AQA
Questions matter

A-level

Mathematics

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Report on the Examination

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General

In comparison to the previous exam series, the average score on this paper showed an improvement of approximately 10%. Students appeared to find the whole paper accessible with fewer gaps seen throughout. Students performed very well on the multiple-choice questions, although none of the options were left unchosen. There were still some students who left one or more of the multiple-choice questions unanswered.

Many students made a strong start to the paper, answering the routine questions with high levels of success.

'Explain' and 'show that' questions continued to provide challenge to the students. Often when students explained something their answer made sense, but it was not always precise enough to gain any credit. In 'show that' questions students did not always show sufficient detail or missed out important steps which meant that full credit could not be achieved. It is important to finish a proof question with a concluding statement.

Strong responses were seen on all questions and there was no evidence that students had insufficient time.

Question 1 (Multiple Choice)

This question was the most successful of the multiple-choice questions with approximately 90% of students choosing the correct answer. The most common incorrect answer was 7.

Question 2 (Multiple Choice)

Just over 80% of students chose the right answer for this question. The most commonly selected incorrect answer was $f^{-1}(x) = \ln(x) - 1$

Question 3 (Multiple Choice)

This was another very successfully answered multiple-choice question with approximately 80% of students choosing the correct answer. The most common incorrect answer was 3.

Question 4 (Multiple Choice)

Just over 70% of students chose the correct graph for question 4. The most commonly chosen incorrect graph was the first option in the top left-hand corner.

Question 5

Over 80% of students scored at least two marks on this question. The most common mistake was to forget the -1 when square rooting, which meant $270°$ was not included as a solution. Some students used the identity $\sin^2 x = 1 - \cos^2 x$ and solved $\cos x = 0$ which often led to a completely correct solution.

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Question 6

This question was well answered by many students with over 80% making some progress. Some students were able to just write down the correct answer. Those who made substitutions to apply the chain rule often made mistakes. The most common error was to forget to bracket correctly. Answers such as $21x^2 + 35\left(x^3 + 5x\right)^6$ were often seen and did not score full marks.

Question 7

This question was a routine test of rationalising the denominator. Approximately 90% of students made some progress with this question, multiplying the numerator and the denominator by $1 - \sqrt{2n}$ or $\sqrt{2n} - 1$. Students who lost marks often did not show enough detail in their solutions or skipped important steps. For example, simplifying $-3\sqrt{2n} + \sqrt{8n}$ to $-\sqrt{2n}$ without showing that $\sqrt{8n} = 2\sqrt{2n}$ was too much of a leap in a 'show that' question where the answer was given. The final mark in this question was often lost through poor use of notation with $\sqrt{2n}$ written as $\sqrt{2}n$. Solutions where students attempted to work backwards often scored no marks as attempts to factorise were usually incorrect.

Question 8

Almost 70% of students scored full marks on part (a). A number of students attempted to use the binomial expansion formula for rational powers. This often led to a mistake where the 2 was extracted as a factor but then not raised to the power of 5. As this question asked for terms in ascending powers of x, students who left their terms unsimplified did not score full marks.

In part (b), the most common error seen was to set up the equation with the 4 on the wrong side, writing $4 \times 80k = 80k^2$ instead of $80k = 4 \times 80k^2$.

Question 9

More than 60% of students scored full marks in part (a). The most common error came from the small angle approximation for $\cos\theta$, where students simplified $1 - \frac{(4\theta)^2}{2}$ incorrectly.

The request in part (b) was to use the answer found in part (a), so we needed to see evidence of students substituting 0.07 into their answer from part (a). A very common error saw students restarting and substituting 0.28, 0.21 and 0.14 directly into the small angle approximations rather than realising they needed to substitute 0.07 into their answer from part (a). Substitution of 0.7 was frequently seen, which scored no marks.

Question 10

Students who used the formula $S_n = \frac{n}{2}\left(a + l\right)$ usually scored full marks in part (a). Over 80% of students scored full marks and those who lost marks often overcomplicated the question using the formula $S_n = \frac{n}{2}\left(2a + \left(n-1\right)d\right)$ and substituted an inexact value for d.

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Students found part (b) to be more challenging with only around 60% scoring full marks. Many different correct approaches were seen. The most successful students usually started by letting the first term equal a and the last term was then $6a$. This efficiently led to the equation $1260 = \frac{9}{2}(a + 6a)$, which was usually solved successfully. Students who started by forming two simultaneous equations involving the first term and the common difference often made mistakes when solving their equations. Some students lost the final mark by forgetting to include units with their answer.

Question 11

In part (a), approximately 90% of students scored at least one mark for drawing a cubic curve. Students who lost the second mark often drew their graph so that it did not pass through the origin or two positive points on the x-axis. Other mistakes included ending the curve prematurely so that it looked like the graph stopped on the x-axis. Less than half of students scored all three marks and this was often due to poor curve sketching, with curves looking too straight, too vertical or curving in the wrong direction.

Just over 50% of students made progress with part (b). Some students scored the first mark by substituting $-2x$ into the equation from part (a) or by describing a reflection in the y-axis and a stretch of scale factor $\frac{1}{2}$ in the x-direction. The second mark was often lost through poor quality sketching.

Question 12

Students were very successful in part (a) with over 90% of students scoring full marks.

Just over 60% of students knew what the word period meant, in part (b). Of the remaining students the most common mistake seen was 5 or -5.

Less than half of students scored full marks in part (c). Many students realised they had to deal with two separate sequences of twos and threes or alternatively grouped pairs of terms together to give a sequence of ones. Common mistakes included miscalculating the number of terms required and some students thought that they needed to use the sum to n terms of a geometric sequence. A commonly seen incorrect answer was 5050, presumably coming from the sum of the first 100 positive integers.

Question 13

Part (a) was a routine test of the factor theorem, but only around 50% of students scored full marks. A very high proportion of students were able to score the first mark by correctly substituting $-\frac{1}{2}$ into the polynomial and obtaining 0. Students often lost the second mark for poor conclusions or incomplete arguments. Some students disregarded the instruction to use the factor theorem and used long division instead, for which they gained no credit.

Students were very successful in part (b) with over 80% scoring full marks. Students who lost the second mark often forgot to write their answer in the required form after finding the quadratic factor.

Part (c) proved to be very challenging. While many students realised that the polynomial had two factors very few successfully went on to explain that neither of the factors could be equal to 1 or the original expression.

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Question 14

Students continue to find the change of sign method a challenge, with only around 30% of students scoring full marks in part (a). In order to score any credit in this question, the given equation needed to be rearranged so that it was equal to 0. Students who managed to rearrange successfully were usually able to substitute suitable values and complete the sign change argument.

Students had greater success in part (b) with around 80% of students scoring full marks. Laws of logarithms and rules of indices were applied successfully in the majority of cases.

Students clearly understood how to use the iterative formula given in part (c)(i), with more than 80% scoring both marks. The most common errors seen were early rounding, leading to incorrect values for x_3 and x_4. Although the question asked for three decimal places, students must use the full answer on their calculator when applying the iteration.

Approximately half of students scored full marks on the cobweb diagram in part (c)(ii). Common errors included not starting with x_1 at the value of 4, which was labelled on the x-axis. Some students forgot to label x_2, x_3 and x_4 on the x-axis and others drew their horizontal and vertical lines in the wrong order.

Approximately 65% of students were able to explain why the iterative formula cannot be used with a starting value of 0. It was hoped that students would be able to explain that the natural log of 0 is undefined and so x_2 cannot be calculated. It was clear that some students had typed this on their calculator and got a 'maths error', but just stating 'maths error' was insufficient as an explanation as it does not demonstrate understanding. A significant number of students confused this with reasons why the Newton-Raphson method fails to converge.

Question 15

Over 80% of students were able to make some progress with part (a) with just over 60% scoring full marks. Most students were able to make a correct substitution for $\sin 2\theta$ and $\cos 2\theta$. Those who used the identity $\cos 2\theta = 2\cos^2\theta - 1$ were generally more successful. There were many disorganised solutions to this part of the question. Students would benefit from practising the presentation of their arguments so that each line follows from the previous one with the correct use of equals signs.

Students found part (b)(i) to be quite challenging, with just over 20% scoring the mark. It was hoped that students would be able to identify that $\cos\theta$ cannot equal 1 because that would mean that $\sin\theta$ would equal 0, which would make the identity used invalid. It was common to see students stating that $\cos\theta \neq 0$ from part (a) meant that $\cos\theta$ cannot be 1. Another common error was to state that $\cos\theta$ could not be negative and so $\cos\theta = -0.25$ was rejected.

Students who rejected $\cos\theta = 1$ in part (b)(i) usually went on to quote the correct two values for θ in part (b)(ii). However, a common mistake was to include $360°$.

Question 16

Almost 90% of students made some progress with this trapezium-rule question, with the most common score being three out of five. The vast majority of students scored the method mark for substituting the y-values correctly into the trapezium rule and many completed this to obtain a correct area. Very few

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students were thrown by the use of negative y-values. Marks were commonly lost through using an incorrect value for h. Some students failed to realise that it was necessary to double the area found while others used an incorrect mixture of units when converting from area to volume. Most students who calculated a correct value remembered to include the correct units with their final answer.

Question 17

Over 60% of students scored one mark for correctly identifying values greater than or equal to 1 in part (a). However, correct use of set notation proved much more of a challenge with less than 40% scoring full marks.

As set notation was not required for part (b) full marks were achieved by approximately 60% of students. The most common mistake was not writing the domain in terms of x.

Students found part (c)(i) much more accessible with almost 80% successfully finding the composite function. The most common mistake here was incorrect use of brackets.

In contrast part (c)(ii) was very demanding with less than 10% of students scoring full marks. Around a quarter of students were able to state that the function did not have an inverse because it was not a one-to-one function. This was enough to score the first mark. Very few students were able to justify why the function was many-to-one, although some very efficient demonstrations were seen eg $\mathrm{h}(-1) = \ln 2$ and $\mathrm{h}(1) = \ln 2$ therefore h is many-to-one.

Question 18

Students were very successful in part (a) with over half of them scoring full marks and approximately three-quarters of students scored at least three marks. Students who lost marks usually did so through poor manipulation when simplifying the integrand to the required form.

Some students attempted to use integration by parts to answer this question which rarely led to any creditable work.

Students were not so successful in part (b) with less than half scoring 4 marks. Students should remember that in a 'show that' question, where they have been given the answer, it is essential that all steps are shown. In this case, it is especially important to demonstrate explicitly the substitution of the limits.

Part (c) proved to be very challenging with only around 35% of students scoring full marks. Far more students demonstrated a good understanding of how increasing the number of rectangles leads to a more accurate answer. However, many responses were not precise enough to gain full credit. Often students would explain that the answer would become more accurate without saying whether the answer would get bigger or smaller or making a comparison with A.

Question 19

There was clear improvement in students' notation when using implicit differentiation: far fewer students than in previous series were seen to start their working out with $\frac{\mathrm{d}y}{\mathrm{d}x} =$. This led to fewer

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algebraic errors. Over 80% of students made some progress with this question, with just under 40% scoring full marks.

Some common errors included incorrectly differentiating the constant term, and mistakes when applying the product rule often leading to an incorrect power of y. Some students attempted to differentiate with respect to y, but these responses were usually not creditworthy.

Question 20

As expected, many students found this differential equation question very challenging, although on each part of the question over half of students were able to make some progress.

In part (a), a pleasing number of students began by setting up a differential equation of the form $\frac{\mathrm{d}h}{\mathrm{d}t} = \pm k(h - 5)$ to achieve the first mark. Unfortunately, this was often followed by a substitution of 1.5 rather than –1.5 for $\frac{\mathrm{d}h}{\mathrm{d}t}$, which led to an incorrect value for k.
Some students tried different combinations of the numbers available in the question until they produced 0.012 — this was not creditworthy.

In part (b) over half of students scored at least 3 marks, with strong attempts at separation of the variables. Common mistakes were not including or finding the value of the arbitrary constant, and incorrect manipulation of the equation when removing natural logs to make h the subject.

Students who did not score full marks in part (b) were still able to make progress in part (c) as the first mark was available for substituting $h = 65$ into their answer and obtaining a value for t.

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Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.

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