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Examiners' report

A LEVEL

MATHEMATICS B (MEI)

OCR Level 3 Advanced GCE in Mathematics B (MEI)

H640

For first teaching in 2017

H640/02 Summer 2025 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 responses 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 [Teach Cambridge].

Paper 2 series overview

H640/02 is the second of three compulsory components in the A Level assessment. It contributes 36.4% of the total A Level and assess content from pure mathematics and statistics.

Section A (23 marks – Questions 1 – 7) is designed to offer a gentle start to the exam, with questions focused on routine procedural work, and little problem solving, from both pure and statistics content. However, the proof required in question 5 was challenging for many candidates.

Section B (77 marks – Questions 8 – 17) is designed to include longer questions on both pure and statistics content with some involving more complex problem solving and are often more scaffolded through multiple question parts. While this section is designed to be more challenging, candidates appeared to be able to demonstrate their knowledge on the topics assessed.

Candidates are expected to have studied statistics using the large data set (LDS 7, Question 10) and to have routinely used spreadsheets and the statistical functions on their calculator. Additionally, they should be familiar with statistical software and be able to interpret output generated by software such as summary statistics and statistical diagrams. They should also be familiar with graphing software.

To do well in this component, candidates need to understand what is signalled by the various command words such as 'Determine' as detailed in the specification. They need to be able to use their calculators in a variety of different contexts such as calculating binomial or Normal probabilities.

When interpreting statistical information, whether it is presented in text, tables or diagrams, they need to support inferences and explanations with reference to the relevant quantitative information.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• understood the requirements of the request to show detailed reasoning • were familiar with the pre-release material • were proficient in routine algebraic manipulation involving negative indices and quadratic equations • made efficient use of the statistical functions and probability distributions on their calculators, and were able to work successfully with summary statistics • used (sometimes given) numerical information to support statistical inferences or explanations • expressed final answers in a simplified form.	• provided insufficient detail of their working when responding to a request to show detailed reasoning • had apparently not worked with the pre-release material • made slips and sometimes fundamental errors when completing routine algebraic work • misunderstood how to use summary statistics and made slips when using probability distributions on their calculators • made speculative comments to support inferences or explanations • left final answers not simplified.

Section A overview

Section A was accessible to nearly all candidates, with many candidates scoring at least 20 marks out of 23. Nearly all candidates obtained at least half marks on this section.

Question 1 (a)

1 The equation of a circle is $(x-4)^2+(y+5)^2-64=0$.

(a) State the coordinates of the centre of the circle. **[1]**

Question 1 (b)

(b) State the radius of the circle. **[1]**

This question was very well answered: nearly all candidates were given both marks. A small minority made a sign error in part (a) or confused radius and diameter and gave an answer of 16 in part (b).

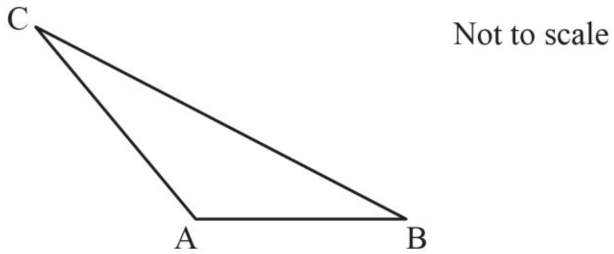
Question 2

2 Determine the coefficient of x^3 in the expansion of $(1+2x)^{12}$. **[2]**

Most candidates answered this question successfully. Those who did less well gave the answer $1760x^3$ or neglected to cube 2, thereby did not gain the A mark. The small number of candidates worked with ${}^{12}C_4$.

Question 3

3 The diagram shows triangle ABC.



AB = 4.7 cm, AC = 6.9 cm and BC = 11.2 cm.

Find the size of angle CAB. Give your answer correct to **3** significant figures. **[2]**

Most candidates answered this question successfully. Those who did less well often showed the correct method but made a slip in the calculation, or did not give their answer to the correct precision. A small minority of candidates misquoted the cosine rule or substituted the lengths incorrectly and didn't score.

Question 4 (a)

4 **(a)** Use the factor theorem to show that $(x-3)$ is a factor of $4x^3-8x^2-11x-3$. **[1]**

Question 4 (b)

(b) Hence show that $4x^3-8x^2-11x-3=(x-3)(ax+b)^2$, where a and b are integers to be determined. **[2]**

Question 4 (c)

(c) Sketch the graph of $y=4x^3-8x^2-11x-3$ on the axes in the Printed Answer Booklet. **[2]**

For the most part candidates answered this question very successfully.

Candidates who did less well may have made a sign error when using long division in part (b) or they may have mislabelled or omitted a label for an intercept in part (c)

Question 5

5 Prove that the sum of the first n positive odd numbers is a square number. **[3]**

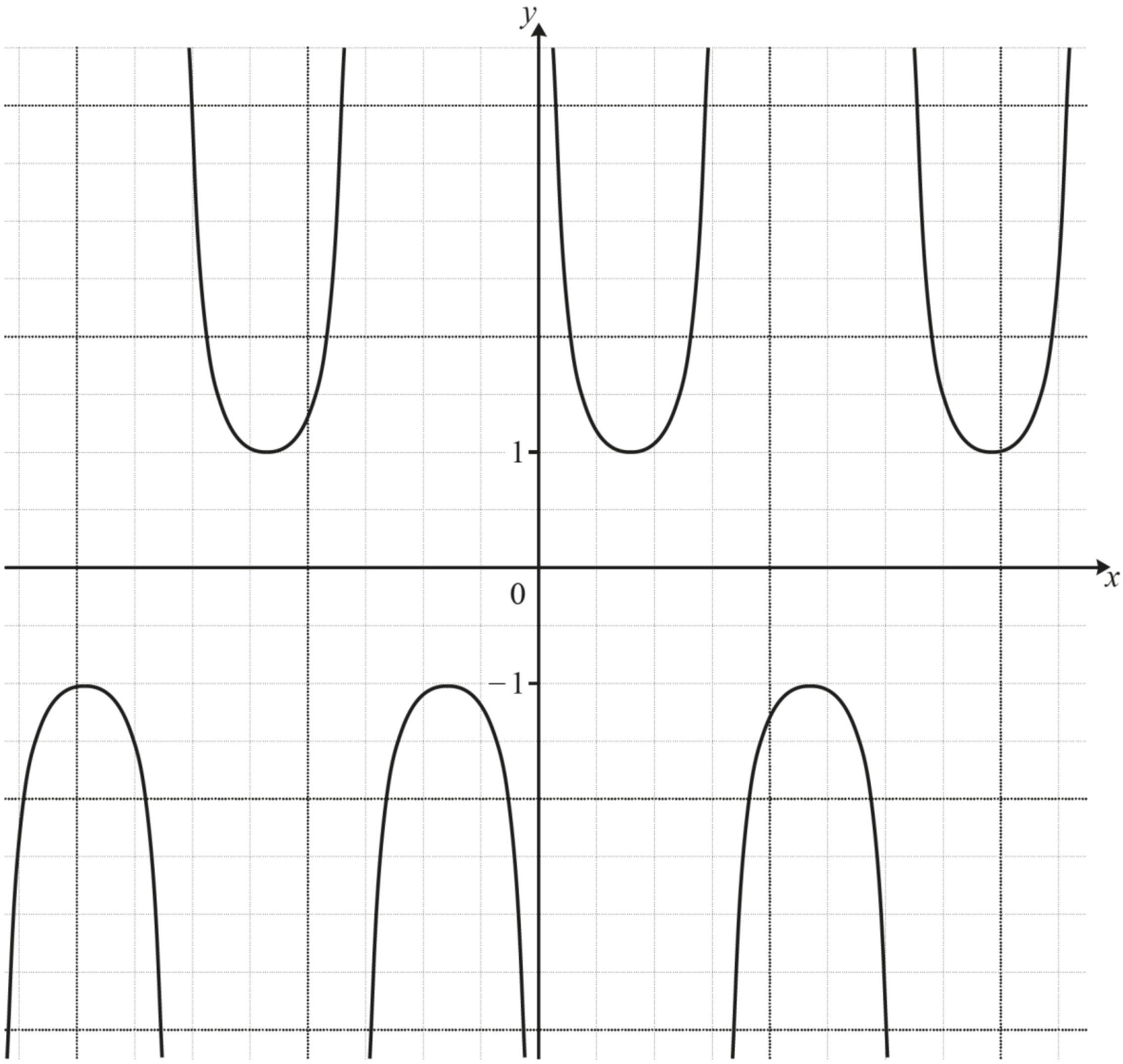
Candidates who did well in this question used $S_n=\frac{n}{2}(2a+(n-1)d)$ or $S_n=\frac{n}{2}(a+l)$ with a = 1 and d =2 or started with $\sum_{i=1}^{n}(2i-1)$ and used the standard formula for $\sum_{i=1}^{n} i$ to obtain the result n^2.

Candidates who did less well worked with a = 3 or made a slip such as an omission of brackets when completing the proof.

Candidates who did not do well attempted proof by exhaustion or proof by contradiction.

Question 6 (a)

6 The diagram shows part of the graph of $f(x) = \operatorname{cosec} 2x$.



(a) State which of the following is the equation of the curve $y = \dfrac{1}{f(x)}$.

$y = \cos 2x$ $\quad$ $y = \operatorname{cosec}(-2x)$ $\quad$ $y = -\operatorname{cosec} 2x$ $\quad$ $y = \sin 2x$ **[1]**

Question 6 (b)

(b) State the exact equations of the asymptotes of $y = \operatorname{cosec} 2x$ for $0 \leqslant x \leqslant \pi$. **[1]**

Candidates who did less well wrote down may have omitted '*y* =' in part (a) or missed one of the equations in part (b). A small number of candidates identified the three asymptotes but presented them as a list of *x*-values instead of giving three equations.

Question 7 (a)

7 Some people have blood type A and some people have brown hair. A person may have both, just one, or neither of these characteristics.

A person is selected at random.

A is the event 'the person has blood type A'.
B is the event 'the person has brown hair'.

You are given the following probabilities.

$\mathrm{P}(\mathrm{A} \cap \mathrm{B}') = 0.3382$, $\mathrm{P}(\mathrm{A}' \cap \mathrm{B}) = 0.0682$ and $\mathrm{P}((\mathrm{A} \cup \mathrm{B})') = 0.5518$.

(a) Show this information on the Venn diagram in the Printed Answer Booklet. **[2]**

Most candidates answered this question correctly.

Candidates who did less well misplaced one of the probabilities or replaced 0.5518 with 0.4482.

Question 7 (b)

(b) Determine whether A and B are independent events. **[4]**

Candidates who did well in this question calculated P(A), P(B) and P(A and B) and then showed by calculation that P(A and B) = P(A) x P(B). A significant minority were equally successful showing that P(A) = P(A|B).

Candidates who did less well usually found P(A and B) correctly but may have mistaken 0.3382 for P(A) and/or 0.0682 for P(B). A few candidates presented the correct argument but made slips with the arithmetic.

A significant minority of candidates did not appear to know what was meant by independence in this context and made little progress on this question.

Question 7 (c)

(c) Explain whether A and B are mutually exclusive events. **[1]**

Candidates who did well in this question explained their answer in terms of P(A and B) being non-zero.

Candidates who did not do well often understood what was meant by mutually exclusive but couldn't explain their reasoning adequately and didn't refer to probability. A significant minority of candidates confused mutually exclusive with exhaustive.

Section B overview

The early marks on each question proved to be accessible to all candidates, and a significant number of candidates were able to achieve full marks on several questions in this section. Questions 14 (d), 15 (d), 16 and 17 proved to be the most demanding.

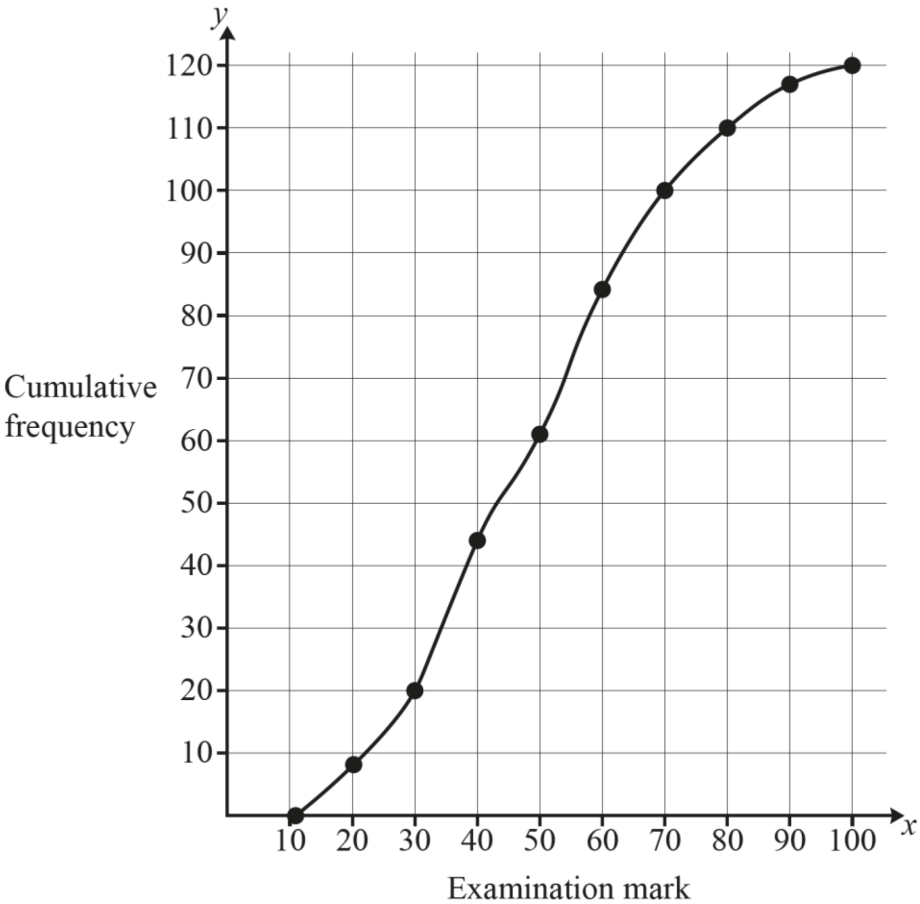
Question 8 (a)

8 At the end of the summer term all 120 Year 8 pupils at Oakmount College sit the same mathematics examination.

The marks obtained by the pupils in the 2024 examination are summarised in the table.

Mark	11–20	21–30	31–40	41–50	51–60	61–70	71–80	81–90	91–100
Frequency	8	12	24	17	23	16	10	7	3

Software is used to produce the cumulative frequency curve shown below.



(a) It is proposed that the 30 pupils with the best marks in the examination are placed in the top set in Year 9.

Use the copy of the cumulative frequency curve in the **Printed Answer Booklet** to determine an estimate of the lowest mark needed for a pupil to be placed in the top set. **[2]**

Question 8 (b)

(b) The person who will teach the top set states that pupils will **not** manage in this class unless they obtain at least 75 marks in the examination.

Use the copy of the cumulative frequency curve in the **Printed Answer Booklet** to determine an estimate of how many pupils will be in the top set if the lowest mark is set at 75. **[2]**

Most candidates did very well in this question, often obtaining all 4 marks.

Candidates who did less well were sometimes careless with their use of the diagrams and did not gain the A mark(s) because their answer was out of tolerance. Both parts of this question requested candidates to 'determine' so those candidates that presented answers with no working could not be awarded full M1A1 marks, but a B1 for correct answers was allowed.

Question 9 (a)

9 The position vectors of the points A and B are $\overrightarrow{OA} = \begin{pmatrix} -1 \\ -2 \\ 0 \end{pmatrix}$ and $\overrightarrow{OB} = \begin{pmatrix} 2 \\ 1 \\ -3 \end{pmatrix}$ respectively.

(a) Write down the vector $\overrightarrow{AB}$. **[1]**

Question 9 (b)

The point C lies on AB such that $2\overrightarrow{AC} = \overrightarrow{CB}$.

(b) Find the vector $\overrightarrow{OC}$. **[2]**

Most candidates did very well in this question, with many earning all 3 marks.

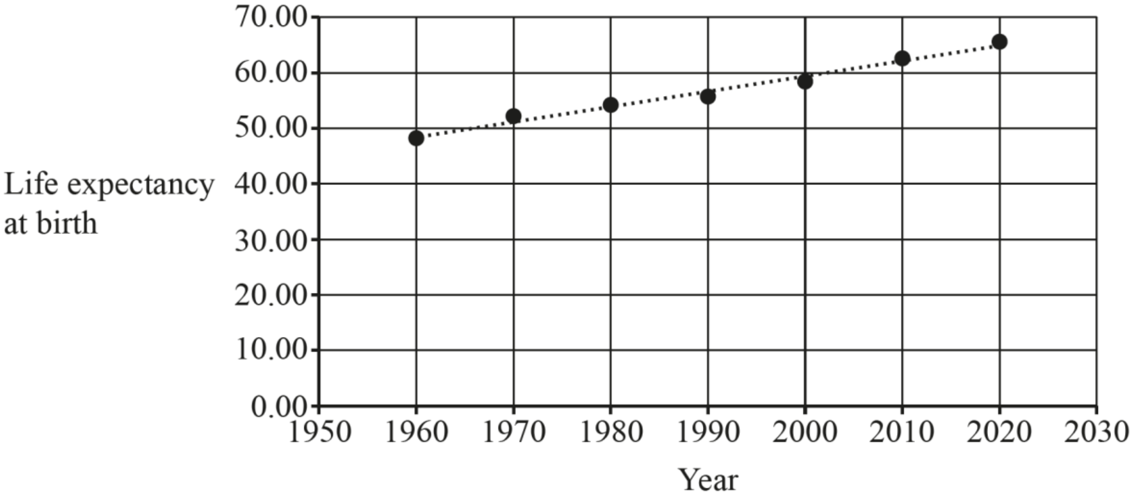
Those who did less well made a slip with the arithmetic or used the wrong multiplier and earned the mark for the special case.

Question 10 (a)

10 The pre-release material contains information about life expectancy at birth for countries of the world at 10-year intervals from 1960 until 2020.

The life expectancy at birth of the population of Sudan for this period, together with a line of best fit, is shown in **Fig. 10.1**.

Fig. 10.1



The equation of the line of best fit is $L = 0.275X - 490$, where X is the year and L is the life expectancy at birth, measured in years.

(a) Use the equation of the line of best fit to estimate the life expectancy at birth in Sudan in 1975. **[1]**

This question was done extremely well, with very few errors seen.

Question 10 (b)

(b) Explain whether this estimate is likely to be close to the true value of life expectancy at birth in Sudan in 1975. **[1]**

Candidates who did well alluded to interpolation or the apparently strong linear relationship to justify the assertion that the estimate is likely to be reliable.

Some candidates who did not do well did not say whether the estimate is likely to be reliable. A minority commented on the value of the life expectancy being between the two values for life expectancy on the graph.

Question 10 (c)

(c) Use your knowledge of the pre-release material to explain whether your answer to part **(a)** is likely to be a close approximation to the life expectancy at birth in the United Kingdom in 1975. **[1]**

Candidates who did well in this question observed that life expectancy in the UK is higher than in Sudan, or that life expectancy is generally higher in Europe than in Africa, so the approximation is unlikely to be close.

Candidates who did not do well compared other variables such as healthcare or standard of living, without actually referring to life expectancy.

Question 10 (d)

The pre-release material also gives the median age of the population in countries of the world.

The table shows the median age of the population and the life expectancy at birth in 2020 for some countries in Africa.

Country	**Median age**	**Life expectancy at birth 2020**
Nigeria	18.6	55.02
Rwanda	19.7	69.33
Saint Helena, Ascension and Tristan da Cunha	43.2	#N/A
Sao Tome and Principe	19.3	70.58
Senegal	19.4	68.21

(d) Explain how the data in the table should be cleaned before these data can be included in a scatter diagram for life expectancy at birth against median age for the countries in Africa. **[1]**

Candidates who did well commented that rows of data with an entry of #N/A should be deleted.

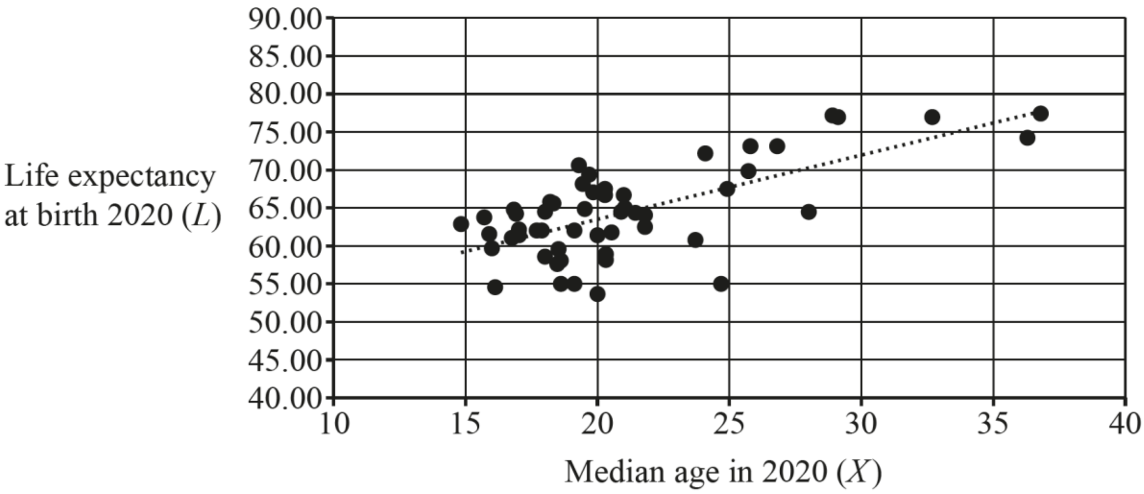
Candidates who did not do well either commented that cells (rather than explicitly referring to the whole row) with an entry of #N/A should be deleted, or didn't refer to missing data in any way, but attempted to identify outliers.

Question 10 (e)

Fig. 10.2 shows a scatter diagram for the cleaned data of life expectancy at birth against median age in 2020 for the countries in Africa. It also shows a line of best fit.

The product moment correlation coefficient for these data is 0.680.

Fig. 10.2



(e) A student decides to use the line of best fit to estimate the life expectancy at birth in 2020 for Saint Helena, Ascension and Tristan da Cunha.

Explain whether this estimate is likely to be reliable. **[1]**

Candidates who did well in this question usually identified extrapolation as a reason for it being unlikely that the estimate will be reliable, although some presented sensible arguments based on the nature of the scatter or the lack of evidence for a linear relationship.

Candidates who did not do well argued that the estimate is likely to be reliable.

Question 11 (a)

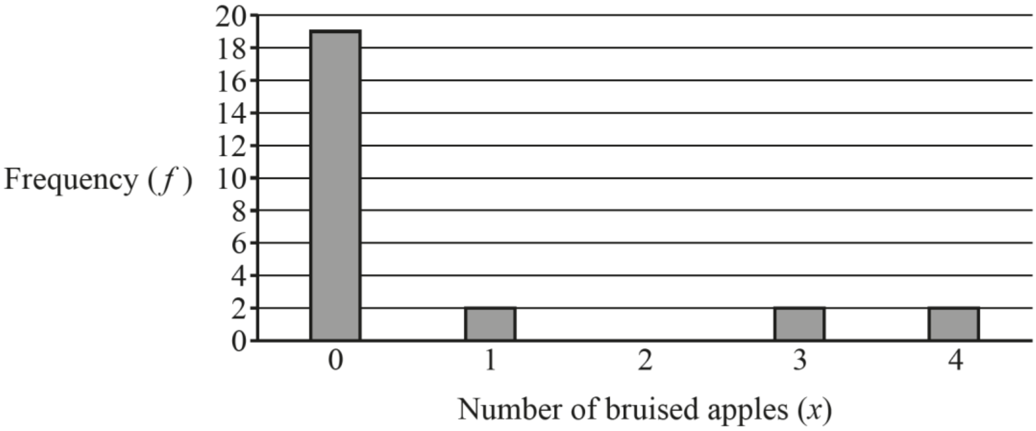
11 Apples are sold in packets of 4. Ling and Sam are investigating the frequency, f, of the number of bruised apples in a packet, x. They each collect a random sample of packets, note the number of bruised apples in each packet and draw a diagram to represent their data.

Ling's results are shown in **Table 11.1** and **Fig. 11.1**.

Table 11.1

x	0	1	2	3	4
f	19	2	0	2	2

Fig. 11.1

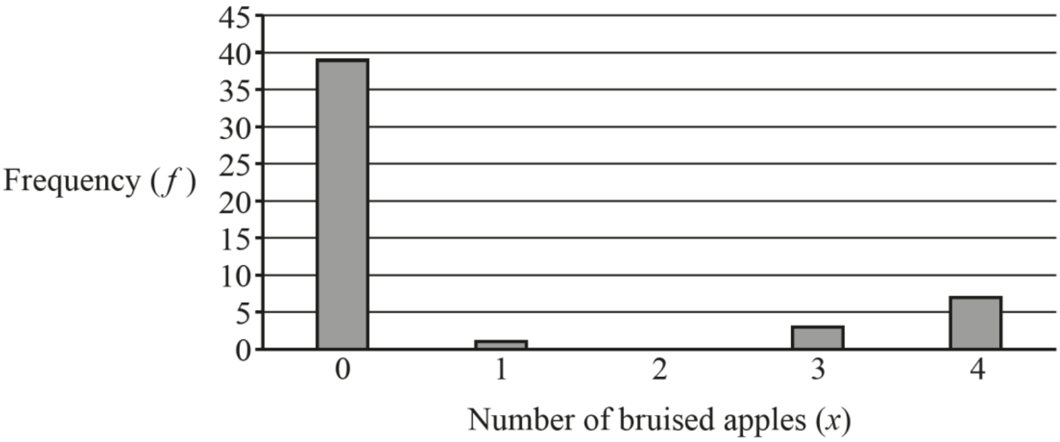


Sam's results are shown in **Table 11.2** and **Fig. 11.2**.

Table 11.2

x	0	1	2	3	4
f	39	1	0	3	7

Fig. 11.2



(a) Explain why Sam's diagram is likely to be a better representation of the true distribution of the number of bruised apples in a packet than Ling's diagram. **[1]**

Most candidates answered this question correctly.

Question 11 (b)

(b) Calculate the mean number of bruised apples per packet for Sam's data. **[1]**

Most candidates answered this question correctly.

Candidates who did not do well rounded their answer to the nearest whole number or evaluated $\frac{0+1+2+3+4}{50}$.

Question 11 (c)

Sam thinks that the distribution of bruised apples may be modelled by a binomial distribution.

(c) Use your answer to part **(b)** to calculate the value of p, the probability that an apple selected at random is bruised, for Sam's model. **[1]**

Candidates who did well in this question divided their answer to part (b) by 4.

Candidates who did not do well in this question, who were in the majority, divided their answer to part (b) by 50.

Question 11 (d)

(d) Calculate the theoretical frequency distribution of the number of bruised apples per packet for Sam's model, giving your answers correct to **2** decimal places. **[3]**

Candidates who did well in this question calculated the probability distribution for B(4, their p), and then the theoretical frequencies by multiplying by 50. They may have rounded their probabilities before multiplying and did not gain a mark.

Candidates who did less well just calculated the probabilities.

Candidates who did not do well usually worked with B(50, 0.0152).

Question 11 (e)

(e) Comment on whether Sam's model appears to be a good fit for the data. **[1]**

Candidates who did well in this question compared their probabilities or their frequencies from part (d) with the given data.

Candidates who did not do well considered the model to be a good fit, or made no reference to their work in part (d).

Question 12

12 In this question you must show detailed reasoning

Solve the equation $3\sec^2\theta + 2\tan\theta - 4 = 0$ for $-180° < \theta < 180°$. **[6]**

Candidates who did well in this question showed the substitution of the Pythagoras identity and the steps to obtain a quadratic equation in $\tan\theta$. They obtained values for $\tan\theta$, usually by factorising, but occasionally by using the formula, before using these to obtain the required values of θ. A small number of candidates obtained a quadratic in $\sin\theta$ or $\cos\theta$: a few successfully found the correct values using this approach and earned full marks.

Candidates who did less well may have omitted to show sufficient details of the initial substitution or not shown any working for obtaining their values for $\tan\theta$. Some candidates made a rounding error in their values of θ.

Candidates who did not do well may have made a sign error when substituting or may have made a slip post substitution to obtain an incorrect quadratic. Some candidates factorised incorrectly and did not gain the last 3 marks.

Quadratic equations and detailed reasoning

When a quadratic equation arises as part of the solution to a question which requires detailed reasoning, candidates must show how they arrive at the values, for example by factorising, completing the square or using the quadratic formula.

Question 13 (a)

13 According to the Office for National Statistics, in 2022 the proportion of people in England and Wales aged 16 or over who were married or in a civil partnership was 0.494.

In 2024 a researcher collected a random sample of 78 people aged 16 or over.

The researcher decided to conduct a hypothesis test at the 1% level to see if there was any evidence to suggest that the proportion of people aged 16 or over who are married or in a civil partnership was lower in 2024.

(a) State the hypotheses for the test. You must define the parameter used to carry out the test. **[2]**

Candidates who did well in this question stated their hypotheses clearly and provided a full definition of the stated parameter.

Candidates who did less well in this question gave an incorrect or incomplete definition of the parameter.

Question 13 (b)

(b) Determine the critical region for the test. **[3]**

Candidates who did well in this question calculated the relevant probabilities and identified the critical region correctly. Some candidates successfully worked with the inverse binomial probability function on their calculator.

Candidates who did less well found the correct critical value but were unable to state the critical region correctly. A few candidates gave the correct answer but provided insufficient working to justify their answer. A small number of candidates found the critical region for a two tailed test.

Many of the candidates that struggled on this question appeared to be using the probability distribution rather than the cumulative distribution, eg $P(X = 28)$ etc.

Question 13 (c)

The researcher found that 26 of the 78 people in the random sample were married or in a civil partnership.

(c) Use your answer to part **(b)** to carry out the hypothesis test. **[3]**

Candidates who did well in this question used their answer to part b as requested to carry out the test. They made the correct deduction and presented a full conclusion in context.

Candidates who did less well gave an incomplete or over-assertive conclusion and did not gain the final mark.

Candidates who did not do well worked with the wrong critical region or re-worked the test using a *p*-value – this was often unsuccessful.

Question 13 (d)

(d) State the probability that the null hypothesis is incorrectly rejected. **[1]**

Many candidates answered this question correctly.

Candidates who did not do well sometimes gave the value for P($X \le 26$) calculated in part (b) or part (c). A variety of other incorrect probabilities were given.

Question 14 (a)

14 The equation of a curve is $y = \frac{16}{x^2} + \frac{3}{x}$.

(a) Determine the coordinates of the point where the curve cuts the x-axis. **[2]**

Most candidates earned both marks.

Those who did less well often did not provide coordinates as requested and left their answer as $x = -\frac{16}{3}$. Some candidates obtained extra, incorrect, coordinates of (0.0).

Question 14 (b) (i)

(b) **(i)** Find $\frac{dy}{dx}$. **[2]**

Most candidates earned both marks, with hardly any sign errors being seen.

Candidates who did not do well divided 16 by −2 instead of multiplying.

Question 14 (b) (ii)

(ii) Hence determine the exact coordinates of the stationary point on the curve $y = \frac{16}{x^2} + \frac{3}{x}$. **[2]**

Most candidates answered this question correctly.

Those who did less well omitted the *y*-coordinate or presented an extra point – usually (0,0). A few slipped up when calculating the *y*-value following correct work to find *x*.

Question 14 (c) (i)

(c) (i) Find $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}$. **[2]**

This was very well done indeed.

Question 14 (c) (ii)

(ii) Hence determine the set of values of x for which the curve $y = \frac{16}{x^2} + \frac{3}{x}$ is concave downwards. **[2]**

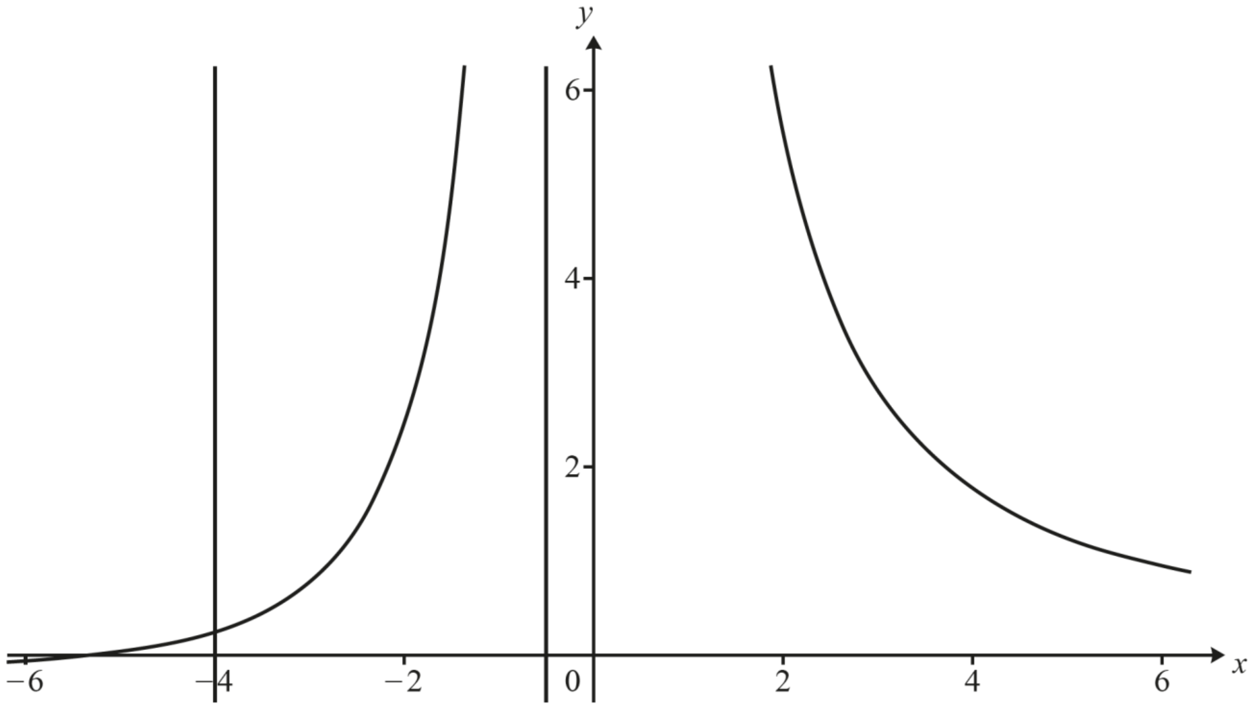
A good number of candidates earned both marks.

Those who did less well often made a sign error and obtained $x < 16$ or $x > -16$. Some candidates obtained an extra value, and a common wrong answer was $-16 < x < 0$.

Candidates who did not do well often incorrectly investigated $\frac{\mathrm{d}^2y}{\mathrm{d}x^2} > 0$.

Question 14 (d)

The diagram shows parts of the curve $y = \frac{16}{x^2} + \frac{3}{x}$, the line $x = -4$ and the line $x = -\frac{1}{2}$.



(d) Determine the exact area bounded by the curve $y = \frac{16}{x^2} + \frac{3}{x}$, the x-axis and the lines $x = -4$ and $x = -\frac{1}{2}$. Give your answer in the form $a + b\ln 2$, where a and b are constants to be determined. **[5]**

Candidates who did well in this question integrated both terms correctly, substituted the limits correctly and used $\ln|x|$ to deal with the negative limits. They usually went on to obtain the correct answer in the requested form. A minority of candidates reflected the curve in the *y*-axis and successfully integrated $\mathrm{f}(-x)$, substituting positive limits to obtain the correct result.

Candidates who did less well integrated correctly but worked with the logarithms of negative numbers to fortuitously obtain the correct result. Those who attempted a reflection in the *y*-axis may have made a sign error (usually with the second term) or neglected to swap the limits.

Candidates who did not do well in this question may have integrated only one term correctly: $16\ln x^2$ and 3 were occasional wrong answers for the first and second term respectively. A few candidates attempted the substitution $u = x^2$, an approach which could only earn part marks.

Integration involving the natural logarithmic function

The integration formula $\int \frac{f'(x)}{f(x)} = ln|f(x)| + c$ must use the modulus when $f(x) < 0$ since $ln(f(x))$ will be undefined. Simply ignoring the negative is not good mathematical practice and will not normally be credited, especially where the command request is 'determine', 'show that', or '**In this question you must show detailed reasoning**'.

Exemplar 1

14(d)

$$\int_{-4}^{-1/2} \frac{16}{x^2} + \frac{3}{x}\,dx$$

$$\int_{-4}^{-1/2} 16x^{-2} + 3x^{-1}\,dx$$

$$\left[\frac{16x^{-1}}{-1} + 3\ln|x|\right]_{-4}^{-1/2}$$

$$\left[-\frac{16}{x} + 3\ln|x|\right]_{-4}^{-1/2}$$

$$\cancel{\left\{\left(\frac{-16}{-1/2} + 3\ln\left|-\tfrac{1}{2}\right|\right) - \left(\frac{16}{-4} + 3\ln|-4|\right)\right\}}$$

$$\cancel{= 32 - 4 = 28}$$

$$\left\{\left(\frac{-16}{-1/2} - 3\ln(1/2)\right) - \left(\frac{-16}{-4} - 3\ln(4)\right)\right\}$$

$$32 - 3\ln(1/2) - 4 + 3\ln(4)$$

$$28 + 3\ln\left(\frac{4}{1/2}\right)$$

$$28 + 3\ln(8)$$

$$28 + 3\ln(2)^3$$

$$28 + 9\ln(2)$$

This response earns M1A1 for both terms being integrated correctly. Unfortunately this candidate has crossed out their substitution with correct use of limits and modulus (which could have earned the second M1) and dealt with $\ln(-\frac{1}{2})$ and $\ln(-4)$ by writing $\ln\left|-\frac{1}{2}\right| = -\ln\left(\frac{1}{2}\right)$ and $\ln|-4| = -\ln 4$, in a single line of working which meant that neither the second or third M1 could be earned and the final answer is incorrect A0.

Question 15 (a) (i)

15 A personal trainer is investigating whether, in the general population, there is any association between resting pulse rate in beats per minute and mean hours per week spent running.

One week he collects a sample by asking 25 of his clients for the relevant data.

(a) **(i)** State the name of the sampling technique used by the personal trainer. **[1]**

Most candidates answered this question correctly.

Those who did not do well sometimes gave close approximations, such as opportunistic sampling and convenient sampling. Quota sampling and stratified were common wrong answers. The specification ref Mp23 provides a list of sampling techniques that candidates should be familiar with.

Question 15 (a) (ii)

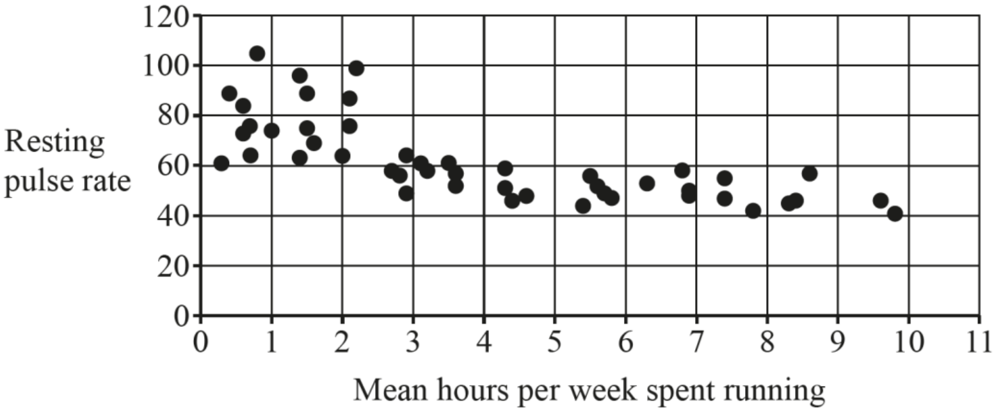
(ii) Explain why this sampling technique might introduce bias. **[1]**

There were very many good answers to this question, with candidates realising that those who use the services of a personal trainer are unlikely to be representative of the general population in this context. This was expressed in a variety of interesting and imaginative ways.

Candidates who did not do well sometimes explained why the sample was not a simple random sample or explained why the trainer's sample might not be representative of the rest of his clients.

Question 15 (b)

A biologist researching the same topic collects a random sample of size 47. She represents the data using the scatter diagram shown below.



(b) Describe the association between resting pulse rate and mean hours per week spent running. **[1]**

Most candidates met the demand of this question by writing down 'negative association' or gave the equivalent in terms of the two variables.

Those who did not do well framed their response in terms of correlation, in spite of the request for a description of the association.

Question 15 (c)

(c) The biologist identifies two distinct regions on the scatter diagram. Identify these regions on the copy of the scatter diagram in the **Printed Answer Booklet** by drawing an appropriate **vertical** line between them. **[1]**

Nearly all candidates earned this mark.

Those candidates who did not do well may have divided the scatter into 3 parts instead of 2. Occasionally they drew diagonal lines or circled two sets of points.

Question 15 (d)

According to medical research, the normal resting pulse rate for an adult is between 60 and 110 beats per minute.

The biologist separates the data into a group to the left of the vertical line on the scatter diagram and a group to the right of the vertical line on the scatter diagram. She calculates Spearman's rank correlation coefficient, r_s, and the associated p-value for each group.

The results are shown in the table.

Group	r_s	p-value
To the left of the vertical line	0.209 36	0.419 98
To the right of the vertical line	–0.613 49	0.000 31

(d) With reference to the two groups identified by the biologist and to the values in the table, explain what may be inferred about the association between resting pulse rate and mean number of hours per week spent running. **[6]**

Candidates who did well in this question considered the magnitude of the two values of r_s compared to 0 or 1 as appropriate. Similarly, they compared the p-values with standard values such as 0.01 or 0.05 and then made inferences about the association between resting pulse rate and mean hours per week spent running.

Candidates who did less well used their comparisons to support their comments but based their conclusions on correlation rather than association.

Candidates who did not do well compared the p-values with the values of r_s and in some cases thought the p-value was the value of the product moment correlation coefficient. Some candidates wrote at length about the different degrees of association, often quite sensibly, but without referring to the p-values or the rank correlation coefficients.

Exemplar 2

15(d)	Group to the left of the vertical line $r_s = 0.20936$ p-value $= 0.41998$:
	~~There is no~~ ~~at~~ ~~5~~ 1% level
	~~associat~~ 0.41998 > 0.01
	there is insufficient evidence to
	suggest that there is some association
	between resting pulse rate and mean
	number of hours per week spent
	running
	~~$\bar{x} = \frac{60+110}{2} = 85$ pulses/min~~
	~~$X \sim B(18, 0.41998)$~~
	~~$P(X < 85) = ...$~~
	Group to the right of the vertical line $r_s = -0.61349$ p-value $= 0.00031$:
	0.00031 < 0.01
	There is sufficient evidence to suggest
	that there is some association between
	resting pulse rate and mean number
	of hours per week spent
	running

In the first part of the response, it was given B0 because there is no consideration of the magnitude of r_s. M1A1 is then earned for comparing the *p*-value with 0.01 and making an appropriate inference.

In the second part, once again there is no relevant comment on the magnitude of r_s, so B0. However, it was given M1A1 for the comparison of the *p*-value with 0.01 and making an appropriate inference.

Question 16 (a)

16 In this question you must show detailed reasoning

The population of puffins on a remote island is estimated to be $P = 58.5$, where P is measured in thousands of birds.

Just after this estimate is made there is a serious oil spill in the area. It is noted that there is a rapid decline in the population of puffins on the island.

The situation is modelled by the differential equation

$\frac{\mathrm{d}P}{\mathrm{d}t} = (72t - 108)\mathrm{e}^{-0.8t}$, where t is the time in years after the pollution incident.

(a) Determine an expression for P in terms of t. **[7]**

Candidates who did well in this question separated the variables and then used integration by parts to express *P* in terms of *t*. They substituted correctly to find the constant of integration and presented the final answer with fractions in lowest terms and like terms collected.

Candidates who did less well may have omitted to show the separation of variables as a first step or made a sign error when integrating by parts. Some candidates earned M1A1 for integration by parts but then made a slip with the second integration.

Candidates who did not do well may have earned the first B1 mark but then made no progress with integration by parts (for a variety of reasons, often the wrong choice of *u* and d*v*).

A few candidates wrote down the correct answer and then may have attempted to justify the answer by differentiating. Such an approach seldom earned more than the first B1 mark.

Question 16 (b)

(b) Determine whether, according to the model, P will recover to 58.5. You may assume that $\lim_{t\to\infty} t\mathrm{e}^{-0.8t} = 0$. **[2]**

Those candidates who did well in this question usually worked with $\lim_{t\to\infty} e^{-0.8t} = 0$ and showed that $P \to 36$ to justify the conclusion that the population of puffins will not recover to its original value, according to the model. Some candidates were equally as successful by beginning their response with as $t \to \infty, e^{-0.8t} \to 0$.

Candidates who did not do well in this question sometimes had the right idea but may have substituted ∞ in their expression for P or set their expression for P equal to 58.5 and look for a contradiction.

Question 17

17 In this question you must show detailed reasoning

Jars of honey contain a nominal mass of 340 grams of honey.

The jars are filled by an automated process so that the actual mass of honey in a jar, X grams, is Normally distributed with mean 350 grams. This is to minimize the chance of a jar which contains less than 340 grams of honey being sold.

During a quality control check, a random sample of 50 jars of honey are checked.

Summary statistics for the check are as follows.

$\Sigma x = 17367 \quad \Sigma x^2 = 6036597 \quad n = 50$

Carry out a hypothesis test at the 1% level to see if there is any evidence to suggest that the mean mass of honey in the jars is less than 350 grams. **[9]**

Candidates who did well in this question set out their working clearly and identified the variance, sample mean and its distribution correctly. They set up the hypotheses correctly and defined μ correctly.

They usually went on to calculate the p-value correctly, although a minority worked with the critical region, and a smaller minority worked with the standard Normal distribution. Having reached this stage, most candidates were able to complete the test correctly and present an acceptable conclusion which was not too assertive.

Candidates who did less well may have defined μ incorrectly (usually by omitting the word population, but sometimes by omitting the word mass), defined the sample mean as μ incorrectly or by neglecting to state the distribution of the sample mean. Some candidates worked with the mean squared deviation instead of the variance but were still able to access the method marks.

Candidates who did not do well may have earned 3 of the B marks – usually for the hypotheses, the sample mean and the variance but then worked with an incorrect distribution either with VAR[X] or with a mean of 347.34. A minority of candidates did not calculate the sample mean at any stage but went on to find P(X < 340), which did not score.

Exemplar 3

17 $H_0: \mu = 350$ μ = Population mean mass of honey in jars

$H_1: \mu < 350$

$\bar{X} = \frac{\Sigma x}{n} = 347.34$

$S_{xx} = \Sigma x^2 - \frac{(\Sigma x)^2}{n} = 4343.22$

$\text{Var } x = \frac{S_{xx}}{n-1} = \frac{4343.22}{49} = 88.64$

$\text{sd} = \sqrt{88.64} = 9.415$

Mean to $X \sim N(347.34, 9.415^2)$

$\frac{\bar{X} - \mu}{s/\sqrt{n}} = \frac{347.34 - 350}{9.415/\sqrt{50}} = -1.9978$

1% 1 tail CV = 2.576

$1.9978 < 2.576$

Cannot Reject ho. evidence suggests that the population mean mass of honey in a jar is not less than 350

This response earns 4 of the first 5 marks, but the final B0 because the correct distribution of $\bar{X}$ is not seen. Since there is an incorrect distribution stated, an element of benefit of doubt has been applied when awarding the first method mark for the attempted calculation of the *z*-score. To earn the second method mark, a comparison needs to be made of their calculated value with the correct critical value, so M0M1, and no further marks are available, as the A marks depend on the award of both method marks.

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