# Examiners' Report
# Principal Examiner Feedback

Summer 2019

Pearson Edexcel International A Level
In Core Mathematics C12 (WMA01/01)

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**General**

This paper proved to be a good test of candidates' ability on the WMA01 content and plenty of opportunity was provided for them to demonstrate what they had learnt. There was no evidence that candidates were pressed for time. Marks were available to candidates of all abilities and the questions that proved to be the most challenging were, 2, 11, 13 and 15.

**Question 1**

This question was attempted by the clear majority of the cohort. Almost all candidates were able to score some marks. Those that scored zero usually did so as a result of an attempt to apply arithmetic series to their work, but this was rare.

In part (a), those candidates who attempted to set up equations and arrive at $r^3 = \frac{8}{125}$ or $r^{-3} = \frac{125}{8}$ were generally far more successful in scoring both marks that those who attempted to verify that $r = \frac{2}{5}$ works. These candidates frequently failed to make a conclusion of any sort and as a result the accuracy mark was withheld. Candidates need to be clear that when an answer is given they must show adequate working and a conclusion if they attempt a verification strategy. A minority of candidates took a less direct approach and used one of the terms and $r = \frac{2}{5}$ to find *a*, and then used *a* and $r = \frac{2}{5}$. As a form of verification, this route similarly failed to score both marks as a simple conclusion was often omitted, although the first mark in (b) was scored at this stage.

In part (b), the most common score was full marks. Nearly all candidates were able to find *a* and candidates were usually able to score the second method mark quite quickly. This was most often for a correct application of the $S_\infty$ formula, but the third method mark was lost frequently because candidates had an incorrect $S_{10}$ formula (usually a power of 9 or for incorrect bracketing of $\left(1-\frac{2}{5}\right)^{10}$ or failed to find the difference between these two sums. The most common reasons for the final mark to be lost was a lack of accuracy in the value for *a*, with a surprising number of candidates rounding 1953.125 early on in their work, or for a bracketing error in the $S_{10}$ formula.

**Question 2**

As one of the earlier questions on the paper, this proved to be a significant challenge to many candidates. Overall, the inability of so many candidates to work correctly with indices was disappointing.

In part (a), failure to write $8^x$ as a power of 2 prevented many candidates from scoring marks. For those who did, the next common source of error was in subtracting indices with $3x-(x-1)$ often leading to $2x-1$. Nonetheless, many of the more able candidates did reach the correct answer.

In part (b), the majority of the candidates did respond to the 'Hence' in the question and proceeded to use their answer to part (a). As with the $8^x$ in part (a), so the $2\sqrt{2}$ also caused problems with a disappointing number of candidates failing to express this as $2^{\frac{3}{2}}$ and thus making no further meaningful progress.

Those candidates who used logs to find *x* generally made good progress provided they recognised the need to use addition/subtraction rules before dispensing with the logs.

**Question 3**

This question was generally well attempted with full marks being common. There were some issues with the labelling of graphs; candidates should be encouraged to be clear in their answers as to which part is which. In rare cases candidates drew their graphs on the original diagram, although many of these candidates did label their graphs clearly. The question stated that coordinates needed to be shown on the diagrams and almost all candidates adhered to this requirement. Those that did not write coordinates on the diagrams were not able to score the second mark in both parts. In both parts, graphs occasionally stopped at the axis, rather than crossing the axis and the first mark was withheld in these cases. Asymptotes were labelled in the vast majority of cases, but there were rare cases where the asymptotes were drawn but no equation for the line could be found anywhere in the response.

In part (a) the most common mistake was to draw $y = \mathrm{f}(-x)$. This almost always scored no marks. Occasionally candidates' graphs entered the first quadrant, losing the first mark. Coordinates were generally correct, although sometimes negative signs were omitted, and so the second mark was scored very frequently. The asymptote was generally correct, although sometimes candidates left the asymptote at $y=1$, or labelled the asymptote $y=1$, despite it being in the correct place.

It was rare for candidates to score no marks in part (b). The shape was generally correct, drawn in the correct three quadrants and the asymptote was usually in the correct place with the correct label. The second mark was lost most often. Here candidates made one of three main errors: stretching the graph in both directions, stretching the graph in the *y* direction only, or stretching the graph in the *x* direction but with scale factor $\frac{3}{2}$ rather than $\frac{2}{3}$.

## Question 4

This question was generally very well answered. The candidates who were successful in dealing with the fraction were those who split it into two separate terms and then simplified each one individually. A small number of candidates tried to use either the product or quotient rule or to differentiate it directly, but usually they were unsuccessful.

The main reason for dropping marks was not being able to deal correctly with simplifying the fraction before differentiating. Common approaches saw candidates split the fraction as $\frac{2x^4}{5\sqrt{x}} - \frac{8}{5\sqrt{x}}$ and then not simplify the first fraction any further; they would just attempt to differentiate the numerator and denominator. Another common error was to split the fraction into $2x^4 - \frac{8}{5\sqrt{x}}$.

Almost all candidates differentiated correctly to reach the first term, $10x$, but many slips were made with the coefficient in the second term with $\frac{1}{2x}$ being converted to $2x^{-1}$ instead of $\frac{1}{2}x^{-1}$.

## Question 5

This question was answered well by a high proportion of candidates with many scoring full marks. Where candidates made a slip on the way to reaching a quadratic equation in part (b) the way in which the scheme was set up still allowed such candidates to score three of the four marks in part (b). In part (a), almost all candidates scored both marks, with just a few leaving $u_3$ in terms of $u_2$.

In part (b), the vast majority formed a three-term quadratic equation, although a significant reached an incorrect quadratic as a result of poor algebra. Occasionally the expression attained was linear, again as a result of poor algebra. However, most candidates went on to deal correctly with their quadratic equations to achieve values for *k*.

## Question 6

There was a good response to part (a) of this question with the vast majority of candidates demonstrating secure knowledge when applying the binomial expansion, gaining full marks. The majority of candidates gained the first two marks, but a minority lost the last two due to bracketing errors or use of inappropriate values of *n* and *r* when calculating the binomial coefficient.

When substituting $\frac{x}{4}$ into the formula for the 3rd and 4th terms they sometimes failed to square or cube the denominator, resulting in the incorrect expansion $1 + 3x + \frac{33}{2}x^2 + 55x^3$. A small minority of candidates thought that the binomial coefficient should be added to the *x* term, and some, when calculating the binomial coefficients using the notation $n\mathrm{C}r$ or equivalent, thought that $n$ and r had to add to 12.

Part (b) proved to be a good discriminator between candidates. There were candidates who successfully expanded $\left(3+\frac{2}{x}\right)^2$ and proceeded to multiply the correct terms of their part (a) efficiently.  A few did lose the last mark for leaving in the '$x$' in their 'coefficient'. Some candidates wasted time, listing all 12 terms then simplifying to give a full expansion of all terms. A few obtained the correct terms in $x$ but failed to add their terms.

It was not unusual to see $\left(3+\frac{2}{x}\right)^2$ expanded to $9+12x+4x^2$, leading to no marks, but those candidates who gave $\left(3+\frac{2}{x}\right)^2 = 9+\frac{4}{x^2}$ were able to pick up the method mark by finding two appropriate terms in $x$. Many candidates had no idea how to start part (b) and some equated their 2nd term in the expansion $\left(3+\frac{2}{x}\right)^2$ with $3x$ from part (a).

**<u>Question 7</u>**

This question was done with varying degrees of success in both parts. It seemed that there was a wide variety of levels of understanding of the content in the question. Many candidates who gained full marks for part (b) did not even attempt the graph of part (a), however most candidates were able to gain some marks on this question (usually scored in (b)), with a score of zero from a minority.

Part (a) was answered in many different ways with varying degrees of success. Where mistakes were made, there seemed to be no common pattern of misunderstanding and many poor attempts were seen. This was most definitely the worst answered part of the question, with a fair number of the graphs either starting at the origin or extending no further than the intercept at $x=\frac{11\pi}{6}$. Some candidates mixed up the order of the coordinates on their graph but were still able to get full marks. The coordinates of the $x$ intercepts were often incorrect, while many of the poorer sketches bore no resemblance to a sine wave.

Part (b) was done better than part (a) with full marks being common. Even those candidates who were unable to attempt the graph in part (a) could go on and score full marks in part (b).  Almost all candidates found $h$ correctly but there were a significant number of candidates who had trouble with the brackets, adding additional terms, or using 'invisible brackets'.  A surprising number of perfectly constructed solutions had incorrect answers, indicating a calculator mistype.

## Question 8

This was generally a well answered question, with a significant number of candidates able to score near full or full marks. Only a small minority worked in degrees, but even if they did, they rarely lost the accuracy marks in (b) and (c).

Part (a) was generally done successfully. There were hardly any occasions when both marks were not awarded and there were even fewer responses that showed no understanding.

Part (b) was rather more varied. Most candidates managed to get the angle *AEB* correct and to understand the need to apply cosine rule (which they usually did correctly). Degrees were occasionally used at this stage. There were only a few cases where the sine rule was used but there were a few attempts at using 'SOHCAHTOA'. There were only a few occurrences of the third mark not being awarded and this was usually due to incorrect sides in the perimeter rather than additional sides being used. There were few occasions when the fourth mark was not awarded if the other three marks had been obtained, although premature approximation sometimes led to the answer 44.8 instead of 44.9.

Part (c), again, was often done well, even when part (b) had been answered poorly. There were a few occasions when the wrong sides or wrong angle were used to calculate the area of the triangle and a few candidates used '*bh*/2' but the area of the triangle was often calculated correctly. The same was true for the area of the sector. Since the second method mark was dependent, candidates who scored the first two marks almost always scored the final method mark, but again the final accuracy mark was sometimes lost due to premature approximation. It was pleasing to see that where formulae were used, they were often quoted first. A few candidates assumed that triangle *ABE* was isosceles, and others that angle *ABE* was a right angle.

## Question 9

In part (a) a disappointing proportion of even the more able candidates failed to score the single mark for this part of the question. The phrase 'Write down..' should have alerted those who proceeded with long multiplication that perhaps there was an easier way. With only one mark available, candidates who left their '32' embedded in an algebraic expression did not score the mark unless they went on to explicitly indicate their answer for the remainder.

Part (b) was completed well with most recognising that the needed to substitute -1 for *x*, expand brackets, equate to 15 and solve. The most common cause for losing a mark in this 'Show' question was the poor use of brackets. Occasional candidates lost a mark for failing to show sufficient working on the way to the given result of $k = 2$.

In part (c) a good proportion of candidates did recognise the need to multiply out brackets and simplify in order express f($x$) as a cubic. These candidates generally achieved the correct expression $3x^3+10x^2-8x$ but having done so many failed to recognise the factor of $x$. Beyond this stage, marks were also dropped by those who achieved the factors $3x-2$ and $x+4$ but then failed to write f($x$) as a product of three factors. Others lost marks as result of writing down solutions to $\mathrm{f}(x)=0$ rather than expressing f($x$) as a product of factors.

Less successful candidates mistakenly thought that either $x+1$ or $x-2$ was a factor of f($x$) and generally scored no marks in part (c).

**Question 10**

This question was accessible to the majority of candidates and generally well answered.
In part (a) most candidates achieved the correct value $p=-24$ by substituting $(1,16)$ into the given equation. There were a few who made arithmetic slips and gave $p=24$, but these candidates were able to get a follow through mark for the centre and the method mark for correctly attempting the radius. Those candidates who attempted to complete the square without first finding $p$ often made errors by failing to use $\frac{p}{2}$ correctly. Completing the square once $p$ was found was the most popular and successful method for finding the radius. Those that used $x^2+y^2+2gx+2fy+c=0$ made more mistakes. The most common error in finding the centre was to have wrong signs for the coordinates.

In part (b) the majority of candidates were able to substitute their changed gradient to find the equation of the tangent using their centre and the given point. A minority, however, proceeded to find the equation of the line through $(1,16)$ and their centre, scoring only one mark. These candidates may have benefited from drawing a diagram.
A few candidates used implicit differentiation to find the gradient of the tangent correctly. Those whose 'implicit differentiation' was faulty were able to pick up the method marks for finding the gradient at (1, 16) and substituting it into the equation of a line. It was disappointing to see candidates getting as far as, $4y-64=-3x+3$ only to write $4y+3x-61=0$, or leaving their coefficients in fraction form.

**Question 11**

In part (a), a good proportion of candidates knew what to do, setting the equations equal, rearranging to form a three-term quadratic equation and using the discriminant to arrive at the inequality for which the equation had no solutions. Most of these candidates scored all three marks.

Occasionally, the final mark was lost, usually for only inserting an inequality sign on their final line of working. candidates, as always, need to note that when a result is given, and the word 'show' appears in the question, then full working must be visible.

Those candidates who were less successful failed to understand that eliminating *y* from the two equations would produce the *x*-coordinates of the points where the two lines crossed and hence could be used to find a condition for when there were no solutions. Some went as far as equating the functions, but then stopped. A few did gain a mark for rearranging the equation with all the terms on one side, equal to zero, but then did not go on to use the discriminant.

In part (b), a very high proportion of candidates were successful on this part of the question, with very few numerical errors. When marks were lost it was sometimes for failing to choose the 'inside region', or for writing an impossible inequality such as $-7 > m > 9$.
More than a few candidates lost the final mark by using *x* rather *m* in their statement of range.

**Question 12**

This question proved to be accessible to most candidates with many scoring full marks or just losing one mark in part (a) as a result of poor use of brackets.

In part (a), a very high proportion of candidates understood the need to multiply appropriately on both sides of the equation and to use the identity $\sin^2 x = 1 - \cos^2 x$. Arithmetic errors were rare, and many candidates achieved the correct quadratic expression in $\cos x$.
Careless use of brackets, or omission of such, occasionally resulted in an incorrect quadratic, or in the accuracy mark being lost in this 'show' question.
A fairly common error was to replace the $3 + \sin^2 x$ with $3 - 3\cos^2 x$.

In part (b), of those candidates who reached the correct result in part (a), most went on to score all of the marks in this part. Occasional candidates lost the final mark as a result of giving answers in degrees rather than radians.
Almost all candidates seemed to have heeded the warning in the question that:
*'solutions based entirely on graphical or numerical methods are not acceptable'*

**Question 13**

This question proved to be a good discriminator as scores varied significantly. Many fully correct responses were seen, but as is common in questions on logarithms, a significant proportion of candidates scored poorly due to a lack of understanding of the topic. There were, as usual, plenty of candidates who had a good grasp of logarithms and some particularly clear and concise responses were seen.

In part (a) candidates generally scored the first method mark for use of the addition law. It was quite remarkable how frequently $\log 900 = \log 9 + \log 10$ was seen in some form. Those who backed this claim up with some evidence of understanding of the addition law of logarithm [e.g. $\log 900 = \log(9 \times 10) = \log 9 + \log 10$ were able to score the method mark. For this reason $p + q$ was a common incorrect answer and in some cases was just given without any working, where candidates may have misread the 900 as 90. candidates were less successful in applying the power law and so the second mark was less often scored than the first, with many candidates incorrectly writing $\log(10^2) = q^2$. Part (a) was, however, well answered by the majority and many candidates scored all three marks.

Part (b) was less well attempted, with the main issue arising from an inability to link 3 with $9^{0.5}$. The subtraction law was, however, used to some good effect in a significant proportion of responses, usually seen as $\log 0.3 = \log 3 - \log 10$. Some candidates used the approach in the mark scheme to get $0.5\log 9$ whilst others used $p = \log 9$ to get $p = 2\log 3$ and $\frac{p}{2} = \log 3$ and then used this instead, which allowed them to score the B mark at least. Some candidates even used log $\left(\frac{9}{100}\right)^{0.5}$ and then generally went on to score full marks because they correctly used $0.5(\log 9 - \log 10 - \log 10)$, which correctly gave $\frac{p}{2} - q$.

**Question 14**

This question as a whole was generally done either very well or very badly.

Most candidates in part (a) managed to get some marks (even if was just for obtaining the two required equations correctly) but full marks were not common. The candidates who attempted to find *d* first were generally more successful than those who found *a* first. Many promising solutions that later correctly proved that $a = 16 - 8k$, earlier left *d* in terms of *k* and *a*, unaware of the requirement that their answers should solely be in terms of *k*.

The most successful attempts solved the simultaneous equations using elimination. Substitution was successful when the candidates worked with integer coefficients, but many struggled when substituting fractional expressions for *a* or *d*. There were few restarts when a correct expression for *a* was not obtained.

Part (b) was generally well answered with most candidates able to get at least one mark. It was very rare not to award the M mark here, and even when the candidate did not obtain the correct value for $k$, they often went on to obtain a further two marks in part (c).

Part (c) was done very well by the majority of candidates, but a significant minority did not attempt the question at all. If a candidate obtained full marks in part (b) they usually managed to get full marks in part (c). Mistakes tended to be numerical, though occasionally an incorrect sum formula was seen. Those candidates who failed to find a value for $a$ (or $d$) scored no marks.

## Question 15

As with question 14, this question was equally effective in identifying those candidates who could analyse the task in hand and set out their working in a tidy and logical form. Again, the work of less able candidates tended to be characterised by muddled thinking and poor presentation.

Part (a) was often very poorly answered with many candidates not realising that the radius of the semi-circle was $\frac{x}{2}$ and losing marks for using $x$, or even $r$, instead of $\frac{x}{2}$ in the area and perimeter formulae. This error also meant they were unable to reach the given equation. The expression stated for the perimeter of the garden sometimes often included the term $2x$. Marks were often lost due to poor manipulation when substituting for $y$ in terms of $x$.
This was a "show that" question, and some candidates lost marks for failing to include working steps in proceeding to the given answer.

In part (b), a good proportion of candidates found $\frac{\mathrm{d}P}{\mathrm{d}x}$ correctly and proceeded to set $\frac{\mathrm{d}P}{\mathrm{d}x}$ equal to zero on the way to finding $x$. Unfortunately, significant numbers then failed to take note that the question required an exact value for $x$, so that many good candidates scored only two marks out of three. Of those who attempted an exact expression for x, such good progress was sometimes spoiled by a failure to simplify that expression to an acceptable form. A small number of candidates mistakenly set the second derivative equal to zero.

In part (c), a high proportion of candidates found $\frac{\mathrm{d}^2P}{\mathrm{d}x^2}$ and either evaluated for their value of $x$ or made reference to the sign of $x$ and thus of $\frac{\mathrm{d}^2P}{\mathrm{d}x^2}$ so that they gained a mark for method. However, the accuracy mark was often lost for either failure to refer to the second derivative being greater than zero, or for evaluating $\frac{\mathrm{d}^2P}{\mathrm{d}x^2}$ incorrectly, or for failing to actually state a conclusion.

Candidates who had completed parts (b) and (c) generally did well on part (d). A few, however mistakenly substituted their value from (c), namely the value of $\frac{\mathrm{d}^2P}{\mathrm{d}x^2}$, rather than their $x$ value from (b).

## Question 16

This question elicited some excellent attempts at a challenging problem. It differentiated well between candidates, with almost all able to attempt something, and full marks gained by a minority. The best candidates often annotated the diagram with coordinates, split the area into the parts required and gave a complete method for substituting in their limits. Candidates should be reminded that use of a calculator alone to integrate between limits will usually not secure full marks.

Part (a) was well done, with most candidates solving the three-term quadratic equation by factorising. candidates should ensure that when a question asks for coordinates the answer is given as in coordinate form; a few candidates here wrote the coordinates the wrong way round and some did not write their solutions as coordinates. Algebraic or arithmetic errors were rare.

In part (b), almost all candidates scored the three marks for integrating the curve and finding the $x$ coordinate of $D$, although many just integrated with no clear idea as to how to use the result. Consequently, the wrong limits were frequently used, and the last four marks lost. Many candidates did find an area above the curve correctly but unable to identify the correct way forward. It was not uncommon to see the area of $R$ found by adding ‘63/8’ to the area of triangle $OAB$.
Only a minority of candidates were able to proceed to a correct area of $R$ by either
66 - (area of triangle $OAB$ + $\int (2x^2 - 11x + 12)\,\mathrm{d}x$ with limits of 5.5 and 4 or 3/2 and 0)
or area of triangle $OAB$ + $\int \left[12 - (2x^2 - 11x + 12)\right]\mathrm{d}x$ with limits of 5.5 and 4.
There were some candidates who found the whole area of $R$ purely by integration. They first found the equation of the line through $A$ and $C$ and then proceeded correctly by an alternative method to find $R$.

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