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A LEVEL

Examiners' report

MATHEMATICS B (MEI)

H640

For first teaching in 2017

H640/02 Summer 2024 series

Version 1

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

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

Candidates are expected to have studied statistics using the large data sets and to have routinely used spreadsheets, graphing and statistical software when studying this course. They are expected to be able to interpret information from software output such as a table of statistics and statistical diagrams. This exam included questions that made use of pre-release Large Data Set 6 (LDS6).

To do well in this component, candidates need to what is required by command words such as 'Determine' as detailed in the specification. They need to use their calculators efficiently in a variety of contexts, such as calculating binomial or Normal probabilities. When interpreting statistical diagrams and tables they need to justify any inferences made with reference to the information given.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• understood that a request to 'Determine' entails providing some justification for their answer • made efficient and appropriate use of their calculators • were familiar with the pre-release material • expressed their solutions clearly and concisely using correct mathematical notation • were confident in routine algebraic manipulation of polynomials and logarithms.	• provided little or no justification for their answers when faced with a request to 'Determine' • did not always appreciate when an answer derived from their calculator was clearly wrong • were not apparently familiar with the pre-release material • presented solutions that were hard to follow and made slips in standard mathematical notation • made slips and sometimes fundamental errors in algebraic manipulation.

Section A overview

Section A proved accessible to most candidates, with most candidates earning at least half marks in this section. Those candidates that scored highly on the whole paper generally earned full marks in this section.

Question 1

1 Calculate the exact distance between the points $(2, -1)$ and $(6, 1)$. Give your answer in the form $a\sqrt{b}$, where a and b are prime numbers. **[2]**

The vast majority of candidates earned both marks on this question. A few candidates made a slip with the arithmetic.

Question 2

2 The equation of a curve is $y = e^x$. The curve is subject to a translation $\begin{pmatrix} 3 \\ 0 \end{pmatrix}$ **and** a stretch scale factor 2 parallel to the y-axis.

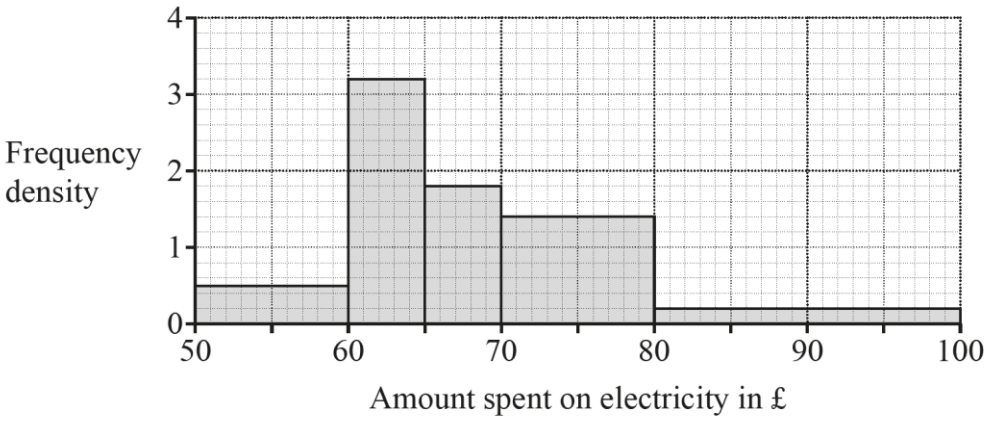
Write down the equation of the new curve. **[2]**

Many candidates earned both marks on this question.

Candidates who did less well may have omitted '$y =$' or correctly incorporated just one of the transformations into the new curve: $y = 2e^{x+3}, y = 2e^x - 3$ and $y = e^{\frac{1}{2}x-3}$ were common incorrect answers which earned M1.

Question 3 (a) and (b)

3 The histogram shows the amount spent on electricity in pounds in a sample of households in March 2023.



(a) Describe the shape of the distribution. **[1]**

A total of 16 households each spent between £60 and £65 on electricity.

(b) Determine how many households were in the sample altogether. **[2]**

This question was very well answered by most candidates. Those who did less well identified the shape of the distribution as Normal or negatively skewed and a few candidates made slips in calculating one of the frequencies.

Question 4 (a)

4 **(a)** On the axes in the **Printed Answer Booklet**, sketch the graph of $y = \sin 2\theta$ for $0 \leqslant \theta \leqslant 2\pi$. **[2]**

There were many well-sketched and clearly labelled graphs, which earned both marks. Candidates who did less well labelled the horizontal axis in degrees or did not label the vertical axis correctly. Candidates who did not do well sketched the graph of $y = \sin\frac{1}{2}\theta$ or $y = 2\sin\theta$.

Question 4 (b)

(b) Solve the equation $\sin 2\theta = -\frac{1}{2}$ for $0 \leqslant \theta \leqslant 2\pi$. **[3]**

Generally this question was answered very well, with candidates presenting their answers in exact form, although a handful presented decimals. Candidates who did less well just presented two correct answers and some just earned M1 for sight of one of the allowed values.

Candidates who did not do well worked with $\sin^{-1}\left(-\frac{1}{4}\right)$ or $2\sin^{-1}\left(-\frac{1}{2}\right)$ or $\frac{\sin^{-1}\left(\frac{1}{2}\right)}{2}$.

Question 5 (a) and (b)

5 M is the event that an A-level student selected at random studies mathematics.

C is the event that an A-level student selected at random studies chemistry.

You are given that $\mathrm{P}(M) = 0.42$, $\mathrm{P}(C) = 0.36$ and $\mathrm{P}(M \text{ and } C) = 0.24$. These probabilities are shown in the two-way table below.

	M	M'	Total
C	0.24		0.36
C'			
Total	0.42		1

(a) In the **Printed Answer Booklet**, complete the copy of the two-way table. **[2]**

(b) Calculate the probability that an A-level student selected at random does **not** study chemistry **given that** they do **not** study mathematics. **[2]**

Most candidates scored full marks in this question. Those who did less well often lost both marks in part (b) because they either gave their answer as 0.46, $\frac{0.46}{0.64}$ or $\frac{0.12}{0.58}$

Question 6 (a), (b) and (c)

6 The probability distribution of the discrete random variable X is shown in the table.

x	0	1	2	3
$\mathrm{P}(X = x)$	0.2	a	$3a$	0.4

(a) Calculate the value of the constant a. **[1]**

(b) A single value of X is chosen at random.

Find the probability that the value is an odd number. **[1]**

(c) **Two** independent values of X are chosen at random.

Calculate the probability that the total of the two values is 3. **[3]**

Nearly all candidates answered parts (a) and (b) correctly. There were also many fully correct answers to part (c). Candidates who did less well earned B1M1 in this part because they omitted the factor of 2. Candidates who did not do well added 0.2 and 0.4, and 0.1 and 0.3 before multiplying the two sums.

Section B overview

All candidates were able to access some marks on each question. A significant number of candidates earned full marks on several questions in this section. Question 14 proved to be the most challenging question.

Question 7 (a), (b), (c) and (d)

7 A sequence is defined by the recurrence relation

$u_{k+1} = u_k + 5$ with $u_1 = -2$.

(a) Write down the values of u_2, u_3, and u_4. **[1]**

(b) Explain whether this sequence is divergent or convergent. **[1]**

(c) Determine the value of u_{30}. **[2]**

(d) Determine the value of $\sum_{k=1}^{30} u_k$. **[2]**

Part (a) was almost always answered correctly. Part (b) needed a statement to 'Explain' why the sequence is divergent. Parts (c) and (d) needed working to justify the results to satisfy the 'Determine' request.

Candidates who did well in this question showed full working in parts (c) and (d). They identified the sequence as being divergent, but may not have articulated why it is divergent sufficiently well to earn the mark. Candidates who did less well did not show sufficient detail of their working in part (c) and/or part (d). They may have identified the sequence as convergent.

A sequence which continues to increase is not necessarily divergent

Candidates who gave an answer such as 'divergent, because it's always increasing' did not earn the mark because some convergent sequences, such as $u_k = 100 - 50 \times 0.5^k$, also increase as *k* increases.

Question 8

8 The equation of a curve is

$$y = 2x^3 + 3mx^2 - 9mx + 4 \ .$$

Determine the range of values of m for which the curve has **no** stationary values. **[6]**

Candidates who did well in this question found $\frac{dy}{dx}$ and set their expression equal to zero. They went on to try to find the range of values for which the discriminant is negative, or the values for which it is zero. They usually scored full marks although a few lost the final mark because they didn't present their final answer correctly. Candidates who did less well slipped up in either finding the discriminant correctly, or in solving the quadratic inequality. Both method marks were available but not always earned, as those who wrote down an incorrect discriminant without showing a correct substitution did not earn the first method mark. A handful of candidates completed the square, but were unable to make further progress.

Candidates who did not do well may have made a slip in differentiating and then made no further progress, or may have worked with the second derivative and made no progress.

Question 9 (a), (b) and (c)

9 A teacher is investigating how pupils travel to and from school each day. Pupils can either travel by bus, train, car, bicycle or walk.

The teacher decides to collect a sample of size 60 for the investigation.

(a) The teacher lives in a village 10 miles away from the school.

Explain how collecting a sample which just consists of pupils who live in the same village as the teacher might introduce bias. **[1]**

The table below shows how many students there are in each year.

Year 7	Year 8	Year 9	Year 10	Year 11
86	105	107	101	101

(b) The teacher decides to use the method of proportional stratified sampling.

Calculate the number of pupils in the sample who are in Year 9. **[2]**

The teacher generates a sample of 10 pupils from the 86 in Year 7 by listing them in alphabetical order and selecting the first name on the list and every ninth name thereafter.

(c) Explain whether this method will generate a simple random sample of the pupils who travel in Year 7. **[1]**

Candidates who did well in this question referred to one of the specified modes of transport in answering part (a), and explained why the sampling method does not generate a simple random sample in part (c). Most candidates earned full marks in part (b).

Candidates who did less well gave a response couched in general terms to part (a), such as 'they may all use the same method of transport as the teacher'. In part (c) they may have simply observed that the data was collected using systematic sampling.

Question 10 (a) and (b)

10 **(a)** Determine the first three terms in ascending powers of x of the binomial expansion of $(8+3x)^{\frac{1}{3}}$. **[4]**

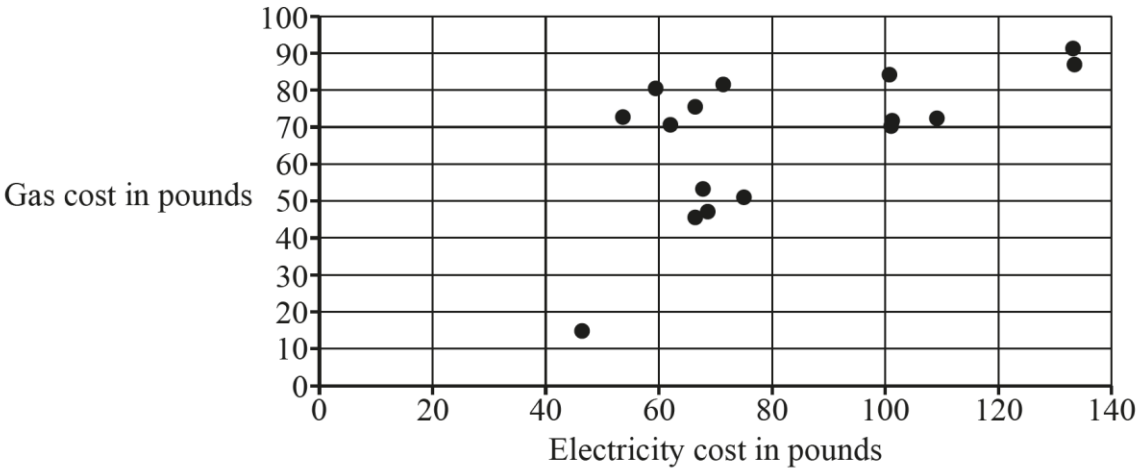
(b) State the range of values of x for which this expansion is valid. **[1]**

Candidates who did well in this question showed full details of the substitution, which they simplified correctly. They may have slipped up in part (b) by omitting the modulus sign.

Candidates who did less well gave insufficient detail of their working to earn M1A1, or factorised incorrectly. $8, \frac{1}{8}$ and $\frac{1}{2}$ were common wrong factors.

Question 11 (a), (b) and (c)

11 A householder is investigating whether there is any relationship between his monthly cost of gas and his monthly cost of electricity, both measured in pounds (£). The householder collects a random sample of monthly costs and presents them in the scatter diagram below.



One of the points on the diagram represents the energy costs in a month when the householder was away on holiday for three weeks. The other points represent the energy costs in months when the householder did not go away on holiday.

(a) On the copy of the diagram in the **Printed Answer Booklet**, circle the point which represents the month when the householder was most likely to have been away on holiday for three weeks. **[1]**

(b) With reference to the diagram, describe the relationship between the cost of gas and the cost of electricity. **[1]**

The householder decides to test whether there is evidence to suggest that there is any association between the monthly cost of gas and the monthly cost of electricity. The value of Spearman's rank correlation coefficient for this sample is 0.4359 and the associated p-value is 0.091 95.

(c) Determine whether there is any evidence to suggest, at the 5% level, that there is any association between the monthly cost of gas and the monthly cost of electricity. **[3]**

Nearly all candidates were given the marks in parts (a) and (b), with the majority of these referring to positive correlation rather than the expected answer of positive association.

Candidates who did well in part (c) compared 0.09195 with 0.025. They may have lost the final mark by referring to correlation rather than association, or by concluding that there is enough evidence to suggest some association.

Candidates who did less well compared 0.09195 with 0.05. Candidates who did not do well compared 0.09195 with 0.4359, or made no reference to 0.09195 at all.

Question 12

12 A survey conducted in 2021 showed that 10% of British adults were vegetarians.

A dietitian believes that the proportion of British adults who are vegetarians may have changed, so decides to conduct a hypothesis test at the 5% level of significance.

In a random sample of 112 adults, the dietitian finds that there are 19 vegetarians.

Carry out the hypothesis test to determine whether there is any evidence to support the dietitian's belief. **[7]**

Candidates who did well in this question set out their solution clearly and concisely. The majority used their calculator efficiently to find $\mathrm{P}(X \geq 19)$ and made a correct comparison with 0.025. They may have lost the final mark due to an over-assertive conclusion, but a significant proportion of candidates scored full marks.

Candidates who worked with the critical region may not have done quite so well, as sometimes they neglected to find the lower tail or made a slip with one of the critical values.

Candidates who did less well worked with $\mathrm{P}(X \geq 20)$ or $\mathrm{P}(X \geq 18)$, thereby losing the first and the final A mark. A small minority of candidates compared their probability with 0.05 instead of 0.025, spoiling otherwise correct work.

Candidates who did not do well sometimes did not define their hypotheses correctly, or worked with $\mathrm{P}(X = 19)$, which meant they were unable to access any subsequent marks.

Question 13

13 Determine the coordinates of the turning points on the curve with equation

$$y^2 + xy + x^2 - x = 1.$$ **[9]**

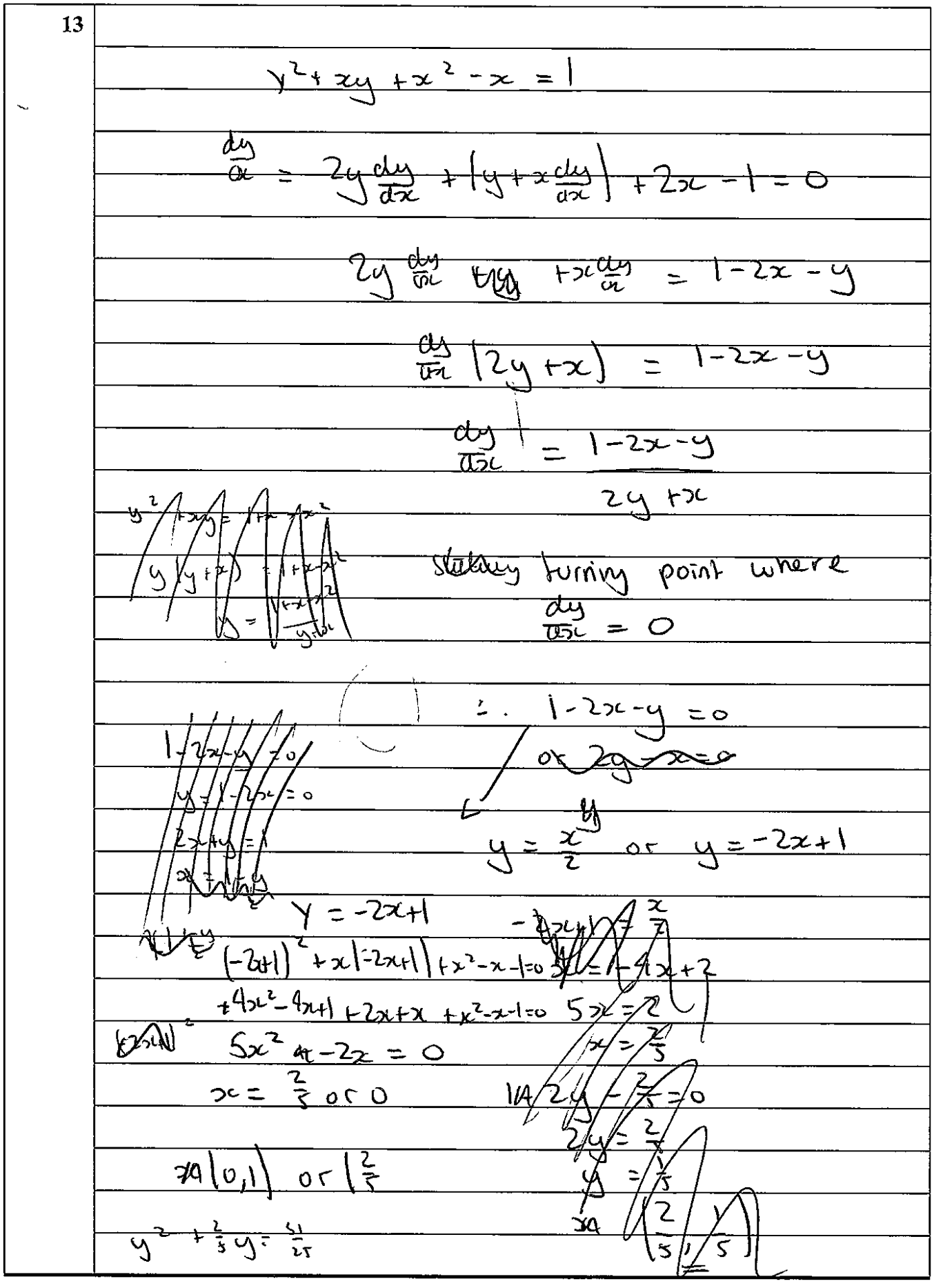
Candidates who did well in this question followed the route laid down in the mark scheme. They may have substituted their *x*-values back into the original equation, and ended up with two extra points. Even so, many of these candidates then checked whether all these points satisfied $\frac{\mathrm{d}y}{\mathrm{d}x} = 0$ and achieved full marks.

Candidates who did less well either slipped up in rearranging to find an expression for $\frac{\mathrm{d}y}{\mathrm{d}x}$ and thus substituted an incorrect expression into the original equation, or made a slip in collecting like terms post substitution. Nevertheless, those who gave sufficient detail of their work were still able to access the method marks, as illustrated in Exemplar 1.

Candidates who did less well may have made a slip in the differentiation – dealing with the product proved most troublesome, but some candidates left 1 on the right-hand side. Some candidates differentiated successfully but then made little, if any progress.

Candidates who did not do well often tried to rearrange the equation to make *x* the subject before differentiating. It was very rare to see this successfully completed.

Exemplar 1



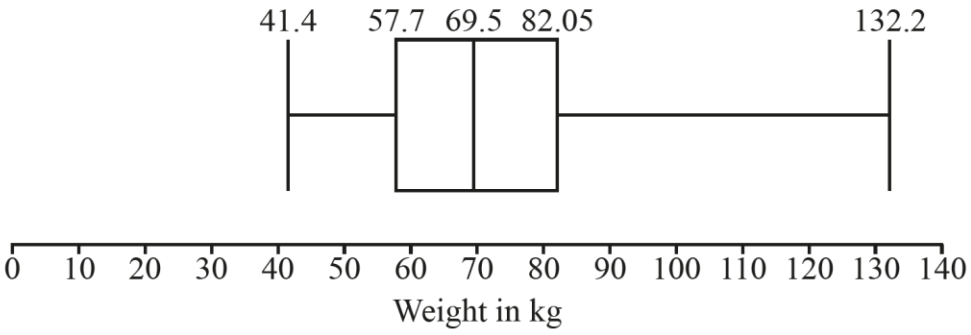
The response starts with $\frac{dy}{dx} = 2y\frac{dy}{dx} + y + x\frac{dy}{dx} + 2x - 1 = 0$. '$\frac{dy}{dx}$' at the start is taken to be a signal that the candidate is differentiating (BOD) as the correct expression is set equal to zero. So this line of working earns B1B1B1. (It is worth noting that some candidates set their solution out in the same way, but did not set the expression equal to zero, resulting in $\frac{dy}{dx} = \frac{y+2x-1}{1-2y-x}$, often leading to a correct final answer. Such responses lost the third B mark and the two accuracy marks.)

The next two method marks are earned for setting $\frac{dy}{dx}$ equal to zero and substituting the expression for *y* back into the original equation to obtain a quadratic in *x*. We can ignore the incorrect $y = \frac{x}{2}$. A slip is then made in tidying up the expression, so A0 for $5x^2 - 2x = 0$. Two *x*-values are found – there is no need to show any factorising for this mark. However, as we are working now with an incorrect pair of values, we need to see a full substitution to earn the final method mark, so M0. The final A mark would have been unavailable anyway. We ignore the crossed-out work on the right-hand side (which would not have earned M1).

Question 14 (a)

14 The pre-release material contains medical data for 103 women and 97 men.

The boxplot represents the weights in kg of 101 of the women from the pre-release material.



(a) Use your knowledge of the pre-release material to give a reason why the weights of all 103 women were **not** included in the diagram. **[1]**

Candidates who did well usually made reference to the spreadsheet entry #N/A in the pre-release material, or gave an equivalent answer in words.

Candidates who did not do well gave a variety of speculative answers for which there was no justification.

Question 14 (b)

(b) Determine the range of values in which any outliers lie. **[3]**

Candidates who did well in this question showed full working to obtain the theoretical intervals which could contain outliers. They then referred back to the diagram and gave the correct range which actually contains outliers.

Candidates who did less well either did not show sufficient detail of their working to earn M1, but were awarded with SC1 or SC2, or did not complete the answer by considering the boxplot.

Candidates who did not do well often worked with median ± 1.5 × IQR.

Question 14 (c)

(c) Use your knowledge of the pre-release material to explain whether these outliers should be removed from any further analysis of the data. **[1]**

Candidates who did well commented that the data is genuine or valid, because it forms part of the large data set.

The many candidates who did not do well usually commented that the outliers should be removed for a wide variety of speculative reasons.

Question 14 (d)

(d) The median weight of men in the sample was found to be 79.9 kg.

Explain what may be inferred by comparing the median weight of men with the median weight of women. **[1]**

Candidates who did well in this question referred to the typical/average man and typical/average woman.

Candidates who did not do well related their answers to all men and all women.

Question 14 (e)

Further analysis of the weights of both men and women is carried out. The table shows some of the results.

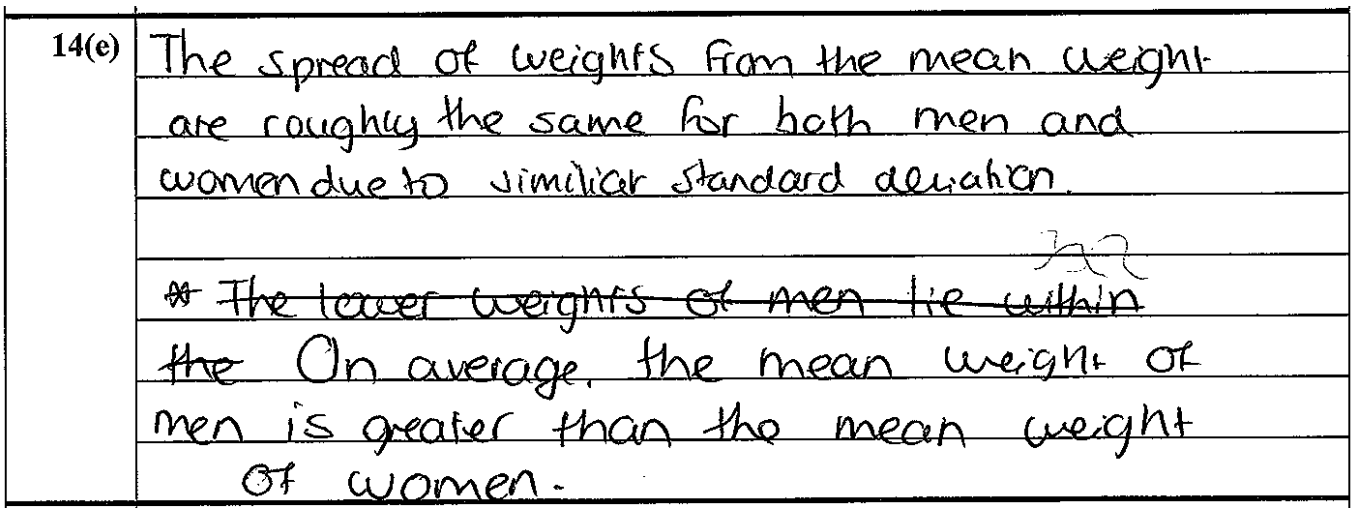
	mean	standard deviation
men	82.69 kg	19.98 kg
women	72.5 kg	19.95 kg

(e) Use the information in the table to make **two** inferences about the distribution of the weights of men compared with the distribution of the weights of women. **[2]**

Candidates who did well in this question made an explicit comparison of the mean weights and then made an appropriate inference. They noted that the standard deviations were almost the same and commented on the spread of weights of men and women.

Candidates who did less well commented on the means and the standard deviations, but only made one appropriate inference. In the exemplar, simply observing that the mean weight for men is greater than the mean weight for women is insufficient.

Exemplar 2



The candidate comments that the spread of the weights from the mean is roughly the same for both men women because the standard deviations are similar, so an inference is made with a justification, earning B1.

The second comment comparing the means is insufficient, however. Having noted that the mean weight for men is greater than the mean weight for women, a comment such as 'on average, men are heavier than women' is needed.

Question 15 (a) (i)

15 Bottles of Fizzipop nominally contain 330 ml of drink. A consumer affairs researcher collects a random sample of 55 bottles of Fizzipop and records the volume of drink in each bottle.

Summary statistics for the researcher's sample are shown in the table.

n	55
$\sum x$	18535
$\sum x^2$	6247066.6

(a) (i) Calculate the mean volume of drink in a bottle of Fizzipop. **[1]**

Most candidates earned the mark for this question. A handful of candidates calculated $\frac{6247066.6}{18535}$, which by an unfortunate coincidence is 337.04, but of course did not score.

Question 15 (a) (ii)

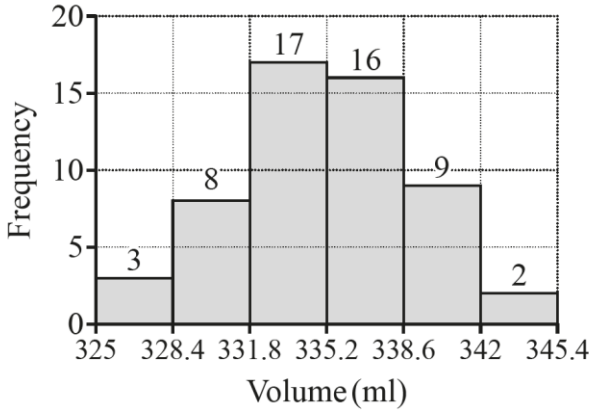
(ii) Show that the standard deviation of the volume of drink in a bottle of Fizzipop is 3.78 ml. **[1]**

Candidates who did well in this question showed the full substitution to demonstrate how 3.78 is obtained and stated the final answer.

Candidates who did not do well either showed incomplete working or did not use the formulae given on the question paper; thus 3.75 was an occasional wrong answer.

Question 15 (b)

The researcher uses software to produce a histogram with equal class intervals, which is shown below.



(b) Explain why the researcher decides that the Normal distribution is a suitable model for the volume of drink in a bottle of Fizzipop. **[2]**

Candidates who did well in this question gave two (or sometimes more) of the acceptable answers from the mark scheme.

Candidates who did less well gave one acceptable reason.

Candidates who did not do well made comments such as the distribution is uniform, the distribution is skewed, it has a mean and a standard deviation.

Question 15 (c)

(c) Use your answers to parts **(a)** and **(b)** to determine the expected number of bottles which contain less than 330 ml in a random sample of 100 bottles. **[3]**

Candidates who did well in this question worked with $\mathrm{N}(337, 3.78^2)$ to find the correct probability. They may have lost the final mark by rounding their answer to the nearest whole number.

Candidates who did less well worked with $\mathrm{N}(335.2, 3.78^2)$ and just earned the second method mark.

Question 15 (d)

In order to comply with new regulations, no more than 1% of bottles of Fizzipop should contain less than 330 ml.

The manufacturer decides to meet the new regulations by adjusting the manufacturing process so that the mean volume of drink in a bottle of Fizzipop is increased.

The standard deviation is unaltered.

(d) Determine the minimum mean volume of drink in a bottle of Fizzipop which should ensure that the new regulations are met. Give your answer to **3** significant figures. **[3]**

A variety of strategies were seen for solving this problem, with most candidates earning full marks. Candidates who did well showed full details of their working and usually worked with the standard Normal distribution.

Candidates who did less well made a sign error in their calculation or used an incorrect value of z. Some may have ignored the request to present the final answer correct to 3 significant figures.

Candidates who did not do well did not appreciate the need to show some working, and just wrote down the answer.

Question 15 (e)

The mean volume of drink in a bottle of Fizzipop is set to 340 ml. After several weeks the quality control manager suspects the mean volume may have reduced. She collects a random sample of 100 bottles of Fizzipop.

The mean volume of drink in a bottle in the sample is found to be 339.37 ml.

(e) Assuming the standard deviation is unaltered, conduct a hypothesis test at the 5% level to determine whether there is any evidence to suggest that the mean volume of drink in a bottle of Fizzipop is less than 340 ml. **[7]**

Candidates who did well in this question set out their hypotheses clearly and worked with $\bar{X} \sim \mathrm{N}(340, 0.378)$ to calculate $\mathrm{P}(\bar{X} < 339.37)$. Sometimes a mark was lost due to an incomplete or incorrect definition of μ. Most considered the *p*-value and went on to reach a correct conclusion, occasionally losing the final mark due to an over-assertive final statement. Those who worked with the critical region were generally equally successful, and a small minority worked with the standard Normal distribution – although this approach was notably less popular than in previous years.

Candidates who did less well defined μ incorrectly and made a slip in calculating $\mathrm{P}(\bar{X} < 339.37)$. Some candidates lost both marks for the hypotheses because they set things up in terms of $\bar{X}$.

Candidates who did not do well used the wrong distribution – see below.

Use of correct distribution

Candidates who worked with, for example, $\mathrm{N}(339.37, 0.378^2)$ or $\mathrm{N}(340, 3.78^2)$ were given M0 and were therefore only able to access the first two marks.

Candidates who stated, for example, $\bar{X} \sim \mathrm{N}\left(340, \frac{3.78}{10}\right)$ but recovered to find a correct probability were not penalised for the slip in notation.

Question 16

16 In this question you must show detailed reasoning.

Find the particular solution of the differential equation

$$\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{9y}{(x-1)(x+2)},$$

given that $x = 2$ when $y = 16$. **[12]**

Candidates who did well in this question usually followed the two routes identified in the mark scheme. Sometimes an accuracy mark was lost by working with the constant in decimal form. A handful of candidates successfully used the integrating factor method to achieve full marks, but more often than not went wrong at an early stage.

Candidates who did less well usually earned the first four marks, but then made a slip in integrating. Mistakes such as $\ln 9y$ on the left-hand side instead of $\frac{1}{9}\ln 9y$ were sometimes made. Some method marks were still available, but were not always earned.

Candidates who did not do well often earned three marks for resolving the partial fractions correctly, and a method mark for separating the variables, but were unable to make further progress.

Misconception

When exponentiating for example $\ln y = \ln(x-1)^3 - \ln(x+2)^3 + \ln 1024$, a common error was to write $y = (x-1)^3 - (x+2)^3 + 1024$

Exemplar 3

16

$$\frac{9}{(x-1)(x+2)} = \frac{a}{x-1} + \frac{b}{x+2}$$

$9 = a(x+2) + b(x-1)$

let $x = -2$:

$9 = -3b$

$b = -3$

let $x = 1$:

$9 = 3a$

$a = 3$

$$\frac{1}{y}\frac{dy}{dx} = \frac{9}{(x-1)(x+2)} = \frac{3}{x-1} - \frac{3}{x+2}$$

$$\int \frac{1}{y}\,dy = \int \frac{3}{x-1} - \frac{3}{x+2}\,dx$$

$$\ln|y| = 3(\ln|x-1| - \ln|x+2|) + c$$

$$= \ln\left(\left|\frac{x-1}{x+2}\right|^3 (A)\right)$$

$$y = A\left(\frac{x-1}{x+2}\right)^3$$

$$16 = A\left(\frac{2-1}{2+2}\right)^3$$

$A = 1024$

particular solution:

$$y = 1024\left(\frac{x-1}{x+2}\right)^3$$

This is an example of a clear solution that earned full credit.

The candidate has initially identified that partial fractions are needed and shown how the coefficients have been evaluated.

The differential equation has then been worked through to find the equation 'y = …' in terms of a constant A (BOD given for the change from 'c' to 'A').

Finally, the candidate has shown a clear substitution to find the particular solution.

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