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AS LEVEL

Examiners' report

MATHEMATICS B (MEI)

H630

For first teaching in 2017

H630/02 Summer 2024 series

Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. A selection of candidate answers is also provided. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from OCR.

Paper 2 series overview

This is the fifth full session of the linear H630 AS Level Maths B (MEI) specification (the Autumn series of 2020 and 2021 were unusual and had very small cohorts). Candidates coped well with the mixture of questions from the Pure Mathematics and Statistics parts of the specification. This paper was taken by candidates after one year of further study in Mathematics beyond GCSE Level. There were 38 marks for Pure Mathematics questions, and 32 marks for Statistics questions, which was in line with previous years. The mean score was higher in this paper than last year, and it was observed that the level of demand was not as high as in previous iterations.

Most candidates found this paper reasonably accessible and were able to accrue marks for demonstrating basic techniques and knowledge, as well as applying what they knew to a variety of modelling situations. Poor algebra was evident among the less successful responses, while knowledge of the pre-release Large Data Set (LDS) material remains divided. This exam used LDS7, which will also be used for the A Level H640/02 paper in 2025. LDS7 is a refreshment of the LDS4 (and LDS1).

Most candidates were able to use the correct statistical language in context, but Questions 5 (c), 10 (a), 10 (c), 15 (a) and 15 (d) proved to be challenging for many candidates: either because they did not understand the nuance of the question, or they were not able to use the correct statistical terminology to articulate their reasoning. Of these, Question 5 (c) had the lowest facility rate (mean score/total marks available) for the whole paper. The distribution of marks was symmetrical on the applied questions and had a clear negative skew on the pure questions. At least one candidate scored full marks and Questions 15 (d) and (e) had the highest no response (NR) rate (proportion of candidates with no written working seen in the answer space), but there was no evidence of candidates running out of time or being unfairly penalised by the application of the mark scheme.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• processed algebraic expressions with little problems, such as when solving equations • had a good understanding of basic calculus, and the underlying techniques • evaluated given data and made assessments of its viability and usefulness • had an appreciation of the limitations of sample data • had an awareness of the data provided in the pre-release LDS material • understood the conditions for binomial distribution and could calculate probabilities in basic responses.	• struggled to critique the viability of given data • misunderstood the idea that different samples give rise to different sets of data, and the need to be wary when drawing conclusions • answered questions which required knowledge of the LDS with suppositions and ambiguous comments • did not quote formulae before attempting to use, for example, quadratic formula • did not use the correct statistical language to communicate their ideas, for example, 'the data is directly proportional' • used incorrect methods to establish the boundary limits for outliers, or incorrect formulae for probability calculations • had limited understanding of what data was presented in the LDS.

Question 1

1 Express $2x(x+3)+5x^2-2(x-3)$ in the form ax^2+bx+c, where a, b and c are integers to be determined. **[3]**

This question proved to be an extremely accessible introduction to the paper, with most candidates scoring full marks. Common errors were with negative signs emanating from the third term, combining terms incorrectly after a correct expansion, or misreading previous lines of working.

Question 2 (a)

2 **(a)** Find the discriminant of the equation $3x^2-2x+5=0$. **[2]**

Many candidates quoted the formula for the discriminant first before attempting to substitute in values. Most were able to progress to the correct result, but several subtracted '4 − 60' incorrectly while others had a square root around their value. This indicated that some candidates did not know what the discriminant was, despite this quadratic leading to a negative discriminant.

Question 2 (b)

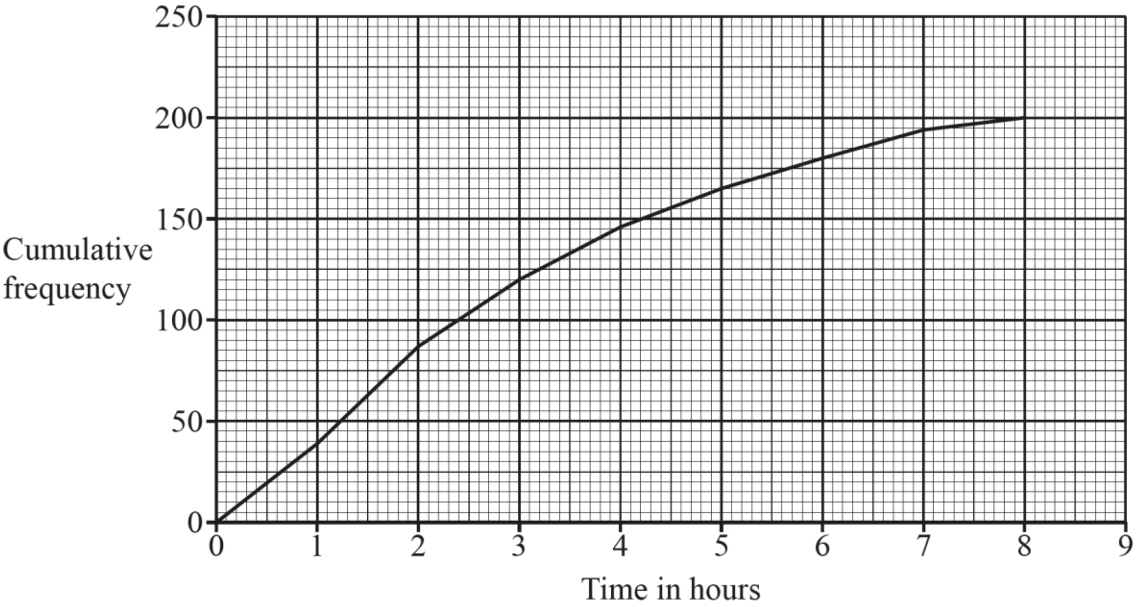
(b) Use your answer to part **(a)** to find the number of real roots of the equation $3x^2-2x+5=0$. **[1]**

This part of Question 2 was extremely well understood and the facility rate was high due to the follow through (FT) mark available for their discriminant value. It was rare to see a contradiction between part (a) and part (b) but most candidates scored as this was not a strict FT on their value.

Question 3 (a)

3 A student conducts an investigation into the number of hours spent cooking per week by people who live in village A. The student represents the data in the cumulative frequency diagram below.

Hours spent cooking per week by people who live in village A



(a) How many people were involved in the investigation? **[1]**

This was the least successful part of the question, with more candidates than expected misreading the diagram. A common incorrect response was 250.

Question 3 (b)

(b) Use the copy of the diagram in the **Printed Answer Booklet** to determine an estimate for the interquartile range. **[2]**

This question asked candidates specifically to use the given diagram, so evidence of using the diagram was needed to score both marks. Some candidates simply wrote down the interquartile range (IQR) with no evidence of using the diagram, while others misread the quartile positions. It was common to see attempts at 62.5 and 187.5 among the incorrect responses, even when (a) was correct.

Question 3 (c)

The student conducts a similar investigation into the number of hours spent cooking per week by 200 people who live in village B.

The interquartile range is found to be 3.9 hours.

(c) Explain whether the evidence suggests that the number of hours spent cooking by people who live in village B is more variable, equally variable or less variable than the number of hours spent cooking by people who live in village A. **[1]**

Most candidates made a good attempt at this question, but candidates who didn't score tended to be too vague with their response and/or did not refer to the specific statistical data that had to be compared (the IQR). This question was asking about variability, so candidates should be reminded that they need to answer the specific question asked, backed up by comparable statistical data.

Question 4

4 In this question you must show detailed reasoning.

Express $\frac{1+4\sqrt{3}}{2+\sqrt{3}}$ in the form $a+b\sqrt{3}$, where a and b are integers to be determined. **[3]**

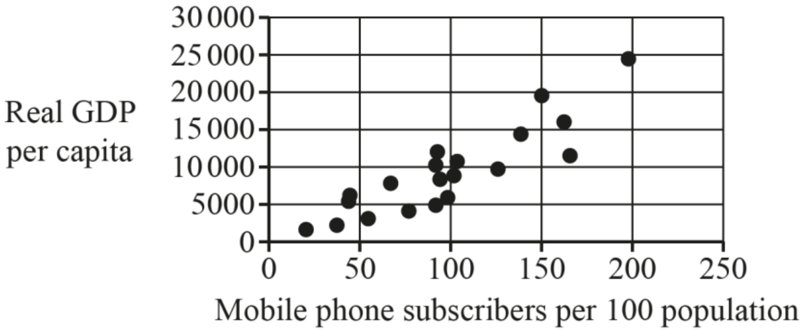
This question was very successful for most, but it was a 'detailed reasoning' question, which stipulates that we must see full working from candidates to justify their response, given that calculators could be used to obtain the correct result. The overwhelming majority of candidates understood this requirement and displayed understanding of how to get the fraction into the required form, with minor sign/coefficient errors spoiling the solution for some.

Question 5 (a)

5 The pre-release material contains information for countries in the world concerning real GDP per capita in US$ and mobile phone subscribers per 100 population. In an investigation into the relationship between these two variables, a student takes a sample of 20 countries in Africa. The student draws a scatter diagram for the data, which is shown in **Fig. 5.1**.

Fig. 5.1

Africa 1st sample



(a) What does **Fig. 5.1** suggest about the relationship between real GDP per capita and the number of mobile phone subscribers per 100 population? **[1]**

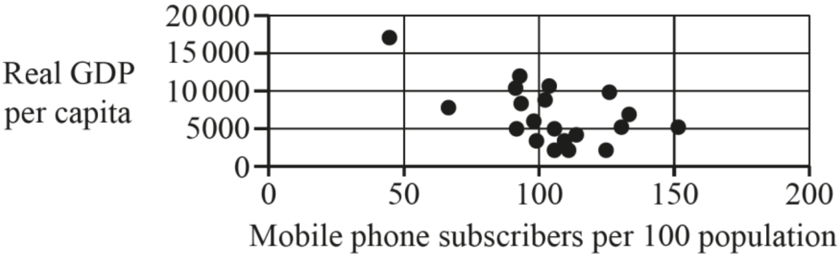
This diagram conveyed clear positive correlation, and many candidates use the correct statistical terminology. However, some referred to the data being 'directly proportional' and although this may be true, we do want to encourage candidates to use the correct statistical terminology. A sizeable number of candidates proceeded to give a contextual interpretation of the correlation, while others did this but did not mention the type of correlation. It was rare to see contradictory statements in this part.

Question 5 (b)

Another student collects a **different** sample of 20 countries from Africa, and draws a scatter diagram for the data, which is shown in **Fig. 5.2**.

Fig. 5.2

Africa 2nd sample



(b) What does **Fig. 5.2** suggest about the relationship between real GDP per capita and the number of mobile phone subscribers per 100 population? **[1]**

Despite the two values to the left of the central cluster, about half of the candidates gave a response of 'no correlation' or 'zero correlation'. Once again there were many candidates who gave a correct contextual interpretation to the negative correlation, but it was more common to see contradictory statements here, such as 'negative correlation so as the mobile phone subscribers decreases, the GDP also decreases' which would be consistent with positive correlation, etc.

Question 5 (c)

(c) Explain whether either of the two scatter diagrams is likely to be representative of the true relationship between real GDP per capita and the number of mobile phone subscribers per 100 population, for countries in Africa. **[1]**

This was one of the most challenging questions in the whole paper for all candidates, as evidenced by the low facility rate. The question was testing whether candidates could critique two sets of sample data, despite there being a clear contradiction in what they were displaying. Among the many incorrect attempts there were numerous references to the sample size being small, despite the LDS having only 55 entries for this data, and that both graphs had the same sample size (20). The idea was that different samples lead to different sets of data, which can give different conclusions. The contradictory nature of the correlations would lead to being dubious about making inferences from either.

However, some candidates showed statistical insight of the LDS by referencing that when all countries are considered in Africa, that the PMCC is positive, and so figure 1 was more representative.

Other candidates attempted to justify that Figure 5.1 was the most representative. Statements such as 'Figure 5.1 is more representative as richer countries have more disposable income and they can then afford a mobile phone' were common, but this does not address the fact that different samples may lead to different outcomes. When sample data aligns with our pre-conceived ideas this can lead to incorrect conclusions being inferred, so it is important to recognise the limitations in extracting conclusions from sample data. Candidates should question samples that give contradictory data.

Question 6

6 Determine the equation of the line which passes through the point (4, –1) and is perpendicular to the line with equation $2x+3y=6$.

Give your answer in the form $y=mx+c$, where m is a fraction in its lowest terms and c is an integer. **[4]**

This was a routine question which was among the most successful in the paper, with virtually all candidates making some attempt at the negative reciprocal to find the perpendicular gradient. As this was not a perpendicular bisector question there was less scope to go wrong once the correct gradient was found. The mistakes, when seen, were generally with algebraic manipulation; very small number of candidates made errors in rearranging, while others struggled to handle negative terms.

Question 7

7 Determine the coefficient of x^5 in the expansion of $(3-2x)^7$. **[4]**

This was a very generous question, with most candidates scoring full marks. Common errors where when simplifying the $(-2x)^5$ aspect or when stating the coefficient as $-6048x^5$. Some candidates underlined their coefficient, or otherwise highlighted their coefficient, scoring full marks.

Question 8

8 **In this question you must show detailed reasoning.**

Determine the coordinates of the point of intersection of the line with equation $y=2x+3$ and the curve with equation $y^2-4x^2=33$. **[4]**

This question was similar to the ones seen in GCSE Mathematics, and it was evident that it presented little problem to most candidates. Almost all candidates attempted to eliminate y and progress to a linear equation in x. Some of the less successful responses resorted to square rooting the non-linear equation. There were very few candidates who attempted to eliminate x, but those that did usually resorted to re-starting and replacing y instead. Very few candidates forgot to state their final answer as a coordinate pair.

Question 9 (a)

9 A fair six-sided die has its faces numbered 1, 3, 4, 5, 6 and 7. The die is rolled once.

A is the event that the die shows an even number.

B is the event that the die shows a prime number.

(a) Write down the value of $\mathrm{p}(A)$. **[1]**

This part accrued the highest facility rate in the whole paper, and the candidates who did not score seemed to miscount from the given set of numbers.

Question 9 (b)

(b) Write down the value of $\mathrm{p}(B)$. **[1]**

A high number of candidates appeared to include 1 as a prime number, leading to the incorrect response of $\frac{2}{3}$.

Question 9 (c)

(c) Write down the value of $\mathrm{p}(A \text{ or } B)$. **[1]**

Due to the FT mark available from their (a) and (b) most candidates were able to score here, but some resorted to multiplying their values, indicating confusion between independence and mutually exclusive. The given events were mutually exclusive so adding their values scored the mark.

Question 9 (d)

The die is rolled again.

(d) Calculate the probability that the sum of the scores from the two rolls is even. **[3]**

This part of the question was designed to be the most challenging, but candidates were relatively successful in scoring marks. The most successful approach was for a sample space to be constructed, and the even outcomes extracted. Listing paired outcomes was the next most successful method, with tree diagrams and the main mark scheme method being less common. For the listed outcomes approach, it would have been easy for candidates to miss an outcome, so method was credited here if there was evidence of consideration of odd paired with odd and even paired with even. Some candidates attempted to calculate the complement of the requested outcome probability and subtract from 1, but such attempts were usually less successful.

Question 10 (a)

10 The pre-release material contains information about the birth rate per 1000 people in different countries of the world. These countries have been classified into different regions.

The table shows some data for three of these regions: the mean and standard deviation (sd) of the birth rate per 1000, and the number of countries for which data was used, n.

Birth rate per 1000 by region

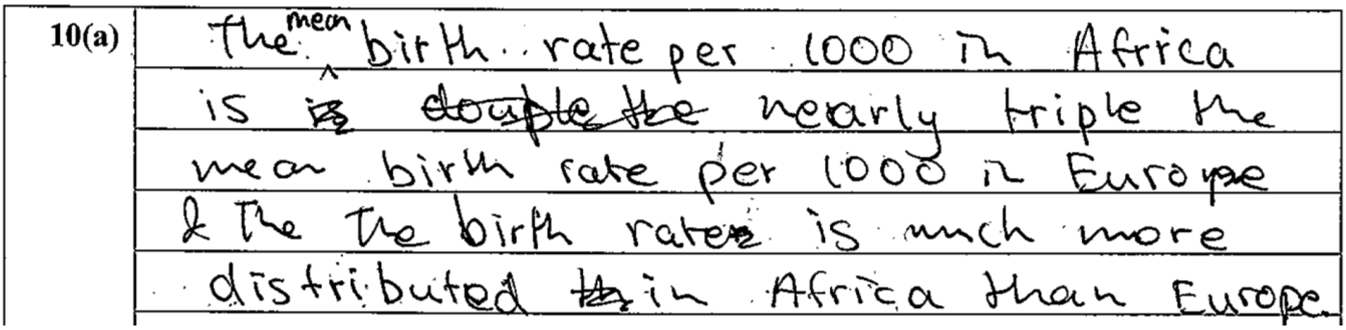
	Africa	Europe	Oceania
n	55	49	21
mean	29.3	10.0	17.8
sd	8.43	1.94	4.50

(a) Use the information in the table to compare and contrast the birth rate per 1000 in Africa with the birth rate per 1000 in Europe. **[2]**

This was a classic statistical comparison question, which required candidates to compare given statistical data, and to give a holistic assessment of what the data tells us. Most candidates were able to make valid comparisons of the statistical data given (either direct or indirect/implicit) but many lacked the awareness to make a holistic statement of what the data tells us, for example, 'the mean birth rate of Africa is bigger than that of Europe', etc. with no holistic comment. It continues to be a challenge to some candidates when making the distinction between 'mean', 'average' and 'on average'. Comparisons of 'averages' is ambiguous, comparisons of 'means' is valid – but this is a measure of 'average' so we need a comment on what this tells us overall, e.g. 'on average the birth rates are higher in Africa than in Europe due to the mean being bigger', etc.

Candidates were generally more successful in accruing the second mark here for comparing the SD values and the consequential inference about dispersion, etc.

Exemplar 1


10(a) The mean birth rate per 1000 in Africa is ~~is~~ ~~double the~~ nearly triple the mean birth rate per 1000 in Europe & The The birth rates is much more distributed ~~th~~ in Africa than Europe.

This candidate has made a good attempt at comparing the mean values with an indirect comparison, but there is no holistic comment on what this tells us overall, so B0 for the first mark. Unfortunately, while they have given a correct holistic comment on the associated dispersion of birth rates between Africa and Europe, there is no comparison of values (direct or indirect) and so this candidate also scores B0 for the second mark.

Question 10 (b)

(b) The birth rate per 1000 in Mauritius, which is in Africa, is recorded as 9.86. Use the information in the table to show that this value is an outlier. **[2]**

Most candidates understood how to calculate outlier limits using $\bar{x} \pm 2\sigma$ but some resorted to using $\bar{x} \pm 1.5\sigma$ or even $\bar{x} \pm \sigma$. Using a different (rounded) value for the mean was also a common source of marks being lost.

Question 10 (c)

(c) Use your knowledge of the pre-release material to explain whether the value for Mauritius should be discarded. **[1]**

There were many valid attempts at this question, but sometimes candidates were not specific enough about the idea that this was valid data. Ambiguous statements were given no credit. The relatively low facility rate indicated that familiarity with the pre-release material (LDS) remains a significant weakness for most candidates.

Question 10 (d)

(d) The pre-release material identifies 27 countries in Oceania. Suggest a reason why only 21 values were used to calculate the mean and standard deviation. **[1]**

Ambiguous statements such as 'there **may have been** missing data for those countries', etc. were given no credit, since in the context of this question on the LDS 'there **is** missing data for those countries'. Through working with the LDS, candidates should know how to deal with missing data.

Assessment for learning

Candidates do not need to memorise data or summary statistics calculated from the pre-release Large Data Set resource. However, candidates need to use the LDS during the study of the statistics strand of the course in order to be familiar with the general trends within the data and the issues involved with handling the data for calculations and for creating charts.

Teachers will find Notes on the large data set provided for each LDS on Teach Cambridge. Blogs are also published regularly looking at aspects of the LDS with teaching ideas and links to extra resources, for example;

- A Level Maths: the introduction of the Large Data Set
- Why three large data sets for the MEI specification?

Exemplar 2

10(d)	Because the ~~Fea~~ remaing 6 data might not be available.

This candidate has the correct idea, but the ambiguous nature of 'might not be available' does not highlight familiarity with using the LDS.

Question 11 (a)

11 In this question you must show detailed reasoning.

The equation of a curve is $y = 5\sqrt{x} - x - 6$ for $x \geqslant 0$.

(a) Verify that the curve cuts the x-axis at $x = 4$ and at $x = 9$. **[2]**

The command word 'verify' was requested here, so candidates were expected to substitute the given values into the equation and verify that the y value was 0. Attempts at solving the equation scored zero. These were relatively rare, indicating that candidates were very familiar with the given command word.

Question 11 (b)

The curve does not cut or touch the x-axis at any other points.

(b) Determine the exact area bounded by the curve and the x-axis. **[4]**

This question was well attempted by most candidates, but some candidates did not show enough working when substituting limits and evaluating their result. Detailed reasoning was required, so candidates had to demonstrate how they dealt with the resulting numerical expression once the limits had been substituted. Less successful responses struggled with the square root term, and incorrect powers were seen.

Question 12 (a)

12 Data collected in the twentieth century showed that the probability of a randomly selected person having blue eyes was 0.08. A medical researcher believes that the probability in 2024 is less than this so they decide to carry out a hypothesis test at the 5% significance level.

(a) Write down suitable hypotheses for the test, defining the parameter used. **[2]**

Candidates at this level should be well practised in extracting the null and alternative hypothesis, and this was confirmed in candidate responses, but it was also evident that they were less confident with the idea of the population parameter. For AS Level the only population parameter that is required is p which is the probability of 'success' in the contextual situation being described. Any references to the 'number' of people having blue eyes, etc. did not score. Some candidates referred to 'X' here or some other variable but did not define it fully. Most did not use the word 'number' or 'amount', etc. Candidates should also understand that the correct statistical terminology is required, and they should always define p appropriately in the context of the question.

Question 12 (b)

(b) Assuming that the probability that a person selected at random has blue eyes is still 0.08, calculate the probability that 3 or fewer people in a random sample of 92 people have blue eyes. **[1]**

It was expected that candidates had access to a scientific calculator with the capability of finding cumulative binomial probabilities for this question. Errors in rounding prematurely were observed so candidates should be reminded to include all figures on their calculator display, before attempting to round. Answers are usually marked at most accurate.

Question 12 (c)

The researcher collects a random sample of 92 people and finds that 3 of them have blue eyes.

(c) Use your answer to part **(b)** to carry out the test, giving your conclusion in context. **[3]**

Most candidates realised that this question required them to compare their response in (b) with the significance level and make an informed decision about the null hypothesis. The most common cause of marks being lost here was when writing the contextual interpretation of the test carried out. Assertive statements such as 'this proves that' or 'this shows that' or 'the proportion has not decreased' or similar, seem to be becoming less common, but candidates would be best reminded to practise writing contextual conclusions using the correct statistical terminology. Once again, a central theme that candidates misunderstand is the fact that different samples lead to different sets of data, which can lead to different conclusions. Hypothesis tests merely consider the likelihood of a given statement of probability, based on the outcome obtained from a sample and comparison with the arbitrarily chosen significance level.

Misconception

?

Statistical hypothesis tests only consider the significance of the outcome obtained from a sample, based on comparison with an arbitrary significance level. At AS Level the only tests considered are those involving the binomial distribution.

Different samples lead to different sets of data, which can lead to different conclusions. Hypothesis tests merely consider the likelihood of a given statement of probability, based on the outcome obtained from a sample and comparison with the arbitrarily chosen significance level.

The blog A Level Maths - hypothesis tests and the art of being non-assertive may be a useful resource to use with candidates.

Exemplar 3

12(c)

$X \sim B(92, 0.08)$

$P(X \leq 3) = 0.0574$

$0.0574 > 0.050$

$\therefore$ reject H_1, insufficient evidence to prove that the probability in 2024 of a randomly selected person having blue eyes is less than 0.08

This candidate has correctly compared their value from part (b) with the significance level and rejected the alternative hypothesis. However, in their conclusion they have given an assertive statement – hypothesis tests do not prove or disprove anything. They merely consider the strength of the evidence provided by a sample and assess its significance.

Question 13

13 Determine the range of values of x for which $y = 4x^3 + 7x^2 - 6x + 8$ is a decreasing function. **[5]**

This question proved to be accessible to virtually all candidates, with many achieving full/almost full marks. This was not a 'detailed reasoning' question, so any attempt to solve their quadratic derivative (even using a calculator if the values given were correct) scored marks. However, candidates would be advised that this is a risky path, as it would be easy for transcription and/or sign errors to manifest when copying values from the calculator. A stated quadratic formula, followed by substituted values and a calculator 'check', would be the best way to avoid errors when solving.

Due to the nature of definitions regarding decreasing/strictly decreasing sometimes appearing contradictory, either strict or non-strict inequalities were acceptable here.

Question 14

14 In this question you must show detailed reasoning.

Solve the equation $5 - \cos\theta - 6\sin^2\theta = 0$ for $0° < \theta < 360°$. **[6]**

Normally these questions prove to be challenging for candidates at this level, but this one appeared to present little challenge to most. It was evident that most had had experience of converting to a quadratic in cosine and proceeding to solve. However, this question did stipulate that detailed reasoning was required, so candidates who solved their 3 term quadratic (3TQ) in cosine without showing full method (on a calculator for example) lost marks. These cases were treated as a special case (SC) in the mark scheme, assuming all other aspects of the solution were correct. Most candidates make good progress on solving the two separate trigonometric equations generated from their quadratic in cosine.

Question 15 (a)

15 Ali and Sam are playing a game in which Ali tosses a coin 5 times. If there are 4 or 5 heads, Ali wins the game. Otherwise Sam wins the game. They decide to play the game 50 times.

(a) Initially Sam models the situation by assuming the coin is fair. Determine the number of games **Ali** is expected to win according to this model. **[2]**

This part was a binomial distribution question, but although most candidates realised this, often writing down the distribution, there were many incorrect attempts seen. Missing or incorrect binomial coefficients for the $p(4H)$ term was the most common incorrect response, leading to incorrect values for the expected number of games won.

Question 15 (b)

Ali thinks the coin may be biased, with probability p of obtaining heads when the coin is tossed. Before playing the game, Ali and Sam decide to collect some data to estimate the value of p. Sam tosses the coin 15 times and records the number of heads obtained. Ali tosses the coin 25 times and records the number of heads obtained.

(b) Explain why it is better to use the combined data rather than just Sam's data or just Ali's data to estimate the value of p. **[1]**

This mark was generous, and most candidates were able to articulate the fact that more data lead to a more accurate value of p being found. Benefit of doubt (BOD) was applied in a lot of cases if candidates had the general idea about increasing the sample size leading to more data and being more representative of the theoretical distribution.

Question 15 (c)

Ali records 20 heads and Sam records 8 heads.

(c) Use the combined data to estimate the value of p. **[1]**

This was a simple application of 'expected number of successes $= np$' but some candidates appeared confused by the separate samples, despite the clear instruction to use the combined data, with values of p = 0.8 and $p = \frac{8}{15}$ coming from $20 = 25p$ and $8 = 15p$ respectively.

Question 15 (d)

Ali now models the situation using the value of p found in part **(c)** as the probability of obtaining heads when the coin is tossed.

(d) Determine how many games Ali expects to win using this value of p to model the situation. **[2]**

This question depended on candidates applying a binomial distribution model with the correct value of p to calculate the expected number of games won, similar to that in part (a). However, there was no FT mark available for an incorrect value of p found in (c) as this was at the very end of the paper and FT was given in part (e).

Question 15 (e)

(e) Ali wins 25 of the 50 games. Explain whether Sam's model or Ali's model is a better fit for the data. **[1]**

Most candidates were able to give a correct FT reason by comparing the estimated number of successes from both models with 25, but a sizeable number of candidates also resorted to comparing values of p. Comparison of values of p yielded no marks, as candidates needed to compare the outcomes from both models to the actual value obtained. Some candidates appeared to be looking for a value that was closest to 0.5 and there was some confusion between 'number of heads' and 'winning the game'.

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