Questions matter

A-level

Mathematics

7357/3

Report on the examination

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General

It was encouraging to see similar levels of performance in both the Pure and Statistics sections of the paper. However, student performance declined slightly compared to the previous examination series, which is largely driven by responses to qualitative or explanation-based questions. As seen in previous years, many students continue to struggle to score full marks on these types of questions. Attention must be paid when rounding values from calculators because careless rounding can lead to lost marks. Overall, while the paper provided good opportunities for students to demonstrate their skills, greater focus on reasoning and interpretation remains essential.

Section A Pure Mathematics

Question 1

This question was answered correctly by a high proportion of students, indicating a good understanding of irrational numbers and counterexamples. Many students correctly identified $\frac{1}{\pi} \times \pi = 1$ as the counter example, recognising that although both $\frac{1}{\pi}$ and π are irrational, their product of 1 is rational, thus disproving the original statement. The most common incorrect response was the third option.

Question 2

This question was answered correctly by a high proportion of students who recognised that the inverse tangent function has horizontal asymptotes at $y = \frac{\pi}{2}$ and $y = -\frac{\pi}{2}$. Most students correctly identified $a = \frac{\pi}{2}$ as the correct value. The most common incorrect response was the second option.

Question 3

This question was answered correctly by a high proportion of students, indicating a strong understanding of the exponential function. Many students correctly identified that the function is increasing and convex. The most common incorrect response was 'increasing and concave' which suggests some confusion between the terms concave and convex, particularly in interpreting the sign of the second derivative.

Question 4

Part (a) was generally well answered, with many students arriving at the correct solution. The most common errors included leaving the expression in the form $2\log_a a$ or incorrectly simplifying the final answer to 1. Several students appeared to misunderstand the question and attempted to solve for a, incorrectly setting up equations or inequalities. This suggests that while most students are confident with basic logarithmic manipulation, a few misinterpreted the intent of the question.

Many students correctly applying logarithmic laws and relevant identities to reach a numerical answer in part (b). However, several common misconceptions were observed. These included misapplying logarithmic rules such as writing $\log_a x - \log_a y = \frac{\log_a x}{\log_a y}$ or errors when converting between fractional and negative indices, and failure to recognise key identities like $\log_a a = 1$. Some students also made basic arithmetic mistakes, particularly with signs and fraction. For example, incorrectly calculating $\frac{1}{2} - -2 = -\frac{3}{2}$. An alternative method, used by some students, involved selecting a specific value for a and evaluating the expression using a calculator. This approach led to the correct answer and is entirely valid for this question. It also provides a useful strategy for all students to verify their final answer, even when using standard logarithmic laws.

Question 5

This question was answered reasonably well, with most students able to score at least one mark. However, a significant number of responses were not given the full mark, often due to overlooking the condition $x \leq 0$ or confusing it with inequalities such as $x \geq 0$, $y \geq 0$ or $y \leq 0$. The most common incorrect responses involved shading only region I or shading both regions I and II. It was also noted that many students used pen to shade their answers, which made it difficult to correct mistakes when errors were identified by students. While credit was given to those who carefully redrew the diagram on additional pages or clearly indicated which region should be marked, in some cases, marks were lost where the shading could not be confidently interpreted and had to be assessed as presented.

Question 6

There were many correct responses to this part (a). Most students adopted one of two common approaches: either expanding individual binomial terms such as ${}^5C_1 \times 2^4 \times (-3x)$ or factorising the expression as $2^5(1 - \frac{3}{2}x)^5$ and then substituting into the formula. In both methods, the most frequent errors involved incorrect signs such as using $(3x)$ or $\left(\frac{3}{2}x\right)$ instead of the correct negative expressions, leading to incorrect values such as $p = 240$. Other common mistakes included arithmetic slips, such as failing to multiply by 2^5 or ${}^5C_1$. It was also common to see students write down and substitute into the binomial formula incorrectly. Students should be reminded to refer to the formula booklet and double-check their substitutions and calculations carefully to avoid these avoidable errors.

In part (b), a significant number of students simply evaluated $1.94^5 = 27.47949$ directly using a calculator, without showing the required method. Most students recognised that they needed to use $(2 - 3x)$ and 1.94 to find a value of x for substitution into their expansion. While some correctly determined x = 0.02, common errors included calculating x = 0.06 or using x = 1.94 directly. Students should be reminded of the importance of clearly showing full working. In many cases, where an error was made in part (a), the method mark for part (b) could only be awarded if the working was visible and logically followed from earlier steps. Without this, marks were often lost. Among those who correctly found x = 0.02, some went on to make calculation errors, failed to round their final answer to the required number of decimal places, or substituted into too few or too many terms, despite the instruction to use four terms, as implied by the word '*hence*' in the question.

Question 7

Most students scored full marks on this question. The most common and successful approach was to identify the three correct terms of the arithmetic progression, equate their sum to 57, and solve to find a = 7. Students who used alternative but valid methods to find a = 7 typically earned the method mark only, often due to errors in their working or incorrect final answers. The majority of students were able to correctly identify the first three terms, form an appropriate equation, and solve it accurately. However, those who attempted to use the formula for the sum of the first n terms were more prone to making mistakes, usually through incorrect substitution or misinterpreting the values of n, a and d. Some students attempted less conventional approaches such as $a\sum_{r=1}^{3} r + \sum_{r=1}^{3} 5$ a which often led to errors, for example producing equations like 6a + 5 = 57.

Question 8

Most students scored full marks on part (a). The most common and effective approach to finding the values of A and B was to express the left-hand side as a single fraction with a common denominator, then equate numerators. Many students then substituted convenient values, typically $x = -1$ and $x = -\frac{1}{2}$ to solve for the constants. Another successful method involved comparing coefficients after expanding and rearranging, leading to a system of simultaneous equations such as $2A + B = 1$ and $A + B = 0.$, which many solved correctly.

In part (b), the most common approach involved correctly integrating each term and then evaluating the definite integral by substituting $x = 4$ and $x = 0$ separately. A frequent error was the incorrect integration of $\frac{1}{2x+1}$ to obtain $-\ln(2x+1)$ or $-2\ln(2x+1)$. Sign errors occasionally appeared during the integration process, particularly in forming the integrands. Another common misconception was simplifying $ln5 - ln3$ incorrectly as $ln2$, showing a misunderstanding of logarithmic rules. A significant number of students also omitted showing the substitution of $x = 0$, which is an important part of a complete and clear solution.

Question 9

Most students were able to score at least one mark on part (a). The most common correct approach was to describe the transformation as a stretch in the y-direction with scale factor 3, followed by a translation or the reverse order, both of which were acceptable. However, a number of students made errors in describing the translation, with common incorrect vectors including $\begin{pmatrix}-4\\0\end{pmatrix}$ or $\begin{pmatrix}0\\4\end{pmatrix}$. Some also incorrectly described the stretch as having a scale factor of $\frac{1}{3}$, reversing the effect of the transformation. Some students did not use the correct terminology for transformations. For example, describing a translation simply as "a move to the right" is not sufficient at this level. Students should be reminded that accurate mathematical language such as specifying the type of transformation, direction, scale factor, and translation vector is essential for full marks.

In part (b), the most common error was giving the equation y = 4 or $y = 3$ or $x \neq 4$ or y=0, indicating a misunderstanding of the nature or position of the asymptote. Part (c) proved challenging for many students. Many recognised that an asymptote existed but failed to specify that it lay between x = 3 and x = 5, which was necessary to earn the first explanation mark. While some students noted the presence of a vertical asymptote or a discontinuity, they often did not relate it clearly to the interval given. Very few students identified that multiple solutions could exist within the stated domain, which was required for another mark. Although some referred to the interval being "large" or mentioned the possibility of "multiple sign changes," these observations were not sufficiently contextualised. A proper explanation was needed to show an understanding that more than one solution could occur due to the function's behaviour within the domain. The most common partial success came from recognising that an asymptote lay within the interval. However, many responses lacked the depth or clarity required for a full explanation.

Question 10

Part (a) was mostly answered well, with most students gaining full marks. Only a minority failed to express the final answer in the required form, thereby losing the final mark. Some students used approximations such as decimals for √29 or gave their answers in radians instead of degrees, contrary to the instructions. Most students were able to gain at least two marks for correctly identifying the values of R and α. However, those who did not explicitly write $R\sin\alpha = 5$ or $R\cos\alpha = 2$ often resorted to using the incorrect relationship $\tan\alpha = \frac{2}{5}$, indicating a lack of conceptual clarity.

In part b(i), few recognised that $\sin(d+\alpha)$ must be maximised at 1 and therefore deduce $d = 90 - \alpha$. The expression inside the sine function must equal 90, leading to the correct deduction that $d{=}90{-}\alpha$. Many gave rounded or whole number answers without justifying them using the relationship $= 90 - \alpha$, resulting in no credit being awarded. Not many students recognised the need to minimise sin(d+68.2) in part b(ii). These students correctly identified that the minimum value of the sine function is –1 and therefore deduced were able to deduce the correct answer of 19.6. The most common incorrect answer was 14.2.

In part b(iii), most students were able to gain the first method mark by correctly equating the model to 15. For the second method mark, most showed some success in rearranging the equation, although a concerning number made errors when handling the negative sign, particularly when isolating the sine term. Many students who initially began with an inequality reverted to an equation partway through, often due to a lack of confidence in manipulating inequalities or recognising that solving the equation would give the values of angles. A common error was failing to realise that two valid positive angles were required. Those who did manage to correctly identify both positive solutions were usually able to complete the final step, subtracting the values and dividing by 7 to determine the number of weeks successfully.

Question 11

Part (a) assessed students' ability to translate a real-world situation into a mathematical model. Many students found it challenging to meet the requirements of the 'Show that' instruction, particularly in structuring their reasoning and presenting a clear, logically sequenced solution. To earn full marks, students needed to establish a correct proportional model involving $\frac{dV}{dt}$, a constant of proportionality and the surface area, then substitute the given values to determine the constant. This should have been followed by substituting back into the model and explicitly stating the printed result in the final line of working. The most frequent error was failing to recognise that the volume was decreasing, and thus incorrectly substituting +7 rather than −7 for $\frac{dV}{dt}$. In many of these cases, students went on to make a compensating sign error, arriving at the correct final equation from incorrect method. Most students attempted to find an explicit expression for the surface area of the cuboid, although a significant number made algebraic or structural errors in doing so. A small minority of students took a more sophisticated approach, noting that the surface area was proportional to x^2 and using this to derive the result without explicitly expressing the full surface area formula. While this method was valid and efficient, it required students to clearly state the proportionality between surface area and x^2 to earn full marks, something that was often omitted, resulting in incomplete justification.

Many students were able to correctly formulate an expression for the volume in terms of x and then differentiate it with respect to x to obtain the correct derivative in part (b). Where errors did occur, they were typically minor numerical or algebraic slips. A common example was incorrectly stating the volume as $V = 8x^2$, which then led to an incorrect derivative of

$\frac{dV}{dx} = 16x$. Despite such errors, most students demonstrated a sound understanding of the differentiation process.

Part c(i) allowed students to apply any correct form of the chain rule, and those who successfully substituted the relevant expressions were awarded the first method mark. It was encouraging to see that many students approached this with greater confidence than in previous sessions, and a significant number applied the chain rule correctly. Where errors did occur, they were most commonly associated with handling reciprocal relationships for example, using $\frac{dx}{dV}$ instead of correctly manipulating the chain rule to find $\frac{dV}{dx}$ or vice versa.

The interpretation question in part c(ii) was not answered well, with many responses lacking the precision required to gain full marks. Students needed to interpret their result clearly in the context of the cuboid, specifically referencing the side lengths. However, many responses failed to do so, instead incorrectly referring to the rate of change of surface area or volume. A correct interpretation also required recognising that the lengths were '*decreasing at a constant rate*', and very few students included both key terms 'decrease' and *'constant'* in their explanation. In addition, students were expected to state the correct numerical rate, following through from their answer in part (c)(i), and include appropriate units. A common error was omitting units entirely or using incorrect units due to a failure to extract the relevant information from the question. Students who stated that the lengths were decreasing at a negative rate were also penalised, as this is not appropriate terminology in this context. This highlights the importance of fully interpreting and communicating the meaning of mathematical results within a modelling framework.

Question 12

This question was not well answered, with very few gaining the full marks. However, it was encouraging to see that many students demonstrated a general understanding of the structure and intent of a proof by contradiction. However, difficulties arose in executing this method accurately and rigorously. A frequent issue was with the initial assumption as many students did not fully negate the original statement. For example, responses often stated "at least one of a or b is rational" rather than assuming both are rational as required. Others set c as rational but made no adjustment to the irrational status of a or b, which weakened the foundation of their argument. Some students instead resorted to inappropriate methods, such as introducing numerical values such as assuming $c = \sqrt{m}$ and proceeding with a proof structure more suited to showing that a number like $\sqrt{2}$ is irrational. Another common technical error occurred when students attempted to combine rational numbers. While many correctly began with products of rational numbers such as $\frac{d}{e} \times \frac{f}{g}$, they often followed this with incorrect algebra, such as writing the sum as $\frac{dg+ef}{eg}$, demonstrating confusion about fraction operations. Students should be mindful when choosing variable names, as many reused the letters a, b, and c from the question, leading to confusion in their arguments. Of the students who successfully reached the correct assumption and logical contradiction, most went on to gain the final mark. However, some lost this mark due to incomplete conclusions. To earn full credit, students must clearly state the outcome of their reasoning, explain why it constitutes a contradiction, and then explicitly conclude with the original statement being proven. Precision in language and logical structure is essential in this type of question.

Section B Statistics

Question 13

This question was answered correctly by a high proportion of students, indicating a sound understanding of the concept of correlation coefficient and how it is represented in scatter diagrams. Many students correctly identified that a product moment correlation coefficient of 0.47 indicates a weak positive correlation and therefore selected the bottom-right diagram. The most common incorrect response was the top-left diagram, which suggests some confusion between strong and weak correlation, as that diagram depicts a much stronger positive relationship than 0.47 would represent.

Question 14

This question was answered correctly by a high proportion of students, indicating a good understanding of the properties of the normal distribution. Many students correctly recognised that approximately 95% of the data in a normal distribution lies within two standard deviations of the mean and therefore selected the correct interval. The most common incorrect response was the first option.

Question 15

The vast majority demonstrated accurate calculator use and obtained the correct value in part a(i), a(ii) and a(iii). There was some incorrect rounding of final answers, with some students giving too few or too many decimal places, or truncating instead of rounding correctly. Students should be reminded to follow any specified rounding instructions carefully, or to provide answers to a sensible degree of accuracy where none is given.

In part (b), only a small proportion of students were awarded the mark for the contextualised response. The most common successful answers were clear versions of the statement that 'the probability of a diner being vegan remains constant.' However, many students gave incomplete or insufficiently contextualised responses. Common incorrect answers included vague or generic statements such as 'there are two outcomes' or 'the probability is the same each time' or 'they are independent.' While these reflect some awareness of the conditions required for a binomial distribution, they lacked the necessary context such as referring explicitly to diners and being vegan to score the mark. The most frequent misconception remained the idea that the probability is independent, which reflects confusion between the concept of independent trials and the notion of constant probability.

Question 16

The most successful responses in part a(i) identified that one small square on the histogram represented 10 individuals and correctly estimated the number of individuals between 3 km and 5 km as 190 by counting 19 such squares. Many began by rearranging the formula frequency density = frequency ÷ class width only to realise that no numerical values were provided on the frequency density axis. When attempting to calculate the area of each rectangle to estimate frequency, a number of students made arithmetic or conceptual errors - either miscalculating the area of one or more bars or incorrectly summing the relevant areas. These errors were compounded when students used their total area to scale the value to 340 individuals, often dividing 340 by their incorrect area and producing unrealistic answers. In such cases, some students attempted a valid alternative approach by estimating the total number of tiny grid squares (typically recognising there were 850), but were then unable to link this to the correct number (475) that corresponded to the region between 3 km and 5 km. Very few students gave a fully correct response to part a(ii) and it was rare to see an answer as concise and precise as that provided in the mark scheme. Among those who were on the right track, many failed to refer explicitly to distance, instead commenting that the individuals were not evenly distributed, demonstrating a misunderstanding of what the histogram represents. The most common incorrect responses included vague or unrelated statements such as 'the data is discrete' or 'the data is continuous' which shows confusion between data types and the specific context of why the histogram's bars are of unequal height.

Most students performed poorly on part (b) in stating correct negative skewness. The most common incorrect responses were 'positive' or 'skewed to the right' indicating a misunderstanding of how skewness is determined from a histogram. Several students also gave vague or incomplete responses such as 'it is not symmetrical' which, while partially descriptive, did not address the direction of the skew and therefore did not earn the mark. In part (c) most students did not demonstrate a clear understanding of the purpose of frequency density in this context. It is common to see incorrect responses, such as stating that the data was discrete or continuous, or offering vague reasoning like 'it's easier to draw' or 'because there's a lot of data.' The correct responses such as 'the class or group intervals are of different widths' or 'it gives a more accurate or better representation of the data' were rarely seen.

Question 17

Most students answered parts (a) and (b) correctly, successfully calculating both the mean and the variance from the given data set. For part (c), most students were able to calculate the mean and variance of the sample data correctly. However, a common issue was the failure to provide a single, overarching conclusion as required. Instead, many students separately commented that the *mean* supported the teacher's belief while the *variance* did not, without clearly stating whether the Binomial model was appropriate overall. This lack of a definitive conclusion meant that the final mark was often not awarded. Only a small number of students adopted the alternative and equally valid approach of forming and solving simultaneous equations in n and p using the sample mean and variance.

In part d(i), most students correctly identified the sampling method as either *opportunity* or *opportunistic* sampling. However, a notable proportion gave incorrect responses, with common errors including random, quota, stratified, or systematic sampling. The majority of students scored the mark in part d(ii) by stating a valid advantage such as the method being quick, easy, or cost-effective. However, a significant number gave disadvantages instead of advantages, despite the question's clear wording. In some cases, students focused on *bias* or representativeness, relevant concerns but not advantages and thus did not receive credit.

Question 18

While many students produced correct responses to part (a), it was evident that a substantial number were unsure of the correct approach, and a significant proportion did not attempt it at all. Among those who answered successfully, most calculated the lower and upper quartiles using direct functionality on their calculators, which greatly simplified the process and led to efficient and accurate answers. This highlights the importance of being familiar with calculator features and using them effectively in statistical questions. Once the lower and upper quartiles had been correctly identified, many students were able to calculate the interquartile range (IQR) successfully by subtracting the two values. However, it was surprising to see how many students were unable to complete this final step, either due to arithmetic errors or a lack of understanding that the IQR is simply the difference between the upper and lower quartiles. Common error includes leaving the answer as a range such as $a < IQR < b$ or misconception that the IQR is the probability such as $P(4.89 < x < 6.51) = 0.5$

Most students correctly stated the null and alternative hypotheses in part (b). However, a few responses incorrectly used symbols other than the μ, such as $\bar{x}, p\ or\ \rho$, or an incorrect inequality sign for H_1. The most common error with the hypotheses was to use 5.6 rather than 5.7. It was more common to see students using the probability method to answer this question, and this approach was generally applied very successfully. However, the test statistic method was more prone to error in this case. A frequent mistake involved using the formula incorrectly, such as calculating $\frac{5.7-5.6}{1.2\div\sqrt{120}}$ leading to a positive value. As the comparison required students to compare a negative test statistic with –1.65, this mark was often lost. Many students were then able to draw the correct conclusion that H_0 should not be rejected and went on to provide a well-worded contextual interpretation. These responses often included appropriate wording such as 'suggests' as well as key terms required by the question. However, the word 'mean' was frequently omitted, which is essential for a complete and accurate conclusion. Students must be aware that when a word is given in bold in the question, it must be used explicitly in their conclusion. Alternative phrasing such as using words with a similar meaning to 'reduced' were not accepted, and marks were lost as a result. Precision in wording is critical in statistical conclusions, particularly in hypothesis testing.

Question 19

Part (a) was largely answered correctly. In part (b), many students were able to complete the Venn diagram successfully, and most students gained at least one mark for correctly identifying the first value. Some students showed confusion over whether to add or multiply in part (c). A common weakness was the inability to accurately match compound set notation to the corresponding regions on the Venn diagram. Many students appeared to struggle particularly with decomposing the expression given $[(X \cap Y) \cup (Y \cap Z)]$ into its constituent parts $(X \cap Y)\ and\ (Y \cap Z)$ before recombining them using the union.

In part (d), if the correct formula was identified, students were generally able to calculate either the numerator or the denominator correctly. Many demonstrated a solid understanding of conditional probability. Even when their interpretation of the probability expressions on the Venn diagram was inaccurate, a significant number still earned the method mark by correctly stating $P(Y'|Z') = \frac{P(Y' \cap Z')}{P(Z')}$. Most accuracy marks were lost due to students struggling to locate the region corresponding to $Y' \cap Z'$ on the Venn diagram. Many students were unable to recall or apply the independence condition fully in part (e). It was common to lose the final reasoning mark, which was often due more to imprecise written communication than to a lack of understanding. For example, students frequently wrote $0.38 \times 0.12 \neq 0.07$ without clearly evaluating the multiplication. Similarly, comparing a fractional probability with a decimal without converting one to match the other was another frequent cause of lost marks.

Question 20

Most students were able to state the correct probabilities in parts (a), (b) and c(i). Few recognised that the normal distribution is continuous in part c(ii). Common responses include stating no limits in the normal distribution or stating that P(F = 0.6) is approximately zero rather than explicitly stating it is zero in a continuous distribution. Furthermore, many failed to realise that the question required a specific explanation relating to the given model, and instead gave a generic response such as P(F = x) =0. In part (d), while some students continued to rely on a direct comparison of the means such as 'the mean in 2010 was less than the mean in 2000, so emissions have reduced over time' there was an improvement in the number of students who addressed the standard deviations with appropriate contextual interpretation with many students correctly identifying and articulating that the 2010 cars showed 'greater variation' in emissions compared to the 2000 cars. Few students were able to provide a generalised statement about the means of nitrogen oxide emissions, often defaulting to a simple, year-on-year comparison.

In part (e), some students made irrelevant comments, such as suggesting that certain cars did not produce nitrogen oxide emissions or referring to electric vehicles in the Large Data Set (LDS). Few students recalled that there were missing values in the dataset. The most common incorrect responses included references to 'cars with a mass of 0 kg' or 'incorrectly recorded values', rather than identifying the presence of missing data as the intended explanation. Many students simply stated that there were only five car brands without naming them in part (f). Some students incorrectly stated that there were few Nissan cars included in the LDS or that data was only collected from three regions.

Mark Ranges and Award of Grades

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