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 – 11	12 – 22	23 – 33	34 – 45	46 – 57	58 – 69	70 – 100

Series and differential equations

Grade:	1	2	3	4	5	6	7
Mark range:	0 – 11	12 – 23	24 – 33	34 – 45	46 – 57	58 – 69	70 – 100

Sets, relations and groups

Grade:	1	2	3	4	5	6	7
Mark range:	0 – 11	12 – 24	25 – 35	36 – 47	48 – 59	60 – 71	72 – 100

Statistics and probability

Grade:	1	2	3	4	5	6	7
Mark range:	0 – 12	13 – 24	25 – 35	36 – 47	48 – 60	61 – 72	73 – 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 2010 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 portfolios produced this session gave ample evidence of the time and effort the candidates devoted to the completion of their tasks. The assessment criteria were generally well understood by both the teachers and the candidates. Unfortunately, the work was not always clearly marked, and some brief comments provided on the back of Form 5/PFCS were not entirely helpful in the moderation process. Observations made by the moderating team are summarised below:

The tasks:

Nearly all portfolio tasks were taken from the current publication*, "Mathematics HL – The portfolio – Tasks for use in 2009 and 2010",* with the most popular being *"Parabola", "Ratios of Areas and Volumes", "Viral Illness*", and *"Freight Elevator"*. There were also a few good teacher-designed tasks submitted by a number of schools. Teachers are encouraged to design their own tasks, keeping in mind the need to satisfy all criteria fully.

Tasks that were abridged versions of published tasks were not appropriate. Tasks which may have been provided in some textbooks as chapter-end revision activities generally did not satisfy all criteria and should not have been used.

There were two issues of concern this session.

1. Some teachers continued to use old tasks taken from a previous TSM. As explained in past Subject Reports and through the Coordinator's Notes, those tasks are no longer eligible for use; hence, a number of candidates lost a significant number of marks through no fault of their own! The teacher must take the responsibility of assigning appropriate tasks.
2. Tasks taken from the document for Mathematics SL are not at a suitable level for Mathematics HL and should not have been used.

Candidates' performance

The majority of candidates performed well against criterion A. Unfortunately, the use of computer notation such as "^" and "E09" were in evidence, and along with $=$ when $\cong$ should have been used, careless notation was often overlooked by teachers. The careless misuse of some terminology (e.g. "plug in", "sub") should also be avoided.

Good communication skills were evident in some samples. Where a candidate's work began with an introduction to the task, and comments, annotations and conclusions accompanied the steps and results, the work was easy to read and follow, and earned high marks in criterion B. However, there were many candidates whose work did not flow, particularly when there was no introduction to a task or when a question-and-answer format to a task was adopted. Unlabelled graphs and the relegation of tables to the appendix rate poorly in terms of an effective presentation and should have been penalised.

Generally, candidates produced good work, and the assessments against criteria C and D by their teachers have been appropriate. However, in some type I tasks, cursory investigation rendered the quick formulation of a conjecture questionable. In some instances, results were merely quoted from internet sources and there was little individual work in exploration and investigation, the key to the Type I task.

In Type II tasks, variables must be explicitly defined. Some realisation of the significance of the results obtained in terms of the created model when compared to the actual situation should have been provided, and candidates should have reflected on their findings. The analyses of data must be quantified, and if a regression analysis were appropriate, the candidate must have provided reasons for a particular choice. The use of software that automatically determines the "best" regression model leaves little for the candidate to interpret by himself and is of little merit.

The use of technology varied considerably. Full marks were often given much too generously for an appropriate but not necessarily a resourceful use of technology, for example, in the mere inclusion of a graph of data. For full marks, the use of technology should contribute significantly to the development of each task.

There were many good pieces of work; however, the awarding of full marks in criterion F requires more than completion and correctness, but the evidence of mathematical sophistication in a piece of exemplary work.

Suggestions to teachers

Tasks from the TSM and earlier publications must not be used in the candidates' portfolio work. Teachers are encouraged to design their own.

Teachers should select tasks that provide candidates with a variety of mathematical activities suitable at higher level. Tasks taken from the Mathematics SL publication do not meet HL requirements. Please ensure that candidates do not lose marks due to inappropriate choices made by the teacher.

The teacher must be fully informed of the portfolio assessment criteria to avoid a significant loss of marks in moderation.

The work in the sample portfolios are expected to be originals with the teacher's marks, not unmarked copies. 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. Some samples contained very few comments, making moderation extremely difficult when it was not possible to determine the basis upon which the teacher awarded marks.

The background information to each portfolio task is required to accompany each sample, either on Form A or through anecdotal comments. Moderators find them very useful in determining the context in which the task was given when confirming the achievement levels awarded; however, such information was often missing.

A solution key for tasks from the current publication, as well as for those designed by teachers, must accompany the portfolios in order that moderators can justify the accuracy of the work, and appreciate the level of sophistication demonstrated by the candidates.

Although the tasks contained in the current document, "Mathematics HL – The portfolio – Tasks for use in 2009 and 2010", may be used by candidates in the November 2010 examination session, they should now be considered to have expired for candidates in the May examination sessions. Candidates completing their diplomas in May 2011 and beyond should not be assigned these tasks.

Paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 – 12	13 – 25	26 – 36	37 – 50	51 – 63	64 – 77	78 – 120

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

On this paper candidates found difficulty with proofs, properties of sigma notation, exponential and logarithms, continuous probability distributions, distinction between minimum and maximum points and quadratic and trigonometric equations. There were also indications that a number of the candidates were not familiar with all aspects of the syllabus. Candidates also found many difficulties in providing coherent and concise explanations, in using consistent and appropriate notation and setting out their work in a logical manner. Most candidates also found difficulties in thinking flexibly and in applying knowledge to unfamiliar contexts.

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

On the whole candidates appeared to be reasonably well prepared for routine questions on certain techniques like differentiation, integration by parts, scalar and vector products and use of factor and remainder theorems. Many candidates were also aware of the need for showing working and/or reasons for their answers. It was pleasing to see evidence of good teaching in some schools whose candidates knew how to present their work clearly, using appropriate notation and terminology and showed all the necessary steps in a logical manner.

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

Question 1

Most candidates attempted this question and it was the best done question on the paper with many fully correct answers. It was good to see a range of approaches used (mainly factor theorem or long division). A number of candidates assumed $(x-3)$ was the missing factor without justification.

Question 2

A small number of candidates gave correct and well explained answers. Many candidates answered the question without showing any kind of work and in many cases it was clear that candidates were guessing and clearly did not know about composition of functions. A number of candidates attempted to find expressions for both functions but made little progress and wasted time.

Question 3

Although many candidates were successful in answering this question, a surprising number showed difficulties in working with normal vectors. In part (b) there were several candidates who found the cross product of the vectors but were unable to use it to write the equation of the plane.

Question 4

Very few candidates knew how to solve this equation. A significant number guessed the answer using trial and error after failed attempts to solve it. A number of misconceptions were identified involving properties of logarithms and exponentials.

Question 5

It was pleasing to see a lot of good work with part (a), though some candidates lost marks due to problems with the algebra which led to one or more incorrect values. Regarding part (b), most candidates did not succeed in finding the new intercepts and asymptotes and were unable to apply the absolute value function. A significant number of candidates misread part (b) and took it as the modulus of the graph in part (a).

Question 6

Many candidates found this more abstract question difficult. While there were some correct statements, they could not “show” the result that was asked. Some treated the vectors as scalars and notation was poor, making it difficult to follow what they were trying to do. Very few candidates realized that $a-b$ and $a+b$ were the diagonals of the parallelogram which prevented them from identifying the significance of the result proved. A number of candidates were clearly not aware of the difference between scalars and vectors.

Question 7

This question proved difficult to the majority of the candidates although a few interesting approaches to this problem have been seen. Candidates who started the question by drawing a tree diagram were more successful, although a number of these failed to identify the geometric series.

Question 8

While only a minority of candidates achieved full marks in this question, many candidates made good attempts. Quite a few candidates obtained the limits correctly and many realized a square was needed in the integral, though a number of them subtracted then squared rather than squaring and then subtracting. There was evidence that quite a few knew about integration by parts. One common mistake was to have 2π, rather than π in the integral.

Question 9

This question was successfully answered by few candidates. Both parts of the question prescribed the approach which was required – “use the substitution” and “hence”. Many candidates ignored these. The majority of the candidates failed to use substitution properly to change the integration variables and in many cases the limits were fudged. The logic of part (b) was missing in many cases.

Question 10

Very few candidates answered this question well, but among those a variety of nice approaches were seen. Most candidates though revealed an inability to deal with sigma expressions, especially $\sum_{i=1}^{i=10} 144$. Some tried to use expectation algebra but could not then relate those results to sigma expressions (often the factor 10 was forgotten). In a few cases candidates attempted to show the result using particular examples.

Question 11

This was the most successfully answered question in part B, in particular parts (a), (b) and (c). In part (a) the horizontal asymptote was often missing (or x = 4, x = 1 given). Part (b) was well done. Use of the quotient rule was well done in part (c) and many simplified correctly. There was knowledge of max/min and how to justify their answer, usually with a sign diagram but also with the second derivative. A common misconception was that, as $-9 < -\frac{1}{9}$, the minimum is at (-2,-9). In part (d) many candidates were unable to sketch the graph consistent with the main features that they had determined before. Very few candidates answered part (e) correctly.

Question 12

Many candidates did not attempt this question and many others were clearly not familiar with this topic. On the other hand, most of the candidates who were familiar with continuous random variables and knew how to start the questions were successful and scored well in parts (a) and (b). The most common errors were in the integral of e^{-at}, having the limits from $-\infty$ to 1, confusion over powers and signs ('-' sometimes just disappeared). Understanding of conditional probability was poor and marks were low in part (c). A small number of candidates from a small number of schools coped very competently with the algebra throughout the question.

Question 13

This question showed the weaknesses of many candidates in dealing with formal proofs and showing their reasoning in a logical manner. In part (a) just a few candidates clearly showed the result and part (b) showed that most candidates struggle with the formality of a proof by induction. The logic of many solutions was poor, though sometimes contained correct trigonometric work. Very few candidates were successful in answering part (c) using the unit circle. Most candidates attempted to manipulate the equation to obtain a cubic equation but made little progress. A few candidates guessed $\frac{2\pi}{3}$ as a solution but were not able to determine the other solutions.

Recommendation and guidance for the teaching of future candidates

Besides covering the entire syllabus and providing extensive practice using past exam questions, teachers are strongly recommended to:

- Ensure that their students have good basic skills and are able to manipulate algebraic expressions easily
- Ensure that students know and understand properties of logarithms and exponentials.
- Ensure that students know how to solve quadratic and trigonometric equations and are able to recognize them
- Provide a wide variety of examples of proofs including proofs by induction, and ensure that students know how to set out their work in a logical manner.
- Provide more problem solving practice to ensure that their students are able to apply their knowledge in a wide variety of contexts
- Ensure that students understand the difference between discrete and continuous random variables.
- Ensure that candidates understand the difference between scalars and vectors and know the properties of their operations.

Paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 – 11	12 – 23	24 – 33	34 – 48	49 – 64	65 – 79	80 – 120

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

It was clear that there were many students who had not been adequately prepared in all areas of the syllabus. Many students did not approach simple matrix questions with a matrix approach and there were many students without adequate knowledge of probability and statistics. It was clear that kinematics had only been covered in a perfunctory way in many cases and students had not seen how differential equations arise in kinematics problems.

In addition, many students approached problems with a formulaic approach and seemed not to have been developing mathematical skills towards problem solving.

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

The use of GDC in questions seemed improved on previous years, although in some cases more sophisticated use could have helped the candidates. Students also seemed better than in previous years in giving the correct degree of accuracy and there were fewer accuracy errors. Students seemed better prepared for the 3-D vector question than has been experienced previously, and the algebraic skills of the students were generally sound.

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

Question 1

Most candidates were able to find a and c, but many had difficulties with finding b.

Question 2

Many candidates attempted an algebraic approach that used excessive time but still allowed few to arrive at a solution. Of those that recognised the question should be done by matrices, some were unaware that for more than one solution a complete line of zeros is necessary.

Question 3

The question was generally well answered, but some students attempted to find the length of arc BC.

Question 4

Many students incorrectly found the argument of z^3 to be $\arctan\left(\frac{2}{-2}\right) = -\frac{\pi}{4}$. Of those students correctly finding one solution, many were unable to use symmetry around the origin, to find the other two. In part (b) many students found the cube of $1+i$ which could not be awarded marks as it was not "hence".

Question 5

Part (c) was well done, but parts (a) and (b) highlighted students' lack of understanding of matrices.

Question 6

There were many good solutions seen by a variety of different methods.

Question 7

Many students added instead of multiplying. There were, however, quite a few good answers to this question.

Question 8

Of those students able to start the question, there were good solutions seen. Most students could have made better use of the GDC on this question.

Question 9

Most students were able to obtain partial marks, but there were very few completely correct answers.

Question 10

This was a difficult question and, although many students obtained partial marks, there were few completely correct solutions.

Question 11

The question was generally well answered, although there were many students who failed to recognise that the volume was most logically found using a base as one of the coordinate planes.

Question 12

Parts (a) and (b) were well answered, but many students were unable to recognise the Binomial distribution in part (c) and were unable to form the correct equation in part (d). There were many accuracy errors in this question.

Question 13

In part (a) students had difficulties supporting their statements and were consequently unable to gain all the marks here. There were some good attempts at parts (b) and (c) although many students failed to recognise r as a constant and hence differentiated it, often incorrectly.

Question 14

Many students failed to understand the problem as one of solving differential equations. In addition there were many problems seen in finding the end points for the definite integrals. Part (b) (i) should have been a simple point having used the chain rule, but it seemed that many students had not seen this, even though it is clearly in the syllabus.

Recommendation and guidance for the teaching of future candidates

Clearly the importance of covering the entire syllabus cannot be overstated. Students will be severely disadvantaged if they have not covered certain sections of the syllabus.

Students do need to develop problem solving skills over the course, and will need to be able to solve problems that may have a slightly different look and feel to the text book problems. As a consequence, they must be given problems that look unfamiliar throughout the course.

Practice exam papers should be used, both in helping to confront exam questions, but also highlighting areas that do need to be reinforced. Different approaches to solving questions could, and should, be discussed.

Paper three – Discrete mathematics

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 – 6	7 – 12	13 – 19	20 – 26	27 – 32	33 – 39	40 – 60

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

The proof of Euler’s Relation and results stemming from it caused problems for candidates.

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

Algorithms involving graphs are generally well understood.

The question involving Fermat's Little Theorem and congruences was generally well done.

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

Question 1

Part (a) was generally well answered with a variety of methods seen in (a)(ii). This was set with Fermat's Little Theorem in mind but in the event many candidates started off with many different powers of 5, eg $5^4 \equiv 2, 5^8 \equiv 4$ and $5^3 \equiv -1 \pmod 7$ were all seen. A variety of methods was also seen in (b), ranging from use of the Chinese Remainder Theorem, finding tables of numbers congruent to 3(mod 4) and 4(mod 5) and the use of an appropriate formula.

Question 2

Part (a) was well done by many candidates although some candidates simply drew the minimum spanning tree in (i) without indicating the use of Kruskal's Algorithm. It is important to stress to candidates that, as indicated in the rubric at the top of Page 2, answers must be supported by working and/or explanations. Part (b) caused problems for some candidates who obtained the unhelpful upper bound of 96 by doubling the weight of the minimum spanning tree. It is useful to note that the weight of any Hamiltonian cycle is an upper bound and in this case it was fairly easy to find such a cycle with weight less than or equal to 80.

Question 3

Parts (a) and (b) were generally well answered. Part (c), however, caused problems for many candidates with some candidates even believing that showing divisibility by 2 and 3 was sufficient to prove divisibility by 12. Some candidates stated that the fact that the sum of the digits was 44 (which itself is divisible by 4) indicated divisibility by 4 but this was only accepted if the candidates extended their proof in (b) to cover divisibility by 4.

Question 4

Parts (a) and (b) were found difficult by many candidates with explanations often inadequate. In (c), candidates who realised that the union of a graph with its complement results in a complete graph were often successful.

Question 5

Most candidates who solved this question used the argument that there are four variables which can take only one of three different values modulo 3 so that at least two must be equivalent modulo 3 which leads to the required result. This apparently simple result, however, requires a fair amount of insight and few candidates managed it.

Recommendation and guidance for the teaching of future candidates

Candidates should be able to justify some of the basic results in graph theory.

Candidates should be encouraged to present their work as neatly as possible. Some of the scripts seen this year were quite difficult to understand and work that cannot be read cannot be given any marks.

Paper three – Series and differential equations

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 – 6	7 – 13	14 – 19	20 – 26	27 – 32	33 – 39	40 – 60

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

Although it is a core topic, some candidates seem to be unable to use integration by parts, especially when repeated use is required.

This option requires a certain level of skill in algebraic manipulation and some candidates do not possess this.

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

Most candidates are able to use Euler's method for solving differential equations.

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

Question 1

Most candidates seemed familiar with Euler's method. The most common way of losing marks was either to round intermediate answers to insufficient accuracy despite the advice in the question or simply to make an arithmetic error. Many candidates were given an accuracy penalty for not rounding their answer to three significant figures.

Question 2

Although this question is based on core material, many candidates were unable to perform the double integration by parts successfully. The difficulty in the method often lies in the choice of *u* and *v* and wrong choices were often made. Many candidates failed to consider adequately what happens at the upper limit (infinity). The question was structured so that the solution to (a) led to the solution for (b) but in many cases, the solutions to (a) and (b) were mixed up often to the candidates' disadvantage. In this case, candidates who obtained the required results, in whatever order, were of course given full credit.

Question 3

Most candidates recognised this differential equation as one in which the substitution $y = vx$ would be helpful and many carried the method through to a successful conclusion. The most common error seen was an incorrect integration of $\frac{1}{4+v^2}$ with partial fractions and/or a logarithmic evaluation seen. Some candidates failed to include an arbitrary constant which led to a loss of marks later on.

Question 4

Many candidates ignored the instruction in the question to use the series for $(1+x)^n$ to deduce the series for $(1-x^2)^{-1/2}$ and attempted instead to obtain it by successive differentiation. It was decided at the standardisation meeting to award full credit for this method although in the event the algebra proved to be too difficult for many. Many candidates used l'Hopital's Rule in (c) – this was much more difficult algebraically than using the series and it usually ended unsuccessfully. Candidates should realise that if a question on evaluating an indeterminate limit follows the determination of a Maclaurin series then it is likely that the series will be helpful in evaluating the limit. Part (d) caused problems for many candidates with algebraic errors being common. Many candidates failed to realise that the best way to find the exact value of the integral was to use the calculator.

Question 5

Most candidates found the radius of convergence correctly but examining the situation when $x = \pm 2$ often ended in loss of marks through inadequate explanations. In (b)(i) many candidates were able to justify the convergence of the given series. In (b)(ii), however, many candidates seemed unaware of the fact the sum to infinity lies between any pair of successive partial sums.

Recommendation and guidance for the teaching of future candidates

This option is likely to include questions which require competence in algebraic manipulation and it is essential to ensure that this is the case.

Candidates should be encouraged to present their work as neatly as possible. Some of the scripts seen this year were quite difficult to understand and work that cannot be read cannot be given any marks.

Paper three – Sets, relations and groups

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 – 8	9 – 17	18 – 26	27 – 32	33 – 39	40 – 45	46 – 60

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

- Some candidates seemed to be unaware that there are several ways of showing that a function is injective and that they should select the most suitable method in a particular case.
- Some candidates found matrix manipulation difficult.
- Some candidates were unfamiliar with permutations.
- Theoretical questions on groups continue to cause problems.

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

Candidates are generally extremely competent in dealing with specific groups.

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

Question 1

Solutions to (a) were often disappointing. Many candidates tried to use the result that, for an injection, $f(a) = f(b) \Rightarrow a = b$ – although this is the definition, it is often much easier to proceed by showing that the derivative is everywhere positive or everywhere negative or even to use a horizontal line test. Although (b) is based on core material, solutions were often disappointing with some very poor use of algebra seen.

Question 2

Solutions to (a) were generally poor. To show symmetry, many candidates assumed incorrectly that matrix multiplication is commutative, stating that ***AH* = *HB*** implies that ***HA* = *BH*.** Candidates who showed correctly that ***AH* = *HB*** implies that $\boldsymbol{BH}^{-1} = \boldsymbol{H}^{-1}\boldsymbol{A}$ often failed to show that $\boldsymbol{H}^{-1}$ is non-singular. To show transitivity, many candidates started with ***AH* = *HB*** and ***BH* = *HC***, not realising that a different '***H***' is required for each relationship. Solutions to (b) were often not clearly expressed.

Question 3

Candidates are generally confident when dealing with a specific group and that was the situation again this year. Some candidates lost marks in (a)(ii) by not giving an adequate explanation for the truth of some of the group axioms, eg some wrote 'every element has an inverse'. Since the question told the candidates that {*A*,*) was a group, this had to be the case and the candidates were expected to justify their statement by noting that every element was self-inverse. Solutions to (c)(ii) were reasonably good in general, certainly better than solutions to questions involving isomorphisms set in previous years.

Question 4

Many candidates scored well on this question although some gave the impression of not having studied this topic. The most common error in (b) was to believe incorrectly that $p_1 p_2$ means p_1 followed by p_2. This was condoned in (i) but penalised in (ii). The Guide makes it quite clear that this is the notation to be used.

Question 5

Solutions to (a) were often disappointing with some solutions even stating that a cyclic group is, by definition, commutative and therefore Abelian. Explanations in (b) were often poor and it was difficult in some cases to distinguish between correct and incorrect solutions. In (c), candidates who realised that Lagrange's Theorem could be used were generally the most successful. Solutions again confirmed that, in general, candidates find theoretical questions on this topic difficult.

Recommendation and guidance for the teaching of future candidates

Candidates should be aware that there are several methods for showing that a function is injective.

More emphasis needs to be placed on matrix algebra which might be needed in questions on groups and equivalence relations.

The notation for combining permutations needs to be made clear.

Candidates should be encouraged to present their work as neatly as possible. Some of the scripts seen this year were quite difficult to understand and work that cannot be read cannot be given any marks.

Paper three – Statistics and probability

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 – 9	10 – 18	19 – 27	28 – 34	35 – 41	42 – 48	49 – 60

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

It is clear that many candidates are not familiar with Type I and Type II errors.

Many candidates do not appreciate the difference between nX and $\sum_{i=1}^{n} X_i$. The situation is not helped by the fact that some candidates write the former to indicate the latter.

Many candidates suffer an accuracy penalty for not giving numerical answers correct to three significant figures.

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

Most candidates are extremely competent in the use of the calculator to solve problems involving statistical inference.

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

Question 1

This was well answered by many candidates. In (a), some candidates chose the wrong standard deviation from their calculator and often failed to square their result to obtain the unbiased variance estimate. Candidates should realise that it is the smaller of the two values (ie the one obtained by dividing by $(n-1)$) that is required. The most common error was to use the normal distribution instead of the *t*-distribution. The signpost towards the *t*-distribution is the fact that the variance had to be estimated in (a). Accuracy penalties were often given for failure to round the confidence limits, the *t*-statistic or the *p*-value to three significant figures.

Question 2

This question caused problems for many candidates and the solutions were often disappointing. Some candidates seemed to be unaware of the meaning of Type I and Type II errors. Others were unable to calculate the probabilities even when they knew what they represented. Candidates who used a normal approximation to obtain the probabilities were not given full credit – there seems little point in using an approximation when the exact value could be found.

Question 3

This was the best answered question on the paper, helped probably by the fact that rounding errors in finding the expected frequencies were not an issue. In (a), some candidates thought, incorrectly, that all they had to do was to show that $\int_0^6 f(x)\,\mathrm{d}x = 1$. In (b), some candidates thought, again incorrectly, that the given distribution was uniform rather than triangular. It was noted that many candidates used the goodness of fit facility on their calculators to calculate χ^2_{calc} and this was of course accepted. This approach does, however, run the risk of mis-entering data and obtaining an incorrect answer for which no method mark could be awarded if the value is simply written down.

Question 4

Solutions to this question again illustrated the fact that many candidates are unable to distinguish between nX and $\sum_{i=1}^{n} X_i$ so that many candidates obtained an incorrect variance to evaluate the final probability.

Question 5

Questions on these discrete distributions have not been generally well answered in the past and it was pleasing to note that many candidates submitted a reasonably good solution to this question. In (a) the most common error was to believe or state that the appropriate distribution was binomial. This gave the correct mean but an incorrect variance. In (b), the determination of the value of p was often successful using a variety of methods including solving the equation $p(1-p)=(0.000396\ ...)^{1/5}$, graph plotting or using SOLVER on the GDC or even expanding the equation into a 10th degree polynomial and solving that. Solutions to this particular question exceeded expectations.

Recommendation and guidance for the teaching of future candidates

Candidates should be made aware of the accuracy rules which require answers to be given either exactly or to three significant figures.

Candidates should be encouraged to present their work as neatly as possible. Some of the scripts seen this year were quite difficult to understand and work that cannot be read cannot be given any marks.