Pearson Edexcel

Examiners' Report
Principal Examiner Feedback

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In Pure Mathematics P2 (WMA12) Paper 01

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General

This paper proved to be a demanding but fair paper on the WMA12 content, and it was pleasing to see that candidates scored on average more marks than on the equivalent paper in the 2210 series. Overall, marks were available to candidates of all abilities and the parts which proved to be most challenging were 4b, and 9c, whilst question 10 proved to be the most challenging overall.

Report on Individual Questions

Question 1

In general, most candidates found the start of this question accessible, but struggled to apply their knowledge when faced with part (b). Few candidates managed to score full marks on this question, however there were very few completely blank responses.

In part (a), most candidates correctly found that $h = 0.5$, which was usually seen within the trapezium rule rather than a separate calculation. The most common error was 0.4 for *h*, incorrectly attempting to divide the area into more strips. The trapezium rule was generally applied correctly, although as with previous questions of this type, the most common error was in bracketing. A few candidates closed the brackets after the initial addition of two terms, then adding the rest afterwards, thus gaining no credit. Very few failed to give their answer to the appropriate degree of accuracy.

In part (b) (i), a lot of candidates struggled to see the connection with their part (a) answer, failing to realise the need to subtract 4 from their answer in (a). A few candidates made errors in their substitution of 1 and -1 into their $2x$, with many of these candidates incorrectly achieving 0. Another common error was to fail to integrate the “2” and simply subtract 2 from their answer in (a). A few candidates attempted to restart the question, incorrectly applying the trapezium rule again to gain an answer. A lot of candidates simply left this part blank.

In part (b) (ii), generally candidates who failed to get an answer to part (i) failed to gain an answer here. There was no common misconception here; many candidates simply added or subtracted a number from their answer to (a). The few that did answer this part, often provided a correct statement as to why the answer must be the same, showing the transformation alongside the limits. Again, a lot of candidates left this part blank as well.

Question 2

Generally, candidates answered the calculus section of this question well, but many found deriving the given formula for the surface area of the cuboid in part (a) to be more challenging.

A significant number did not gain any marks for the “show that” element of the question in (a) as they did not write an expression for the surface area in an acceptable form (and some candidates offered no attempt). Most candidates wrote a correct expression for *h* in terms of 972 and *x*, but many did not use this expression appropriately. For those candidates who managed to achieve the first two marks, the vast majority also scored the final mark. The most common reason for not securing the final mark was the absence of "$S =$" at some point in their response.

Finding the first derivative in part (b) was usually done correctly and most candidates went on to find the value of x for which S is stationary in part (c). The majority of candidates used algebra to solve their equation and obtain their value of x, although a few used some calculator technology to assist them. Candidates either tended to get both marks or no marks for part (c), the former being by far the most common.

Finding the second derivative in part (d) was also done correctly by the vast majority of candidates. Sign errors tended to be the cause of this mark not being awarded as opposed to a lack of understanding of how to differentiate. Proceeding to show that the value of x obtained earlier gave the minimum value of S was done well by many candidates, but some neglected to observe that the value of their second derivative was greater than zero so they did not gain the second mark. A relatively small number of candidates instead set their second derivative equal to zero and solved for x.

Finding the minimum surface area of the brick in part (e) was again generally done well, but a few candidates used an incorrect value of x, obtained by setting their second derivative equal to zero. Some candidates offered no work for part (e).

Question 3

This question was examining both binomial expansion and arithmetic series and was attempted by nearly all candidates with the majority gaining 3 or 4 marks in part (a). Part (b), as expected, was found to be more challenging, with a significant number of candidates leaving this part blank or making a very limited non-credit worthy attempt.

Many candidates were able to demonstrate their knowledge of binomial expansion and scored full marks in this part. There was roughly an equal mix of vertical brackets and C notation used. Nearly all wrote their answer in one or two lines, and it was rare to see terms listed in a column. The majority of responses were written out clearly with binomial coefficients combined with the correct power of x, the correct power of 2 and with brackets in the correct places; these gained the first M mark. There were occasional responses where binomial terms were added instead of multiplied, or incorrect powers were combined, and these gained no marks.

The alternative method in the mark scheme of factorising out the 27 was not very common and those using this method typically only scored the first M mark, or no marks at all. This was mostly due to incorrect coefficients inside the bracket and commonly 2(….) rather than 27(….) was seen. The B mark in this question was awarded for the $128+56kx$ term, with most candidates gaining this mark. Rarely, candidates left the 128 as 27 and they did not achieve this mark. Nearly all candidates who attempted the alternative method did not gain this mark due to inaccurate binomial coefficient calculation.

The A marks were concerned with the third and fourth terms of the expansion. The first A mark was for a correct unsimplified coefficient with the binomial part calculated in at least one of the terms. The main errors here came from failing to square or cube the denominator or considering that $\frac{kx}{8}$ might be equivalent to $8kx$. These errors were more prevalent in the third term and this mark could be awarded if the fourth term was correct or vice versa. Incorrectly writing kx^2 and kx^3 also lost this A mark.

The second A mark was for both the third and fourth terms correct and simplified. The majority of candidates are now much more successful in writing kx in brackets so that the $(kx)^2$ and $(kx)^3$ terms are dealt with correctly as k^2x^2 and k^3x^3. Those who did not expand were unable to achieve the final A mark. This mark was also lost for not simplifying their fractions or for using a rounded decimal, usually $1.09k^3x^3$.

In part (b), candidates needed to start with coefficients of the form Ak, Bk^2 and Ck^3 from (a) in order to be able to achieve any marks in this part. The most common successful strategy was to find the common difference and equate them to form a cubic in *k*.

There were however many other correct alternative methods seen:

- Averaging the 1st and 3rd terms and setting equal to the 2nd
- Calculating the 3rd term using the arithmetic term formula
- Solving the pair of simultaneous equations
- Solving the pair of simultaneous equations
- A rarer approach used the summation formula, setting it equal to the sum of the first three terms.

Any correct strategy starting with coefficients in the correct form from (a) achieved the first M mark. Some candidates incorrectly used 128 as their first term and others failed to realise that they only needed to include the coefficients, ending up struggling with some very complicated equations involving *k*'s and *x*'s and making no progress. Some incorrectly used the sum of an arithmetic series formula or added their three identified terms and set equal to 0. A few candidates considered a geometric series instead of an arithmetic one. The final mark was for the correct answers. This final mark in some cases was not achieved as the wrong three term cubic had been solved, due to incorrect rearranging or because their terms from (a) were incorrect. It was, however, pleasing to see a large number of candidates realise from the given information that *k* had to be greater than 0 and therefore not include the $k = 0$ in their answer. Rarely candidates expressed their answer as $3.2 < k < 16$ or similar, and these lost the final mark.

Question 4

This question was well done by the majority of candidates, with most gaining at least 3 out of the 6 marks.

Part (i) was well attempted with the majority of candidates being able to demonstrate at least one law of logarithms successfully. Some candidates did not attempt this question part, although there were many candidates gaining full marks.

Most candidates opted to group the two log terms on one side of the equation before using log laws. The most common correct approach was to reach log $\log_3\left(\frac{5x+7}{4x}\right) = 2$ and then to remove the logs. Slightly fewer reached $\log_3\left(\frac{4x}{5x+7}\right) = -2$ before removing logs.

An alternative approach was to rewrite 2 as $\log_3 9$, then to use log laws to proceed to $\log_3(...) = \log_3(...)$ and then to remove logs to reach the linear equation.

Unfortunately, however, there was a lot of incorrect approaches using logarithms. A fairly common mistake was to rewrite $\log_3(5x+7)-\log_3 4x$ as $\frac{\log_3(5x+7)}{\log_3 4x}$. Some then crossed out $\log_3$ in the numerator and denominator as though simplifying a fraction. Another mistake, common for this type of question, was to expand the brackets within the log function, writing $\log_3(5x+7)$ as $\log_3 5x+\log_3 7$. Both errors resulted in no marks.

Some candidates made sign errors during the rearranging and a few candidates made errors when removing the logs. Those who gained no marks in this part showed a lack of understanding of the rules of logarithms and were unable to express 2 as $\log_3 9$ or to combine the two log terms correctly. Surprisingly, several candidates, having achieved $31x=7$, then wrote $x=\frac{31}{7}$, losing the final accuracy mark.

Part (ii) was found to be one of the most challenging parts on the paper and very few candidates achieved full marks. A significant minority of candidates made no attempt at all, although a significant number of candidates managed to score at least 1 mark out of 3. For those who were able to expand both summations, some were able to proceed further with the resulting log equation. Those who used a substitution, e.g. $x=\log_a y$, often made more progress, finding the equation reduced to $x^2=2x$ and found themselves on much more familiar ground. For those who did reach $\log_a y=2$, the majority also reached the final answer $y=a^2$, indicating a good general understanding of removing logs from an equation. Some candidates reached $y=a^2$ and a second possibility $\log_a y=0$, but among these candidates there was a fairly good recognition that any second solution arising had to be rejected.

Sigma notation was confusing for some candidates, and many could not write out the terms of either summation. Some candidates were able to write one side or both correctly and achieved one mark, but made no further progress, whilst a common misconception was to remove sigma signs, but then to be left with expressions involving r on both sides. The manipulation of the logs also proved challenging, particularly understanding the difference between $\log_a y^2$ and $(\log_a y)^2$. Therefore, many were not able to reach $\log_a y=2$. The $(\log_a y)^2$ term was particularly troublesome for many; rewriting $(\log_a y)^2$ as $2\log_a y$ was a very common mistake and for these candidates, the expressions on either side of the equation became the same and further progress was impossible. This question part certainly differentiated between candidates who knew the laws of logarithms well and were able to apply them in an unfamiliar looking equation, from those without this level of expertise.

Question 5

Generally, this question was answered very well, with many candidates scoring full marks. Of those who failed to achieve full credit, it was not uncommon for the error to be due to the careless use, or omission, of a negative sign.

In part (a), the majority of candidates used the factor theorem and were generally very successful. The most common error when using this method was the omission of $=0$ at some point in their proof. Of those who opted for a division method, most used long division, but many became increasingly confused by the complicated nature of the remainders at each stage. These attempts were frequently abandoned, or the given answer surprisingly appeared from incorrect working.

Part (b) was less well answered than part (a), mainly due to the algebraic nature of the root and/or the non-zero remainder. However, most candidates correctly used the remainder theorem to demonstrate the required result. Of those who successfully substituted the correct root, a minority failed to realise that the expression should be equated to 9. Common errors were due to poor use of brackets and/or negative signs. Attempts at long division were rarely successful.

In part (c), the majority of candidates were able to eliminate *q* to achieve the correct quadratic equation in *p*. Most subtracted one equation from the other and rearranged, eliminating *q* in one step, whilst some rearranged the first equation for *q* and then substituted $-51-9p$ into the second equation. Some candidates used their calculator to solve the quadratic equation, whilst others factorised. However, a significant minority of candidates failed to reject the negative value of *p*, and so calculated two possible values for *q*.

In part (d), most candidates used long division to find the required function, and these were generally very successful. The minority of candidates who failed to score any marks in this part were normally using a fractional value for *p* and became bogged down with the algebraic manipulation required. It was pleasing, however, to see a good number of candidates who were able to score the method mark using their value for *p*.

Question 6

A significant number of candidates were able to access the question and make progress with both parts. Overall, this question was a good differentiator of abilities between the candidates.

Part(a) was well done with the vast majority of candidates able to gain full mark from this question. In (a)(i), many candidates obtained the correct coordinates of the centre. A common error was stating the centre as (4, -2). Part (a)(ii) was also usually answered well with many candidates either giving $r=\sqrt{20}$ or $r=2\sqrt{5}$. A few candidates went on to calculate $2\sqrt{5}$ as a decimal despite the question asking for an exact answer. The most common error was giving the answer $r=20$.

Part(b) proved to be more challenging, but was still accessible to a large number of candidates. The majority of candidates had the right idea how to find *P*, but not all were able to find it without making errors. The two most common methods were either

- to solve simultaneously the equations of the tangent and the circle. There were often errors in expanding and simplifying, but those who reached a correct quadratic were generally able to find point *P*. The $(-2y-10)$ substitution for *x* was more successful than the $(-0.5x-5)$ for *y* which led to work involving fractions.
- to find the equation of the normal and then solve simultaneously with the tangent. These candidates generally gained full marks.

A minority of candidates used Implicit differentiation to get the coordinates of *P*.

There were a number of candidates who failed to see a strategy on how to attempt this question; they would often attempt an equation of a line parallel to the tangent, passing through the centre point.

In part (c), many candidates showed a good understanding of finding the equation of the normal and were able to get the full marks. Most candidates were able to find the correct gradient (2), but some went on to find the negative reciprocal and use this as their normal gradient.

It was quite common with the various approaches to find the equation of the normal whilst trying to find the coordinates of *P*. It was important in these cases that the candidate still stated the equation in part (c), even if it was found earlier to demonstrate they understood what they had found. In some cases, candidates, proceeded in (c) to find a different equation of a line (which was incorrect), when they had actually managed to find a correct equation of the normal earlier on.

Question 7
Most candidates scored well on this question although full marks were not that common.

Part (a) was more of a challenge than anticipated for what was a relatively straightforward “show that” question. Many candidates struggled with presenting sufficient detail in their solution to secure the mark. Most approached this part by writing the terms as $ar^4 = 12.8,\ ar^2 = 20$, finding the quotient and setting equal to r^2. They then correctly square rooted this expression to achieve the required statement of $r = 0.8$.

Part (b) was generally answered accurately by most all candidates. Some worked out the value of *a* in part (a) before then going on to achieve $r = 0.8$. If so, the candidate needed to use or state their working in (b) to score.

The majority of candidates could set up a correct equation or inequality in order to satisfy the requirements for the first mark in (c). A small number treated it as a single term or as an arithmetic progression. If the first mark here was achieved, many went on to be able to achieve the second mark, but candidates who went wrong here usually did so from poor manipulation of logarithms with 31.25×0.8^n often becoming 25^n. Incorrect use of inequality or equality signs was not penalised in this question so those that successfully attained the second mark did often go on to achieve at least one, if not two, of the other marks in this part. However, the requirement to use logarithms meant that many relying on their calculators went from an inequality or equality with 0.8^n as the subject to a value for *n* which was not sufficient for the marks here. Use of correct inequalities was extremely rare. The use of trial and improvement should also be discouraged as this is unlikely to score many, if any, marks.

Question 8
This question proved to be a good discriminator with an even spread of marks between the candidates.

In part (i), most candidates successfully achieved the first 2 marks. They were able to rearrange the equation to the form $\sin(3x+1) = \ldots$ and understood the use of the inverse function to obtain the angle, correctly adjusting to find at least one value of *x*. This was usually the value $"-0.17"$. The mark scheme was fair to candidates in allowing the use of $\pm\frac{2}{5}$ and ±0.1. However, very few candidates scored both accuracy marks and many were unable to achieve one accuracy mark as this required at least two correct angles. There was very little evidence of the use of CAST diagrams or graphs, which may explain the shortage of candidates scoring the final two A marks. Many candidates however attempted to generate subsequent answers beyond the principal answer by a process of adding/subtracting multiples of π. Only a small number of candidates attempted to work in degrees with almost all of these being unsuccessful as they did not identify the need to convert 0.1 into degrees for this approach to yield more than the first M mark.

In part (ii), candidates were much more successful in scoring all five marks than they had been in securing more than two marks in part (i). Most candidates identified the need to use the identity $\tan\theta = \frac{\sin\theta}{\cos\theta}$ but a number of candidates were less successful in multiplying across by $\cos\theta$ to gain an equation in $\sin\theta$ and $\cos\theta$ only although the mark scheme was allowed slips allowing for "at least one term". The second method mark was usually scored, although it was disappointing to see candidates use incorrect identities such as $\sin\theta = 1 - \cos\theta$. Some candidates went awry at this point due to poor notation; most notably a lack of understanding that $\cos^2\theta \neq \cos\theta^2$. There were a considerable number of sign errors during this process which led to the loss of the A mark for a correct quadratic. The next method mark could be awarded very fairly for those candidates who attained a 3TQ and were able to apply the inverse cosine function. Most successful candidates did gain the final A mark, giving both angles and no others, however, many only identified 70.5. Again, there was a noticeable lack of CAST diagrams or graphs for this part of the question.

Question 9

This was a challenging question for candidates with most solutions only achieving three out of the eight marks available.

Part (a) was answered correctly by the vast majority of candidates. There were rare cases where the coordinates were transposed or where the *y* coordinate was incorrect.

In part (b), where the candidates needed to find the *x* coordinates of the points of intersection of the line and the curve, the method of solution was understood by the vast majority of candidates. There were a minority of solutions where the line was ignored altogether, and an attempt made to find where the curve intersected the *x*-axis thus gaining no credit. Those who just stated the coordinates did not gain credit for this.

Part (c) required the candidates to demonstrate clearly correct strategies to find the required areas R_1 and R_2. R_1 was an area bounded by the curve *C*, the line *l* and the *y*-axis. Many attempted solutions simply integrated the equation of the curve and evaluated between the limits 0 and 1, thus completely ignoring the requirement to subtract the area under the line *l*. This gained no credit as it was not a correct strategy for R_1.

Although rare, there were some attempts that used a calculator to evaluate the integral which gained no credit as there was no method shown.

Attempts at finding the area R_2 were often difficult to follow with candidates finding various areas which were difficult to identify. There were many different approaches of varying complexity. The simplest was to subtract the area of R_1 from the area of suitable triangle and was the one seen most often. Another popular method was to find the area bounded by *C* and the line joining *D* and *F*, and then to subtract the area bounded by the curve and the line segment *EF*.

Candidates should be encouraged to explain clearly what they are trying to do rather than just providing many calculations. It was disappointing to see the final mark lost in otherwise fully correct solutions because of an inability to deal with the quotient of two fractions correctly.

Question 10

Despite the start of this proof question being provided to guide candidates, this proved to be the most challenging question on the paper. There were very few complete proofs, and many candidates did not attempt this question. It was extremely rare for candidates to score full marks and it was quite often the case that candidates did not score any marks on this question. The main issue for candidates was that they were required to consider two further cases but quite often just maintained their focus on the case given in the question which had already been completed. Candidates who considered two further cases, e.g. $3k+1$, $3k+2$ or $3k-1$ on the whole proceeded to multiply out accurately, express in a form to show that it was not a multiple of 3 and make the statement " not divisible by 3" before writing a concluding statement. Some lost the A marks by not writing "not divisible by 3" or not giving a concluding statement at the end (which had been demonstrated within the question). A number of candidates still tried to explore odd and even cases using $2n$ and $2n+1$, despite the scaffolding within the question splitting the set of numbers into three cases.

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