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Examiners' Report
Principal Examiner Feedback

Summer 2022

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In Mathematics (1MA1)
Higher (Calculator) Paper 3H

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

Introduction

The time allowed for the examination appears to have been sufficient for most students to complete this paper. The great majority of students seemed well suited to entry at the higher tier.

Most students entered for this examination presented their working in a clear and logical way. This helped examiners to award any credit due where final answers were not correct. Only a very small proportion of low attaining students presented weak scripts. Questions where working was often not so well organized included question 7 (algebraic expression for an area) and question 13 (manipulation of column vectors).

The paper gave the opportunity for students of all abilities to demonstrate positive achievement. All questions were accessible to some students but, as you would expect, there were relatively few students able to work confidently on all questions. In particular, questions 1 (Pythagoras' rule), 2 (formulae), 3 (ratio), 4 (best buy) and 11 (product rule for counting) were answered well by a large majority of students whereas questions, 10 (reverse percentage), 13 (column vectors), 14(a) (factorisation) and 15 (circle theorems) proved more of a challenge to the students in the attainment range they were aimed at.

REPORT ON INDIVIDUAL QUESTIONS

Question 1

This question provided a good start to the paper. Most students gained the full 2 marks. However, a significant number of students did not apply Pythagoras' rule correctly and instead added 4^2 and 8.5^2. These students could not be awarded any marks. It was surprising to see many students forget to take a square root and give the answer 56.25. A brief recap of the diagram might have alerted some students to there being an error in their working. In a small number of cases, trigonometry was attempted but the method was often incomplete and so no marks could be awarded.

Question 2

There was a disappointing proportion of fully correct answers to part (a) of this question. It has to be said that there was a great deal of sloppiness in students' notation when making the substitution and far too many students failed to write the −3 in brackets. They very often wrote $4 \times -3^2 - 11$, with most of these students then going on to use their calculators with little understanding of how to deal with the square of –3. This resulted in many answers of −47 instead of the correct 25. Students are advised to put brackets round any negative numbers when working with algebraic expressions

involving substitution both when writing down their working and when inputting any expression into their calculator.
Part (b) of the question was done quite well. Students usually changed the subject by subtracting 4 from both sides first and then dividing by 3. Only a small minority of students divided by 3 as their first step. Students who did do this often forgot to divide the 4 by 3. Students are reminded that they should give a complete answer on the answer line, including the "p =". A number of students just wrote "$\frac{d-4}{3}$" on the answer line.

Question 3

A majority of students scored full marks on this question. Many students in this higher tier paper used an algebraic approach, formulating and solving an equation, then using the solution to find a ratio and the value of p. Students usually worked accurately, but there were a number of students who wrote down a correct equation but collected terms in x to get $4x$ instead of the correct $5x$. Other students, having got the correct equation, $5x - 6 = 54$, then made an error in the first step to solve it, writing $5x = 48$.

A significant proportion of students adopted a purely numerical approach, finding, by trial and improvement, three numbers which satisfied the criteria given in the question, then using them to form a ratio. Some students found the number of counters for Rick and for Tony but did not form a ratio. There were also some other students who did form a ratio but did not write it in the ratio $1 : p$.

Question 4

A good discriminator between lower attaining students, this question attracted many fully correct solutions. Despite there being a number of possible routes that students could take, there were also many incorrect or incomplete solutions. The most common approach was to find the cost of 15 rolls of wallpaper at each of the shops, though credit was given for comparing any number of rolls, for example 1 roll or 5 rolls. A high proportion of students compared £180 with £184.80 and reached a correct conclusion to score all 4 marks. However, some students worked out the discount and took that to be the cost of the wallpaper at Style Papers.

A common error seen was, for students who did not appear to have access to a calculator, to use a build-up method to find 12%, for example by writing down 10%, 1% and 1%. Students who did this often made an error with the arithmetic and lost marks because they did not show the calculation, for example the addition of the three percentages or how they worked out the 10% or 1%. Students are reminded that when showing their calculation of a percentage, they should show a full method, so for example instead of writing 12% of £70 = £8.40, they should write $\frac{12}{100} \times 70 = 8.40$ or $0.12 \times 70 = 8.40$. This is so that in the event of an incorrect answer, marks for a correct method can be awarded.

Question 5

This question was quite well answered and descriptions of the mistakes made when the frequency polygon was drawn were generally clearly described. There were two mistakes to identify and students needed to describe them both to score the full 2 marks. Examiners were surprised that more students gained the mark for stating that the point plotted at (50, 5) should have been plotted at (45, 5) than gained the mark for stating that 40 had been omitted from the scale on the frequency axis. Any statement equivalent to one of these, and which was unambiguously stated, earned a mark. The most commonly seen unacceptable statements included not joining the polygon to (0, 0) and not joining the ends of the polygon.

Question 6

The majority of students made a good attempt at this problem on distance, time and average speed. Many students produced a concise, accurate and complete solution. Lower attaining students sometimes lost accuracy in their working because they used 0.6, 0.66 or another decimal approximation when coverting 40 minutes to hours. These students were still able to be given 3 of the 4 marks available if they had used and shown correct processes in their solutions. A significant number of students appeared to ignore the units in the question and were very fortunate to get a correct answer because the nature of the problem depended on the ratio of the times taken, rather than the times themselves. Of those students who answered the question incorrectly, many did so because they did not know the formula and divided the speed by the time, instead of multiplying them.

Question 7

This question was a good discrminator. There were a number of routes which could be followed in order to show the given result. The most popular method was to use the formula for the area of the trapezium *QUVR*. Once a student had found the length of *QU* (= $x + 5$), they could make substitutions into the formula then simplify it to show $A = 2x^2 + 20x$. Many students found this to be quite straightforward.

A second commonly seen and generally successful method was to use
Area of trapezium *QUVR* = Area of rectangle *TUVS* − Area of trapezium *TQRS*.
Perhaps the most straightforward way was to find the area of the rectangle with length and width $4x$ and 5 then add the area of a triangle of base x and height $4x$. It was surprising how few students took this approach.

The presentation of students answers was often not very clear with examiners having to search the working space for relevant working. However, many students did use algebra in a confident way to show the given result. The absence of brackets to make working clear sometimes led to a student losing marks but examiners were sympathetic where intentions were clear.

Question 8

Many students found this question to be straightforward. They often used a triangle where readings were easy to take and gave a value for the gradient of the graph within the accepted range, more often than not 0.14. For some other students who drew a small triangle on the line getting an accurate answer was less likely. However, if the value given for the gradient was outside the range 0.135 to 0.145, examiners awarded both marks in part (a) provided a correct method was clearly shown. A small number of students used "increase in x ÷ increase in y" or counted squares rather than using the scales on the axes. These students could not be credited with any marks in part (a).

Part (b) was answered less well and many incorrect or ambiguous statements were seen. An answer equivalent to "cost per unit of electricity" was expected but many students merely described what the graph, not the gradient, showed and statements such as "cost of how many units used" were often seen.

Question 9

Just over a quarter of all students completed part (a) of this question successfully to gain all 3 marks. A commonly seen final answer was 10^{120}. This could only score 1 mark. However, about two thirds of all students got as far as simplifying the expression to $\sqrt{10^{120}}$. Some of these students left this as their answer while other students went on to evaluate it incorrectly.

Answers to part (b) were often marred by a lack of clarity. Answers such as "Liam should have multiplied the numbers inside and outside the brackets" were commonplace but could not usually be rewarded with the mark available. Another common incorrect response was for a student to state that the 12 should be squared. More successful responses usually referred to the answer Liam should get, that is 12^{100} or that Liam should have multiplied 50 and 2, not worked out 50^2.

Question 10

This question was not well done. Too many students showed the misunderstanding that, to reverse a 10% decrease, they had to increase the value of the car by 10%, so they multiplied by 1.1 rather than using the correct method of dividing by 0.9. It was relatively unusual to award 1 or 2 marks for responses. Students usually either showed a good understanding or no understanding of the processes required to solve the problem.

Question 11

This question was generally well answered with most students scoring the full 2 marks. Where examiners saw errors, most either involved adding 16, 5 and 3 instead of multiplying, or multiplying the 16, 5 and 3 but then adjusting their answer by, for example dividing by 3 or dividing by 2, as they mistakenly believed that the 240 included repeats. This latter approach was given some credit for the $16 \times 5 \times 3$.

Question 12

In answering this question, most students showed a good understanding of how to apply trigonometrical ratios to this 2 stage problem. However, a significant proportion of them made errors in manipulating the ratio used in the second stage of the problem.

It was envisaged that students would use the trigonometry of right angled triangles to solve this problem and most did. However, a large number of students used the sine rule to get their answer. Examiners were surprised how few students realised that triangle *ACD* was isosceles and so they were not able to write down the length of AC without further calculation. However, they usually used $\tan 45 = \frac{AC}{8}$ correctly to get 8 cm for the length of *AC*. Most students were then able to write down a relationship which would enable them to find the length of *AB*, and this was awarded some credit. However, too many of these students did not rearrange their equation correctly and instead of getting $AB = \frac{8}{\sin 20}$, wrote down $AB = 8 \times \sin 20$, leading to an incorrect answer.

Question 13

This question was successfully answered by just under a half of all students who took this paper. Nearly all students scored a mark for finding 3**a** as a column vector. However, students often failed to write their responses in a clear, logical manner. Few students manipulated the equation to get $-2\mathbf{b} = \begin{pmatrix} 8 \\ 17 \end{pmatrix} - 3\mathbf{a}$ or $2\mathbf{b} = 3\mathbf{a} - \begin{pmatrix} 8 \\ 17 \end{pmatrix}$ before substituting for **a**. This might have led to a clearer approach and the avoidance of errors with signs. As it was, examiners were often left not knowing whether the student was trying to find the value of $-2\mathbf{b}$ or $2\mathbf{b}$ with a consequent loss of marks for those students who did not get a fully correct final answer. Students who got one correct component of **b** were given the benefit of the doubt and rewarded with two of the three marks available.

Question 14

A minority of students scored full marks for their responses to this question. However, most students were able to gain some marks and the question was a good discriminator between students who could manipulate algebraic expressions with accuracy and those who made, sometimes unnecessary, errors.

A fully factorised expression was asked for in answering part (a) of this question. It was disappointing to see so few students factorise the expression fully and it was much more usual for students to gain just one of the two marks available for getting as far as, for example, $4(p^2 - 9)$ or $(2p - 6)(2p + 6)$.

Students usually scored well in part (b) which required the expansion of a product of three linear expressions to give a fully simplified cubic expression. Students generally showed their working in an organized way or used a grid to show 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. For students who did not give a fully correct answer, it was commonplace for them to earn 2 or 3 of the available marks in part (b).

Question15

There were some excellent complete, concise and clear proofs to this question involving the application of circle theorems. However, these were only seen in a minority of cases and students need to be aware of the need to state results clearly using the statements indicated on the mark scheme as guidance. There were many students who could not give reasons or who gave them with a lack of clarity. These students often gained some credit for matching up at least two pairs of equal angles. A clear indication of this on the diagram was accepted by examiners.

Of students who completed the proof successfully, most used statements of the same segment theorem together with a pair of vertically opposite angles. Students should note it was not enough to state "same segment theorem" – they needed to say what the theorem states, for example "angles in the same segment are equal". Some students used the result that angles in a triangle sum to 180° as a reason to support the equality of their third pair of angles. This was, of course, acceptable. A small number of students used the result that the angle at the centre of a circle is twice the angle at the circumference to show that angle PQX = angle PRS and that angle QPR = angle QSR, another acceptable approach.

About one in ten students obtained full marks for their proof.

Question 16

This question discriminated well between more able students sitting this paper with many students being awarded each of the 0, 1, 2 or 3 marks available. Some students did not attempt the question and many lower attaining students restricted their answer to working out the value of p by substituting $e = 6.8$ and $f = 0.05$. This gained no credit. Of those students who did score marks, many of them scored just one mark for writing down at least one of the bounds for e or f. Students who substituted bounds for e and f into the expression for p were split between those who calculated 2[UB of e] ÷ [LB of f], the correct expression and those who calculated 2[UB of e] ÷ [UB of f]. Some students who had the correct fraction, failed to take the square root or made an error in taking the square root and so lost the final accuracy mark.

There was a significant number of students who calculated [UB of 2e] $\div$ [LB of f], that is $\frac{13.65}{0.045}$ instead of $\frac{13.7}{0.045}$. These students could not be awarded full marks even though their final answer worked out to be in the range 17.4 to 17.5

Question 17

In part (a) of this question, lower attaining students often drew a bar chart and did not recognise the need to find and use frequency densities. Some students used the midpoints of the class intervals erroneously together with the frequencies to get values which they then used to draw a diagram. Having said that, there was a good proportion of students who did successfully calculate frequency densities and use these to draw a histogram. It was interesting to note that a significant number of students drew the first four bars correctly but then made an error drawing the bar representing the interval $3.0 < d \leq 5.0$

Part (b) of the question was less well done with only a small proportion of students able to use the ratio of the areas of the two bars concerned to find a correct expression. Examiners did award one mark to a significant number of students who showed that they needed to compare the heights, widths and areas of the two bars concerned.

Question 18

It is encouraging to report that the majority of students gained some credit for their attempt at this question. The length of *TC* was often found successfully and a good proportion of students were also able to find the length of at least one of *SD* and *TD*. Only the higher attaining students were able to identify the angle which was required and put everything together in order to find the size of this angle, that is the size of angle *DTS*. Errors commonly seen included, substituting 12 and 14 incorrectly into the formula for the area of the cross section and making an error in the use of Pythagoras' rule to find the length of *DT*.

Question 19

Fully correct answers to this question were seen infrequently. However, a significant proportion of students taking this paper were able to score at least one mark for using a correct common denominator and writing at least one of the three terms with that common denominator, usually the first fraction as $\frac{3x(x-2)}{x^2-4}$. Only the best students were able to work accurately in order to gain more credit for their responses. The question discriminated well between high ability students aiming to get one of the two top grades. For many students, this question proved to be the most challenging question on the paper. In particular mistakes were often made with signs when the fraction $\frac{(x+2)(2x+1)}{x^2-4}$ was subtracted from the fraction $\frac{3x(x-2)}{x^2-4}$ or in writing $-(x^2 - 4)$ as $-x^2 - 4$.

Question 20

Though a significant number of students did not attempt this question, many of those students who did attempt it scored full marks for a complete and correct solution. The most common error seen was for students to write down a correct equation, $29\,600 = 24\,000a + 800$ but then make an error in solving the equation. It was not unusual for students to divide 29600 by 24800 as a first step, then subtract 800. Some students who found a correct value for "a" went on to use the iterative relationship correctly but only went as far as finding the profit made by the shop in the year 2020.

Question 21

Higher attaining students usually made a good start on this question on probability and identified the non-replacement nature of this problem. They usually presented at least one correct product of three fractions with denominators 9, 8 and 7 respectively. Only a small proportion of students gave all four possible ways of getting an even sum with the resultant correct answer, $\frac{11}{21}$. Students who drew a tree diagram were generally more successful at finding all 4 correct combinations.

Very few students approached the problem by finding the probability that the result was an odd number then subtracted from 1. Those students who did do this were rewarded appropriately.

Question 22

This question was accessible to and discriminated well between the most high attaining students sitting this paper. These students often gave a complete and fully correct solution and scored full marks. They usually used the approach of eliminating y to get an equation in x. This was more straightforward to deal with than the corresponding equation in y. The most common errors made by students included expanding $(2x - 5)^2$ incorrectly, often as $4x^2 + 25$, and making errors when re-arranging their quadratic equation to get all terms on one side of the equation. Some students who did get the correct quadratic equation to solve, made errors when trying to factorise and so restricted themselves to the award of 2 marks.

Summary

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

- make sure you put negative numbers in brackets when substituting them into algebraic expressions or when using a calculator.
- check all your working for careless errors and to make sure you have not miscopied numbers or algebraic expressions either given in the question or in a previous line of your working.
- practise the addition and subtraction of algebraic fractions.
- check your working when expanding brackets and collecting terms, especially when finding the product of three linear expressions or when removing brackets after a subtraction of one expression from another.
- ensure you have a good understanding of how to use multipliers in problems concerning reverse percentages.
- practise drawing histograms and using them to solve problems.

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