MATHEMATICAL STUDIES

Overall grade boundaries

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 16	17 - 30	31 - 44	45 - 58	59 - 72	73 - 84	85 - 100

Standard level project

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 4	5 - 6	7 - 8	9 - 11	12 - 14	15 - 16	17 - 20

Range and suitability of work submitted

This session there was a wide range of work submitted and the majority of the titles were suitable. Even more projects than usual were of a statistical nature but other areas covered included modelling, measurement, financial mathematics, calculus, trigonometry and geometry.

Many of the projects involved questionnaires. A copy of the questionnaire was not always included with the project. In some cases the candidate did not include any raw data, making it impossible to check the calculations.

More and more candidates are using technology to do the mathematics for them and often do not do any mathematics themselves. Any mathematical processes using technology only is considered simple. Also some candidates perform processes and then fail to comment on their results. This has the result of leaving the moderator to wonder whether or not the candidate really understood what they were doing.

When using the internet the candidate must remember to include the web address in their bibliography. More candidates are now including a bibliography.

The length of some projects was also a cause for concern. They varied from 1 or 2 pages to well over 50 pages. It is stated that the length of the project should not normally exceed 2000 words (excluding graphs, appendices and bibliography). There is no lower limit stated, but a project would have to contain several pages if it were to satisfy all the assessment criteria. This year there was an increase in the number of candidates who scored less than 5 marks for their project. In most cases this was the result of an extremely incomplete piece of work.

Some teachers gave their candidates a “blueprint” to follow as all the projects in the sample had the same format and all used the same mathematical processes. This should be discouraged as the project then loses its originality.

The comments made by the teachers on the 5/PJCS forms were very clear and helpful. Teachers are also encouraged to write on the projects and indicate where the mathematics has been checked for accuracy.

Candidate performance against the criteria

A. The statement of the task was usually evident and most candidates described a plan that they would follow. It is important to actually follow the stated plan. If the plan is well documented, then the rest of the work flows from it. Candidates with clear statements of task and plan tended to be able to extract more depth from their projects because they knew what they were looking for. Not all plans were well focused. Some projects did not have a title.

B. The majority of candidates collected their data and set it up in tables ready for the analysis. Some candidates had obviously collected data (via a questionnaire or otherwise) but omitted to include this data in their project. If the raw data is not present then the moderator cannot check the accuracy of the mathematical processes used. A large number of candidates just downloaded data straight from the internet with little thought being given as to how much of that information was really relevant to their task. It is also important to state the website in the bibliography. Data varied from 2 pieces of data to well over 100 pieces. The candidates must realise that having a lot of data does not always mean that it has the quality needed to gain full marks in this section.

C. Many candidates only included simple mathematical processes in their projects. Many used technology only to perform sophisticated techniques without realising that this is considered as simple mathematics. Some candidates introduced mathematical processes that were totally irrelevant. When a scatter diagram indicates that there is no correlation between two variables then it is meaningless to go on and calculate the correlation coefficient or line of best fit. Also working out standard deviations without having a meaningful discussion on what the results indicate is of no value. This can actually result in the candidate losing marks. The most popular sophisticated process was the chi-squared test but many candidates and their teachers are not clear on this. The entries in the contingency table must be frequencies and the expected frequencies must not be less than 1 and no more than 20% between 1 and 5, otherwise the test is invalid.

D. Most candidates produced results that were consistent with their analysis but often these were rather brief. Few candidates produced detailed discussions. In many cases the conclusions were obvious and not very thorough.

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E. More candidates are now saying why they are using certain mathematical processes and are discussing the validity of these processes and the results that they have obtained. Unfortunately only a very few of the candidates do this thoroughly.

F. Most of the projects were well laid out, with many candidates recording their actions at each stage. It is important to ensure that the notation and terminology is correct. Many candidates lost marks this session due to errors in either notation or terminology.

G. The majority of the teachers appear to have awarded marks appropriately.

Recommendations and guidance for future teaching

Teachers can help their candidates in many ways:

- The project exercise should be introduced at an early stage in the course to avoid rushed and often poor work handed in just to satisfy a requirement
- Give them examples of "good" projects so that they know what is expected of them.
- Make sure that they are aware of (and understand) the assessment criteria
- Write full and clear comments on the 5/PJCS form
- Stress the importance of using appropriate mathematical notation
- Give candidates a second chance to correct errors
- Stress the significance of collecting sufficient data
- Encourage them to think up their own task and explain the plan thoroughly
- Tell them to include all raw data – but not <u>all</u> the completed questionnaires. A sample is sufficient as long as they gather all the data in organized tables
- Check that the mathematics used in the project is relevant
- Encourage the candidates to use more sophisticated mathematics
- If candidates are using technology then remind them that they are expected to give an example by hand of what they are doing before they start to do any mathematics on the calculator
- Explain to the candidates how to evaluate their work, draw conclusions, examine the mathematical processes used and comment critically on them
- Send the original work of the candidate to the moderator
- Meet with the candidates at regular intervals to monitor the progress of the project

Standard level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 13	14 - 27	28 - 39	40 - 52	53 - 66	67 - 79	80 - 90

General Comments

The paper appeared to be accessible and of appropriate length. The comments on the G2 forms were appreciative of the syllabus coverage and of the level of difficulty.

The areas of the programme and examination which appeared difficult for candidates

The question on number sets appeared to be difficult for many students. The logic question also proved to be challenging, with many students unable to distinguish between the converse and inverse of a statement and provide an example. Although it is a standard question, many students also have difficulty writing the equation of a straight line, even when they had the gradient and a point on the line. Many students found identifying the range of the function in question 11 quite challenging, as well as finding the coefficients of the quadratic function in question 13, and finding the conditional probability in question 14.

The areas of the programme and examination in which candidates appeared well prepared

The majority of the candidates showed good time management skills and very few questions were not attempted. Almost all students were able to find the mean, median and mode of a given data set, the area of a rectangle and the coordinates of the midpoint of two given points. The tree diagram was also completed by almost all students, as well as the box and whisker diagram drawn carefully with a straight edge. Most candidates were able to demonstrate good knowledge of the learned mathematical concepts and their applications.

The strengths and weaknesses of candidates in the treatment of individual questions

Question 1: Mean, mode and median

This question was well answered by most candidates.

Question 2: Number sets

About half of the students answered this question correctly. The placement of $\cos 120$ and π appeared to cause the most problems.

Question 3: Standard form, error and percentage error

This was generally well done except for missing or incorrect units. Most candidates could give their answer in standard form and find the percentage error.

Question 4: Arithmetic sequence

Most candidates recognized the arithmetic sequence and used the correct formula, although some used a list to find the answers. A significant number of candidates were unable to find the sum of the first 100 terms and attempted to find the 100th term instead.

Question 5: Median, mode and box and whisker plot

The box and whisker plot was well done, even when the students had incorrect values. Most candidates found the correct median but a few could not find the 25th and 75th percentiles.

Question 6: Calculus

This was a fairly standard question. However, some candidates found $f(-3)$ instead of $f'(-3)$. Quite a few candidates were unable to answer part (c) as they tried to find $f'(0)$ instead of finding x when $f'(x) = 0$.

Question 7: Logic

There was confusion among some students about which was the inverse and converse of the given statement. Part (c) was poorly done with very few students able to provide an example that shows that the converse is not always true.

Question 8: Currency conversion

Most students gained full marks on this question. However, some students found the required format of the answer in part (a) confusing.

Question 9: Tree diagram and probabilities

This question was answered well. A few students were unable to do part (c).

Question 10: Coordinate geometry

While parts (a) and (b) were answered or at least attempted with various success, few candidates made progress in part (c). Some candidates used the coordinates of point A or B rather than M and others could not find the gradient of the perpendicular line.

Question 11: Range of an exponential function

This question was generally answered well in part (b). Part (a) proved to be difficult to gain the maximum marks as, although candidates could find the end points, they did not seem to be able to identify the range of the function. Many students gave a list of values for the range, which indicates that this concept was not understood well.

Question 12: Exponential function

This question was well answered by many candidates, particularly part (a). However, a significant number of students lost a mark for rounding up rather than down in part (b). Part (c) proved to be the most difficult both for generating the equation and for solving it.

Question 13: Coefficients of a quadratic function

This question was one of the most difficult in this paper. Many students left this question blank, showed incorrect working or gave answers without any preceding working.

Question 14: Venn diagram and conditional probability

Part (a) was done well. Very few were able to answer (b).

Question 15: Compound and simple interest

This question was answered well by many candidates, with a majority of them gaining maximum marks. Some candidates used the proper formula but had done incorrect substitution.

Recommendations and guidance for the teaching of future candidates

- All relevant working should be shown in each question with the question part indicated in the working box. Follow through marks can be then awarded where appropriate.

- Proper labelling is necessary as much to help your quick review at the end of the exam as for the examiners when reviewing and marking your work.

- Understand all the relevant functions and use of GDC. There is no need for explaining how the GDC was used, i.e. which keys were pressed, etc

- Candidates should be reminded to check their answers to ensure they are reasonable in the context of the question.

- Candidates should familiarize themselves with previous papers, their format, and key terms that are used.

Standard level paper two

Component Grade Boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 14	15 - 28	29 - 42	43 - 53	54 - 64	65 - 75	76 - 90

General Comments

Most candidates attempted all the questions, though there were a number of trivial attempts at question 3. It was also clear that time was not an issue for the majority, and the better candidates were able to display their knowledge and skills, thereby achieving high marks. The examination was deemed to be an appropriate test of the syllabus by the majority of teachers submitting G2 forms.

A number of candidates lost marks in the “show that” parts of the questions. When candidates are required to reach a given answer that is written to a specified accuracy, they must write down that value with a higher degree of accuracy (unrounded value). Further, premature rounding resulted in marks being lost.

In the questions asking for angles it is becoming far less common to find candidates using their GDC in radians; this is an encouraging trend. Similarly, the loss of the correlation coefficient due to GDC reset is less of a problem than was previously the case.

The areas of the programme and examination which appeared difficult for candidates

- Formal differential calculus
- Trigonometric modelling
- Showing how to obtain expected values
- Implication in logic

The areas of the programme and examination in which candidates appeared well prepared

- Venn diagrams
- Formal logic other than implication
- Chi-squared test on the GDC

The strengths and weaknesses of candidates in the treatment of individual questions

Question 1: Trigonometry

Part A) This part proved accessible to the great majority of candidates. The common errors were (1) the inversion of the tangent ratio (2) the omission of the units and (3) the incorrect rounding of the answer; with 58° being all too commonly seen.

Part B) Again, this part proved accessible to the majority with a large number of candidates attaining full marks. However, there were also a number of candidates who seemed not to have been prepared in the use of trigonometry in non right-angled triangles. Also, failing to round the answer in (a) to the nearest 10m was a common omission.

Question 2: Sets and logic

Part A) This part was successfully attempted by the great majority. The less familiar form of the Venn diagram seemed not to cause too many problems, although a common mistake was the failure to add the 20 in set A in part (b).A surprising number seemed unfamiliar with set notation in (d) and thus were not able to attempt this part.

Part B) The work on logic also proved accessible to the great majority with a large number of candidates attaining full marks. The most common errors were the omission of the "If" in the conditional statement in (b) and the inability to follow the implication in the truth table in (c).

Question 3: Trigonometric modelling

This question was either very well or very poorly done and incomplete attempts were seen; there were very few "middle of the road" responses. This perhaps indicates a lack of preparation in this area of the syllabus from some centres, though it is recognised that trigonometric functions are one of the more problematic topics for the candidature.

Parts (a), (b) and (g) were well attempted by the great majority. Elsewhere, the responses were mixed. A number of perfect solutions were seen.

Question 4: Statistics

Part A) A straightforward question that saw many fine attempts. Given its nature – where much of the work was done on the GDC – it must be emphasised to candidates that incorrect entry of data into the calculator will result in considerable penalties; they must check their data entry most carefully.

(a) The use of the inappropriate standard deviation was seen, but infrequently.

(b) It is expected that the GDC is used to calculate the correlation coefficient; the covariance was given to aid those candidates for whom the reset process removes this function from the display. It is anticipated that this hint will not be given in future papers.

(e)(ii) The dangers of extrapolation should be clearly explained to students.

Part B) Once again, a straightforward question on chi-squared testing that was either highly successful (for the majority) or showed a lack of syllabus coverage. A surprising number of candidates lacked knowledge of the theory underlying the test and were thus unable to attempt (b). In (c)(i) it is worth stressing that the test is for the mathematical **independence** of two characteristics and this determines the null hypothesis. A number of candidates confuse the critical value and p-value approach to the test and thus lost marks in (e)(iv).

Question 5: Curve sketching and differential calculus

Undoubtedly, this question caused the most difficulty in terms of its content. Where there was no alternative to using the calculus, the majority of candidates struggled. However, for those with a sound grasp of the topic, there were many very successful attempts.

Part A) (a) The most common error was using the incorrect domain.

(b) Many had little idea of asymptotes. Others did not write their answer as an equation.

(c) The intercepts being inexact or unlabelled was the most frequent cause of loss of marks.

(d) Often, only one solution to the equation was given. Elsewhere, a lack of appreciation that the solutions were the *x* coordinates was a common mistake.

(e) The maximum is the *y* coordinate only; again a common misapprehension was the answer “(1, 4)”.

(f) This was a major discriminator in the paper. Many candidates were unable to follow the analytic approach to finding a maximum point.

Part B) This part was challenging to the majority, with a large number not attempting the question at all. However, there were a pleasing number of correct attempts that showed a fine understanding of the calculus.

Recommendations and guidance for the teaching of future candidates

- Ensure candidates can use the GDC efficiently, especially with graphs of functions and statistics
- Time management – a mark a minute is the guide – and ensure that all questions are attempted
- Cover the whole syllabus; it will all be examined
- Practice with “show that” questions by having candidates communicate through their mathematics
- Ensure candidates label and scale the axes whenever they draw **or sketch** a graph

- Ensure candidates start each question on a new page and to show all their working
- Formula booklet should be part of everyday teaching so that candidates become familiar with it