Examiners' Report
Principal Examiner Feedback

Summer 2019

Pearson Edexcel International A Level
In Core Mathematics C34 (WMA02/01)

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Summer 2019
Publications Code WMA02_01_1906_ER

C34 JUNE 2019 Examiners Report

General

This paper proved to be a good test of candidates' ability on the WMA02 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. Examiners reported that they saw some very good work but also that some of the algebraic processing was weak and there were some careless errors in places, particularly when copying work from one line to the next. Marks were available to candidates of all abilities and the questions that proved to be the most challenging were, Q6(c), Q7 (d), Q9, Q11, Q12, Q13 and Q14.

Question 1

It was rare to see an error in part (a). The vast majority of candidates efficiently rearranged the equation in a couple of steps. A small minority forgot to divide by 2, leading to a = 20 and b = 1. A small minority left the 3 off the root.
Part (b) was also completed correctly by the vast majority of the candidates with answers being written to 3 dp. A few proceeded with further iterations. As the first mark was for substituting 2.1, those who did not show any working but made a calculator error lost both marks and a few square rooted instead of cube rooting.

In part (c) a few candidates lost a mark by carelessly omitting a zero from their calculated values, and while most used 2.077 +/- 0.0005 a narrower interval was occasionally seen. A few candidates chose inappropriate intervals which were much too wide and were unable to demonstrate that the root was accurate to 3 decimal places. The vast majority gave at least a minimal conclusion, scoring both marks however, some candidates lost a mark for either not referring to the sign change or giving a conclusion. Part (d) discriminated well. Answers here were often incorrect, commonly 2.077 or 4.077 and sometimes this part was left blank. Despite the question saying "hence state a root" and it being for only one mark, quite a few candidates spent time attempting to solve the equation from scratch.

Question 2

A good number of candidates were able to earn full marks for this question, though many lost the final mark. A small but significant number of candidates scored zero as they were unable to integrate the term in $\frac{1}{x}$.
In part (a) the vast majority split the expression into two terms and integrated their term in $\frac{1}{x}$ correctly to achieve a term in ln x. A few attempted to integrate (4x+3) and 1/x as a product of integrals. It was rare to see attempts at integration by parts.
In part (b) those candidates who attempted to separate the variables usually had no difficulty in integrating $y^{-0.5}$ and realised that they could use their result from part (a). The constant of integration was sometimes omitted, preventing further progress.
There were few errors with arithmetic or signs whilst substituting the given values for x and y, until the final stage where candidates were required to make y the subject of their equation. Too often, there were errors in dividing by 2 and occasionally the square root rather than the square of both sides was taken. Those who did not use the separation of variables approach were unsuccessful.

Question 3

In part (a), while some candidates were able to state the value of k correctly, there were many cases when this mark was not scored. Some candidates omitted this part of the question; others incorrectly stated $k = \sqrt{3}$, taken from the initial expression given for x. Some candidates gave answers in terms of π, suggesting a lack of understanding of limits when working with parametric equations.
(b) Generally this part of the question was answered well with candidates making use of the identity $\sec^2 x = 1 + \tan^2 x$ and often scoring full marks. There were a few cases where candidates were unable to successfully evaluate $\left(\frac{x}{\sqrt{3}}\right)^2$, and as a result they ended up with $\frac{x^2}{9}$ and consequently lost the answer mark. Some candidates quoted the identity incorrectly (usually with a sign error) and were unable to score any marks for this part of the question. A few candidates worked with sin$x$ and cos$x$, from a right-angled triangle and, although there were occasional slips in the use of Pythagoras, these candidates generally obtained the correct answer in the correct form.
(c) Generally candidates who scored M1A1 in part (b) were often able to score full marks here. Occasionally candidates substituted $\frac{\pi}{6}$ for x rather than using $\theta = \frac{\pi}{6}$ to determine $x = 1$ and then substituting this into their $\frac{\mathrm{d}y}{\mathrm{d}x}$. Many candidates who attempted to differentiate the parametric equations and then use $\frac{\mathrm{d}y}{\mathrm{d}\theta} \div \frac{\mathrm{d}x}{\mathrm{d}\theta}$ also scored well. Mistakes were more common using this method however, in particular, when differentiating the expression for y.

Question 4

In part (a), the product rule was nearly always attempted on $3ye^{-2x}$, although mistakes in differentiating the exponential term e.g. losing the negative sign were seen. Sometimes the 3 was factorised at the beginning, but then only one term was multiplied out. It was extremely rare to see the dy/dx missing here.
The term in y^2 was nearly always differentiated correctly. Unfortunately, some candidates correctly differentiated all the terms in variables but left the constant "2" in their differentiated form. When rearranging, $\frac{\mathrm{d}y}{\mathrm{d}x}$ was nearly always factorised correctly, although mistakes were sometimes seen in copying work from one line to the next, unnecessarily losing accuracy marks.

In part (b), many candidates who had achieved an incorrect expression for $\frac{\mathrm{d}y}{\mathrm{d}x}$ were able to score the first 2 marks for finding a value of the gradient of the curve, and then using the negative reciprocal to find the gradient of the normal. Some candidates had not read the question properly and used the tangent gradient instead of the normal; others used just the reciprocal of the tangent gradient. It was pleasing to see the number of candidates who gave the equation in the necessary form.

Question 5

There were many fully correct solutions to this question.
Part (a) was easily accessible and it was very rare to not see the correct answer.
In part (b) there were many very good solutions in which all the steps in logarithmic manipulation were seen to get the final given answer. Others were more economical but gave enough steps to be convincing. A few lost the final mark by moving from $-16k = \ln\frac{1}{4}$ to

$k = \frac{1}{8}\ln 2$ without an intermediate step. Some got as far as $k = -\frac{1}{16}\ln\frac{1}{4}$ then did not proceed any further.
Part (c) was answered well with very few errors seen and any errors usually stemmed from an incorrect answer in part (a) or by a slip such as substituting t = 4 instead of t = 40.
The explanation required in part (d) proved problematic for some candidates although there were a variety of responses that were considered acceptable. Many realised that 20 was the limit of the temperature, though a few said that 20 was the maximum instead of the minimum. Others tried to calculate the value of t for a temperature of 19 and reached ln of a negative number, which they then stated was not possible. Another common response was as t tends to infinity, the temperature tends to 20. Some stated that the exponential function is greater than zero, so 20 is the minimum temperature, though there were those who concluded that the temperature would be greater than or equal to 19. Some erroneously thought that the initial temperature of the bath was 20 degrees.

Question 6

The majority of candidates found this question accessible.
In part (a), the vast majority scored both marks. There were some who lost marks for not explicitly stating the values of the ordinates and occasionally the a or the negative sign on
– 5a/2 was missing.
Part (b) was well done by most candidates, though the most common error was to sketch $y = |x - a|$.
The intersections were, on the whole correctly labelled though there were a few who did not label the intersection with the negative x axis. There were some very poor responses such as a V shape sitting sideways with the vertex on the negative y axis.
Part (c) proved more challenging although there were a substantial number who correctly solved $4x + 10a = -x - a$ and $-4x - 10a = -x - a$ and gained 3 marks.
Candidates seemed comfortable considering $4x + 10a$ and $-4x - 10a$ for the lhs of the equations to be solved, but were not as confident with $|x - a|$.
Of particular note was the lack of appeal to "hence" in the question, indicating that they should refer to the graphs. There was some lack of consideration that the intersections with $|x| - a$ were on the branch with a negative gradient.
A good number however managed to get 2 out of the 3 marks by getting one correct solution or by finding all four solutions and not identifying the two correct solutions.
There were some attempts at squaring but these did not reach the correct solutions.

Question 7

The majority of candidates knew the processes required to solve this question but many failed to achieve full marks.
Part (a) was usually well done with candidates finding R by using $\sin^2 A + \cos^2 A = 1$ or simply stating $R = \sqrt{5^2 + 3^2}$, and then finding α by using $\tan A = \frac{sinA}{cosA}$ and inverse tan. Only a few had their fraction

upside down, working out arctan of 5/3 rather than 3/5. The appropriate degree of accuracy was usually given, although a significant number of candidates gave an approximate decimal answer for R despite the question demanding an exact value. It was pleasing to see most candidates confidently working in radians with many achieving full marks for this part.

In part (b) the majority of candidates coped well with the unusually complex form of the angle, and the correct value of the cosine was often seen. Many then went on to find a correct value for t. A few candidates did not appreciate that parts (a) an (b) were connected and went through the process again. Many worked with the exact value of $-\frac{7\sqrt{34}}{85}$ and were able to reach the correct values for t, demonstrating accurate algebraic skills. A few failed to give a sufficient degree of accuracy once they had found the value of t and additionally were confused as to the units of their answer. After achieving $t = 3.05$ a significant number of candidates gave the answer "3 minutes" rather than finding 3.05 hours to the nearest minute. Many candidates failed to find the second possible value of t.
A popular approach for some candidates was to find the acute angle, which was approximately 1.07, and then to use π - 1.07 and π + 1.07 to find t.
Sign errors were common. Occasionally α was changed into degrees in part (b) and little further progress was made.
Although the question had asked for "the times at which" the height of the water would be 4.6m, full marks were available to those candidates who found the time elapsed. The final mark was lost by those who were unable to accurately convert their value for t into a time.

Question 8

Some parts of this question proved quite challenging for candidates with very few scoring full marks throughout.

In part (a), most candidates recognised the need to apply the quotient rule to differentiate the function, however there was some incorrect multiplication of negatives. A minority chose to use product rule rather than quotient rule which made it more difficult for them to combine their expression into a single fraction.

In (b), candidates who got part (a) correct, invariably picked up the marks here and there were a lot of candidates who picked up recovery marks in this question by using a correct method.

There was mixed success in part (c) with some candidates deciding to double their x coordinate rather than halving it. As with part (b) many candidates were able to recover marks in this part of the question despite incorrect previous answers. A small number of candidates applied the transformation to both their maximum and minimum points without drawing a distinction between them.

In part (d), many candidates recognised the need to substitute $x = 0$ into the function to get 0.4, however in their range many chose to put $g(x) > 0.4$ or in other cases not do anything with it. Fewer managed to deduce that the minimum value of the range would be -0.6, with most not gaining the final mark.

Question 9

In part (a), it was pleasing to see a majority of candidates who confidently expanded $\sin(2x + x)$ using the formula for $\sin(A + B)$ and then went on to produce an error free solution, substituting $\cos 2x = 1 - 2\sin^2 x$ and $\cos^2 x = 1 - \sin^2 x$, accurately to produce

$\sin(3x) = 3\sin x - 4\sin^3 x$. There were variations where $\cos 2x = \cos^2 x - \sin^2 x$ was substituted first but these candidates often went on to complete a slightly longer correct solution. A few candidates made errors by omitting the 2 when substituting for $\cos 2x$ and others who just made arithmetical errors which led to an incorrect answer.
It was rare to see no attempt made at all, however a few only scored the first M1 by expanding the sin (3x) as sin (2x + x) correctly and made no further progress. Generally there were fewer notational errors than in previous years and candidates helped themselves in most cases by writing clearly enough to avoid mis – copies from line to line.
Part (b) was much more demanding for most candidates with a wider variety of both correct and incorrect solutions.
The question explicitly used the word "hence" and so the few candidates who chose to use a factor formula to move forward gained no marks. Of the candidates who appreciated that the strategy was to use the answer to part (a), the commonest solution seen was to substitute the expression from (a) and then write the product of $\sin x$ and $\cos x$ in terms of $\sin 2x$ and integrate to a term in $\cos 2x$ and the $\sin^3 x \cos x$ term being directly integrated to a term in $\sin^4 x$. Some taking this approach only gained the two method marks due to numerical errors.
There were some who did not realise that they had expressions in a form easy to integrate, and wasted time using trig identities to change into different forms. Of these, some eventually integrated successfully or reached an incorrect expression.
A popular variant which swiftly led to the solution was to use a substitution such as
$u = \sin x$. Of those choosing this route all either successfully changed the limits to the new variable or changed back to the original variable. Integration by parts was attempted by some which is a viable approach but no complete solutions using this method were seen.

Question 10

This question was well done by the majority of candidates. Solutions to part (a) were generally correct. Most candidates tried to take out a factor, although the factor was occasionally 2, 8 or 1/2 rather than 2^{-3}. The majority used the binomial expansion formula correctly, with the 3/2 in the x^2 term usually squared correctly.
In both parts of (b) candidates were expected to identify the coefficient of
x^2 rather than the complete term. Very few realised that there was a 'shortcut' for (b)(i), with most starting again, usually correctly achieving the correct result. Sometimes the 'shortcut' used was to multiply the x^2 coefficient by 2 instead of 4. For (b)(ii), however, most did realise that their answer from (a) could be used. There were many correct answers here, though numerical slips were not uncommon. A few candidates made it difficult for themselves by attempting somehow to expand $(4 - x)$ by the binomial theorem.

Question 11

In part (a) Many candidates were able to score full marks although arithmetic slips sometimes resulted in an incorrect answer for one or more values of A, B and C. Some candidates incorrectly rearranged the given equation when removing the denominators.

Part (b) was often well attempted with many candidates scoring full marks. Most candidates made the link between (a) and (b) and attempted to integrate their expressions from part (a). Log functions were generally found correctly, with occasional sign errors. Some candidates struggled to integrate $-\frac{3}{t^2}$ correctly, sometimes this term was differentiated and there were also candidates that attempted to make incorrect use of logs when integrating this term. The majority of candidates scored the mark for substituting the limits and subtracting. Although manipulation of logs was usually well attempted, the triple dependent method mark (dddM), often meant that credit could not be gained from this work where previous method marks had not been scored, in particular, for those candidates that had struggled to integrate $-\frac{3}{t^2}$.

In part (c), candidates who used the formula for the volume of revolution with parametric equations, generally scored at least 2 marks here for a differentiated expression for *x* and a correct substitution into the formula. Some candidates showed no evidence of changing the limits, thus losing the last mark. A fairly common incorrect approach was for candidates attempt to find a Cartesian equation and then use the volume of revolution formula. This scored no marks as candidates were unable to integrate the resulting expression.

<u>Question 12</u>

This question was well answered with the majority of candidates getting 10 out of the 13 available marks. The correct answer in part (a) was easily achieved, with just a few adding the vectors instead of subtracting, or including **i**, **j**, and **k** within a column vector which lost the accuracy mark.
In part (b) the correct method for the vector equation was invariably used, though there were some who wrote **r** = (2**i** – 3**j** – 2**k**) + γ(3**i** + 2**j** + 5**k**) using a position vector instead of a direction vector for **AB**. There were a substantial number who lost the accuracy mark for writing l = or just stating the equation without including "**r** = " despite this being highlighted in previous reports.
A large majority of candidates achieved full marks in part (c). There were occasional sign slips calculating AC. Those who calculated CA rather than AC getting an answer of 117.2 were able to recover if they then realised that they needed the acute angle and stated 180 – 117.2 = 62.8. However there were some who, getting -28 as their dot product, wrote 62.8 as their answer without justification, so lost the accuracy mark. Some candidates showed lack of understanding by using position vectors for A and B in their dot product.
Part (d) was easily accessible and the majority achieved full marks. There were a few who omitted the ½ in the formula or used cos instead of sin. As in part (b), some lack of understanding was shown by those who used position vectors for A and B and calculating ½ ab sin 62.8
Although there were a fair number of correct responses to part (d), this proved a challenge to most candidates and a significant number did not attempt it. Those who drew a sketch however were able to see the simplicity of the solution by evaluating
(2**i** – 3**j** – 2**k**) +/- 2(**i** + 5**j** + 7**k**).
There were many approaches to the solution involving a lot of working but in order to gain the method mark, a scale factor of 2 or close to 2 had to be achieved and used to find a position vector for the point D. Often the scale factor achieved in decimal form was correctly used to find OD, but did not gain the accuracy marks as it was not rounded to 2. A substantial number equated the area of triangle CAD to 54.4 but in most cases, were unsuccessful.

<u>Question 13</u>

Most candidates were able tackle this question but there was a good spread of marks, as some elements proved good discriminators.
The majority of candidates tackled part (a) successfully. The few candidates who did not score all 3 marks mainly used $h = 0.2$ (using the number of points rather than strips to calculate h). Occasionally candidates had problems with the structure of the brackets or omitted brackets.

In part (b), most candidates were able to form a reasonable structure to the proof. Some similarity in the way many candidates wrote *u* and *x* did not help marking and indeed caused issues for the candidate on occasion. Those who used limits with the integral sign throughout sometimes failed to ensure they matched with the d*x* or d*u*. Some candidates worked backwards from the *u* integral to the *x* integral, often showing correct working but without the required conclusion. With the result being given on the question paper, a fully convincing argument was required, with no missing steps.
Part (c) proved a good discriminator, but good candidates often achieved full marks. It would help candidates if they quoted the integration by parts formula and showed their preliminary integration and differentiation. The differentiation of $\ln(2u)$ was the first major discriminator here with $1/2u$ being a common incorrect expression. When it came to substituting limits it was not uncommon for a component term to be omitted. The log work was done well by the majority who reached this stage but was another useful discriminatory element.

<u>Question 14</u>

This was an unusual question which was badly done by many candidates.
In part (a) most candidates worked out at least one of the intersections correctly. A common mistake was to think that $e^0 = 0$. Some candidates found both intersections but then subtracted incorrectly and therefore lost the A mark. The A mark was also lost by those who resorted to decimals. Some responses unnecessarily used Pythagoras's Theorem, not seeming to appreciate that the points were both on the *y* axis.

For part (b) the first M mark was almost always achieved, but from then onwards progress was often poor, with candidates dealing incorrectly with the exponential terms, typically taking logs of the individual added terms. Those who managed to take out a factor of e^x often went on to gain full marks. Some lost the final A mark as they did not simplify the $e^{\ln(..)}$ term when substituting in to find y. The alternative methods noted on the mark scheme were rarely seen.

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