

May 2017 subject reports

Mathematical Studies SL – Timezone 2

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 2017 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:	0–14	15–26	27–38	39–50	51–63	64–75	76–100

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

This was the first May examination session where the Mathematical Studies SL projects were uploaded and marked onscreen.

As usual nearly all of the candidates opted for a statistical analysis. There were a few projects that should have been actively discouraged by the teacher as they lacked any originality. There were also some projects that seemed to be more like a homework assignment than a Mathematical Studies SL project. These projects did not show the time requirement and also showed that teachers did not give sufficient guidance to their candidates. It would be nice for

schools and teachers to steer candidates away from the obvious into more substantial investigation. There was a wide variety in the quality levels across schools. Some schools and teachers seemed to understand the criteria and the expectations for the project quite well, whereas, in other centres, projects were generally weak, data collection was sparse and the teacher did not seem to understand the assessment criteria. Many candidates used surveys or Internet referenced sources to collect their data. It was pleasing to see sources referenced but often the survey to which they referred was not given. Quite a few projects were missing the raw data and it was not always easy or possible to verify results. The vast majority of projects had structure and developed logically. Most had at least some appropriate notation and terminology. Unfortunately, there were still careless errors in calculations, notation and terminology and often variables were not defined.

Teachers are also encouraged to make comments throughout the project in the margins and check the accuracy of the mathematics. There are still a significant number of projects that only develop one process, either simple or further, repeating it a number of times, and considering it as separate processes. Also, some develop only further processes not realizing how this affects the criterion C level awarded for the project.

The conclusions drawn were mostly consistent with the results. Validity was, as always, the criterion that was least well addressed although there are improvements in this area.

Candidate performance against each criterion

A: Some candidates did not include a title and others had no plan or did not mention any mathematical processes and so could not be awarded any more than 1 mark for this criterion. Candidates, generally, were able to achieve level 2 as projects contained an aim, a title and a plan, if at times brief. Candidates usually mentioned some of the mathematical processes they would use. Although, at times there are processes not mentioned in the plan that are carried out in the analysis. This deprives the candidates of achieving more than level 2. Giving reasons for the mathematical processes appears to be challenging for the candidates but they have to include this in order to be awarded full marks.

B: Some candidates did not show the raw data collected so it was not possible to verify all of the calculations.

In general, candidates understand this objective well. Candidates are able to gather raw data either by personal collection or from the Internet and organize it in a manner appropriate for analysis. Very few candidates seem aware of how to collect a random sample. Most samples are convenience samples or a candidate seems to think that if they stand in a hallway and ask whoever passes by, that this is a random sample. Unfortunately, too many teachers seem to think this as well. Sampling processes could be better described. Most candidates are able to earn a 2 for this criterion but not a 3. Frequently the data is just too sparse for the intended analyses, especially if the χ^2 test is an intended process. It is also, too frequently, very simple in nature. In the Teacher Support Materials (TSM) the guidance on a correlation or χ^2 statistics project is that a project is strengthened if at least three variables are chosen. Then the candidate can investigate which of two factors is most related to the third. This rigor is present in too few projects.

C: There were often times when the simple processes were not correct or not relevant to the task and this limited the award to level 1 or 2. Most candidates and teachers were aware of the need to present some sample calculations by hand, or to present their calculations in the context of the formula. However, many teachers and candidates did not seem to focus on the relevance requirement to earn level 3. In many centres, there was a "more processes the better" attitude which had a negative impact on a candidate's overall score in this criterion. Also there were many cases of invalid χ^2 tests and regression lines which were irrelevant. This last mistake is particularly disturbing because, if you present a scatter plot, you should use it (or a calculation of the correlation coefficient) to determine if it is relevant to find a regression line. Many candidates use Excel and then only add a trend line, a calculation of the regression equation and a calculation of r^2 without demonstrating any understanding. These poor practices preclude higher marks. Too few candidates proceeded with regression in the logical order of scatter plot, calculation of the coefficient, followed by a regression line if appropriate. In addition, if the regression line is not used in any meaningful way, it is hard to understand the purpose of the calculation, whether it is mathematically valid or not. Also, too many candidates failed to label graphs and axes or to represent data in a logical manner

D: Most candidates drew conclusions consistent with their mathematical processes. Candidates commonly earned a 2. Sometimes there were inconsistencies which detracted from the work and led to level 1 being achieved. In the better projects, candidates presented partial conclusions as they went along, and then summarized these at the end. Few candidates earned a level 3 for this criterion because the projects were too simple in conception to allow for a substantive discussion. Overall, the majority of candidates were able to produce thoughtful interpretations. Candidates should be discouraged from making unsubstantiated conjectures about the reasons for their findings.

E: It was usually the stronger candidates who commented meaningfully upon the processes used and the results found. Some went on to discuss the limitations of their results. Many candidates commented on the validity of their data in a manner that went beyond "I needed more data." A number of candidates also successfully commented on the validity of their processes, but most candidates think 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. Based on candidate understanding of this criterion, it appears that there are many teachers who do not fully grasp the objective of this criterion.

F: All projects had some structure and most developed logically. A few projects lacked explanation at each stage. Others had graphs and mathematical processes out of order. Many candidates did not ensure that their charts and graphs were clearly labelled and sometimes it was difficult to know to which chart or graph they were referring. Many candidates relied on Excel graphs and regression features which were not always appropriate for their data, or they included unexplained trend lines. In addition, computer/calculator notation was used when it should not have been. Bibliographies/referenced sources were often seen in an Appendix. Level 3 was not achieved mainly because, although the project was quite good, it was too simple. Level 3 was also not achieved as there was a lack of explanation on how the categories for the χ^2 test were subdivided. Teachers and candidates seem unaware of the need to clearly explain how their data was divided up for the χ^2 test.

Surveys were not always submitted with the projects or raw data was organized into a contingency table without presenting the raw data, making it impossible to check the results.

G: Most candidates were able to earn one of the two marks for this criterion but few candidates earned both marks. Terminology was sloppy and vague and notation was varied in its incorrectness. Candidates should be taught how to use a simple equation editor. Also, the variables were often not explicitly described.

Recommendations for the teaching of future candidates

Teachers should:

- make sure that the candidates include ALL raw data collected in the body of the project or the Appendix.
- ensure the simple processes used are meaningful and relevant to the task.
- ensure that the candidates define the variables.
- ensure that candidates show some/all calculations that lead up to the result.
- ensure, when found, that the equation of the regression line is used.
- explain sampling to the candidates.
- encourage candidates to show calculations by hand even if they are making use of technology such as Excel.
- instruct candidates to fully explain any information being conveyed through screenshots. Examiners are not expected to know Excel formulae or the calculator notation of different devices. Where screenshots are used, the image should be clear and the candidates should explain what is being shown, using correct notation in the body of the work.
- help the candidates to understand how to address validity.
- show the candidates how to use an equation editor for correct notation.
- make sure that all candidates read the assessment criteria and are fully aware of what they demand.
- explicitly provide evidence, on the IA projects (preferably by annotating the pages directly) for awarding the different levels of achievement for the criteria.
- give candidates examples that show good work, not so good work and bad work, so they can better understand the differences between them.
- monitor candidate work, and give candidates suggestions about how to increase the sophistication of their analysis.
- preview the electronic version of the work, prior to upload, ensuring all pages are present and correctly oriented, and that any comment boxes are expanded and not covering any part of the work. Examiners will only see a static image of the work and cannot expand or move comment boxes.

Further comments

It would greatly help the moderation process, if schools wrote comments related to each criterion, where the evidence is located on the body of the projects; some schools did and this was extremely helpful for the moderator. Schools should follow the upload instructions (available on IBIS) regarding annotating directly onto word-processed work. Examiners will see

a static image of the work and cannot expand comment boxes or move them to read text beneath them. To that end, comments should be fully expanded, but positioned in regions of whitespace (such as the margin) prior to the work being uploaded.

Teachers could, as an alternative, write their comments in the text box at the point of upload, stating the page where the evidence for awarding each level of achievement for the different criteria is located.

Standard level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0–10	11–20	21–30	31–42	43–55	56–68	69–90

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

This paper proved to be challenging to many candidates but, in particular:

- finding the cube root,
- translation of textual data to a Venn diagram,
- giving an answer in correct units,
- gradient of a line from textual data,
- calculating an expression for a mean from a frequency table,
- solving simultaneous equations,
- solving complicated inequalities using the GDC,
- probability,
- Normal distribution – in particular interquartile range,
- determining the equation of a normal and the drawing of this normal,
- exponential models.

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

- standard form,
- creating a correct equation from a Venn diagram,
- correctly using trigonometric ratios,
- arithmetic sequences,
- simple currency exchanges,
- common ratio and specific terms in geometric sequences,
- using correct mensuration formulae.

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

Question 1: Decimal places, significant figures and standard form

A significant number of candidates misunderstood the notation and instead of finding the cube root of $\frac{p}{q}$, found, instead, $3 \times \sqrt{\frac{p}{q}}$. Some other candidates simply left the denominator out of the root sign. As a consequence, fewer than expected scored maximum marks on the first part of this question. Although two decimal places did not prove to be a significant issue, giving an answer correct to three significant figures often led less confident candidates to simply write down three figures rather than giving the necessary zeros as well. Part of the demand for part (c) was in bold but this instruction was not followed and, as a consequence, at least one mark was lost by many candidates here.

Question 2: Venn Diagrams

Whilst confident candidates were able to be successful with this question, many candidates were unable to translate the given information into meaningful data, particularly on the Venn diagram. As a consequence, many answers of the form $\frac{B}{2}$, $2x$ or $\frac{1}{2}x - 15$ were seen in part (a) and, in part (b), many diagrams showed either $2x$, 15 , x or $x - 15$, 15 , $\frac{1}{2}x - 15$ instead of the required $2x$, 15 and $\frac{1}{2}x$. Despite many incorrect diagrams seen, candidates were able to recover in part (c) to find a correct follow through answer and earn both marks. In part (d), simply adding 15 to their answer to part (c) usually earned the mark for this part unless, of course, the answer exceeded 120.

Question 3: Trigonometry and Circumference of a Circle

The majority of candidates recognized that the use of trigonometry was required in part (a) but a minority chose the incorrect ratio, often arriving at an answer of 34.6 cm (by using $\tan 60$) rather than the required 40 cm. In part (b), some candidates seemed to be confused between the area and the circumference of a circle but generally, candidates showed good method in this part of the question. What seemed to be problematic for a significant number of candidates was giving their answer in centimetres correct to the nearest millimetre and, as a consequence, many incorrect answers of the form 2857 (mm) were seen.

Question 4: Gradient and Equation of a Straight Line

To determine the gradient of a line by giving lengths of line segments rather than coordinates caused many problems for a significant number of candidates. Some candidates simply interpreted *three times* as simply the gradient of 3 and did not take into account the negative slope. A significant number of candidates compounded any error in part (a) by substituting the given coordinates the wrong way round into the equation of a straight line. More confident candidates were able to successfully complete the question although some lost the final mark by giving a coordinate pair rather than simply the x -coordinate.

Question 5: Arithmetic Sequences

Many correct answers were seen here, particularly in part (a), although a significant number of candidates seemed to arrive at the correct answer of 17 without the appearance of a stated formula for the n th term of an arithmetic sequence. Indeed, some candidates persevered with a correct list of terms. Whilst many correct answers were seen in part (b), a significant number of candidates simply determined the number of sticks required to make up *Diagram 24* (73) rather than the total number of sticks required (924). Such candidates lost all three marks in this last part of the question.

Question 6: Ogives and Percentage Error

Parts (a) and (b) were generally correctly read from the graph. A common error in part (c) was where the candidate read the lower 10% of the graph (7) instead of the upper 10% (10.5). Following through from their answer to part (c) with a correctly substituted percentage error formula, allowed many candidates to recover and score both marks in part (d). Some incorrect denominators of 9.5 were however seen in this final part and some less confident candidates simply ignored the modulus sign and gave a negative answer.

Question 7: Frequency Tables and Means

This question proved to be one of the most challenging on the paper with many candidates failing to get beyond the first mark. Indeed, the key to this question was the calculation of the mean from a frequency table – something most candidates should have been well able to do. However, many simply used the numerator of $18 + x + y + 22$ or, as proved to be quite common, simply divided by 4 rather than by 100. As a consequence, in part (c), many candidates were left with inconsistent equations which could not be solved.

Question 8: Currency Exchange

In part (a), many candidates correctly multiplied 8000 by 0.09819 for the first method mark. Rather than multiplying this answer by 0.98, many preferred to work out 2% and subtract. Whilst there was nothing wrong with this method, arithmetical mistakes seemed to be more prevalent with this alternative method. A particularly significant error evident was in the truncation rather than the rounding of their final answer. Many candidates seemed to know where to start in part (b) by determining $85/0.08753$ (971.095...) but then, rather than dividing 14.57 by 971.095..., many simply subtracted 14.57 arriving at an unrealistic answer. For the final method mark, the correct fraction needed to be multiplied by 100. Answers of the form 0.015... invariably lost the final marks for part (b).

Question 9: Geometric Sequences

Many correct answers were seen in parts (a) and (b). Of those candidates who wrote down an answer of 2 to part (a), most recovered in part (b) with a follow through answer of 288. At this point, many simply left part (c) blank. For those who did persevere, many set up the correct inequality. Indeed, much correct working here was spoilt by candidates who arrived at an answer of 15.2... and decided to round down to 15 rather than to round up. As a consequence, a mark of 5 out of 6 proved to be more popular than full marks. Some candidates were successful in using lists but were required to show quite a number of terms.

Question 10: Probability

This question proved to be quite challenging for the vast majority of candidates, as very few scored no more than 3 marks for this question. Indeed, whilst many correct answers of 0.93 were seen in part (a), a significant number of candidates used a without replacement method in part (b)(i) and consequently lost marks here. Many failed to recognize that the required answer to part (b)(ii) was the complement of their answer to part (b)(i) and instead, evaluated two of the three required probability terms – forgetting to evaluate the probability that both light bulbs are defective. As a consequence, the vast majority of candidates lost both marks for this part of the question. The mark for part (c) was very rarely achieved with many candidates simply not identifying this requirement, building on part (b), as the complement of the probability of three non-defective light bulbs.

Question 11: Normal Distribution

Recognizing, for a normal distribution, the probability that a mass is greater than the mean is 50% proved to be known by many candidates and the mark for part (a) was generally earned. Part (b), however, proved to be more challenging and many candidates simply wrote down the incorrect answer of 366 with no working shown. Indeed, a diagram drawn with the correct 25% shaded would have helped candidates to decide on which side of the mean the required answer

was positioned. The majority of candidates failed to see the connection between parts (b) and (c) and, as a consequence, very poor attempts were made at finding the interquartile range. Of those that did recognize that their answer to part (c) was Q_3 (or Q_1 depending on their answer), many were able to arrive at the required answer.

Question 12: Volume of Cylinders and Spheres

Much correct working in part (a) was frequently spoilt by missing or incorrect units in the candidate's answer. In part (b), many candidates used a correctly substituted formula for the volume of a sphere but then incorrectly chose to subtract this from their answer to part (a) rather than add. Methodology was further compromised by a significant number of candidates who failed to equate their resultant volume to a volume of a cylinder in terms of h . As a consequence, many incorrect, or blank, answers were seen for part (b).

Question 13: Tangents and Normals

Many scripts showed little more than a correct answer to part (a). Indeed, many did not seem to know what to do in part (b) as fewer than expected used the correct gradient of the normal to generate the required equation. Of those who did use the correct gradient and the given coordinates, many simply stopped at the equation $\frac{1}{2}x - y + \frac{5}{2} = 0$, clearly not understanding the required format that a , b and $d \in \mathbb{R}$. In part (c), there were many blank responses and, where a line was drawn, it often did not pass through A, or, if it did, it was often not the normal to the curve at A. Clearly, the evidence of the candidates' responses to this question indicates that much work needs to be done to reinforce the concept of a normal to a graph.

Question 14: Mathematical modelling – exponential model

A significant number of candidates interpreted the amount saved per month as the amount after one month and the answer of (\$) 2400 proved to be a popular, but erroneous, answer. Not showing method in part (b) proved to be the downfall of many candidates with many scoring zero for this part. Centres should encourage their candidates to at least show a clear mathematical statement (in this case $8500(0.95)^t = 400 \times t + 2000$) or a sketch of both functions to gain method as an incorrect answer, on its own, earns no marks. Although correct answers were seen in part (c), there were many erroneous statements of the form $(X - 2800)$ where 'X' had not been clearly defined as a calculation derived from using the function P .

Question 15: Quadratic Functions

A simple, but effective method in this question would have been to simply select numerical values which match the conditions given and use their GDC to find the required sketch. So, for the first set of conditions, $a = 2, b = -1, c = 3$ would require the candidate to sketch $y = 2x^2 - x + 3$ which would clearly indicate Graph 2. Repeating this process for the remaining five conditions would have led candidates to six correct solutions.

Recommendations and guidance for the teaching of future candidates

Candidates should be encouraged to:

- read the instructions carefully, especially if presented in bold.
- unless demanded in the question, show all working (with unrounded values) and give answers to at least three significant figures. (Remember, follow through answers are generally not awarded if working is not seen.)
- 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.
- draw diagram(s) in questions on normal distributions shading appropriate areas where necessary. If a final answer is incorrect, a correct diagram can earn some of the method marks.
- practise the use of the GDC for questions involving statistics, normal distribution and solving complicated inequalities.
- ensure that they are fully conversant with the formulae which appear in the information booklet and where exactly these formulae are to be found in the booklet prior to the examination.
- Answers should be written in pen, with pencil reserved for diagrams. Candidates should not write all of their working/answers in pencil as the responses are scanned and information may be lost if the pencil lines are too light.

Standard level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0–12	13–25	26–37	38–46	47–56	57–65	66–90

General comments

This paper appeared to be accessible to most candidates. The variety of questions and level of difficulty of this paper provided opportunities for candidates to demonstrate their knowledge and understanding of the course. They were able to select and apply the appropriate mathematical processes. Effective use of the GDC was noted. It was pleasing to see that the incorrect use of radians were rarely seen. In general, answers were accompanied by their correct units. The majority of candidates showed the stages of work in a proper manner. As a result, examiners were able to award follow through marks whenever applicable. However, many candidates seemed unclear about the command terms “Sketch”, “Draw” and “Show that”.

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

Many candidates found it difficult to solve problems involving compound probability and conditional probability. They struggled to interpret and to use a truth table. Furthermore, explaining the meaning of the correlation coefficient in the context of the problem appeared challenging. They found it hard to use the regression line to solve problems. Candidates were not always successful at the “Show that” questions. The expected stages of work were not always present and as such they could not score the highest marks. Lastly, using the compound interest formula or the finance software on the graphic calculators to find the time, given the interest rate is compounded half yearly, appeared difficult to many candidates.

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

The majority of candidates were successful at calculating simple probability. They seemed to be quite comfortable with using the graphic display calculator to find the χ^2 value. They completed the truth table and found the truth value of a compound statement with not much difficulty. Furthermore, it was pleasing to see the number of candidates who were successful at using the graphic display calculator to find the product moment correlation coefficient and at finding an equation of the regression line. They were successful at drawing scatter graphs with correct scales and labelled axes and at drawing the correct regression line on their scatter graph. They were well prepared in using the cosine rule, the sine rule and the triangle area

formula. They were also able to make good use of the compound interest formula to solve problems when the interest rate was compounded yearly. Finding the derivative of a function and evaluating a function were carried out well.

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

Question 1: Probability and χ^2 test for independence

Full marks were usually awarded for the simple probabilities in parts (a)(i) and (ii). It was pleasing to see most candidates recognized the reduced sample space in part (a)(iii). The compound probabilities in part (b) proved more difficult. The most common error occurred when the candidates used sampling with replacement. Overall candidates showed a good level of understanding of the χ^2 test for independence. Most of the candidates identified the correct null hypothesis with few using incorrect terminology. The expected frequency was demonstrated correctly and the number of degrees of freedom found. However, some candidates used their graphic display calculator to highlight 12 in their obtained expected frequency matrix. Candidates were adept at finding the χ^2 statistic and many made a correct comparison. A common error was to compare of the p -value with the χ^2 critical value. Many candidates struggled to state clearly the correct reason for their conclusion.

Question 2: Logic

In part (a) candidates wrote the compound proposition in symbolic form, including an implication, disjunction, and negation in correct order. Many candidates however failed to include parentheses in the consequent. Candidates were able to write the compound proposition in words, but many were unsuccessful into recognizing the exclusive disjunction. The truth values were usually correct for the compound proposition. While many candidates showed some understanding of a logical contradiction, few made explicit reference to the final column of the truth table. It was pleasing to see many candidates identify a value of x which satisfied the truth values in the table.

Question 3: Bivariate Statistics

This question was accessible to the great majority of candidates. Axes labels were included and correct scales were used. Though candidates took great care to plot their points accurately, many had difficulty reading the scale for the March, May and June data points. The coordinates of the mean point were correctly calculated, and the point was well labelled. The correlation coefficient was found without error, but in some cases was given as an incorrectly rounded number. The responses to part (e) indicate a partial knowledge of the validity of a regression line. Many candidates stated both strength and direction. The coefficients of the equation of the regression line were given correctly. Most candidates drew their regression line through

point M, and usually had the correct y -intercept. Part (h) proved to be a discriminating component of this exam. Few candidates equated the revenue function with their regression equation. It was common to see candidates substituting $x = 2.99$ into their equation for the production cost.

Question 4: Trigonometry

Most candidates showed a good understanding of trigonometry although weaker candidates could not distinguish when to use right-angled trigonometry and when to use the sine and the cosine rules. Nearly all completed part (a) with full marks but few achieved the same on part (b). Most candidates correctly substituted into the sine rule but failed to understand that in a “Show that” question both the consistent unrounded and rounded answers must be seen to ensure the final answer has indeed been found and not simply quoted from the question. Instead of just using the sine rule, some candidates attempted to find BC first, using the cosine rule and the ‘equation solver’ feature of the graphic display calculator. Most were able to use the correct area formula and so receive at least one mark in part (c). Many candidates had difficulty finding the correct angle \hat{CDB} . Errors were often made with the angles/sides; particularly in area of triangle BCD when they substituted 110° instead of 21.3° . This resulted in few correct answers. Parts (d) and (e) were often poorly done as candidates did not appreciate that CE had to be perpendicular to BD. Many incorrectly either assumed E bisected BD or that CE bisected angle DCB. Few used the radian mode, which is good.

Question 5: Quadratic functions and Compound interest

The “Show that...” in part (a) was poorly done by many. Of those who had the correct area expression in part (b), some had the parentheses missing. In part (c), few candidates used differential calculus to maximize the area. Others knew the shape would be a square and so were able to gain full marks. In part (d) candidates rarely realized the link with their answers to parts (b) and (c). Most could use their GDC or the compound interest formula to complete parts (e) and (f) scoring most if not all of the marks. Those who correctly set up the formula in part (e)(ii) were sometimes unable to provide an answer. Many struggled with the interest compounded half-yearly. Others used a trial and error approach, showing that 9 years satisfied the conditions but not accurately enough. They then used a similar approach in part (f) with an answer of 6%, thus losing 5 marks in total. Others just gave the 1 sf answer 6%, so got zero in part (f).

Question 6: Calculus, Domain and Range of a function

There was little difficulty in finding the y -intercept in part (a). Most candidates were able to find the correct terms for the derivative, but appeared to have limited understanding of the significance of this result in part (c). Though many substituted $x = 2$ into their derivative, few equated their derivative to zero. Most candidates were able to evaluate their function at $x = 2$. It was not uncommon in part (d) to see an answer of $x = -2$ and $x = 2$. Candidates somehow

overlooked the x -coordinate of the local minimum. Parts (d)(ii) and (e) revealed that candidates have a poor understanding of function terminology. Very few expressed their answer with inequality notation. There was uncertainty about the strictness of inequalities. The most common answer in part (f) was to list the x -coordinates of the points of intersection between function f and $y = 5$. Most candidates were not successful in part (g). Some candidates misinterpreted the question, thinking it was asking for specific values.

Recommendations and guidance for the teaching of future candidates

- To work on the requirements of “Show that” questions. Teachers are encouraged to highlight that, in questions where the answer is given, candidates should ensure that there is sufficient method shown. The working must be clearly shown.
- When answering “Show that” questions candidates should state both the unrounded and final answers to ensure they have found the value and not simply quoted it from the question.
- It is important to point out that substituting the known value in an expression and/or equation is ‘reverse engineering’ and invalidates the process of a “Show that” question.
- Premature rounding off can be an issue for multi-part questions. Candidates should be encouraged to use unrounded answers as far as possible.
- To understand clearly the requirements of the command terms such as Find, Sketch, Draw, Calculate and so on.
- Teachers are encouraged to help candidates understand the default settings in their calculator, especially following any sort of reset/exam mode.
- Candidates should be conversant with appropriate terminology for each area of the course. For example ‘range’ in functions has a different meaning to that in statistics.
- Where possible to use diagrams and sketches to illustrate given information.
- Graphs should be drawn on graph paper and axes labelled and scaled as per the given instructions.
- Candidates are encouraged to practise more questions involving high degree polynomials, especially where interval notations are required.
- It is important that candidates be able to interpret their results in the context of the given problem.
- To reinforce teaching and learning of conditional probability and choosing two (or more) events without replacement.
- To be able to use differential calculus to find a maximum/minimum point or value.
- To understand the difference between being dependent, being related and being correlated.
- Greater focus on the use of the correct notations for logic.
- When a justification is required, answer should be unambiguous. For example, to make specific reference to the truth values of the compound argument or clearly identify the relevant column in the truth table.

- To read instructions carefully. For instance “Copy and complete” requires the candidate to show the whole of the answer and/or working in the answer booklet. Examiners will not see the paper 2 question booklet and so any working written there will not be marked.
- Final answers should be to at least to 3 significant figures with no premature rounding in working.
- To improve on their time management skills and set out work clearly, appropriately labelled, and on a separate sheet for each question.
- Answers should be written in pen, with pencil reserved for diagrams. Candidates should not write all of their working/answers in pencil as the responses are scanned and information may be lost if the pencil lines are too light.
- In Paper 2, candidates should follow the rubric and not write any responses in the question booklet, as these will not be marked; all responses must be written in the answer booklets provided.