Examiners' Report

Principal Examiner Feedback

Janaury 2023

Pearson Edexcel International GCSE

In Mathematics B (4MB1)

Paper 02

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January 2023
Publications Code 4MB1_02_2301_ER

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Introduction

Students were generally prepared for this paper and there were some excellent responses. To enhance performance in future series, centres should focus their student's attention on the following topics:

- Understanding set notation and Venn diagrams.
- Finding the inverse of a quadratic function.
- Questions that involve the demand to show all working.
- Following the instruction in graph questions when asked to find by drawing a straight line.
- In general, students should be encouraged to identify the number of marks available for each part of a question and allocate a proportionate amount of time to each part of the question. In addition, students should also be advised to read the demands of the question very carefully before attempting to answer. It should be pointed out that the methods identified within this report and on the mark scheme may not be the only legitimate methods for correctly solving the questions. Alternative methods, whilst not explicitly identified, earn the equivalent marks. Some students use methods which are beyond the scope of the syllabus and, where used correctly, the corresponding marks are given.

Report on Individual Questions

Question 1

Students tended to either get zero marks or full marks on this question, in the latter case this was achieved either by formulating an algebraic equation or calculating and comparing distances, with both methods equally likely to lead to success. When zero (or very few) marks were awarded, there were some common errors:

- Ignoring time and trying to calculate the average speed as $(60 + x) / 2 = 64.2$.
- To treat 60 and x as distances rather than speeds (i.e. calculating $60 / 2$ and/or $x / 3$).
- Not using the 2 or the 3, so getting $60 + x$ for the total distance.
- Not dividing by 5 but setting the total distance equal to 64.2 or some other number.
- Not recognising that average speed is total distance divided by total time.
- Converting to minutes.
- Some applied proportion methods, assuming the speed to be the same on both parts of the journey.

Question 2

Most students gained the method marks for finding length AE (and EC), however many did not then understand how to correctly substitute these values into the formula for the area of a trapezium, ending up with, e.g. $\frac{1}{2}\times(14.8...+3)\times 9.$ Another common error was applying the 1 : 2 ratio incorrectly to DE/BC and therefore finding $BC = 6$ rather than $BC = 9$.

Some other common errors were:

- Premature rounding to 1 decimal place led to inaccurate lengths; not penalised on this occasion.
- Those using trigonometry to find lengths were more likely to have rounded incorrectly.
- Misinterpreting the ratio as a multiplier and getting BC = 6 from 2×3.
- Not applying the area of a trapezium formula correctly: using $\frac{1}{2}\times(BD+CE)\times DE$ rather than adding the parallel sides.
- Using Pythagoras incorrectly on triangle ADE, so adding the squares rather than subtracting.

Question 3

This question discriminated extremely well with fully correct answers being very uncommon. Many students did not spot the need to use Pythagoras to get the missing lengths. However, those that used Pythagoras correctly, tended to proceed to the correct answer.

Common errors seen:

- Subtracting the correct two expressions to find the 16 but not halving it to get the base of the right angled triangle.
- Numerous examples were seen where students added the expressions given and equated to 172 to solve for x, ignoring AB and CD completely.
- Poor simplification of their linear equation, i.e., getting $9x$ instead of $12x$.
- Using only the vertical height as AB/CD in the perimeter.
- Using multiplication instead of addition to find the perimeter.
- Assuming AB and CD to be x rather than applying a correct method to find these lengths.

Question 4

Most students gained at least one method mark for finding the area of a sector, and a good number of students gained five or six marks on this question. A common misconception was to calculate angle AOB incorrectly, either equating it to angle ACB (giving AOB = 70) or incorrectly applying the angles at the centre and circumference theorem giving AOB = 140 degrees. The most common method leading to the correct answer was to divide the quadrilateral into two congruent triangles and then, having found the length of AC, to calculate 2 times the area of triangle OAC minus the area of the minor sector. A number of students lost out on the final accuracy mark due to early rounding, suggesting students should be encouraged to use values in their calculations which have a higher degree of accuracy than the final answer requires (or to save them in the calculator's memory).

Common misconceptions:

- That the area equation for a sector included $\pi \times d$ or that it included ½ as well, or that AB was the diameter and halving to get the radius.
- Incorrect trig ratios used.

Question 5

The majority of students gained at least one method mark for substituting one equation into the other, however mistakes when expanding brackets (both linear and quadratic) were very common. Where brackets were expanded correctly, students generally went on to gain full marks (or at least the first five marks as some students forgot to find both the x and y values). Very few students spotted that their equations could be factorised, preferring to use the formula (or very rarely completing the square).

Common errors were:

- Sign errors or errors when expanding brackets.
- Using the quadratic formula to find y but labelling it as x, and then substituting this value(s) into one of the two given equations to find y again.
- Subtracting one equation from the other and ignoring the extra terms this would create.
- Incorrectly expanding $(7 – 5y)^2$ as two terms with no y term.

Question 6

Most students attempted part (a) extremely well, with only less able students not using signs correctly or only finding $\overrightarrow{AC}$ rather than $\overrightarrow{OC}$.

In part (b) a few students spotted the similar triangles and applied the ratio correctly. Many did not set up correct equations (for either $\overrightarrow{OD}$ or $\overrightarrow{BD}$) using the two given properties so were not able to make meaningful progress.

Common errors:

- For less able students, misuse of direction and vectors as journeys.
- Not recognising the use of multipliers for parallel vectors.
- Not being able to set up and solve pairs of equations.

Question 7

Most students scored one or two marks in part (a) with a common error being to either treat 1 as a prime number or to include it with the 25 (so not as a member of any of the three given sets). A small number of students did not read the question carefully and included even numbers in their Venn diagram, or 0 and 30. In a number of solutions, the same values were seen in multiple regions within the Venn diagram.

A significant number of students did not have a clear understanding of the meaning of the notation n(...) in part (b) and either gave their answers as a set or added values together rather than adding the number of values (e.g., in (b)(i) giving the answer as {3, 5} or 3 + 5 = 8 instead of the correct answer of 2). A common incorrect answer in (b)(ii) was to only include the ‘7, 11, 13, 17, 19, 23, 29’ region and therefore giving an answer of 7.

Most students gained at least one mark in (c) and/or (d), even if they had an incorrect Venn diagram in (a).

Common errors:

- Thinking 1 was prime.
- Thinking that every region required a value except the outer region (so not including 25 or misplacing it).
- Thinking 0 denotes an empty set.
- Not using the diagram to shade in and out regions.
- Set notation: confusing union and intersection; missing the mark for complement; not knowing that n means number of elements.
- Not using the Venn diagram to count elements; not understanding the condition ‘A given B’.
- Using total values rather than number of items.
- Probabilities in (c) and/or (d) were often > 1.

Question 8

Surprisingly, part (c) was generally answered better than both parts (a) and (b), where perhaps more careful reading of the question was required.

A common mistake in (a) was not to realise that the 80 represented 2 parts of the ratio, and instead many calculated $\frac{7}{12}\times 80$.

Similarly, in (b), a significant number of students did not identify that the 270 was the weight of granola rather than the weight of nuts and therefore calculated $\frac{270}{500}\times 26$, with \$14.04 being by far the most common incorrect answer seen.

In part (c), most students set out their working clearly and the US cost was generally well done, but there were two common misconceptions in the calculation for the UK cost; the first was to multiply the shipping cost by 10 (as well as the cost of the raspberries) and the second was to calculate the interest by adding 0.25 to the cost. With regard to the first of these errors, students perhaps need to be encouraged to think about the reasonableness of their answers in the context of the question. A lot of students seemed to ignore the US offer entirely and work out a full cost, ignoring the “extra free” and there were errors where students would subtract postage, rather than add it on. The most common method for unit conversion was \$ to £ and very few students incorrectly used this conversion factor.

Some students in part (c) would add the tax and the postage onto the 50g price and then use this 10 times, getting an incorrect answer.

Common errors/misconceptions:

- Misunderstanding the context particularly ratios in recipes and using multipliers or fractions.
- Tabulating the information to organise it was very rare but would generally lead to more marks.

- For (c): Misunderstanding the context particularly using proportions e.g., scaling up, applying special offers, and postage as a fixed rate extra charge.
- For the less able students, needing to convert to the same units for a numerical comparison.

Question 9

In (a) less able students scored zero or one mark (usually from the area of triangle *FGH*) with the errors including treating two or three of the rectangles as equal or missing that there are three rectangles. This part led to a full range of marks, from zero to four with a good proportion of students scoring well. A number of students left out one of the three rectangular faces.

Part (b) tended to be full marks or zero/one mark. Those students that could track through the lengths and use Pythagoras correctly scored full marks. Some students used the rectangle *GHIJ* not triangle *FIJ* or used trigonometry or Pythagoras with errors when trying to build the relevant lengths, with a common error being to calculate tan *FJI* = 5/23.3... instead of 23.3/5. Some students worked out the angle *KJI* or *FGH*, not *FJI*.

Many students seemed to confuse surface area and volume in part (c) and a common mistake was either finding the surface area of the cube and dividing by 660 or correctly calculating 60^3 but still dividing by the surface area of the wedge that had been calculated in part (a). Very few showed partitioning the three dimensions to stack the wedges. Using volumes was more common, although not necessarily with cube divided by wedge.
Less able students squared the 60 rather than cubing it and a number did not deal successfully with the prism, treating it as a cuboid.

Common errors:

- Confusing area, surface area, volume, and the calculations for these.
- Not being able to visualise the prism and identify the component faces and lengths.

Question 10

It was surprising how many students did not even attempt this question and, where it was attempted, how few students answered part (a) correctly. The most common error was to consider green then white but not white then green. A few repeated a denominator of 10. Those using a probability tree would often obtain the correct answer.

In (b), many students were able to state that P(Red) = $\frac{n}{n+28}$ however many didn't seem to realise that they needed to equate this to $\frac{6}{11}$ to create an equation. When the equation was set up correctly it was generally solved well and led to a valid conclusion. Some referred to 11 (or 6) being smaller than 28 and therefore not possible. Often students would try to give a written description rather than show any mathematical working/reasoning.

In part (c) an attempt to write the probabilities as algebraic expressions was common, with many picking up method marks at different stages.

Common errors (particularly in part (c)):

- Less able students used replacement of the items throughout, therefore repeating the same error.
- Not dealing with $28+n-1$ successfully.
- Attempting the complement $1-p$ and then making sign errors when expanding.
- Not substituting correctly into the quadratic formula, or not proceeding correctly with the arithmetic to get the solutions.
- Less able students used denominators of 28 rather than $28+n,$ made errors with expansion and simplification of their expressions (particularly with signs and dealing with like terms) and did not solve the resulting equation correctly. A few students used 21 rather than 36, even stating that it had to be greater than 28.
- Misinterpreting the wording of the question – so wondering if it was replacement or not?
- Not recognising when order matters and when it doesn't.
- Not identifying the total number of items when the information includes variables.
- Not using the variables to set up equations correctly; or treating them as values.
- Not treating, for example, x^2 as distinct to x when gathering terms.

Question 11

Part (a) discriminated well, and a number of students did not attempt it, or substituted into y rather than using differentiation. Where students knew to apply differentiation, it was answered well with suitable care taken to include enough working to gain the method (and on occasion the accuracy) marks.

The table in part (b) was generally completed correctly although often students would round the 0.0625 to a value with too little (or incorrect) accuracy.

In (c) the plotting of points from the table was mostly accurate and smooth curves were drawn well. However, the majority of students failed to realise that they need to find and plot the minimum, leading to maximum score of 2 marks in part (c), which then also caused problems in part (d). The last point in the table was also the least likely to be plotted accurately.

In (d) where the straight line was drawn correctly there was often no overlap with the curve due to the missing minimum point so no possible critical values could be found. Where the minimum was plotted and included in the curve in (c), students almost always then gained full marks in (d). This part, however, frequently scored zero marks.
Common errors:

- Some appeared not to know differentiation, or at least what it was used for in part (a).
- The importance of a minimum/maximum for accurate curve sketching.
- The use of two lines / two curves etc for identifying common regions

Question 12

Overall, the full range of marks was awarded in this question, with very few students scoring zero marks but also few scoring full marks.

Part (a) was generally answered well with the most common error being to state the excluded value from the domain as either 0 or 5.

Part (b) was generally well done too. Occasional errors were incorrectly finding g(8) and calculating 20 / (5+8) rather than forming an equation in k (or x).

Less able students started to struggle from part (c) onwards. Most students did not find $\mathrm{g}(-3)$ then use this value in f even though this would have been easier; most attempted to find an expression for $\mathrm{fg}(x)$ and then substitute $x=-3$. Those students that did think to substitute -3 into the given equations, often substituted into f(x) first rather than g(x).

Part (d) was rarely fully correct. Those that 'completed the square' made some progress but taking out the factor of 2 and then creating a correct square to isolate x was rarely seen. The majority of students were unable to rearrange the quadratic equation to make x the subject. Common errors: writing $x(x-2)=\ldots$, dividing by x then disregarding it as part of the inverse. Those that attempted this part using the quadratic formula rarely included the y in their constant term.

Less able students did not attempt part (d), or (occasionally) gave the reciprocal of f as the inverse.

Those that used h(1.7) = f(2.5) in part (e) were generally successful in scoring most of the available marks. Those that substituted h(1.7) into their inverse struggled to simplify, with numerical, sign and algebraic errors appearing. The majority of students who attempted to answer this part used their inverse function from (d) and in most cases (due to errors in (d)) limited the marks that were available to them. Surprisingly few students realised that this part could be answered without needing to calculate the inverse required in part (d), i.e., that $\mathrm{f}^{-1}\mathrm{h}(1.7)=2.5$ could be rearranged to h(1.7) = f(2.5). In fact, this was the simplest method and consistently achieved the correct final answer when applied.

Common errors:

- Giving the answer to part (a) as ≠ -5 which while condoned was the exact opposite of what was required.
- fg(x) being interpreted as f(x) multiplied by g(x).
- f^{-1} being interpreted as the reciprocal of f.
- Isolating x^2 and taking the square root as being sufficient to find the inverse, despite other x terms being present in the expression – so not understanding the need to completely isolate the variable.
- Difficulties with the quadratic formula: not dealing with the square root part correctly, particularly when it is not purely numerical.
- Not recognising that $\mathrm{f}^{-1}(x)=y$ is equivalent to $x=\mathrm{f}(y)$.

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