A-level
MATHEMATICS
Paper 2
Report on the Examination

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General

The paper discriminated well between students of varying abilities. While the cohort was reasonably small, students were fairly evenly spread across nearly the whole range of available marks. Students found the multiple-choice questions very accessible and many made good progress on some of the less structured, new style questions. Students seemed to find most questions on this paper accessible, but many struggled when it came to interpretation of results or criticising models. There was no evidence that students were short of time with the majority making a complete attempt at all questions.

One of the topics which caused greatest difficulty to students was variable acceleration, in question 15, which is new to the A-level maths specification.

There was evidence of allowed calculator technology being used well by some students, but most missed opportunities to reduce the amount of routine manipulation required. This was most evident in questions 3, 8bi, 9, 15, and 16. Students (and teachers) should be confident that if a calculation can be done or an equation solved using allowed calculator functions then they will not be penalised for doing so, provided they are answering the question they have been asked. In cases where an exact value or a proof is required, calculators may be less useful but still provide a valuable check.

Some students had clearly understood the implications of the instruction “Fully justify your answer”, and there were very good examples of reasoning being explained and justifications for calculations used. Students who ignored this instruction often gave partial solutions and while they could score method and accuracy marks, they lost marks for explanation or reasoning.

Question 1

This was an easy question, which was answered correctly by a very high proportion of students. The most frequent incorrect selection was $x^2 = 4 \Leftrightarrow x = 2$.

Question 2

This was a routine question, which was answered correctly by a high proportion of students. The most frequent incorrect selection was evenly split between 42 and 21, but 4 was not far behind. This may suggest that students who did not know the answer guessed rather than being an indication of a particular misconception.

Question 3

This question was answered correctly by a high proportion of students. Scripts showed evidence of algebraic integration from many students, whereas it had been expected that they would simply evaluate using allowed calculator functions. By far the most frequently chosen wrong answer was 60 and it is likely that these students evaluated one integral rather than splitting the area into two sections.

Question 4

Part (a) was well attempted and most students gained some credit. Too many students lost marks for poorly drawn curves, which had the wrong curvature, lacked symmetry or were excessively wobbly.

The most frequent mark for part (b) was 2/4. The question discriminated well between students of varying abilities. While most students correctly used the discriminant > 0 for two real roots, many overlooked the fact that the roots were both positive, so only found half of the solution. Few students achieved full marks as insufficient justification/explanation was seen.

Question 5

Most students realised that proof by exhaustion was required and the majority achieved the first mark for starting to check for factors. The second mark could only be achieved through a rigorous proof and a variety of approaches ranging from very efficient to very inefficient were seen. Some students checked every integer between 1 and 23 with the consequence that missing out one number lost a mark. Others explained they only needed to check prime numbers and a few realised they only needed to check the two prime numbers less than $\sqrt{23}$ and, provided this was explained, full credit was given.

Question 6

This question saw most students making some progress, with a full range of marks being awarded. A high proportion of students realised that implicit differentiation should be used, but very few differentiated efficiently. Instead, the approach seen most frequently was to first expand the brackets and then differentiate. This resulted in more work to find the required solution. The most frequent mark seen for this question was 7/7. Students who made mistakes at the beginning were still rewarded for using correct techniques.

Question 7

This question discriminated well between students of varying abilities. The majority of students understood that they had to integrate and chose the appropriate technique, often applying integration by parts successfully. A significant number of students made no attempt to go any further and completely ignored the constant of integration. These students generally achieved three marks.

Students who realised they had to determine the constant of integration often made good progress and scored 7 or 8 marks. Those who dropped marks at this point generally showed insufficient detail to fully justify their answer. Several very thorough, complete solutions were seen.

Question 8

Many students made good progress with this question and chose an appropriate technique to be able to determine the transformations. Most identified $R\sin(x-\alpha)$ as the best approach, although some students chose $R\sin(x+\alpha)$ and a few individuals started with $R\sin(x\pm\alpha)$, which often resulted in sign errors.

Having decided on an approach, most students handled well the routine of finding R and α although some used some inefficient methods and did not seem sufficiently well practiced in what is a very standard technique.

In order to fully justify their answer a clear comparison of the given equation and their $R\sin\left(x\pm\alpha\right)+4$ needed to be made and in a few cases students' reasoning was not clear. Most students achieved some credit for correctly describing transformations relating to their $R\sin\left(x\pm\alpha\right)+4$. All was not lost if mistakes were made early in the solution.

Part (b)(i) hinged on students realising that the denominator had to be maximised and so their $\sin\left(x\pm\alpha\right)$ had to equal 1. Students who had gone wrong in part (a) could still achieve some credit in part (b)(i). Many students gave several lines of working to rationalise the denominator of their fraction. This was unnecessary given allowed calculator technology.

The mark for part (b)(ii) was available to students who had gone wrong in part (a). Provided they used their R correctly, work was followed through.

Question 9

Part (a) was done well by the majority of students. Most knew how to set up the initial differential equation and those who did generally scored full marks. There were a few numerical slips seen and some students did not complete the argument to *show* the required result.

A high proportion of students made good progress on part (b) with over half of students scoring 2 or 3 marks. Having correctly integrated, many students gave no consideration to the constant of integration and, although it was zero, its value needed to be found to correctly show the given result.

Part (c)(i) was well attempted and saw the full range of marks awarded. Over half of the students scored at least 4 marks with 6/6 being the most frequent score awarded. Many students realised that simultaneous equations had to be solved and usually eliminated a variable to form a correct equation. Students often made algebraic slips when solving their equation and a more efficient use of allowed calculator functions would have helped here.

In part (c)(ii) many students made some good criticisms of the equations they had found, but did not link these to the model used by the trader, which was the rate of sales is proportional to $\dfrac{8-t}{x}$.

Question 10 (multiple choice)

This question was well answered with approximately two thirds of the students selecting the correct response. The most frequently chosen incorrect response was $0.71\,\mathrm{m\,s^{-2}}$.

Question 11 (multiple choice)

Almost every student selected the correct response to this question. There was no significant pattern in the incorrect responses.

Question 12

Surprisingly, only just over half of students got part (a) correct. The most frequent errors seen were numerical slips, writing –4 when the question asked for magnitude and picking the wrong section of the graph. Most seemed to know they had to find a gradient.

Just under half of students scored full marks on part (b). Of the students who knew they had to compare areas above and below the time axis, several used correct but elaborate methods often setting up equations involving time. The most successful students simply counted squares often showing any working on the diagram. Common errors included working with gradients instead of areas or counting incorrect sections of the graph as positive areas when they should have been negative.

Question 13

Nearly all students made good progress with part (a), with over half scoring full marks. Nearly all students successfully found the maximum possible friction and made a comparison with the applied horizontal force. The most frequently seen error was when students wrote a statement that was incorrect, often along the lines of "friction is greater than 150N so there is equilibrium". This showed a misunderstanding of the friction model and could not be overlooked.

Part (b) was also well answered, but a lack of detail often meant that students had not fully justified their answer. Several impressive and detailed answers were seen, where students explained clearly that the horizontal component of the applied force was greater than the maximum friction so that the crate would not remain stationary.

Resolving of forces was generally successful.

Question 14

Question (a) was completed successfully by most students. The most common error was a sign mistake.

Well over half of the students scored at least two marks on part (b) The best students realised they had to do very little to answer this question and, provided they explained their arguments rigorously, they achieved full marks. Most students completed more calculations than necessary (there was no need to find the lengths of all sides), but failed to complete their arguments in sufficient detail. For example, they may have explained why the shape was a parallelogram, but not explained why it was not a rhombus.

Question 15

In part (a) there was a significant proportion of students who scored zero marks and, in many cases, this was because they incorrectly used constant acceleration equations. Most students who realised the problem involved variable acceleration and integration completed the question successfully. For these students the most frequent error was a failure to consider the constant of integration, which generally only cost them one mark.

In part (b), it was surprising to see several students who had used constant acceleration equations in part (a) correctly deciding to integrate in part (b). Students who went on to make a correct comparison with their answer from part (a) could be awarded full marks. Consequently, part (b) had a higher proportion of solutions awarded full marks.

Part (c) was poorly answered. Many students gave unacceptable, non-specific reasons about one minibus taking longer to “get going” or “start-up” than the other. Instead, students had to explain that the times for each bus were so close together that driver reaction time could have a significant effect on the outcome of the test.

Question 16

Part (a) was successfully attempted by well over half of the students. However, the value of g to be used in this question was 9.81 and a significant number of students gave their answer to the wrong degree of accuracy, usually costing them one mark. This is the only place in the paper where this was penalised.

There were many inefficient methods seen for this question. There seemed an over reliance on set routines rather than choosing the best equation to suit the known information. For instance, several students doubled the time and set the vertical displacement to zero. This works and the method received full credit if done correctly, but these students often showed a lack of intuition or insight.

In part (b) most students made some progress, but there were several error prone, inefficient methods seen. A significant number of students unnecessarily split the motion of the projectile into two stages.

In this question, correct answers only received full credit if they included the correct units, which was not always the case.

Question 17

A high proportion of students had great difficulty in forming an appropriate equation of motion for part (a)(i). Those who attempted to treat the system as a whole made mistakes such as using the wrong total mass, including incorrect tension forces, using weight instead of mass or forgetting to include the resistance on the buggy. Some students considered the skater and buggy separately and similar errors were seen, however a fairly common error was to subtract the mass of the skater from the mass of the buggy in the equation of motion of the buggy.

Those students who wrote down a correct equation of motion usually completed the question successfully. Approximately half of the students scored full marks on part (a)(i).

In part (a)(ii) students were still able to make progress even if they had gone wrong in (a)(i). Provided their equation of motion was correct using their R they were given credit. Over half of students scored at least 2 marks.

Part (b) was a request for assumptions in a very standard model. A significant number of students gave assumptions that did not need to be made, as they were given in the question. For example, it was unnecessary to assume the road was flat as the question stated “horizontal road”. Students should also avoid words like “flat” or “straight” when they mean “horizontal”. A correct assumption would be that the rope was horizontal.

In part (c)(i), students who had gone wrong in earlier parts of the question were still able to make good progress and they were credited for using correct techniques. Correctly using their incorrect

R from part (a)(ii) often resulted in 4/5 marks. Common errors were caused by students over complicating the problem, often attempting, unnecessarily, to find the time taken for either the buggy or skater to stop.

Over half of students made some progress on (c)(ii), but the general standard of explanation was poor. A significant number of students showed a misunderstanding of the forces model, or may have been trying to over-explain. Statements like “the rope has been dropped so the buggy no longer feels the resistance from the skater” are not accurate. It is more concise and accurate to simply say “there is no tension acting on the buggy”.

Mark Ranges and Award of Grades

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