their work. Others made great efforts to obtain their answer in terms of ln10 by introducing other factors. On the whole, this question worked well to allow a good spread of marks and a number of access points for candidates to re-enter the question irrespective of errors in earlier parts.

Question 8

Part (a)(i) was well done in general. The correct answer of $\left(\frac{b}{2}, a\right)$ or $x = \frac{b}{2}, y = a$ was often seen. Both marks were occasionally lost for writing coordinates the wrong way round.

In part (a)(ii) most candidates gained the correct coordinate of $(0, a - b)$ or even just stated $y = a - b$. If errors were made it was typically in writing the y intercept coordinate as $(0, a + b)$.

In part (a)(iii) most candidates were able to gain some credit in this part of the question. Even without fully appreciating the effect of the modulus sign, working was often shown to the effect $0 = a - (2x - b) \Rightarrow 2x = a + b \Rightarrow x = \frac{a+b}{2}$. A typical incorrect answer was

$2x = a - b \Rightarrow x = \frac{a-b}{2}$. The majority of candidates proceeded to find the other correct answer that arose from $0 = a + (2x - b) \Rightarrow 2x = b - a \Rightarrow x = \frac{b-a}{2}$. As in other parts of the question it was acceptable to just state the values as $x = \frac{a+b}{2}$ and $x = \frac{b-a}{2}$ without the need to write them as a coordinate pair.

In part (b) most candidates were able to produce a correct symmetrical V shaped graph for $y = |x| - 1$ with its minimum at $(0, -1)$ and many labelled the intercepts of the graph, although it wasn't necessary. A small number of candidates gained some credit by drawing a V shaped graph with a minimum on the $x -$ axis at (1, 0) thus translating the graph of

$y = |x|$ by $(-1,\ 0)$ as opposed to the correct $(0, -1)$. Some candidates were considering drawing the line $y = x - 1$ and then reflecting this in the y–axis. If this was the case it was important to delete the part of the line of $y = x - 1$ for values where $x < 0$.

In part (c), the majority candidates gained 1 mark or 2 marks in this section with a small number of candidates scored full marks in solving $|x| - 1 = a - |2x - b|$ and substituting the correct x values of $x = -3$ and $x = 5$ in the correct combinations to produce 2 simultaneous equations in a and b which were $a - b = 8$ or $a + b = 14$. A common error was to make a sign error when substituting $x = -3$ in $(-x) - 1 = a + (2x - b)$. Similarly, when substituting $x = 5$ into $x - 1 = a - (2x - b)$ but making errors when expanding the brackets. This part of the question was sometimes approached by considering the y values for the stated x values in the equation $y = |x| - 1$ meaning when $x = -3 \Rightarrow y = 2$ and when $x = 5 \Rightarrow y = 4$ but again marks could only be scored once the values had been substituted into the correct combination of equations. There were many incorrect pairings of equations scoring no marks and also correct answers with no working which scored no marks.

Question 9

As the last question this was understandably the one that students expected to be the most challenging, however the majority of candidates made a good attempt, particularly in part (a). Proving the given trigonometric identity was straightforward for many. Even though students completed the proof correctly as required, many didn't notice they could simply use the identity $(\cos\theta - \sin\theta)(\cos\theta + \sin\theta) = \cos^2\theta - \sin^2\theta$ and then directly proceed to $\cos 2\theta$. Instead, they expanded the brackets on the RHS which led to more complicated manipulation to reach the required result. Some clear solutions were seen using a number of different first steps. Those who used an incorrect identity for $\sin 2\theta$ and replaced $3\sin\theta\cos\theta$ with $3\sin 2\theta$ lost marks.

In part (b) the lack of guidance as to what method to use to solve the equation led to various approaches. The majority of those who were successful used Way 1 on the mark scheme, writing the expression in the form $Rsin(2x - \alpha)$ or $Rcos(2x + \alpha)$ and correctly obtaining values for R and α, scoring the first two marks. At this point, many wrote down an incorrect equation, most commonly $5\sin(2x + 0.927) = 2$ or $5\cos(2x + 0.644) = 2$, losing the accuracy mark. The last method mark, dependent on both previous method marks, was for a valid attempt to solve their equation of the correct form by carrying out the correct order of operations to find x. Many lost the final accuracy mark by giving more than one value within the range. Many answers outside the given range of x were presented, which were ignored for the purposes of marking. Another popular choice for part (b) was to try to rewrite the expression, typically by use of the double angle formulae as in Way 3, although other ways were possible. Many who tried this approach gained only one mark as they struggled to obtain a suitable 3TQ as they did not divide by $\sin^2 x$ or $\cos^2 x$ to obtain a quadratic in a single trigonometric function. A number tried to use $\cos\theta = \sqrt{(1 - \sin^2\theta)}$ and then to rearrange and square both sides but such attempts often did not lead anywhere. Others who tried squaring terms as in Ways 2 and 4 frequently did so incorrectly and gained no marks at all. However, some went on to obtain the correct equation in $\tan 2x$ but then lost the final mark for giving more angles than were needed in the range, or for failing to divide by 2 to find x. Some candidates attempted to solve an equation with terms in $\sin 2x$ and $\sin x$ and made no progress. The small number of candidates who gained full marks in part (b) are to be commended for their perseverance as this was a challenging question.

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