



Level 3

Mathematical Studies

1350/2C Graphical Techniques

Report on the examination

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Criteria used to award marks

There were several items in the exam where follow-through from previous question parts was expected. Question 4 was marked in its entirety to allow such follow-through, and students were not impeded by any incorrect values from part (a) or (b)(i). Incorrect independent marks could also be used in subsequent method, for example Question 5 allowed many marks to be accessed even if an initial graph reading was incorrect.

Several items on the paper required a conclusion (i.e. validating a statement) and the majority of students remembered to do this when commanded.

Question 1

The vast majority of students were able to identify the correct multiple-choice response on **part (a)**, with the majority of incorrect responses selecting the incorrect denominator.

In **part (b)**, about half of students were awarded full marks. Use of time proved problematic for many. The misconception that a time such as 6m23s can be expressed as 6.23 was common. Using this notation would unlock one of the ranges successfully as the numbers were forgiving but not the other, and so the accuracy mark would be lost.

The explanation required for the critical analysis in **part (c)** was less well attempted. The most common correct answer was that a value had been used twice. Of those who put forward adequate reasoning, more than half could also provide the ideal answer. Incorrect explanations were either too vague, for example stating “a mean was calculated” with no reference to data; or were contradictory to the data itself.

Question 2

Part (a) was very well attempted. Alternative method 1 was the most common correct response by calculating and comparing proportions directly. Incorrect answers would often stem from comparing irrelevant values from the preliminary material. A minority of students misinterpreted the values as not being approximately equal.

Part (b) was again well attempted, with most students able to identify AC Milan as the correct football team and then using alternative method 1 as the most common and reliable route to success. It was more common for the other methods to be incomplete. Students who declared Real Madrid to match the ratio were awarded SC2 providing full equivalent working was shown.

Very few students scored the mark in **part (c)**. The question commanded an example calculation, and a minority of students did not attempt to provide one. For those who did, two common errors recurred: first, totals that summed to 715 or 714.5 (for example, $303.8 + 319.8 + 90.9$), and second, correct overall sums paired with one figure falling outside the valid range (for instance, $304 + 320 + 90$).

Part (d) required two reverse percentage calculations, from which a difference would be calculated. Students were very successful in reversing the 16% increase. By contrast, reversing the 6% decrease was not attempted well, typically treating the 2021/22 figures as the original amount and calculating 144×1.06 . Method had to be shown (as commanded in the question) given invalid methods could also lead to a rounded answer of €80m.

Part (e) was generally answered well, with many students earning both marks. The most frequent criticisms identified missing labels or suggested the use of 3D can distort interpretation. Among those who scored only one mark, the typical error was to repeat essentially the same criticism twice (for example, “missing y-axis label” and “no currency units”), or to make incorrect observations such as “there are no gridlines.”

Students who recognised the need to calculate a mean generally gained both marks in **part f(i)** by showing a correct working and arriving at a value close to –€50 million. Errors occurred when students omitted essential steps or confined their calculation to the four loss-making clubs only. A significant minority did not attempt any statistical computation, instead commenting on individual club losses, and so did not score.

The most common successful answer in **part f(ii)** was to identify Paris Saint-Germain as an outlier whose large loss unduly influences the mean. Some students hinted at the presence of an outlier without naming PSG and consequently did not score. Incorrect responses often noted simply that not all clubs incurred losses, which did not address the question of the mean’s sensitivity to extreme values.

Questions 3-7 – General Comments

Questions 3-7 were unique to paper 2C and addressed all specification references from G1.1 to G8.2. Some larger mark items (question 4b(ii) and question 5(a)) increased the level of investigative work and challenged the problem-solving skills of students. The distribution of the number of marks awarded on these items evidenced the majority of students could access the methods but were still challenged. These items were shown to differentiate out the top performing students.

Question 3

Part (a) was an MCQ that saw the most common response being that of the correct graph, however this was identified by less than half of students. The three other options were all selected by a significant number of students, but the most common incorrect was second graph that did not intercept at the origin.

In **part (b)**, the majority of students correctly took a graph reading at 200 cm leading to two marks for identifying a size of 48 inches. Less than a quarter of students then interpreted this reading in context to the question and additional information, requiring a deduction that the largest available TV within that parameter would be 43 inches.

Question 4

In **part (a)** the majority of students did correctly establish the coefficients of the linear equation. The independent mark for identifying the constant was obtained easily providing the correct column from the table was used. Students who could not establish the gradient commonly tried using the value 10 in their working in some form, but did not apply it as a division to the difference in readings between 2011 and 2021.

Part (b)(i) was also very well attempted and identifying values of Y from the context did not prove a hindrance. Errors generally only occurred in either forgetting to round values as commanded or doing so incorrectly. The most common incorrect score was therefore 2 marks.

Part (b)(ii) required students to demonstrate four skills: exponential graphing, linear graphing, intersection reading and interpretation. As a large-mark item there was high variance in the allocation of marks. The majority of students could plot their points from the exponential mode and join them into a smooth curve.

There was less success in plotting the linear equation from part(a), although extending a line through two readings from the original data table was commonly done to recover from an incorrect part (a) and was awarded.

Marks lost for the linear plot were from either not extending the line to the domain stated in the question, or from the misconception that the linear plot should simply be a horizontal line at $N=350$ (assumedly taken as 50% as 700, the maximum value on the axis).

There were a significant number of non-attempts at drawing the linear plot. Of those who did draw two valid plots, the majority knew to take an intersection reading, but only about two thirds of students went on to interpret this as a calendar year to obtain the accuracy mark.

The one mark available on **part (b)(iii)** was awarded to less than half of students, with the most common incorrect responses being that reliability is due to either rounding of values of accuracy of the graph.

The majority of students could obtain one mark on **part b(iv)** by either describing the rate of one of the functions correctly, or by stating that the exponential curve always had a larger rate of increase.

A very small minority explained that the linear model has a constant rate, and the exponential an increasing rate.

The language used by students was often vague and it was apparent that many could not differentiate or communicate effectively the difference between the actual values increasing and the rate of change increasing/remaining constant.

Question 5

Part (a) was generally well attempted with more than one third of all students scoring the full seven marks, and over half scoring five marks.

The question required the comparison of two speeds. The estimated walk speed calculation proved most problematic for students. It should have been calculated using a time value from Naismith's formula that in turn required graph readings. Common issues from this procedure included inaccurate graph readings, or not realising the distance was applicable to the whole walk (typically taking $d=9.5$ rather than $d=19$).

Many students who calculated the time correctly from this formula assumed their answer from the formula was a value of speed, without realising further work was required. In these cases, the E1ft mark for comparing speeds could not be awarded as it led to an invalid comparison. The majority of students could calculate the true speed correctly, but again there were a significant number of errors reading the graph scale.

Part (b) was not very well attempted. Incorrect conversions between km and metres were common, as was dividing the wrong side of the ratio such that the unit value represented the incorrect variable.

Question 6

Part (a) was the lowest scoring item on the paper. Less than 15% of students identified the acceleration as zero, and less than half of these responses could provide valid reasoning that specifically referred to the graph (as commanded).

The majority of responses that attempted to justify zero acceleration simply stated the person was travelling fastest at this point (implying they could not accelerate any further), but this repeats the wording of the question itself and does not refer to the properties of the graph. The most common incorrect numerical responses came from an attempt to take an average acceleration between 0s and 0.45s, often coupled with the reasoning that the graph is steepest in this period.

Part (b) was a typical instantaneous acceleration question requiring a gradient to be taken from a tangent at $t=4s$.

Only one third of students were able to complete this task successfully which is unusual for this type of item.

The mark scheme did allow a method mark from invalid tangents, making the question more accessible to some students who either took a tangent from an invalid point, or at an angle that would be out of range for the final answer.

A significant number of students took an average reading between $t=0$ and the peak at $t=4.45$ and this would score zero marks.

This item had the largest proportion of non-attempts on the paper.

Question 7

Part (a) was well attempted with more than two thirds of students scoring, and around 40% awarded the full four marks.

To access marks on this question, students had to either identify the coefficient $A=250$ or begin to manipulate the algebra of the exponential model.

There were a significant number of students who attempted to use logarithms but did so incorrectly. Those who attempted to take a logarithm of the full equation generally could not follow through with correct manipulation as they could not apply any appropriate logarithm laws (this would be awarded as equivalent method).

The majority of students that did a division prior to applying natural logs to both sides of the equation generally had success.

Although correct final answers from trial and improvement methods could be awarded, the question did not lend itself well to this technique and there were very few students attempting to do so.

Part (b) was difficult for students to provide adequate reasoning. One quarter of students did access one of the two marks.

The most common route to one mark was stating that the exponential formula should have been used.

A significant number of students decided that numerical validation was necessary despite the question stating a calculation is not required. Although the mark scheme allowed a validation it was often incomplete, with the majority of zero-mark responses simply stating that 2220000×1.3 was required (to calculate the correct number of Scoville units) with no reference or further work to show how this equates to the heat rating.

Particular strengths of students' responses

Students generally remembered to give conclusions when commanded. Larger mark items were being attempted with the majority of students showing enough work to award partial credit even if the final answer was not obtained. Competency of using technical skills such as using logarithms have been demonstrated.

Particular aspects of less successful performance or misconceptions

Less sufficient unit conversion and incorrect use of time was evident on several items. Reading from graph scales still causes problems particularly if (for example) a minor grid square represents 0.4 units. Other numerical skills from prior learning remain a hindrance particularly reverse percentages that often features on the common questions.

Reasoning questions and communicating using mathematical language remains a challenge for many students; this is particularly true for recognising the properties of rate of change.

Elements of question command are being ignored. For example, if an item asks a student to reference the graph it will be a requirement of their explanation to access marks. When working with gradient of acceleration, students should take note of the wording average or instantaneous.

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the [Results Statistics](#) page of the AQA Website.