May 2015 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 2015 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:	0–15	16–29	30–39	40–52	53–65	66–76	77–100

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

Compared to last year there was a much better grasp of the new criteria, especially the relevance of mathematical processes. Candidates seem to be reflecting more on why they are using certain processes in their project. It was pleasing to see that many candidates were aware that they needed two simple and one further process. Projects were much more focused and plans were well presented on the whole. If marks were below 5 then it was usually because the project was incomplete. Most of the candidates, as usual, opted for statistical analysis. 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.

Candidate performance against each criterion

A: 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 that were mentioned in the plan were not carried out. To be awarded level 3 there should be no surprises when reading the project.

B: Many candidates were able to achieve level 2 since the data collected was sufficient and organized 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 the failure to include their raw data.

C: Quite a few of the candidates used at least two simple processes along with a further process. The most common further processes were the chi-squared test and the correlation coefficient. In some schools the candidates were aware that they needed to apply Yates Continuity correction when the degree of freedom was 1. In other schools they did not. Many candidates had expected values less than 5 and made no attempt to regroup their data. Some candidates found the regression line even although their value for *r* was weak. Some teachers ignored the fact that, if there are no simple processes in the project, 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 limited the possible score for this criterion.

D: Candidates were, on the whole, able to draw one conclusion from their results. The stronger candidates had quite a detailed discussion of their results. The project reads well if partial interpretations are written after each mathematical process. Some candidates still gave irrelevant or unsupported conclusions or wrote down their own personal beliefs.

E: 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.

F: Overall the projects had structure and they developed logically. 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: Many candidates only scored one mark for this criterion. Many candidates are not using the correct symbol for χ or for multiplication. At times variables were not explicitly described. 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 the mathematical processes that are described in their plan.
- Variables should be defined.
- Sampling should be explained more fully.
- 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.
- Encourage candidates to show calculations by hand.

Standard level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0–13	14–27	28–35	36–47	48–58	59–70	71–90

General comments

The examination was well received by both candidates and teachers. Several candidates received full marks on this paper, and a significant number of candidates received marks on parts of the most challenging questions.

The less usual wording of some questions showed to be hurdle for several candidates. However it is important to include these type of questions; as per the course summary we aim to “place more emphasis on candidate understanding of fundamental concepts than on symbolic manipulation and complex manipulative skills”.

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

- Rounding to given decimal places or significant figures.
- Percentage error.
- Use of GDC to solve equations.
- Finding the equation of a parallel line through a given point.
- Conditional probability.
- Normal distributions.
- Quadratic functions.
- Optimization problems.
- Applying their knowledge to non-routine questions.

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

- Measures of central tendency and dispersion.
- Arithmetic sequences.
- Simple probabilities.
- Correlation and regression line.
- Finding the midpoint of a line segment and the slope of a line.
- Finding the volume of three dimensional solid figures.
- Calculating compound interest.
- Choosing and using correct formulae.
- Questions similar to the ones that have regularly appeared in recent past papers.

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

Question 1: Decimal places, significant figures and percentage error

Despite a significant number of candidates scoring well on this question, many candidates failed to use their calculator correctly. Common errors identified were: the use of radians; incorrect use of the double parentheses, calculating $\tan(61)$ instead of $\tan(60)+1$; or premature rounding. Such candidates earned, at most, method in part (a). Despite errors in part (a), part (b)(i) tended to be often a correct follow through answer but some candidates struggled to give a 2 sf answer correctly, using truncation instead of rounding or dropping the leading zeros. Part (b)(ii) was more often answered correctly. In part (c) many candidates used the percentage error formula incorrectly, reversing the estimated and the exact value, or using one of the rounded answers from part (b) as the exact value.

Question 2: Descriptive Statistics, measures of central tendency and basic probability

Part (a) was generally well done although some candidates seemed to be confused between the mean and median. In part (b) it was not unusual to see an upper quartile of 5.5 (resulting from $(5+6)/2$). A significant number of candidates had difficulty with "at least four" in part (c), answering $2/10$ which resulted from calculating the probability of a grade equal to 4 and not at least 4.

Question 3: Midpoint, gradient, equation of a line

Parts (a), finding the midpoint, and (b) finding the gradient, of this question were done well by the majority of candidates. Some candidates substituted incorrectly into the gradient formula or reversed the numerator and denominator. There was a significant number of candidates who calculated the equation of the normal to the given line and not the equation of a parallel line. It seemed those candidates answered the question they expected and not the question asked.

Question 4: Correlation coefficient and regression line.

In part (a)(i), the majority of candidates knew how to calculate Pearson's correlation coefficient using their GDC. The most common errors were incorrect rounding and omitting the – sign. In part (a)(ii) many candidates correctly found the equation of the regression line, again with rounding errors being the most common. A very common error was to use the second list as the frequency for the statistics. In part (b) substitution of 28 in the regression line was done correctly by many candidates. Candidates seemed to be well prepared for this type of question.

Question 5: Volume of a sphere, scientific notation

In part (a) many candidates correctly substituted the volume formula and wrote correctly their answer using scientific notation. The calculator notation $\mathrm{E}12$ was very rarely used. A minority converted to metres, resulting in an incorrect exponent. Some candidates used an incorrect equation or used their calculator incorrectly. In part (b) many candidates subtracted the values, where they should be divided, resulting in an answer of an unrealistic magnitude. Some reversed the numerator and denominator, leading to an answer of 0.02, which would have rounded to the unrealistic answer of 0. When a reasonable answer was found, the final mark for rounding was lost by some candidates when there was no rounding or when rounding was incorrect. There seemed to be little understanding of whether or not an answer was reasonable.

Question 6: Currency conversion

Many candidates lost at least two marks on this question for using an incorrect rate. The difference between "Bank buys" and "Bank sells" was not understood by many candidates. Their use of the table was often not consistent, leading to the candidates losing 4 marks, 2 in part (a) and 2 in part (b). Only very few candidates were confused on when to multiply and when to divide by a conversion rate. It was disappointing to see that so many candidates were not able to apply their knowledge of currency conversion in the real world context where both rates are given and the candidate had to decide which one to use. Methods marks were given out frequently, showing candidates were confident to calculate currency conversion with given rates.

Question 7: Arithmetic and geometric sequences

Part (a) was answered correctly by many candidates, but working using equations was rarely seen. A "trial and error" method, based upon a list of terms was the most seen method. In part (b) many found the correct answer, but many others did not. Some gave the seventh term of the arithmetic sequence, some gave a term of an incorrect order and some a completely incorrect answer. Finding the correct ratio was the most common problem. Often repeated multiplication was used to find the answer, but also the formula for the nth term of a geometric sequence was used. Several did not use the correct three terms from the question.

Question 8: Probability and Venn diagram

The Venn diagram in part (a) was successfully completed by the majority of candidates. Many identified correctly the set $B \cap A'$, but listed the element instead of writing the number of elements in the set. In part (c) the majority stated that Shin was incorrect giving probabilities of $3/8$ ($3/6 \times 3/4$) or $3/7$ as being the correct probability. The few candidates using a sample space diagram usually answered correctly, tree diagrams were hardly used. Many candidates did not realize that it was not enough for each to roll one of the three numbers in the intersection, but that they needed to roll the same number. Probabilities of joined events seemed to be too difficult for the majority.

Question 9: Geometry of three-dimensional solids, Pythagoras and volume.

In part (a) many candidates struggled to identify right angled triangles correctly. A regular mistake was to calculate the slant height and not the vertical height. Often values were used which did not correspond to a right angled triangle in the diagram, such as 13 and 8. Another common mistake was incorrect use of Pythagoras, where the hypotenuse was not correctly identified or was incorrectly substituted into the formula. Despite the problems to obtain a correct answer for part (a), in part (b) many candidates wrote down a correctly substituted formula for the volume of a pyramid (with their height substituted) and received follow through marks. Very few, having calculated their volume correctly, failed to give the correct units. Some candidates used the perimeter (28) of the base and not the area.

Question 10: Finance

Many correct answers were given for part (a). Incorrect answers were in most cases the result of incorrect substitution into the compound interest formula, or incorrect use of the calculator, both in using the formula or when using the finance application. A common mistake was the use of 0.045 instead of 4.5 for r in the formula. In part (b) a correct equation was often given, but an analytical or graphical solution was rarely found. When the finance application of the GDC was used candidates often found the correct answer.

Question 11: Probability

Surprisingly, in part (a) the majority of candidates answered incorrectly. The usual answer was 0.225, resulting from 0.25×0.9; the probability that Peter walks and arrives on time. In part (b) the answers were mostly correct as the candidates repeated the same procedure, which was correct for this part. The conditional probability in part (c) was too much for most. In some cases a correct numerator or denominator was found. More candidates could have received method marks if working had been shown.

Question 12: Mathematical modelling

The equations in part (a) and (b) were given correctly by the vast majority of the candidates. Part (c) was in most cases either completely correct or awarded no marks at all. Only few were able to find the values of m and c, and therefore the length at $40^{\circ}\mathrm{C}$. Part (c) was often left open or answered incorrectly. A common answer was $L = 40m + c$. Very few partial correct responses were given. Some candidates managed a correct 3 sf answer by intelligent guessing. As the question was not structured asking for the m and c values explicitly, not many candidates made an attempt to find those values. Very few seemed to realize they could find those values using their GDC. An attempt to use simultaneous equations was the most common approach.

Question 13: Normal distribution

A significant number of candidates did not answer this question. It was very rare that a correct method was shown for any of the parts of this question. Often a normal distribution graph was drawn with indication of the mean and multiples of the standard deviation, with indication of the corresponding probabilities, but not a diagram identifying the area under the curve corresponding to the questions. There were however many correct answers for part (a). For part (b) many answered incorrectly; the most common incorrect answer was 1008, resulting from adding 2 sd to the mean. Very few correct answers were given for part (c).

Question 14: Quadratic functions and simultaneous equations

This question was left unanswered by many candidates. For candidates who attempted the question, one method mark was often awarded for a correct equation resulting from substitution of the point $(6, 0)$. Many were unable to find the value of q, and therefore did not continue to find the value of p. Part (c) was poorly attempted, although the range was independent of the values of p and q. The most common error was confusion between domain and range, resulting in an answer of $(-\infty, \infty)$.

Question 15: Modelling and Calculus

The model in this question seemed to be too difficult for the vast majority of the candidates, and therefore was a strong discriminator between grade 6 and grade 7 candidates. An attempt to find an equation for the volume of the cube often started with $V = x \times 2x \times h$. Many struggled to translate the total length of the edges into a correct equation, and consequently were unable to substitute h. Some tried to write x in terms of h and got lost, others tried to work backwards from the expression given in the question. As very few found a value for a, often part (b) was not attempted. When a derivative was calculated this was usually done correctly.

Recommendations and guidance for the teaching of future candidates

- Show, where possible, the formula, the substitution, the unrounded answer and the rounded answer; too many candidates are losing marks for incorrect rounding when the unrounded answer is not given.
- Answer the questions that are asked; read questions carefully.
- Critically examine their answers to see whether or not they are sensible in the context of the problem set.
- Do not cross out their work unless it is to be replaced – crossed out working earns no marks at all.
- Encourage candidates to use diagrams for normal distribution questions. Many are showing the GDC commands which do not earn any method marks.
- Practise past paper questions so that they become familiar with the terminology and the type of questions likely to be set.
- Practise more questions where a mathematical justification is required.
- Candidates should be exposed to non-routine applications of the content to deepen their understanding and to prepare them to answer these types of questions.
- 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.
- Practise use of GDC for questions involving statistics, normal distribution and finance.

Further comments

- Candidates should label their work in the working box and structure their responses in a clear manner.
- With the exception of graphs and diagrams, all working and final answer should be written in pen to ensure it is able to be read by the examiner.

Standard level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0–11	12–24	25–35	36–45	46–56	57–66	67–90

General comments

The great majority of candidates attempted all the questions; however, time may have been a problem for a minority, since questions 5 and/or 6 saw a number of "no responses". There were, as ever, a number of trivial attempts at questions 1, 4 and the latter parts of 3 – the calculus and the statistical techniques; there remain centres that seem not to teach the entirety of the course and their candidates are disadvantaged as a consequence. In addition, this year saw logic being tested to a greater extent compared to previous years and performance on this question tended either to be very sound or very poor. Nonetheless, the better candidates were able to display their knowledge and skills over the entire paper, thereby achieving high marks. There was an unusually large number of candidates who attempted nothing, but who simply submitted a blank paper; this is a concern. The examination, when considered with Paper 1, was felt to be an appropriate test of the syllabus by the majority of teachers submitting G2 forms and pitched at the correct level.

As ever, candidates lost marks in the "show" questions. It is again reiterated that when candidates are required to reach a given answer, written to a specified accuracy, they are required to first, write down the value they obtain correct to a higher degree of accuracy and second, write down the given value so that these can be seen to be the same. It is also reiterated that when a value for a parameter is asked to be shown, substitution of that value is not deemed a valid approach. Further, when a value is given, then this value **must** be used in subsequent question parts.

In trigonometrical questions where angles are required, the use of radians is far less prevalent than in previous years, though there was perhaps an increase compared to 2014.

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

- Proper presentation and sketching of graphs.
- Formal differential calculus.
- Interpreting and stating the correct conclusion from the results obtained.
- Visualisation of objects in three dimensions.

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

- Reading results from graphs.
- χ^2 test on the GDC.

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

Question 1: χ^2 test

The great majority of candidates found this question to be a good start to the paper, with many perfect scores accruing. A common problem was the inability to form consistent null and alternative hypotheses. Also, calculating the expected value "by hand" as part of a "show that" question was left blank by a number of candidates; to reiterate again – to attain full marks, both the unrounded and the consistent and correctly rounded answer must be stated.

And, lastly, incorrect comparison of statistics when forming a conclusion was a common fault.

Question 2: Logic

Forming the statement in part (a) was attainable by the great majority, although the lack of parentheses was a common fault. The truth table in part (b) saw less success and it was clear that some centres simply had not prepared their candidates in this area of the course. Where the truth table was correctly constructed many candidates were not aware of the conditions required for an argument to be valid and in part (d) the converse and the inverse were often confused.

Question 3: Statistics

For the great majority, this was a straightforward and accessible question. There were many, however, who had no appreciation of medians, percentiles and quartiles – all straightforward concepts. Most were able to read from the graph, using correctly the scales; only the weakest misinterpreting these. Calculation of the mean and standard deviation are expected to be completed using the graphic display calculator (GDC) – formulae are no longer required and the covariance will **not** be given in questions. Many candidates, however, were unable to calculate the mean and standard deviation of a (grouped) frequency distribution, instead treating the data as raw; comments on the G2 forms from schools indicated that some teachers were also unable to do this and advice must be sought.

Question 4: 3D trigonometry and area

Most candidates were able to recognize and use the cosine rule correctly in part (a) and then to complete part (b) – though perhaps not giving the answer to the correct level of accuracy. It is expected that candidates can use "distance = speed x time" without the formula being given. The work involving sine rule was less successful, though correct responses were given by the great majority and the area of the course was again successfully completed by most candidates. A common error throughout these parts was the use of the total length of the course. A more fundamental error was the halving of the angle and/or the base in calculations – this error has been seen in a number of sessions and perhaps needs more emphasis.

In part (e), unless evidence was presented, reasoning marks did not accrue; the interpretative nature of this part was a significant discriminator in determining the quality of a response.

There were many instances of parts (f) and (g) being left blank and angle of elevation is still not well understood. Again, the interpretative nature of part (g) – even when part (f) was correct – caused difficulties.

Question 5: Calculus and coordinate geometry

Differentiation of terms including negative indices remains a testing process; it will continue to be tested. There was, however, a noticeable improvement in responses compared to previous years. The parameter k was problematic for a number of candidates.

In part (b), the manipulation of the derivative to find the local minimum point caused difficulties for all but the most able; note that a GDC approach is not accepted in such questions and that candidates are expected to be able to apply the theory of the calculus as appropriate. Further, once a parameter is given, candidates are expected to use this value in subsequent parts.

Parts (c) and (d) were accessible and all but the weakest candidates scored well.

Part (e) discriminated at the highest level; the gradient of the normal often was not used, the form of the answer not given correctly.

Curve sketching is a skill that most candidates find very difficult; axes must be labelled and some indication of the window must be present; care must be taken with the domain and the range; any asymptotic behaviour must be indicated. It was very rare to see sketches that attained full marks, yet this should be a skill that all can attain. There were many no attempts seen, yet some of these had correct answers to part (g).

Part (h) was not well attempted in the main; decreasing (and increasing) functions is a testing concept for the majority.

Question 6: Exponential function

Comments on some of the G2 forms indicated that teachers felt the presence of three parameters in the formula was inconsistent with the aims of Mathematical Studies; however, one parameter was given and a justification required, a second required knowledge only of $k^0 = 1$ and the third was also given. Candidates should have been exposed to graphs of this type in their classwork.

The response of the candidature indicated that most were able to make some progress with the question, though for many the “show that” part was not attempted. As in previous sessions, comments were made about the use (or not) of logarithms in the final part – logarithms are not part of the Mathematical Studies SL syllabus (however, their correct use is never penalized), but efficient use of the GDC is very much part of a candidate’s “toolbox”. Questions of this nature – essentially requiring the use of the GDC as part of a problem solving exercise – will continue to be set.

Recommendations and guidance for the teaching of future candidates

- Ensure candidates can use the GDC efficiently especially with graphs of functions and statistics.
- Ensure candidates label the axes and give some indication of scale whenever they sketch a graph.
- Cover the whole syllabus; it will all be examined – if not in Paper 2 then in Paper 1.
- Practise “show that” questions; candidates must communicate through their mathematics and note that, in such questions, unrounded and rounded answers are both required.

Ensure candidates start each question on a new page and show their working.