Pearson Edexcel

Examiners' Report
Principal Examiner Feedback

Summer 2023

Pearson Edexcel GCSE (9 – 1)
In Mathematics (1MA1)
Higher (Calculator) Paper 3H

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Summer 2023
Publications Code 1MA1_3H_2306_ER

GCSE Mathematics (1MA1/3H)
Principal Examiner Feedback – Higher Paper 3

Introduction

Students entered for this examination generally presented their working in a clear and logical way and found that the time allowed for the examination was sufficient for them to complete the paper. Only a small proportion of students presented very weak scripts, suggesting that most students who sat this paper were entered appropriately for the higher tier.

Nearly all students showed enough working to enable examiners to award partial credit where answers were not correct. However, examiners noticed a significant number of occasions where it was difficult to read the candidate's writing, for example where indices were written or when numbers or algebraic expressions were miscopied. Calculators were usually used efficiently to evaluate numerical expressions with accuracy.

All questions were accessible to some students but, as expected, only the higher attaining students were able to work with confidence on questions towards the end of the paper. Questions 1 (indices and expansion), 2 (multi stage problem), 3 (geometry), 8 (mass, volume and density), 9 (percentages), 11 (box plots) and 12 (product of three linear expressions) were answered well by a large majority of students whereas questions, 4 (inverse proportionality), 13 (algebraic proof), 15(b) (factorisation), 16 (enlargement), 21 (equation with algebraic fractions) and 22 (vectors) proved more of a challenge for students in the target attainment range.

REPORT ON INDIVIDUAL QUESTIONS

Question 1

This question provided a good start to the paper. Most students gained full marks. Nearly all students scored the marks available in parts (a) and (b) though examiners did see m^5 and x^{40} from some lower attaining students. $2x^{13}$ was also seen occasionally as an answer in part (b).
Part (c) was also done well. However, a significant number of students gave the correct answer in the working space but then misguidedly tried to "simplify" the expression by combining the two terms to give an expression such as $16p^5$ for their final answer.

Question 2

The majority of students scored full marks on this question. There were a number of routes through the question and stages in the working could be seen in different orders. Most students started by calculating 68% of 800 then proceeded to take into account the other factors stated in the question. However, some students did not include all the factors, for example, forgetting that each person will drink 2 cups of coffee. In cases where a student did not get a correct answer for the amount of coffee needed, a common error made was dividing 1088 by 10.6 instead of multiplying to give a final answer of 103g. Nearly all students earned the mark in part (b) for stating that “more coffee would be needed”, or equivalent. Students should be reminded that if they calculate and use values to support their answer in part (b), the values must be correct.

Question 3

This question proved to be a good discriminator of attainment at the lower grades awarded in this paper. It provided the opportunity for students to choose one of several routes to find the size of the angles in triangle *ADC* and hence show the triangle was isosceles. There were many clear and complete answers comprising of accurate working, the marking of angles on the diagram and well expressed reasons. Some students were less successful in giving a reason linked to parallel lines. The majority of students used a chain of reasoning which included finding angles *CFG*, *ACD*, and *ADC* before using “Angles in a triangle add up to 180” to show angle *CAD* was equal to angle *ACD* and hence the triangle was isosceles. Sometimes a single letter was used to describe an angle. Students should avoid this as it can be ambiguous. Similarly, reasons were not always linked clearly to working seen or to the size of angle found. Common errors made included showing that triangle *AFG* (not *ACD*) was isosceles, assuming that angles *ACD* and *ADC* must be equal and assuming that the triangle *ACD* was isosceles in order to find the size of angle *CAD*.

Question 4

There was a disappointing proportion of correct answers to this question testing inverse proportionality in a real life context. Many students approached the question using direct proportionality and so came to the conclusion that it would take less time (11.2 hours) for 4 pumps to fill the water tank than it does if 5 pumps are used. It was perhaps surprising that few students did a common sense check on this figure which may have led them to question whether they had applied the correct processes in their working.

Question 5

Students who had a good understanding of the concepts of highest common factor and lowest common multiple found this question to be straightforward. However, this was often not the case, with many students confusing the two terms or being unable to apply the concepts to numbers given in index form. A significant number of students gave a correct answer to part (a) on the answer line for part (b) and vice versa. They could not be awarded any marks. Many students used a Venn diagram approach but often they did not have a good understanding of how to use their diagram to answer the question. In both parts, answers left in index form or as a product of factors received full credit. In part (a) the most commonly seen incorrect answers included 3, 7 and 9. In part (b), common incorrect answers included $2^2 \times 3^4 \times 7 \times 3^2 \times 7^2$ (or 1000188) and

2 × 2 × 3 × 3 × 7 (or 252). Some students were able to gain a mark for listing at least 3 multiples of 2268 and at least 3 multiples of 441 though these students were less likely to find a correct final answer.

Question 6

The majority of students made a good attempt at this problem. There were many fully correct solutions. Answers of 65 or 66 were accepted to reward students who rounded their answer to the nearest day and those who rounded up because they reasoned that in 65 days, not quite enough lava had flowed from the volcano. Students who could not be awarded full marks often scored one mark for either dividing by 11.9 or for a correct process to convert between seconds and days. The latter process is exemplified by 24 × 60 × 60 (= 86 400) or by successively dividing by 60, 60 and 24. The most common errors seen were from students who multiplied together 67, 205, 600 and 11.9 and from students who used incorrect conversion factors such as 60 × 24 or 60 × 60 × 12.

Question 7

Part (a) of this question attracted a high percentage of correct answers. The most common incorrect responses seen included (−3, 1), where the *x* and *y* coordinates were transposed, and answers where the roots of the equation $x^2 - 2x - 2 = 0$ were given on the answer line for this part of the question.
Part (b) was less well answered. Examiners asked for only one root so it was surprising to see so many students give both roots. A more serious error seen was for students to give an answer to the nearest integer not realising that the term "estimate" referred to the fact that using a graph could only provide an estimate for the roots. Many students took the request for an estimate as an instruction to round their answer. A further common error was for students to give both *x* and *y* values at the points where the graph crossed the *x*-axis when only the value of *x* was required. There were also a considerable number of students who gave the intercept of the graph with the *y*-axis (−2) as their root.

Question 8

Most students found this question to be straightforward. However, a minority of students divided 72 by 9 or divided 9 by 72 so could not be awarded any marks.

Question 9

This question was also well answered. A wide variety of successful approaches were seen using fractions or decimal multipliers or both. Of those, a small number of students who scored one of the two marks available, gave an answer of 0.56 or 5.6. Students who attempted the question but scored no marks for their responses usually added or subtracted the 70% and 80% or expressed one as a percentage of the other.

Question 10

A good discriminator, this question tested trigonometry within the context of right-angled triangles. Higher attaining students found the question to be routine but it also gave most students the opportunity to apply their knowledge and skills to show a process or processes to find the length of *AC* as an intermediate stage. A high proportion of students got this far. Many students were also able to progress to find a relationship involving *DC*, for example tan 55 = $\frac{4.46}{DC}$ so scored the second mark. Fewer students could rearrange the relationship to get "*DC* =" so could not obtain the final accuracy mark. A common sense check that the length of *DC*, often calculated as 6.4, should be less than the length of *AC* may have alerted some students to the error made at this stage. A small minority of students used the sine rule as an alternative approach, sometimes, finding the length of *AD* as a first step. This was, of course acceptable for the award of the first mark. These students sometimes then progressed to get a correct answer by using right-angled triangle trigonometry and/or Pythagoras' rule. A significant number of students lost the final accuracy mark because they rounded too much earlier in their working.

Question 11

This question was generally well answered with most students scoring 3 marks for a correctly drawn box plot and at least 1 mark for a correct comparison of the two distributions. The main error seen by examiners in part (a) was a misinterpretation of the scale. Unfortunately, these usually led to students drawing a diagram with only one correct measure plotted and so no marks could be awarded. In part (b), examiners expected to see a comparison of the medians and either the ranges or the interquartile ranges with specific reference to the measure used. A comparison of, for example, the greatest heights was not acceptable. This is a topic that would benefit from more emphasis at centres. Some students merely stated values without comparing them. For example, "the median for adults = 177 whereas the median for teenagers = 169" cannot be given any credit but "the median for adults is greater than the median for teenagers" can be. It should also be noted that there is no need to give values in the comparisons but, if they are given, they must be correct. Students quite often failed to refer to the context of the question and so restricted themselves to the award of only one of the two marks available.

Question 12

Students usually scored well in this question involving the expansion and then simplification of a product of three linear expressions. They generally showed their working in an organized way or used a grid to show the terms in their products. Errors were usually restricted to incorrect terms or difficulties in dealing with the signs when collecting terms together, rather than a flawed strategy although some students omitted terms from their expansion when at the stage of multiplying a quadratic expression by a linear expression. For students who did not give a fully correct answer, it was commonplace to see 2 marks or 1 mark awarded.

Question 13

A minority of students scored full marks for their responses to this question and there were more students than average that did not attempt the question. Weaker responses include those where a student had substituted a value or values for *n*, but of course, this could not serve as a proof and so could not be given any marks. Students who did approach the question more generally and attempted to write down an expression for the next triangular number term often wrote down incorrect expressions such as $\frac{n(n+2)}{2}$, $\frac{n+1(n+2)}{2}$ or $\frac{n(n+1)}{2}$ + 1. Students writing down the expression $\frac{n+1(n+2)}{2}$ sometimes recovered their error in omitting brackets and went on to give a correct proof. Not all students who obtained the expression $n^2 + 2n + 1$ could factorise it to prove it was a square number.

Question 14

Just under a half of students scored full marks for their responses to this question. However, many other students were able to gain some marks and the question was a good discriminator between students who could show a good understanding of the cosine rule and those who had little understanding of the application of trigonometry to non right-angled triangles. There were a significant proportion of students who could correctly write down an expression for OB^2 by using the cosine rule but then did not observe the correct order of operations and calculated 9 cos35° instead of $117 - 108\cos 35^\circ$. Students who made a good start to the problem were often able to complete it successfully, but some students used OB^2 rather than *OB* as the radius when finding the area of the sector. Other errors seen included using $\frac{1}{4}$ rather than $\frac{80}{360}$ when finding the area of the sector and assuming that the radius of the circle was 6 cm.

Question 15

Part (a) of this question was not well answered with under a half of students taking the paper giving a correct factorisation. Very few students took the hint from part (a) about how to make progress with part (b) of the question. Those who did realise there was a connection and factorised the numerical expression were usually able to reason why this represented a product of two consecutive odd numbers. Some students wrote down $(2n + 1)(2n - 1)$ indicating that they knew this was a general expression for the product of two consecutive odd numbers. Unfortunately, it was rare for students to securely link this expression with $2^{40} - 1$. A small number of students evaluated each of $2^{20} - 1$ and $2^{20} + 1$. This was accepted by examiners. Centres are encouraged to complete work with students where results in algebra, for example the difference of two squares, can be used with number.

Question 16

This question discriminated well between more able students sitting this paper but students generally scored 0 or 2 marks. Some carelessness was seen in some student responses where vertices were plotted at (4, 5) and (8, 5) instead of at (4, 4) and (8, 4). Students who scored full marks tended to use construction lines though some used vectors from the centre of enlargement to each vertex and multiplied them by −2. Common errors seen included triangles drawn by using a scale factor of $\frac{1}{2}$ or $-\frac{1}{2}$ or 2.

Question 17

In part (a) of this question, examiners saw many excellent answers with a clear and accurate tangent drawn at time 2.5 seconds followed by a clear method to work out the gradient of the tangent. Students who did not draw a tangent at the correct point were unable to access any marks here. An incorrect interpretation of the request to "estimate" resulted in some students prematurely rounding figures. Centres may like to remind students that the very nature of the process of drawing a tangent to estimate the gradient is in itself bound to give an estimate and that this is often the case when using readings from a graph. No further rounding is needed in the calculation. In this question, provided the student had drawn an acceptable tangent at time 2.5 seconds, examiners followed through their use of the graph and were able to award full marks for a correct method using figures correctly taken from their diagram together with an accurate evaluation of their numerical expression for the gradient. Some students did not use the scales on the axes correctly when calculating the gradient. It was encouraging that only a small proportion of students tried to find the gradient without drawing a tangent first and that few students used "increase in x ÷ increase in y" for the gradient or counted squares rather than using the scales on the axes.
Students usually quoted "speed", or the equivalent, in part (b) of the question to score the mark available. The most commonly seen incorrect answer was "acceleration".

Question 18

The successful completion of this question depended upon students being able to use direct proportion to find the radius of the top of the frustum. Many students realised this but there was also a significant number of students who merely halved the radius of the base of the frustum and used 1.5 in their calculations. This severely limited the number of marks examiners could award for these students' responses. Students working below the attainment level for which this question was designed often scored the mark available for working out the area of the circular base of the solid or two marks for finding the radius of the top of the frustum and the curved surface area of the frustum. Higher attaining students often gave a complete and correct solution to this question to obtain full marks. Some students subtracted either the curved surface area or the total surface area of the cone with base radius 1.8 cm from the total surface area of the cone with base radius 3 cm and did not properly take into account the area of the top of the frustum.

Question 19

It is encouraging to report that a good proportion of students gave an acceptable description of what was wrong with Sana's graph. Examiners gave credit to any student who had, in one way or another, clearly identified that the graph should not pass through the origin or said that $3^0 \neq 0$ or equivalent. Most students who correctly identified the error were clear in their explanation. There were, however, some students who could not be awarded the mark because their statement was too vague. For example, "she has drawn the graph wrong" or "the graph should start at 1". Lower attaining students often gave responses such as "the axes are not labelled" or "she did not draw a straight line". There were many and varied incorrect responses seen.

Question 20

There were many good attempts at this question. Most students who understood the method used either $1000x - 10x$ or $100x - x$. The detail and presentation of the proof could have been clearer in some cases but it was usually good enough to award some marks for the response. For full marks, examiners expected to see an indication that recurring decimals were being used, for example, by the use of "..." at the end of the numbers or by dots above the 2 and the 3. Students who gave a correct and complete method without this were awarded 2 of the 3 marks available.

Question 21

Most students attempted this question testing algebraic techniques and it discriminated well between higher attaining students. The most concise method of multiplying throughout the equation by $(x + 4)$ and $(2 - 2x)$ as a first step was not used by many students. Instead, most students tried to combine the two algebraic fractions on the left-hand side of the equation first. A good proportion of students were able to deal with the fractions to write an equation of the form $(2 - 2x) + 3(x + 4) = (2 - 2x)(x + 4)$ or equivalent. A much lower proportion of students could work with accuracy to write the equation with all terms on one side to get $2x^2 + 7x + 6 = 0$ or $-2x^2 - 7x - 6 = 0$. Students who did get this far, often went on to get correct values for x, though examiners did see a significant number of incorrect factorisations and errors in using the quadratic formula. Errors in using the quadratic formula were often the result of substituting in three negative values for a, b and c. Centres could encourage students to multiply through an equation by -1 in such cases before using the formula.

Question 22

Fully correct answers to this question were seen infrequently and there were many students who made no attempt to answer the question. However, a significant proportion of students were able to score at least one mark for writing down a correct vector equation and/or two simultaneous linear equations from the information given. The most success was achieved by students who wrote down and solved the equations $2a + 8b = 13$ and $6a + 2b = 6$ to get $b = \frac{3}{2}$ and $a = \frac{1}{2}$ then used this to write down a correct expression for b in terms of a. Some students formed simultaneous equations but then used only one equation to find a relationship between a and b. Of those students who did solve the equations to get the value of a and the value of b, some failed to complete the question to get b in terms of a. Approaches using $a\binom{2}{6} + b\binom{8}{2} = k\binom{13}{6}$ where k was treated as a general constant or using $\frac{2a+8b}{6a+2b} = \frac{13}{6}$ as a start were rarely seen.

Question 23

This question was accessible to and discriminated well between the highest attaining students sitting this paper. There were a number of routes through the question available to students. The most concise route was for students to find the gradient of the tangent at the point (−3, 4) on the circle and compare it with the gradient of the line joining the point (−8, 0) to the point (−3, 4). Few students chose this route, instead opting to find the equation of the tangent at the point (−3, 4), then show that the tangent would not pass through the point with coordinates (−8, 0) but through one of the points $(-\frac{25}{3}, 0)$ or $(-8, \frac{1}{4})$. Though this was the most frequently seen route, a significant number of students did not get as far as a correct conclusion supported by correct reasoning and necessary values. A number of students opted to approach the problem by using Pythagoras' rule to show the triangle with vertices (−8, 0),(−3, 4) and (0, 0) was not right-angled. It was rare to find a complete solution from students using this strategy.

Question 24

This question also discriminated well between high attaining students. Most students who made a good attempt at the question recognised the non-replacement nature of the problem and were able to make a start by forming expressions for probabilities in terms of x and/or y. A good proportion of these students were also able to use the ratio given in the question to make a substitution in order to get their expressions in terms of x only or y only. However, a significant number of students used "$y = 4x$" instead of the correct "$y = 3x$". Invariably and sensibly, the overwhelming majority of students opted for getting their expressions in terms of x only. Those students who attempted substituting $3x$ for y into their probabilities before combining their products had more success than those who substituted later as the algebra became more complex. A significant number of students obtained correct expressions for the probability of Freda taking two pink counters and the probability of her taking two blue counters but gave the probability of her taking two green counters as $\frac{2x-5}{3x} \times \frac{2x-4}{3x-1}$ instead of $\frac{2x-5}{3x} \times \frac{2x-6}{3x-1}$. This had clearly arisen from an error with signs earlier on in a student's working. It was encouraging to see a good number of fully correct solutions from students working at the highest level.

Summary

Based on their performance on this paper, students are offered the following advice:

- carry out a check to make sure you have not miscopied any numbers given in a question before you complete the question.
- check that you have not miscopied algebraic expressions from a previous line in your working.
- practise solving equations involving algebraic fractions.
- compare the medians and either the ranges or the interquartile ranges in context when asked to compare two distributions represented by box plots.
- ensure you can write and manipulate algebraic expressions accurately particularly with regard to the use of brackets and the signs of terms.
- practise solving real life problems involving inverse proportionality.
- carry out common sense checks where possible.

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