May 2016 subject reports

Mathematical Studies SL – Timezone 1

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 2016 examination session the IB has produced time zone variants of Mathematical Studies SL papers.

Overall grade boundaries

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0–16	17–30	31–42	43–55	56–67	68–79	80–100

Standard level internal assessment

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

The range and suitability of the work submitted

There appeared to be a decline in the standard of work seen this session with a disturbing number of incomplete projects. Candidates opted almost unanimously for a statistical analysis. There is a bit of a paradox when candidates have for their title "Is there a correlation between….". Surely anything other than correlation is irrelevant. Putting "Relationship" in the title instead would allow for more flexibility. It was pleasing to see that many candidates were aware that they needed two simple and one further process. However, when an error was made in one of the simple processes then candidates lost marks which was a shame given their overall standard. Including a third simple and relevant process can be a safeguard for achieving a higher level in this criterion. It would be nice for teachers to steer their candidates away from the obvious into a meatier investigation. Most of the samples from the centres had the full range of marks. If marks were below 5 then it was usually because the project was incomplete. Data collection was generally by questionnaire or internet sources (which were not always quoted). Unfortunately, there were still careless errors in calculations, notation and terminology and often variables were not defined.

Candidate performance against each criterion

A: The stronger candidates spent time on Criterion A to set up a framework for progression that allowed them to successfully address subsequent criteria successfully. Weaker ones did not establish this platform and struggled thereafter. Candidates generally were able to achieve level 2. Often candidates mentioned the mathematical processes that they would use but did not justify the reason for choosing each of the processes carried out. Occasionally processes not mentioned in the plan were carried out in the analysis or processes mentioned in the plan were not carried out. To be awarded level 3 there should be no surprises when reading the project.

B: In general, candidates understood this criterion well. Many candidates were able to achieve level 2 since the data collected was sufficient and organised ready for analysis. At times the data was limited or the quality was not good. Most candidates did not describe the sampling process. Phrases such as “I chose at random 50 participants” were often seen. Much more focus on sampling is needed. Only the very best projects included any details of the sampling technique selected. Some candidates needlessly threw away marks by failing to include their raw data.

C: Most candidates were able to perform some relevant mathematical analysis but there was not a wide range of techniques. Quite a few of the candidates used at least two simple processes along with a further process. At times the simple processes were not relevant to the task and this limited the award to level 2. Candidates often showed insufficient calculations in the simple processes and did not quote the formula they were using and calculator generated results appeared without working or interpretation and this made it difficult to assess understanding. The most common further processes were the χ^2 test, and the correlation coefficient and equation of the regression line. Some candidates found the equation of the regression line before the correlation coefficient and often the equation of the regression line was not used. Some candidates found the regression line even although their value for r was weak. In some centres the candidates knew that they had to use Yates continuity correction when the degree of freedom was 1. In other centres they did not. Many candidates had expected values less than 5 and made no attempt to regroup their data. Some teachers ignored the fact that, if there are no simple processes in the project, then the first two further processes are counted as simple. Results were sometimes copied directly from the GDC with no explanation. This makes it difficult for the moderator to assess the level of understanding. Sometimes the processes were out of context with the aim and therefore not relevant. Other times the projects contained arithmetical errors which limits the possible score for this criterion.

D: Nearly all the candidates drew at least one conclusion from their results. However, some inconsistencies marred a few of the interpretations. Some candidates did not score highly in this criterion because the projects were too simple in conception to allow for substantive discussion. The stronger candidates had quite detailed discussion of their results. The project reads well if partial interpretations are written after each mathematical process. Candidates should be discouraged from making unsubstantiated conjectures about the reasons for their findings as these sweeping generalizations detract from the project.

E: This criterion is still the least well addressed. Some candidates made no attempt to fulfil this criterion. However, quite a few did comment meaningfully upon the processes used and the results found or they discussed the limitations of their results. Candidates think that their processes are valid if they have checked their calculations or they have performed their analysis on Excel. It was common for valid and accurate to be treated as synonyms.

F: Overall the projects were generally well structured and logically presented. A few of the projects did not contain comments throughout the task and this detracted from communication. Some candidates gave bibliographies and referenced sources. Commitment was lacking in some projects as some were too short and lacked mathematical analysis. Photographs of work done on paper should be discouraged as the projects will have better presentation if the work is typed and graphing software used.

G: Most candidates were able to earn one of the two marks for this criterion but few earned both. Terminology is sloppy and vague and variables are often not defined. Candidates should be taught how to use a simple equation editor. Many candidates are not using the correct symbol for χ or for multiplication. Some candidates still refer to "finding a correlation" rather than a relationship with reference to the χ^2 test.

Recommendations for the teaching of future candidates

- Read the subject reports.
- Encourage candidates to fully explain the reasons for using mathematical processes described in their plan.
- Ensure that the simple processes are meaningful and relevant to the task.
- Encourage candidates to show calculations that lead up to the result.
- Emphasise the importance of defining the variables.
- Emphasise the importance of clearly explaining any sampling process.
- Make sure that candidates include ALL raw data.
- Have candidates assess previous projects so that they understand the assessment criteria.
- Encourage candidates to use a different range of topics.
- Give candidates suggestions about how to increase the sophistication of their analysis.
- Give candidates the opportunity to correct errors in calculation and notation.

Standard level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0–13	14–26	27–35	36–47	48–59	60–71	72–90

General comments

Much of this paper proved to be accessible to the majority of the candidates and the full range of marks – from zero to 90 was seen; however a large number of candidates scored fewer than 10 marks, so that one wonders as to their preparation or commitment. Lack of time did not appear to be a problem for most candidates. The comments from teachers were encouraging with the great majority of teachers stating that the examination was appropriate to the course. Whilst there were many fine scores from a range of centres, it appeared that other centres did not prepare their candidates properly for this examination: certain topics being omitted; notably the Normal distribution, the differential calculus and, surprisingly, boxplots. Stating answers to the correct degree of accuracy, whilst showing an improvement over time, remains a source of lost marks and candidates should be cautioned against the premature rounding of intermediate answers. The questions that posed the greatest problem to the candidature were questions 2, 3, 5, 8 and 13.

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

Drawing a boxplot, right-angled trigonometry, the normal distribution, currency exchange, interpreting familiar work in an unfamiliar context (the χ^2 test) and coordinate geometry. The use of the full GDC answer in intermediate calculations should be taught as a matter of some importance.

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

Working was shown by the majority of the candidates so that follow-through marks and method marks could be awarded when parts of questions were incorrect.

The questions on probability, volume and the exponential function were well answered by the majority of the candidates.

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

Question 1: Tree diagram

This was a good starting question and answered correctly by the majority of the candidates. However, some candidates were unable to interpret part (b). The weakest seemed not to be aware that the sum of the probabilities on the branches should equal 1.

Question 2: Trigonometry and area

The response to this question was mixed, with many fully correct attempts. Those failing to score 6 marks often either lost a mark due to the use of Pythagoras and premature rounding or due to an incorrect trigonometric ratio used in a right angled triangle. The use of sine and cosine rule often led to errors.

Question 3: Statistics – boxplot

Whilst there were many fine attempts, the number of poor responses to this question was surprising. The interquartile range was little understood, yet quartiles were correctly plotted. The lack of precision – due mainly to not using a ruler – in drawing the boxplot was also disappointing.

Question 4: Volume

Part (a) was generally answered well, as was part (b); misreading of the question was the main problem. Part (c), though straightforward in concept, was not well understood by a number of candidates, and many did not give the answer as a number of cents as instructed in the question.

Question 5 Logic

In part (a), the majority of candidates were able to state the negation, but surprisingly many were unable to give an example of a non-rational number.

In part (b), a common error was the lack of parentheses in the antecedent. A further error was the use of the “intersection” symbol rather than that for conjunction; care must be taken in this regard.

Part (c) proved problematic for all but the best candidates.

Question 6: Arithmetic sequence and series

This question was well attempted by the majority.

In part (a), a common error was calculating the difference as 5.

Part (b) was well attempted by the majority; with full follow-through being obtained.

In part (c) The incorrect denominator was the major error here.

Question 7: Perpendicular Line

The response to this question was mixed.

Part (a) was well attempted by the majority.

In part (b), the gradient was not fully calculated (being left as a reciprocal) by a large number of candidates.

In part (c), the common error was the use of c from part (a) in the line.

In part (d), the notation for integer was not understood by a large number of candidates.

Question 8: Normal distribution

Part (a) was correctly answered by the majority.

Part (b) was generally well attempted by those who had studied this part of the course. However, it was clear that many centres simply do not teach this part of the course.

In part (c), the two common faults were calculation of the bottom “tail” and incorrect rounding.

Question 9: Currency exchange

In this question, incorrect rounding was once again the cause of many lost marks. It was surprising how many candidates have little idea about currency exchange and even less about the notion of commission. This part of the course is tested every year.

Question 10: χ^2 test

Without doubt, this question was the subject of most comment in the feedback from teachers; opinion was divided between those who wanted the straightforward formulaic approach that can be taught in a recipe-book manner and those who saw the critical thinking nature of the question's intent; being able to take the data, set up the two-way table and design the test. These are necessary skills for the IA project and they should be transferrable to an examination. That said, the unfamiliar form of the question caught a number of candidates unaware, most noticeably in the statement of the critical region; which is still felt – despite the GDC's use of the *p*-value – to be an important concept that should be introduced to candidates and will continue to be tested. Calculating the degrees of freedom was also subject to many errors.

Question 11: Equation of tangent

Part (a) was generally well answered.

In part (b), many candidates substituted the value of the function, rather than its gradient; this was usually correctly followed through into part (c).

Question 12: Compound Interest

The use of the TVM solver, with lack of working, remains a source of concern, though many more are writing down the calculator display; candidates are advised still to write down substituted formulas prior to using the TVM solver. Compounding periods remain a source of confusion

The use of the 0.15 and 0.17 was a common error, as was the computation of the amount in part (a).

Question 13: Golden ratio

This question was partially answered by all but the best candidates. Parts (a) and (b) yielded the most success. Only the best candidates were successful in part (d).

Question 14: Exponential Function

This question was well-answered by the majority of candidates.

Part (a) was generally accessible, unless subtraction was used in the rearrangement of the formula.

Part (b) required an integer value.

Part (c) saw good use of the GDC – with many sketch graphs being shown on paper (this is to be encouraged) – as well as attempts using logarithms. Use of the GDC is to be encouraged as its efficient use is a mandatory part of the course. Logarithms are not discouraged – but they are not a necessary component of the course and it is easy to construct equations that are not accessible to solution by logarithms.

Question 15: Optimization

Many candidates were able to differentiate in part (a), but then were unable to relate this to part (b). However, it seemed that many more had not studied the calculus at all.

Recommendations and guidance for the teaching of future candidates

Candidates need as much practice as possible in answering questions written in different styles; the χ^2 distribution, for example, in this paper.

The whole syllabus must be taught and teachers need to be aware of any changes to the syllabus that have occurred; calculus, the normal distribution, logic.

All relevant working should be shown in each question so that follow-through marks can be awarded when necessary. Full GDC display answers to intermediate parts should be used to avoid incorrect answers due to premature rounding.

Candidates should write answers in pen to ensure their responses are legible to examiners. Pencil should only be used for diagrams.

The candidates must use a ruler in drawing boxplots.

Standard level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0–14	15–29	30–41	42–51	52–60	61–70	71–90

General comments

Concern was raised about the seemingly increasing number of candidates who do not show their working. Also, many candidates wrote their responses in pencil which makes it difficult for the examiners to read on screen; candidates should be instructed to write answers in pen and only use pencil for diagrams.

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

- Understanding when use of a regression line will provide a reliable estimate.
- Correctly filling in a Venn diagram when values are not explicitly given.
- Conditional probability.
- Translate contextual questions into mathematical equations to be solved.
- Prove given results (i.e. “Show that” questions).
- Interpreting information in a geometrical diagram.
- Use of GDC to solve equations.
- Solving quadratic equations.
- Trigonometry, both in right angled triangles and non-right angled triangles.
- Using a mathematical model in a contextualized situation.
- Arithmetic and geometric progression.
- Optimization problems.
- Interpretation of derivatives.
- Applying their knowledge to non-routine questions.

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

- Reading graphs.
- Mean, correlation and regression line.
- Interpreting the information in a Venn diagram.
- Simple probabilities.
- Expected value.
- Substitution of values in a function.
- Differentiation of a quadratic function.
- Pythagoras' Theorem.
- Finding the volume of three dimensional solid figures.
- Scientific notation.
- Choosing and using correct formulae.
- Using the GDC to find summary statistics.
- Questions similar to the ones that have regularly appeared in recent examination papers.

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

Question 1: Reading scatter diagram, mean, correlation and regression line.

The majority of the candidates scored very well on this question. There were only a few candidates who read the diagram incorrectly. The most common mistake in parts (b), (c) and (d)(i) were rounding errors, sometimes resulting in candidates losing follow-through marks when working was not presented. Part (d)(ii) was answered incorrectly by most candidates. The most common incorrect answer was based on strong correlation. Some commented on the trend of decreasing PM10 values for increasing distances, showing lack of understanding about extrapolation.

Question 2: Venn diagram, probability and expected value.

Candidates were able to draw a labelled Venn diagram and correctly place 40 and 25. A common mistake was to misinterpret the intersection of sets. In most cases this resulted only in the loss of 2 marks. Many added correctly the values in their diagram and follow-through marks were awarded irrespective of working seen, allowing the candidates who produced an incorrect diagram to obtain full marks further in the question. The most common error was not including the 25 in their total. For part (c) many correct areas, but also many incorrect areas were seen. Again follow-through marks were awarded for part (c)(ii) irrespective of working shown. Some candidates just counted the number of regions. The simple probabilities in (d)(i) and (iii) were answered correctly by the majority, the conditional probability in part (d)(ii) had very often an incorrect denominator. Some candidates with an incorrect Venn diagram lost a mark in part (d)(i) as they used the value from their diagram for the numerator and not the 100 given in the question. Candidates should be aware that when values are given in the question those should always be used and follow-through marks will not be available. Many were able to find the expected number of students in part (e). Some candidates lost follow-through marks for not showing their working here.

Question 3: Quadratic function, problem solving.

Parts (a) (finding the initial height) and (b) (finding the height after 15 seconds), were done very well by the majority of candidates. Many struggled to translate question (c) to find the (positive) zeros of the function, or did not write that down, losing a possible method mark. The derivative in part (d) was no problem for most; only very few used x instead of t. The maximum height reached was calculated correctly by the majority of candidates, but many lost the mark in part (e)(i) as they simply substituted 40 into their derivative or calculated the height at points close to 40. Only a few candidates showed correct method for part (f). Several were still able to obtain 2 marks as a result of “trial and error” of integer values for t. Some candidate seem to have a problem with the notation “$h(t) = ...$”, where this is interpreted as $h \times t$, resulting in incorrect answers throughout.

Question 4: Trigonometry, volume and area.

Many were able to write a correct trig ratio for part (a). The most common error was not to write the unrounded or the rounded answer. Some incorrectly used the given value of 186 in their proof. Part (b) was mostly answered correctly, with only a few candidates using Pythagoras’ Theorem incorrectly. Most candidates used the correct formula to calculate the volume of the pyramid, but some did not find the correct area for the base of the pyramid. Some lost a mark for missing or for incorrect units. Even with an incorrect answer for part (c), candidates did very well on part (d). In part (e) some excellent justifications were given. However, many struggled to convert kilometres to metres, others were confused and compared surface area instead of volume. Some thought the volumes needed to be the same. For part (f) candidates often assumed a right angle at BAW or BWA. When they used the sine and cosine rule, this was mostly done correctly.

Question 5: Arithmetic and Geometric progression

Most candidates calculated the salaries in the second year correctly. The most common error was to calculate the salaries for the third instead of the second year. In part (b) the use of n instead of $n-1$ was very common. For the geometric sequence often a ratio of 0.05 instead of 1.05 was used. Also many of the expressions given did not represent a geometric sequence. Candidates who used a list for part (c) did usually better than the ones that tried to solve an equation. In part (d) the sum of the arithmetic progression was done better than the geometric series. Many candidates calculated the 15^{th} term of the progression and not the series. In general this question part was not answered well.

Question 6: Functions and Calculus

Many candidates were able to calculate $f(0)$ although some had a problem with 2^0. Very few were able to find both roots in part (b), even when they represented correctly both zeros in their sketch. Many sketches were reasonably well drawn, presenting a smooth curve with correct points of intersection. Many lost a mark for not labelling their axes and the given scale was ignored by some, which was not penalized but often resulted in sketches which were difficult to read. The stronger candidates calculated $g'(1)$ correctly, but very few represented the gradient of the function at $x=1$ correctly.

Recommendations and guidance for the teaching of future candidates

- Read questions carefully and answer the questions that are asked.
- Show, where possible, the formula, the substitution, the unrounded answer and the rounded answer; too many candidates are losing marks for incorrect or premature rounding.
- In “Show that” questions both the rounded and unrounded answer must be shown to obtain full marks.
- Candidate should practise “show that” questions and be aware that they cannot use the given result in their justification. (The command for this would be “Verify”, not “Show that”.) A “show that” question should be seen as a “Find” or “Calculate” question where the answer is known to help the candidates and/or to ensure that candidates are able to answer questions that depend on the answer.
- Encourage candidates to critically examine their answers to see whether or not they are sensible in the context of the question.
- Make sure candidates write answers in pen to ensure responses are legible for examiners. Pencil should only be used for diagrams.
- Make sure candidates label and scale axes when drawing graphs.
- Practise past paper questions so that they become familiar with the terminology and the type of questions likely to be set. They should understand the command terms.
- Practise more questions where a mathematical justification is required.

- Candidates should be exposed to non-routine applications of the content to deepen their understanding.
- Ensure that they are fully conversant with the formulae which appear in the formula booklet and where exactly these formulae are to be found in the booklet prior to the examination.
- Encourage candidates to show all calculations and display the steps they make. When they change to a different method they must cross out the work that is not to be marked.
- Although candidates show proficiency in using their GDC in statistics and basic calculations, they often fail to use it effectively to solve equations or to evaluate less familiar functions.
- More practice using trigonometry.
- Past papers are excellent to test candidate understanding of the curriculum, but preparing candidates for exams should focus in the first place on understanding and not on teaching how to answer “standard” questions.