MATHEMATICS HL TZ1

(IB Latin America & IB North America)

Overall grade boundaries

Discrete mathematics

Grade:	1	2	3	4	5	6	7
Mark range:	0-13	14-27	28-40	41-52	53-63	64-75	76-100

Series and differential equations

Grade:	1	2	3	4	5	6	7
Mark range:	0-13	14-28	29-41	42-53	54-65	66-77	78-100

Sets, relations and groups

Grade:	1	2	3	4	5	6	7
Mark range:	0-13	14-27	28-39	40-51	52-62	63-74	75-100

Statistics and probability

Grade:	1	2	3	4	5	6	7
Mark range:	0-13	14-26	27-38	39-50	51-62	63-74	75-100

Time zone variants of examination papers

To protect the integrity of the examinations, increasing use is being made of time zone variants of examination papers. By using variants of the same examination paper candidates in one part of the world will not always be taking the same examination paper as candidates in other parts of the world. A rigorous process is applied to ensure that the papers are comparable in terms of difficulty and syllabus coverage, and measures are taken to guarantee that the same grading standards are applied to candidates' scripts for the different versions of the examination papers. For the May 2012 examination session the IB has produced time zone variants of the Mathematics HL papers.

Internal assessment

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0-6	7-13	14-18	19-23	24-29	30-34	35-40

The range and suitability of the work submitted

The portfolios produced this session were of a very good quality. Generally, the writing was clear and concise; unfortunately, some candidates produced massive documents, containing seemingly endless pages of tabular output or using a cut-and-paste approach.

The assessment criteria generally appeared to be well understood by the teachers and candidates with a few exceptions. Observations made by the moderating team are summarised below:

The tasks:

The majority of the tasks were taken from the older of the two publications in use, “Mathematics HL – The portfolio – Tasks for use in 2011 and 2012” with the most popular tasks still being “Patterns within Systems of Linear Equations” and “Modelling a Functional Building”. There were some tasks taken from the newer publication, “Tasks for use in 2012 and 2013”, and a very small number of teacher-designed tasks submitted. One task, “Patterns from Complex Numbers”, from this newer publication proved to be quite problematic, with many students (and some teachers) misreading the instruction and producing a familiar and trivial consequence of De Moivre’s theorem: that <u>consecutive</u> nth roots of unity when connected form a regular polygon. However, the instruction in this task, stated for cube roots and later applied to nth roots, specifically required the student to “Choose a root and draw line segments from this root to the other two roots”, resulting in a tree by graph theory definition or, if viewed non-mathematically, a diagram resembling the frame of an oriental fan.

Candidate performance against each criterion

Overall, the candidates performed well against criterion A. The use of calculator notation and the absence of “dx” after the integrand appear to be declining steadily, but such careless use or absence of notation was often overlooked by teachers.

Some candidates failed to make a distinction between the terms, “equation”, “function”, and “expression”, which is a recurring shortcoming.

Communication skills have improved notably over the past few years. However, in spite of the instruction directed to students to avoid a “Q&A” approach given at the top of each statement of task, there were some candidates who continued to use such a format. Missing introductions and unlabelled graphs were still in evidence. Some student work, though correct, was far from concise, with the most extensive piece of work this session being in excess of 100 pages! The emphasis needs to return to quality over quantity.

Overall, the candidates produced good work, and the assessments against criteria C and D by their teachers have been appropriate. However, in some type I work, the investigation was extremely limited, with no evidence of a pattern to warrant a conjecture, let alone a generalisation, particularly in the task, “Patterns within Systems of Linear Equations”. Unfortunately, in the apparent haste to reach a generalisation, many students did not qualify their conclusion to consider limitations involving dependent systems of equations.

In type II tasks, the choice of an appropriate model was seldom justified by the student, for example in the “Functional Building” task. However, improvement was noted in the candidates’ careful definitions of variables and parameters. Many students did not pay enough attention in their type II task to the requirements in criterion D, generating results to an inappropriate degree of accuracy, such as a millionth of a second or billionth of a metre. Of concern was the failure to consider the reasonableness of parameter values, such as the choice of a “jogging speed” of 10 m/s in the task, “Running with Angie and Buddy”.

The use of technology varied considerably. It should be noted that the mere inclusion of graphs is not sufficient to demonstrate a resourceful use of technology that enhances the work. Full marks were often given much too generously for the use of an overwhelming collection of similar graphs. Some graphs were carelessly included that did not support the work, as when a semi-circle was drawn to model a parabolic roof. Should the task require the domain to be limited to positive values, the graphs should have been so adjusted.

On the other hand, the use of sliders to adjust parameters provided an excellent investigative approach. The use of conditional statements in spreadsheets also worked very well in the modelling task, “Running with Angie and Buddy”.

There were many pieces of good and complete work; however, the awarding of full marks in criterion F requires more than completion and correctness, but the evidence of mathematical sophistication that extends beyond the requirements of the task. Work that is considered “very good” but is not characterised as exemplary should be awarded one mark against criterion F.

Recommendations for the teaching of future candidates

The portfolios in this session could have comprised tasks taken from the two documents mentioned above, but not taken from earlier publications. Please note that a significant penalty is applied in moderation for the use of “expired” tasks. Teachers may certainly choose to use a task proposed by a colleague or offered at a workshop, but be mindful that some such tasks may have been reused year after year and not always successfully by other teachers.

The portfolios in the sample are expected to contain originals with the teacher’s marks, not unmarked photocopies. Teachers are expected to write directly on their candidates’ work, not only to provide feedback to the candidates, but information to the moderators as well. The use of Form B would allow the teacher to indicate more relevant and descriptive comments.

There has been a noticeable improvement in the provision of background information to each portfolio task that is required to accompany each sample, particularly with the use of Form A or through anecdotal comments. Moderators find them very useful in determining the context in which each task was given when confirming the achievement levels awarded.

A solution key for each task in the sample must accompany the portfolios in order that moderators can justify the accuracy of the work and understand the teacher's expectations.

For candidates completing the diploma in 2013, the tasks contained in the document, "Mathematics HL – The portfolio – Tasks for use in 2012 and 2013", are the only published tasks eligible for use.

Paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0-16	17-33	34-47	48-61	62-76	77-90	91-120

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

Candidates typically found difficulties in applying mathematical techniques in less familiar situations, regardless of the difficulty of the question. This was particularly evident in the interpretation of information found graphically. Many marks were lost throughout the paper through manipulation errors, frequently through a failure to lay out their work in a clear and orderly fashion, and a failure to read the question properly. Where a question says "hence" then the expectation is that the student should use the previous result to find an answer. An alternative method is unlikely to be awarded marks. The two questions with complex numbers caused some difficulties indicating a weakness with this topic. There were also indications that a number of the candidates were not familiar with all topics of the Mathematics HL course.

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

Trigonometry seemed to be well prepared and basic techniques in calculus were well done, indicating that the candidates had a sound grounding in calculus techniques, albeit with insufficient exposure to non-text book conceptual ideas. A sound knowledge of logarithms was also evident. Most candidates were also aware that working needed to be shown.

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

Question 1

The question was well done generally. Those that did make mistakes on the question usually had the first term wrong, but did understand to use the formula for an infinite geometric series.

Question 2

Most candidates were able to produce a good graph, and many were able to interpret that to get correct answers to part (b). The most common error was to give 4 as the answer to (b)(iii). Some candidates did not recognise that the "hence" in the question meant that they had to use their graph to obtain their answers to part (b).

Question 3

Most students had an idea of what to do but were frequently let down in their calculations of the modulus and argument. The most common error was to give the argument of z_2 as $\frac{3\pi}{4}$, failing to recognise that it should be in the fourth quadrant. There were also errors seen in the algebraic manipulation, in particular forgetting to raise the modulus to the power 6.

Question 4

Most students were able to sketch the correct graph, but then many failed to recognise that they could use their solution to determine the solution of part (b). Those who did were generally successful and those who embarked on attempts to find the inverse function did not realise that this was leading them nowhere.

Question 5

Part (a) was well answered, although many candidates lost a mark through not giving sufficient solutions. It was rare for a student to receive no marks for part (b), but few solved the question by the easiest route, and as a consequence, there were frequently errors in the algebraic manipulation of the expression.

Question 6

Generally well answered by most candidates. Basic algebra sometimes let students down in the simplification of the ratio in part (c). It was not uncommon to see $\frac{\log A}{\log B}$ simplified to $\frac{A}{B}$.

Question 7

There were some good solutions to this question, but those who failed to complete the question failed at a variety of different points. Many did not know the definition of the modulus of a complex number and so could not get started at all. Many then did not think to equate real and imaginary parts, and then many failed to solve the resulting irrational equation to be able to find *x*.

Question 8

Some good solutions to this question and few candidates failed to earn marks on the question. Many were able to change the base of the logs, and many were able to deal with the 2, but of those who managed both, poor algebraic skills were often evident. Many students attempted to change the base into base 10, resulting in some complicated algebra, few of which managed to complete successfully.

Question 9

Many students were able to obtain the first marks in this question by implicit differentiation but few were able to complete the question successfully. There were a number of students obtaining the correct final answers, but could not be given the marks due to incorrect working. Most common was students giving the equation of the normal as $y-0=\frac{y}{2x}(x-1)$, instead of taking a general point e.g. (*a*, *b*)

Question 10

Many good solutions to this question, although some students incorrectly stated the value of arcsin ($\frac{1}{2}$). A surprising number of students had greater difficulties with part (d).

Question 11

Although most students showed knowledge of proof by induction, there were many candidates who failed to show the various steps needed for a proof. As is often the case, many students did not obtain the final R mark, failing to state the implication – typical statements were true for $n=k$ and $n=k+1$.

Part (b) was poorly done in general, and many students failed to recognise that the result in (ii) needed to be used in part (iii).

Question 12

Part (a) was generally well done, although few candidates made the final deduction asked for. Those that lost other marks in this part were generally due to mistakes in algebraic manipulation. In part (b) whilst many students found the second derivative and set it equal to zero, few then confirmed that it was a point of inflexion. There were several good attempts for part (c), even though there were various points throughout the question that provided stopping points for other candidates.

Recommendations and guidance for the teaching of future candidates

Clearly the whole syllabus needs to be covered in order to obtain good marks in the paper. Furthermore, it is necessary to leave sufficient time to practice questions combining topics in a variety of different contexts. Although there was an improvement this year, there is still the need to make students aware of the need to lay out their work clearly, both in terms of helping them to keep their thoughts orderly in longer questions, and also so the examiner can see their processes to be sure they get the marks.

Certainly providing practice at longer questions can help the candidates with the layout of their work and also in developing the concise algebraic skills needed.

Higher level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0-14	15-28	29-44	45-58	59-72	73-86	87-120

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

Use of discriminant of a quadratic, applications of theoretical probability distributions, setting up the expression and calculating the volume of revolution and problem solving in coordinate geometry

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

Basic probability and combinatorics, expansion and manipulation of algebraic expressions and basic calculus

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

Question 1

Generally candidates answer this question well using a diversity of methods. Surprisingly, a small number of candidates were successful in answering this question using the discriminant of the quadratic and in many cases reverted to trial and error to obtain the correct answer.

Question 2

This question was well attempted by most candidates. However many were not alert for the necessity of using GDC to calculate the definite integrals and wasted time trying to obtain these values using standard calculus methods without success.

Question 3

Most candidates answered this question well although in some cases candidates were not able to distinguish the use of permutations from combinations. Almost all candidates scored the two marks of part (c), but many of these were follow through marks.

Question 4

Many different attempts were seen, sometimes with success. Unfortunately many candidates wasted time with aimless substitutions showing little understanding of the problem.

Question 5

Very few candidates were successful in answering this question. In many cases it was clear that candidates were not familiar with box-and-whisker plots at all; in other cases the explanations given revealed various misconceptions.

Question 6

This question was well attempted but many candidates could have scored better had they written down all the steps to obtain the final expression. In some cases, as the final expression was incorrect and the middle steps were missing, candidates scored just 1 mark. That could be a consequence of a small mistake, but the lack of working prevented them from scoring at least all method marks. Some candidates performed the transformations well but were not able to use logarithms properties to transform the answer and give it as a single logarithm.

Question 7

Many candidates did not attempt this question and many others did not go beyond setting the equation up. Among the ones who attempted to solve the equation, once again, very few candidates took real advantage of GDC use to obtain the correct answer.

Question 8

Most candidates attempted this question using either the formula given in the information booklet or the disk method. However, many were not successful, either because they started off with the incorrect expression or incorrect integration limits or even attempted to integrate the correct expression with respect to the incorrect variable.

Question 9

Many correct answers were seen, although most candidates used rather inefficient methods (e.g. expanding the brackets in multiple steps). In a very few cases candidates used the binomial theorem to obtain the answer quickly.

Question 10

Most candidates had difficulties with this question and did not go beyond the determination of the intersection points of the lines; in a few cases candidates set up the expression of the area, in some cases using unsimplified expressions of the coordinates.

Question 11

Candidates answered parts (a) and (b) of this question well and, although many were also successful in part (c), just a few candidates gave answers to the required level of accuracy. Part d) was rather challenging for many candidates. The most common errors among the candidates who attempted this question were the confusion between tangents and normals and incorrect final answers due to premature rounding.

Question 12

Generally, candidates had difficulties with this question, mainly in applying conditional probability and interpreting the expressions ‘more than’, ‘at least’ and ‘under’ to obtain correct expressions. Although many candidates identified the binomial distribution in part (b) (ii), very few succeeded in answering this question due to incorrect interpretation of the question or due to accuracy errors.

Question 13

Parts (a) and (b) were well attempted with many candidates achieving full or nearly full marks in these parts. Surprisingly, many candidates were not able to find the coordinates of the midpoints in part (c) leading to incorrect equations of the planes and, in many cases this affected the performance in part (d). Very few answered part (d) correctly. In parts (e) and (f) very few candidates made good attempts of using the ‘show that’ procedure and used a parametric approach. In most attempts, candidates simply verified the condition using the answer given. In a few cases, candidates noticed that G is the barycentre of [ABCD] and found its coordinates successfully. Some candidates were also successful in determining the bounding angle using the information given. Unfortunately, many candidates instead of finding the angle simply quoted the result.

Recommendations and guidance for the teaching of future candidates

- Raise awareness of the need to support answers with sketches and/or indication of the method even when the answers can be obtained with GDC.
- Encourage candidates to use the GDC to solve equations and integrate numerically; provide a wide range of problems that allow students to explore more advanced features of the GDC.
- Encourage candidates to store numerical answers obtained with the GDC or show how to carry work through using enough significant figures so that the final answers are correct to the appropriate degree of accuracy.
- Emphasize correct ‘show that’ procedure and provide many examples of mathematical proofs.

- Clarify the meaning of each of the command terms in the Mathematics HL guide.
- Provide a wide range of probability questions in context and clarify the meaning of expressions such that 'less than', 'fewer than', 'at least', 'at most',
- Ensure that candidates understand and are able to apply properties of logarithms to simplify expressions.
- Ensure that candidates are familiar with transformations of graphs of functions and their effects on the expression of the transformed functions.
- Ensure that candidates are familiar with the use of parametric equations of lines and their applications.
- Provide many examples of past exam questions and teach efficient ways of answering these questions; provide timed practice to improve candidates' efficiency in answering exam papers.

Paper three – Discrete mathematics

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0-8	9-17	18-25	26-31	32-36	37-42	43-60

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

Many candidates were not able to cope with the demands of the instruction 'Prove that'. In particular, Question 4(b) was poorly answered. This was disappointing, as HL candidates should realise that reasoning is just as important in Mathematics as carrying out standard routines.

Some candidates failed to realise that in Question 2 it was necessary to demonstrate that they had really used Prim's algorithm. The order of addition of edges is fundamental to the algorithm, so just giving the minimal weight spanning trees, without comment, gained few marks.

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

Candidates performed well on questions involving the application of standard algorithms and procedures: Q1 (a); .Q2; Q3 (a) (c); Q4 (a); Q5 (a) (b). So the Euclidean algorithm, Prim's algorithm, drawing a graph from adjacency/weight data and the use of Fermat's Little Theorem, were secure areas of the syllabus for many candidates.

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

Question 1

The majority of candidates were successful in parts (a) and (b). In part (c), some candidates failed to understand the distinction between a particular solution and a general solution. Part (d) was a 1 mark question that defeated all but the few who noticed that the gcd of the numbers concerned was 3.

Question 2

This question was well answered by many candidates. A disappointing minority failed to realise that the instruction 'Use Prim's ..' means that they have to convince the marker that they have actually used the algorithm. It is not good enough to just draw the minimal weight spanning trees. It is the order in which edges are added that is the important part of the algorithm. A (very) few candidates started at A – this was minimally penalised.

Question 3

Parts (a) and (c) were generally correctly answered. In part (b), a minority of candidates failed to mention that the starting and end points had to coincide. A large number of candidates gave all walks (trails were asked for) – an unnecessary loss of marks.

Question 4

Part (a) was well done. The various parts of Parts (b) were often attempted, but with a disappointing feeling that the candidates did not have a confident understanding of what they were writing.

Question 5

Many candidates were able to complete part (a) and then went on to part (b). Some candidates raced through part (c). Others, who attempted part (c) using the alternative strategy of repeatedly solving linear congruencies, were sometimes successful.

Recommendations and guidance for the teaching of future candidates

Although this is an option with some topics involving the implementation of algorithms, we also expect candidates to be familiar with the basic notions of proof and that they may be expected to explain their work.

Examiners expect candidates to have covered the whole syllabus.

Paper three – Series and differential equations

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0-9	10-19	20-29	30-36	37-42	43-49	50-60

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

On this paper a significant number of candidates found difficulty in recognising the difference between a sequence and a series. It appeared that many candidates were applying knowledge that they had learnt without reflecting on whether the conditions were appropriate to apply this knowledge. Candidates also found it difficult to identify and confirm specific conditions for convergence tests to be applied. Finally, candidates often lacked the confidence to adequately prove or provide rigorous demonstrations when they were asked to “show that” in a problem.

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

A significant majority of candidates showed good knowledge of the conditions and technique required to find a limit using L’Hopitals rule. Most candidates were also confident in solving differential equations using Euler’s methods and there were also many candidates who were able to solve a differential equation using separation of variables. Candidates who recognised the need to use the Integration Factor techniques were usually successful in applying it.

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

Question 1

The vast majority of candidates were familiar with L’Hôpitals rule and were also able to apply the technique twice as required by the problem. The errors that occurred were mostly due to difficulty in applying the differentiation rules correctly or errors in algebra. A small minority of candidates tried to use the quotient rule but it seemed that most candidates had a good understanding of L’Hôpital’s rule and its application to finding a limit.

Question 2

Most candidates had a good knowledge of Euler’s method and were confident in applying it to the differential equation in part (a). A few candidates who knew the Euler’s method completed one iteration too many to arrive at an incorrect answer but this was rare. Nearly all candidates who applied the correct technique in part (a) correctly calculated the answer. Most candidates were able to attempt part (b) but some lost marks due to a lack of rigour by not clearly showing the implicit differentiation in the first line of working. Part (c) was reasonably well attempted by many candidates and many could solve the integrals although some did not find the arbitrary constant meaning that it was not possible to solve (ii) of part (c).

Question 3

Perhaps a small number of candidates were put off by the unusual choice of variables but in most instances it seemed that candidates who recognised the need for an integration factor could make a good attempt at this problem. Candidates who were not able to simplify the integrating factor from $e^{2\ln t}$ to t^2 rarely gained full marks. A significant number of candidates did not gain the final mark due to a lack of an arbitrary constant or not dividing the constant by the integration factor.

Question 4

The “show that” in part (a) of this problem was not adequately dealt with by a significant minority of candidates and simply stating the limit and not demonstrating its existence lost marks. Part (b), whilst being possible without significant knowledge of limits, seemed to intimidate some candidates due to its unfamiliarity and the notation. Part (c) was somewhat disappointing as many candidates attempted to apply rules on the convergence of series to solve a problem that was dealing with the limits of sequences. The same confusion was seen in part (d), where also some errors in algebra prevented candidates from achieving full marks.

Question 5

A good number of candidates were able to find the integral in part (a) although the vast majority did not consider separately the integral when $k = 1$. Many candidates did not explicitly set a limit for the integral to let this limit go to infinity in the anti – derivative and it seemed that some candidates were “substituting for infinity”. This did not always prevent candidates finding a correct final answer but the lack of good technique is a concern. In part (b) many candidates seemed to have some knowledge of the relevant test for convergence but this test was not always rigorously applied. In showing that the series was not absolutely convergent candidates were often not clear in showing that the function being tested had to meet a number of criteria and in so doing lost marks.

Recommendations and guidance for the teaching of future candidates

- Candidates need to be clear about the difference between a series and a sequence.
- Candidates need to be able to recognise the conditions when an integrating factor is required.
- Candidates need to apply the necessary rigour and level of communication required by a problem asking a student to prove a statement or show that it is true.
- Candidates need to clearly understand the criteria and conditions for applying a rule of convergence.

Paper three – Sets, relations and groups

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0-7	8-15	16-22	23-28	29-33	34-39	40-60

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

On this paper candidates found difficulty with problems that required the application of concepts in general and abstract situations although in a particular concrete situation they had more success. Candidates often had difficulty in applying their knowledge to prove results taking account of all the conditions of the problem being asked. Also candidates seemed often to lack the skills to clearly communicate their thinking. In particular candidates had difficulties when dealing with injective and surjective functions. Also, despite candidates knowing the conditions for an equivalence relation, they had difficulty showing it to be true.

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

It was pleasing that so many candidates showed knowledge of the syllabus throughout the exam paper. This did not always mean that the candidate was able to correctly answer questions but it was rare to see a student who did not have a minimum of knowledge to attempt a problem. Students were particularly successful in this paper on answering simpler problems in group theory and also displayed a good knowledge of sets.

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

Question 1

This was on the whole a well answered question and it was rare for a candidate not to obtain full marks on part (a). In part (b) the vast majority of candidates were able to show that the set satisfied the properties of a group apart from associativity which they were also familiar with. Virtually all candidates knew the difference between commutativity and associativity and were able to distinguish between the two. Candidates were familiar with Lagrange's Theorem and many were able to see how it did not apply in the case of this problem. Many candidates found a solution method to part (iii) of the problem and obtained full marks.

Question 2

This was also a well answered question with many candidates obtaining full marks on both parts of the problem. Some candidates attempted to use a factorial rather than a sum of combinations to solve part (b) (ii) and this led to incorrect answers.

Question 3

Candidates were mostly aware of the conditions required to show an equivalence relation although many seemed unsure as to the degree of detail required to show that the different conditions are met for the example in this question. In part (b) many candidates found the correct set although a number were unable to write down the set correctly, including or excluding elements that were not part of the equivalence class. Part (c) saw candidates being less successful than (b) and relatively few candidates were able to prove the equivalence class in part (d) although there were a number of very good solutions.

Question 4

Nearly all candidates were aware of the conditions for an injection and a surjection in part (a). However, many missed the fact that the function in question was mapping from the set of integers to the set of integers. This led some to lose marks by applying graphical tests that were relevant for functions on the real numbers but not appropriate in this case. However, many candidates were able to give two integer counter examples to prove that the function was neither injective or surjective. In part (b) candidates seemed to lack the communication skills to adequately demonstrate what they intuitively understood to be true. It was usually not stated that the number of elements in the sets of the image and pre – image was equal. Part (c) was well done by many candidates although a significant minority used functions that mapped the positive integers to non – integer values and thus not appropriate for the conditions required of the function.

Question 5

This question was by far the problem to be found most challenging by the candidates. Many were able to show that ghg^{-1} had order one or two although hardly any candidates also showed that the order was not one thus losing a mark. Part a (ii) was answered correctly by a few candidates who noticed the equality of h and ghg^{-1}. However, many candidates went into algebraic manipulations that led them nowhere and did not justify any marks. Part (b) (i) was well answered by a small number of students who appreciated the nature of the identity and element h thus forcing the other two elements to have order four. However, (ii) was only occasionally answered correctly and even in these cases not systematically. It is possible that candidates lacked time to fully explore the problem. A small number of candidates “guessed” the correct answer.

Recommendations and guidance for the teaching of future candidates

- Candidates need to practise constructing mathematical arguments that clearly communicate their ideas and arguments.
- Candidates need to look carefully for the conditions given in a problem.
- In problems involving functions candidates need to take care with the sets being used for the domain and range.

- Candidates need to review carefully the demonstration of the conditions for equivalence relationships.
- Candidates need to be exposed to problems that require a sophisticated level of mathematical communication.

Paper three – Statistics and probability

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0-7	8-14	15-20	21-26	27-33	34-39	40-60

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

Surprisingly, the cumulative distribution function was an area of the programme that seemed difficult for many candidates. There was a feeling amongst examiners that many candidates were just carrying out routine procedures without any real understanding of how to tackle situations that were slightly different from those previously encountered.

Candidates did not seem to be aware of the shape of the Poisson distribution.

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

Candidates were generally competent at hypothesis testing – both the t-test and the chi-squared test. There was a good use of the GDC.

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

Question 1

A successful question for many candidates. A few candidates did not read the question and adopted a 2-tailed test.

Question 2

In part (a) some candidates thought that the geometric distribution was continuous, so attempted to integrate the pdf. Others, less seriously, got the end points of the summation wrong.

In part (b) it was very disappointing that may candidates, who got an incorrect answer to part (a), persisted with their incorrect answer into this part.

Question 3

Many candidates picked up good marks for this question, but lost marks because of inattention to detail. The mean of the data was usually given correctly, but sometimes the variance was wrong. It may seem a small point, but the correct hypotheses should not mention the value of the estimated mean. Some candidates did not notice that some columns needed to be combined.

Question 4

There was a curious issue about the lower quartile in part (a): The LQ coincides with a quarter of the range of the distribution 2/4= 0.5. Sadly this is wrong reasoning – the correct reasoning involves a consideration of areas.

In part (b), many candidates used hand calculation rather than their GDC.

The random variable Y was not well understood, and that followed into incorrect calculations involving Y – 2X.

Question 5

Most candidates were able to complete part (a). The remainder of the question involved some understanding of the shape of the distribution and some facility with algebraic manipulation.

Recommendations and guidance for the teaching of future candidates

Although this is an option with some topics involving the implementation of standard techniques, it is important that students obtain some understanding of the real applications and limitations of statistics.

Examiners expect candidates to have covered the whole syllabus.