Example Candidate Responses

Cambridge International AS & A Level

Cambridge International AS and A Level Mathematics

9709

Paper 7

Cambridge Advanced

CAMBRIDGE International Examinations

Version 1.0

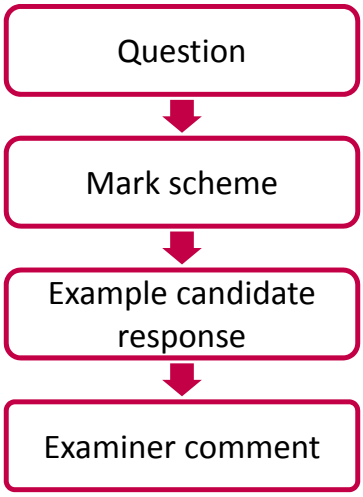
Contents

Introduction

The main aim of this booklet is to exemplify standards for those teaching Cambridge International AS & A Level Mathematics (9709), and to show how different levels of candidates' performance relate to the subject's curriculum and assessment objectives.

In this booklet candidate responses have been chosen to exemplify a range of answers. Each response is accompanied by a brief commentary explaining the strengths and weaknesses of the answers.

For ease of reference the following format for each component has been adopted:



Each question is followed by an extract of the mark scheme used by examiners. This, in turn, is followed by examples of marked candidate responses, each with an examiner comment on performance. Comments are given to indicate where and why marks were awarded, and how additional marks could have been obtained. In this way, it is possible to understand what candidates have done to gain their marks and what they still have to do to improve them.

Past papers, Examiner Reports and other teacher support materials are available on Teacher Support at https://teachers.cie.org.uk

Assessment at a glance

The 7 units in the scheme cover the following subject areas:

- Pure Mathematics (units P1, P2 and P3);
- Mechanics (units M1 and M2);
- Probability and Statistics (units S1 and S2).

Centres and candidates may:

- take all four Advanced (A) Level components in the same examination session for the full A Level.
- follow a staged assessment route to the A Level by taking two Advanced Subsidiary (AS) papers (P1 & M1 **or** P1 & S1) in an earlier examination session;
- take the Advanced Subsidiary (AS) qualification only.

AS Level candidates take:

Paper 1: Pure Mathematics 1 (P1)
1¾ hours About 10 shorter and longer questions 75 marks weighted at 60% of total

plus **one** of the following papers:

Paper 2: Pure Mathematics 2 (P2)	Paper 4: Mechanics 1 (M1)	Paper 6: Probability and Statistics (S1)
1¼ hours About 7 shorter and longer questions 50 marks weighted at 40% of total	**1¼ hours** About 7 shorter and longer questions 50 marks weighted at 40% of total	**1¼ hours** About 7 shorter and longer questions 50 marks weighted at 40% of total

A Level candidates take:

Paper 1: Pure Mathematics 1 (P1)	Paper 3 Pure Mathematics 3 (P3)
1¾ hours About 10 shorter and longer questions 75 marks weighted at 30% of total	**1¾ hours** About 10 shorter and longer questions 75 marks weighted at 30% of total

plus **one** of the following combinations of two papers:

Paper 4: Mechanics 1 (M1)	Paper 6: Probability and Statistics 1 (S1)
1¼ hours About 7 shorter and longer questions 50 marks weighted at 20% of total	**1¼ hours** About 7 shorter and longer questions 50 marks weighted at 20% of total

or

Paper 4: Mechanics 1 (M1)	Paper 5: Mechanics 2 (M2)
1¼ hours About 7 shorter and longer questions 50 marks weighted at 20% of total	**1¼ hours** About 7 shorter and longer questions 50 marks weighted at 20% of total

or

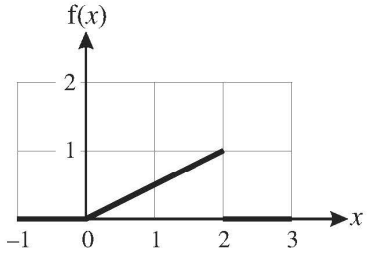
Paper 6: Probability and Statistics 1 (S1)	Paper 7: Probability and Statistics 2 (S2)
1¼ hours About 7 shorter and longer questions 50 marks weighted at 20% of total	**1¼ hours** About 7 shorter and longer questions 50 marks weighted at 20% of total

Teachers are reminded that the latest syllabus is available on our public website at **www.cie.org.uk** and Teacher Support at **https://teachers.cie.org.uk**

Paper 7

Question 1

1

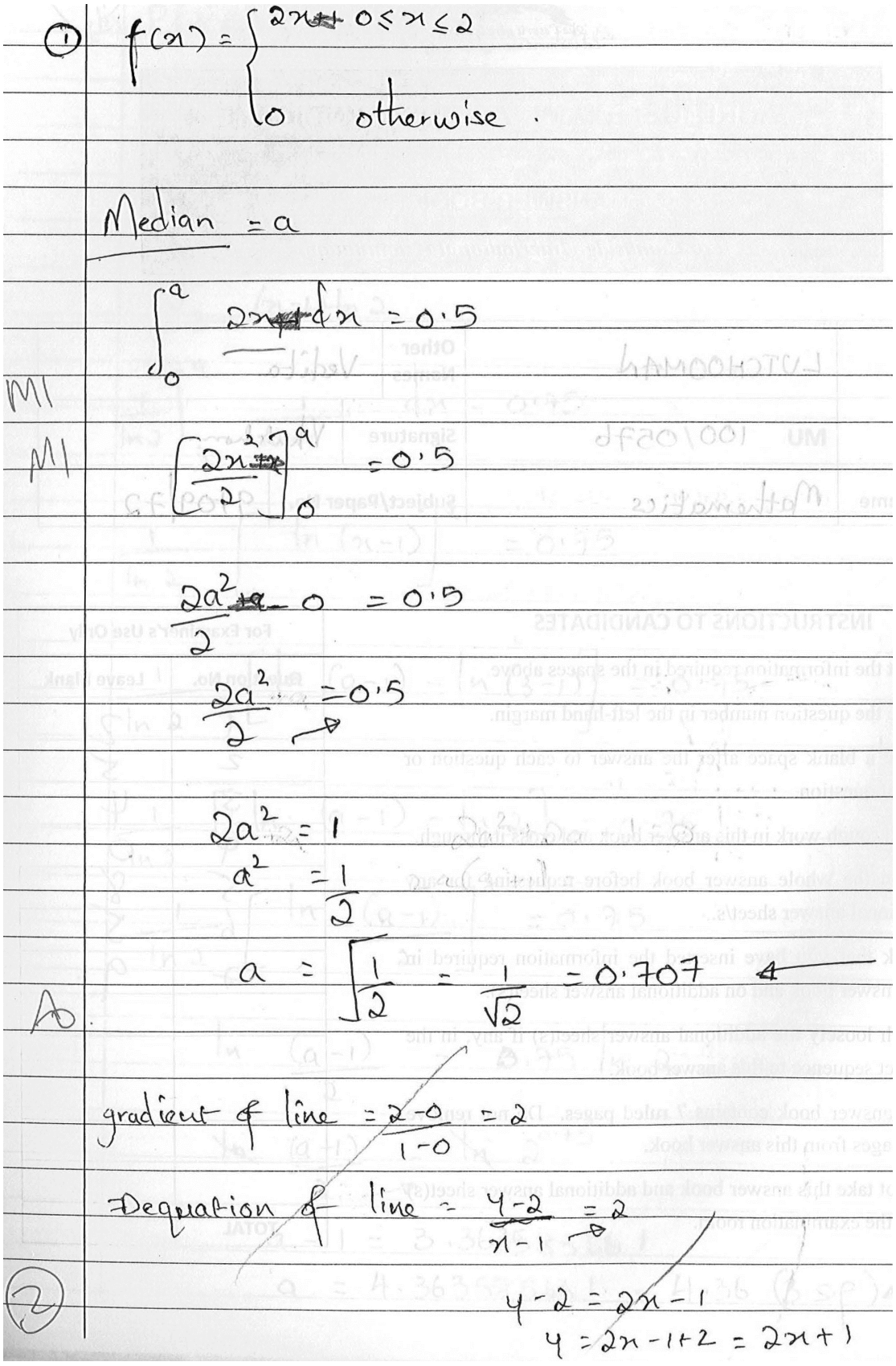


The diagram shows the graph of the probability density function, f, of a random variable X. Find the median of X. [3]

Mark scheme

1	$(\frac{m}{2})^2$	M1	$y = \frac{1}{2}x$ (attempt at linear equ with c = 0)
	$(\frac{m}{2})^2 = \frac{1}{2}$	M1	$\int_0^m (\frac{1}{2}x)\mathrm{d}x = \frac{1}{2}$
	$m = \sqrt{2}$ or 1.41 (3 sfs)	A1 [3]	(Note: $\pm\sqrt{2}$ as final answer scores A0)

Example candidate response – 1



Total mark awarded = 2 out of 3

Example candidate response – 2

1. $\int_0^{q} f(x)\ dx$.

Gradient : $\frac{y_2 - y_1}{x_2 - x_1}$

$\therefore \frac{1-0}{2-0} = \frac{1}{2}$.

$Q_2 = \int f(x)\ dx = 0.5$

$=$

$f(x) : \frac{y-1}{x-2} = 0.5$

$0.5(x-2) = y-1$

$0.5x - 1 = y-1$

$y - 1 = 0.5x - 1$

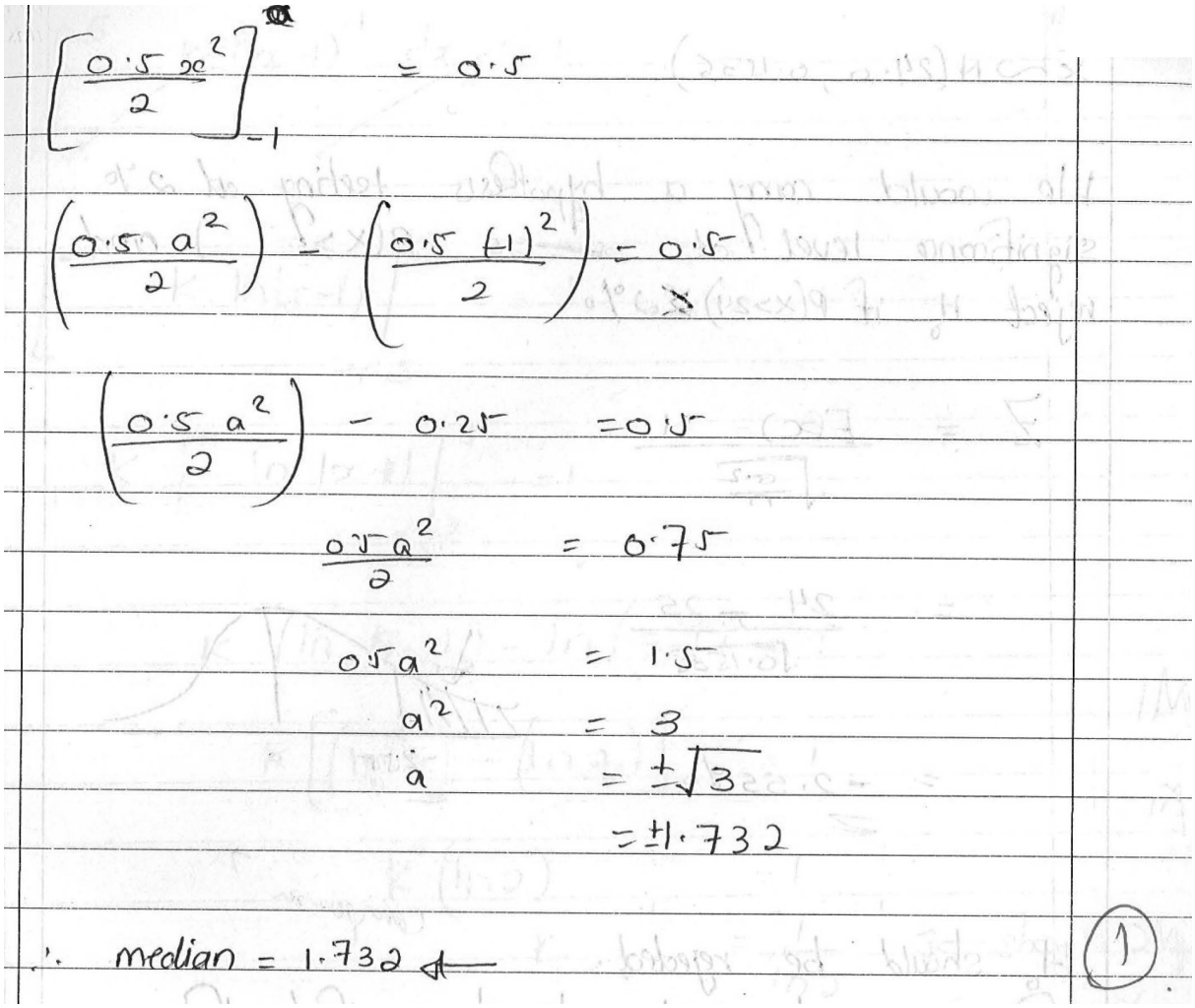
$y = 0.5x$

$\int_{-1}^{Q_2} f(x)\ dx = 0.5$

M1 $\int_{-1}^{Q_2} 0.5x\ dx = 0.5$

M0 $\left[\frac{0.5x^2}{2}\right]_{1}^{Q_2} = 0.5$

Example candidate response – 2, continued



Total mark awarded = 1 out of 3

Examiner comment – 1 and 2

Both of the candidates realised the need to find the equation of the straight line between 0 and 2, and both candidates found an equation of the correct form ($y = mx$).

In order to find the median, it was then necessary to integrate from 0 to 'm' and set this equal to 0.5. Candidate 1 did this correctly and would have gained full marks for the question if their equation of the line had been correct.

Candidate 2 was unable to apply their knowledge to this particular question and made the error of integrating the probability density function from -1 to 'm' and consequently did not gain the method mark for this step of the process.

Question 2

2 The heights of a certain type of plant have a normal distribution. When the plants are grown without fertilizer, the population mean and standard deviation are 24.0 cm and 4.8 cm respectively. A gardener wishes to test, at the 2% significance level, whether Hiergro fertilizer will increase the mean height. He treats 150 randomly chosen plants with Hiergro and finds that their mean height is 25.0 cm. Assuming that the standard deviation of the heights of plants treated with Hiergro is still 4.8 cm, carry out the test. [5]

Mark scheme

2	H_0: Pop mean = 24.0 H_1: Pop mean > 24.0	B1	Allow 'μ' but not just 'mean'
	$\frac{25-24}{\frac{4.8}{\sqrt{150}}}$	M1	Standardise, with $\sqrt{}$ 150. Ignore cc. Accept sd/var mixes. OR find x_{crit}
	= 2.55(2) Comp z = 2.054 or 2.055 Evidence that Hiergro has incr hts	A1 M1 A1ft [5]	For correct z or area or x_{crit} Valid comparison (z values/areas/x values) Correct conclusion No contradictions (Note 2 tail test can score B0 M1 A1 M1 (z = 2.326) A1ft)

Example candidate response – 1

9. Let ~~H~~ be the random variable of the heights of a certain types of plant.

μ ~~H~~ $\sim N(24.0, 4.8^2)$

$n = 150$

$\bar{\mu}$ ~~H~~ $\sim N\left(24.0, \frac{4.8^2}{150}\right)$

$H_0 : \mu = 24.0$

B1 $H_1 : \mu > 24.0$

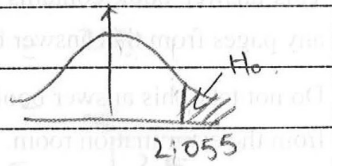
If H_0 is true, $\bar{x} \sim N\left(24.0, \frac{4.8^2}{150}\right)$

We use a upper tail test at 2% significance level.

$100\% - 2\% = 98\%$

$= 0.98$

$= 2.055$



$Z = \frac{\bar{x} - \mu}{\frac{\sigma}{\sqrt{n}}}$

$Z = \frac{25 - 24}{\frac{4.8}{\sqrt{150}}}$ M1

$Z = 2.552$ A1

no comp.

Since the test statistic is 2.552, it falls in the rejection area therefore we reject H_0 in favour of H_1. mo A0 (3)

Total mark awarded = 3 out of 5

Example candidate response – 2

2. let x be the heights of a certain type of plant

$X \sim N(24.0, 4.8^2)$ *

$\bar{x} = 25$

$H_0 = 24.0$ $H_a > 24.0$ (upper tail test)

Assuming H_0 is true,

$\bar{X} \sim N\left(24.0, \frac{4.8^2}{150}\right)$ B0

standardization

$$\bar{z} = \frac{X_0 - \mu}{\frac{\sigma}{\sqrt{n}}}$$ M1

$$= \frac{25.0 - 24.0}{\frac{4.8}{\sqrt{150}}} = \frac{1}{0.3919} = 2.552$$ A1

At 2 % significance level. 98%

(upper tail)

2.552 > 0.02 M0

we reject H_0, since ~~the mean height has increased~~ we have enough evidence to prove that the height has increased.

2

Total mark awarded = 2 out of 5

Examiner comment – 1 and 2

Both candidates attempted to define the null and alternative hypotheses. Candidate 1 did this correctly using "μ" to signify the population mean. Candidate 2 wrote that $H_0 = 24$ and $H_1 > 24$ without reference to the population mean, and thus did not gain the mark available.

The calculation of the z value was done correctly by both candidates.

Candidate 1 did not then show their comparison, and although the correct conclusion was reached it was not justified. It is important that either the inequality (e.g. $2.552 > 2.054$ or equivalent for area comparisons) is stated, or the two points are shown on a clearly labelled normal distribution diagram, so that the conclusion reached is fully justified.

Candidate 2 was unable to gain any marks for their comparison as it was not valid; the candidate compared a z value with an area.

Question 3

3 The cost of hiring a bicycle consists of a fixed charge of 500 cents together with a charge of 3 cents per minute. The number of minutes for which people hire a bicycle has mean 142 and standard deviation 35.

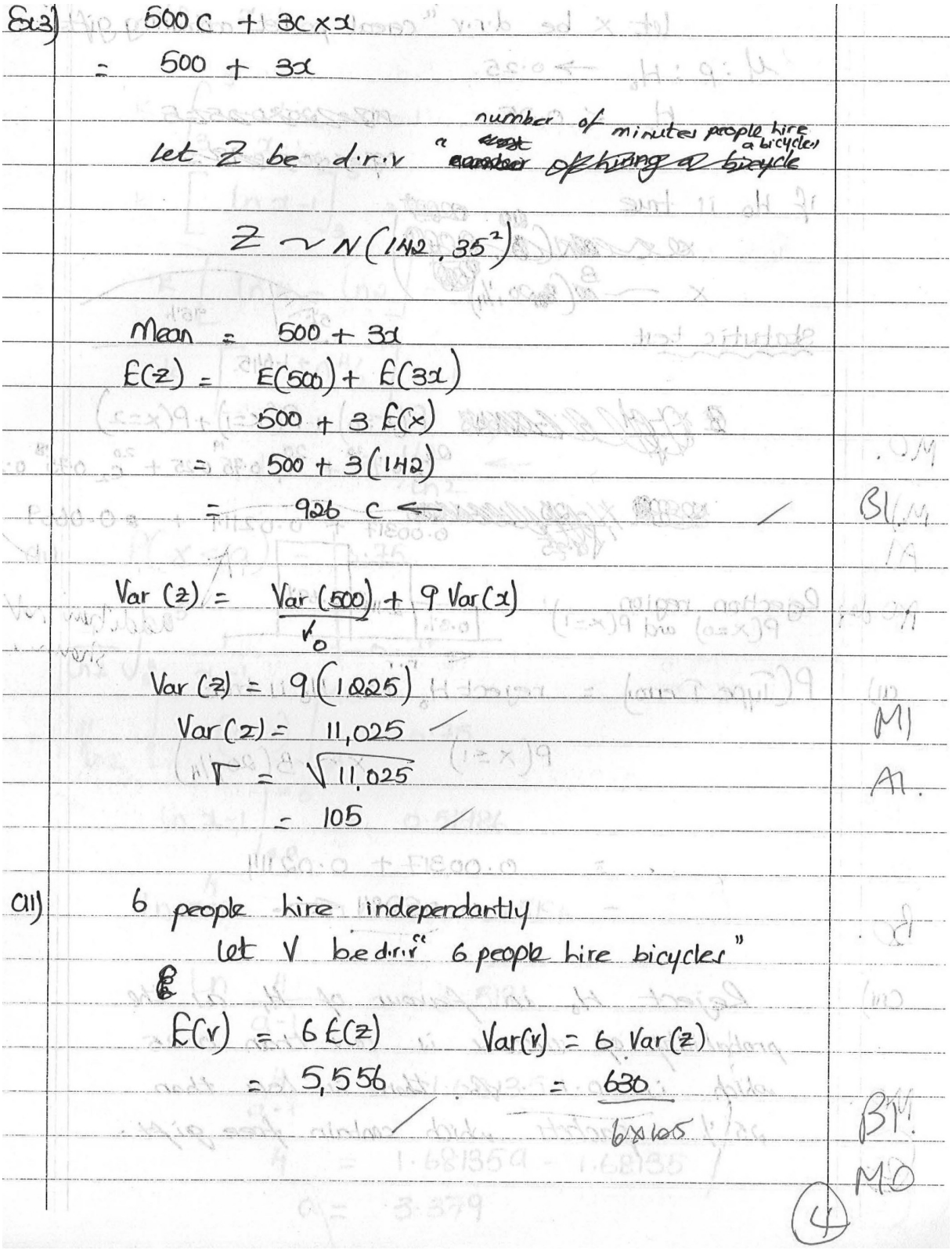
(i) Find the mean and standard deviation of the amount people pay when hiring a bicycle. [3]

(ii) 6 people hire bicycles independently. Find the mean and standard deviation of the total amount paid by all 6 people. [3]

Mark scheme

3	**(i)**	Mean = 500 + 3 × 142 = 926 (cents)	B1	
		SD = 3 × 35 = 105 (cents)	M1 A1 [3]	Or 9×35^2 seen Accept $\sqrt{11025}$
	(ii)	Mean = 6 × '926' = 5556 (cents) 6 × '105'^{2} (= 66150) (SD = $\sqrt{66150}$) = 257 (cents) (3 sf)	B1ft M1 A1 [3]	 or SD = $\sqrt{6}$ × '105'. ft their (i) Accept $\sqrt{66150}$

Example candidate response – 1



Ex3) $500c + 3cx$

$= 500 + 3x$

let Z be d.r.v "number of minutes people hire a bicycle" ~~"number of hiring a bicycle"~~

$Z \sim N(142, 35^2)$

Mean $= 500 + 3x$

$E(z) = E(500) + E(3x)$

$500 + 3E(x)$

$= 500 + 3(142)$

$= 926c$ ← B1 M1

$Var(z) = Var(500) + 9Var(x)$

0

$Var(z) = 9(1025)$

$Var(z) = 11,025$ M1

$r = \sqrt{11,025}$

$= 105$ A1

a(ii) 6 people hire independantly

let V be d.r.v "6 people hire bicycles"

$E(r) = 6E(z)$ $Var(r) = 6Var(z)$

$= 5,556$ $= 630$

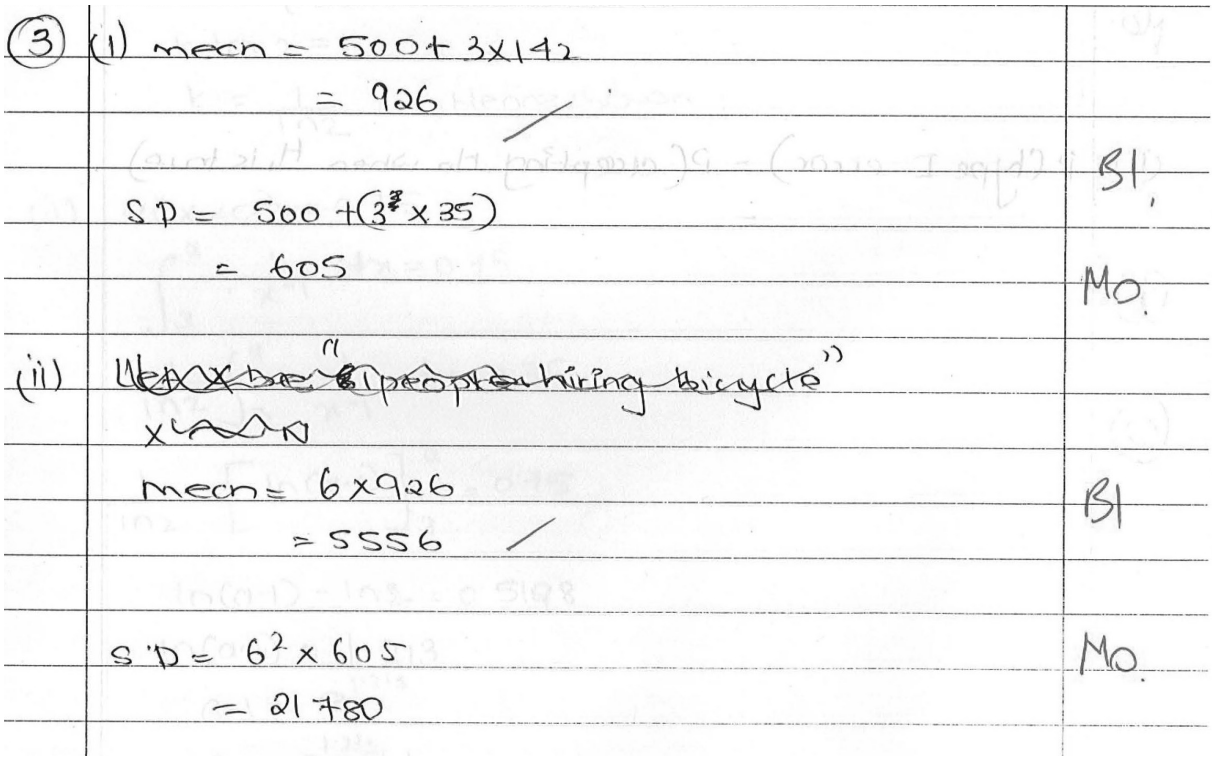
6×105 B1 M0

4

Item marks awarded: (i) = 3/3; (ii) = 1/3

Total mark awarded = 4 out of 6

Example candidate response – 2



Item marks awarded: (i) = 1/3; (ii) = 1/3

Total mark awarded = 2 out of 6

Examiner comment – 1 and 2

(i) Both candidates 1 and 2 were able to correctly find the mean.

To find the standard deviation the correct calculation was performed by candidate 1, but candidate 2, incorrectly, added 500.

(ii) Again, both candidates 1 and 2 correctly found the mean, but neither found the correct variance.

Candidate 1 calculated $6\times$ standard deviation rather than $6\times$ variance (it may have been their intention to calculate $6\times$ variance, but unfortunately this was not what the candidate actually did). Candidate 2 was not clear about what was required and calculated $6^2\times$ their standard deviation.

Question 4

4 A cereal manufacturer claims that 25% of cereal packets contain a free gift. Lola suspects that the true proportion is less than 25%. In order to test the manufacturer's claim at the 5% significance level, she checks a random sample of 20 packets.

(i) Find the critical region for the test. [5]

(ii) Hence find the probability of a Type I error. [1]

Lola finds that 2 packets in her sample contain a free gift.

(iii) State, with a reason, the conclusion she should draw. [2]

Mark scheme

4	**(i)** $P(X \leqslant 1) = (0.75)^{20} + 20(0.75)^{19}(0.25)$ $= 0.0243$	M1 A1	Attempt correct expression
	$P(X \leqslant 2) = (0.75)^{20} + 20(0.75)^{19}(0.25) +$ $^{20}C_2(0.75)^{18}(0.25)^2$ $= 0.0913$ or 0.0912	M1 A1	Attempt correct expression OR Find P(2) $= 0.0669$ or 0.0670
	Critical region is 0 or 1 pkt contain gift or < 2 pkts contain gift oe	A1 [5]	dep M1M1 & their $P(X \leqslant 1) < 0.05 <$ their $P(X \leqslant 2)$ (S.R. Use of Normal: $N(5.3.75^2)$ used B1 $-1.645=(x + 0.5 - 5)/\sqrt{3.75}$ M1 $x < 1.31$ A1 (3/5))
	(ii) P(Type I) = 0.0243 (3 sfs)	B1ft [1]	ft their $P(X \leqslant 1)$ dep < 0.05 ft Normal
	(iii) 2 is outside rej reg No evidence to reject claim	M1 A1ft [2]	or $P(X \leqslant 2) > 0.05$ No contradictions

Example candidate response – 1

4) Sol:-

(i) Let x denotes : Sample of 20 packets

Let p : proportion of free gift in each packet

$H_0 : p = 0.25$

$H_1 : p < 0.25$

IF H_0 is true : $X \sim B(20, 0.25)$

$P(X < \alpha) < 0.05$

Critical region :

$P(0) = \binom{20}{0} (0.25)^{0} (0.75)^{20}$

$= 0.003 17\ldots$

$P(1) = \binom{20}{1} (0.25)^{1} (0.75)^{19}$

$= 0.021 14\ldots$

$P(2) = \binom{20}{2} (0.25)^{2} (0.75)^{18}$

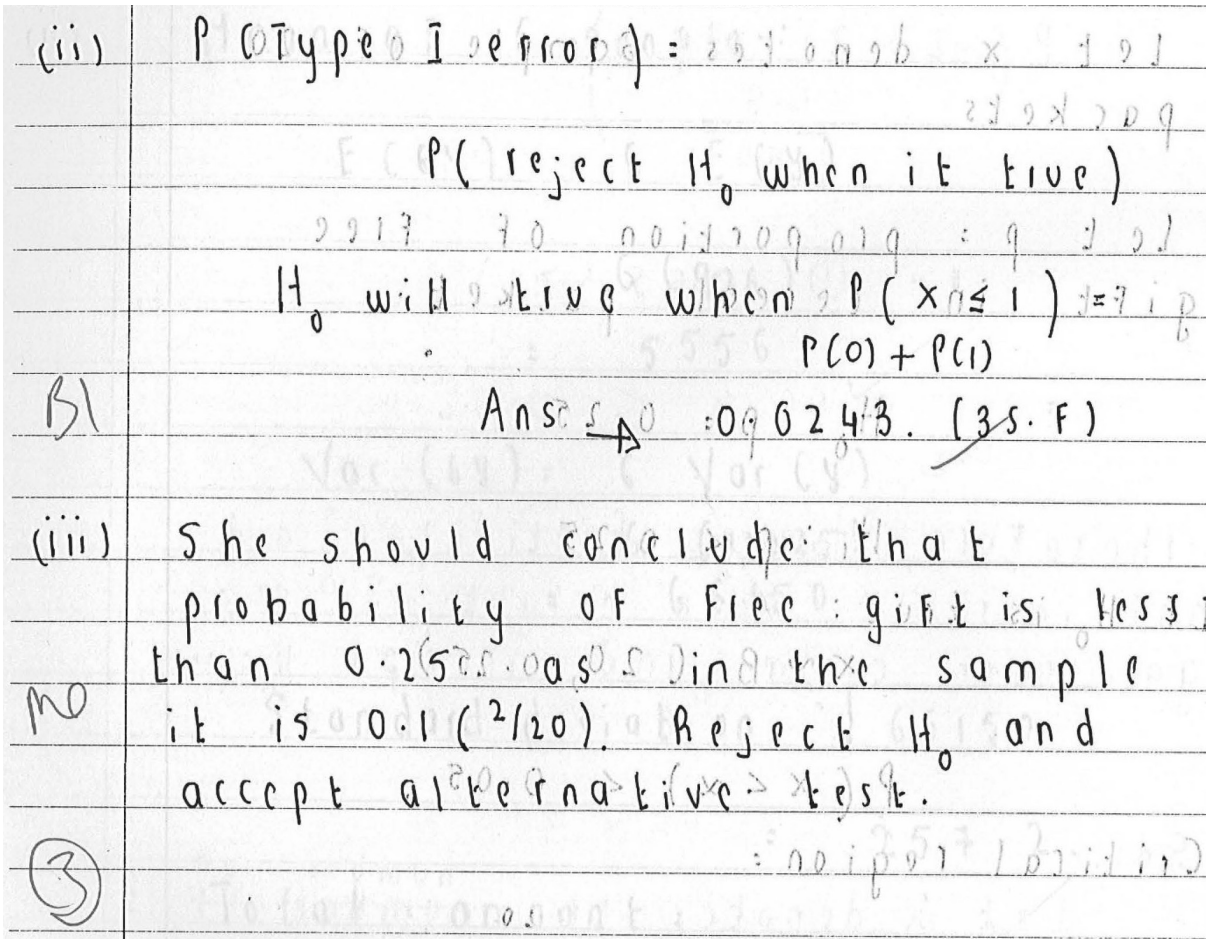
$= 0.0669$

$P(0) + P(1) + P(2) > 0.05$

∴ Critical region : $P(0) + P(1)$

Ans : $P(X \leq 1)$

Example candidate response – 1, continued



Item marks awarded: (i) = 2/5; (ii) = 1/1; (iii) = 0/2

Total mark awarded = 3 out of 8

Example candidate response – 2

Question 4

Let X be the r.v, "a cereal manufacturer claiming cereal packets"

$X \sim B(20, 0.25)$

$H_0 \leq 0.25$ (Reject H_0) $H_1 > 0.25$ (Accept H_1)

(i) P(Type I error) = P(Reject H_0 / H_0 is true)

= P($H_0 < 0.25$ / (20, 0.25))

$1 - \phi(a) = 0.05$

$\phi(a) = 0.95$ = level of significance

$a = 1.645$ = 1.645

~~0.4148~~ 0.415 ← (critical region)

P(X < 0.25) < 5 % → Reject H_0

$^{20}C_0 (0.25)^0 (0.75)^{20} + {}^{20}C_1 (0.25)^1 (0.75)^{19} +$

$^{20}C_2 (0.25)^2 (0.75)^{18} + {}^{20}C_3 (0.25)^3 (0.75)^{17} +$

M0 $^{20}C_4 (0.25)^4 (0.75)^{16} + {}^{20}C_5 (0.25)^5 (0.75)^{15} + {}^{20}C_6 (0.25)^6 (0.75)^{14}$

M0 $+ {}^{20}C_7 (0.25)^7 (0.75)^{13} + {}^{20}C_8 (0.25)^8 (0.75)^{12} + {}^{20}C_9 (0.25)^9 (0.75)^{11}$

$+ {}^{20}C_{10} (0.25)^{10} (0.75)^{10} + {}^{20}C_{11} (0.25)^{11} (0.75)^9$

(ii) P(Type I error) = 1.645

B0

(iii) This means that there is significant evidence as it does ~~lies below~~ not lie in the critical region

M0

0

Item marks awarded: (i) = 0/5; (ii) = 0/1; (iii) = 0/2

Total mark awarded = 0 out of 8

Examiner comment – 1 and 2

(i) Finding the critical region was not, in general, well attempted.

Candidate 1 used $B(20, 0.25)$, but calculated $P(0)$, $P(1)$, and $P(2)$ separately without combining the probabilities to find $P(X \leq 1)$ and $P(X \leq 2)$, so although the candidate identified the correct critical region (although not expressed correctly) full justification (i.e. $P(X \leq 1) = 0.0243 < 0.05$ and $P(X \leq 2) = 0.0913 > 0.05$) was not shown.

Candidate 2 also used $B(20, 0.25)$, but did not calculate any relevant probabilities and used 1.645 (a normal distribution value).

(ii) Candidate 1 correctly found the probability of a Type I error (0.0243) from previous working.

Candidate 2 gave an answer of 1.645 which, for a probability, could not have been correct. It is important that candidates always think about how sensible their answers might be.

(iii) In general, candidates on this part of the question did not draw conclusions relating back to the test.

Candidate 1 had the correct critical region and could have gained marks here by realising that '2' was not in the critical region. However, no marks were gained.

Although candidate 2 did make reference to the critical region, no justification for their (vague) statement was made. Candidates should be specific with comparisons; "it" does not lie in the critical region is too vague.

Question 5

5 A random variable X has probability density function given by

$$f(x) = \begin{cases} \dfrac{k}{x-1} & 3 \leqslant x \leqslant 5, \\ 0 & \text{otherwise,} \end{cases}$$

where k is a constant.

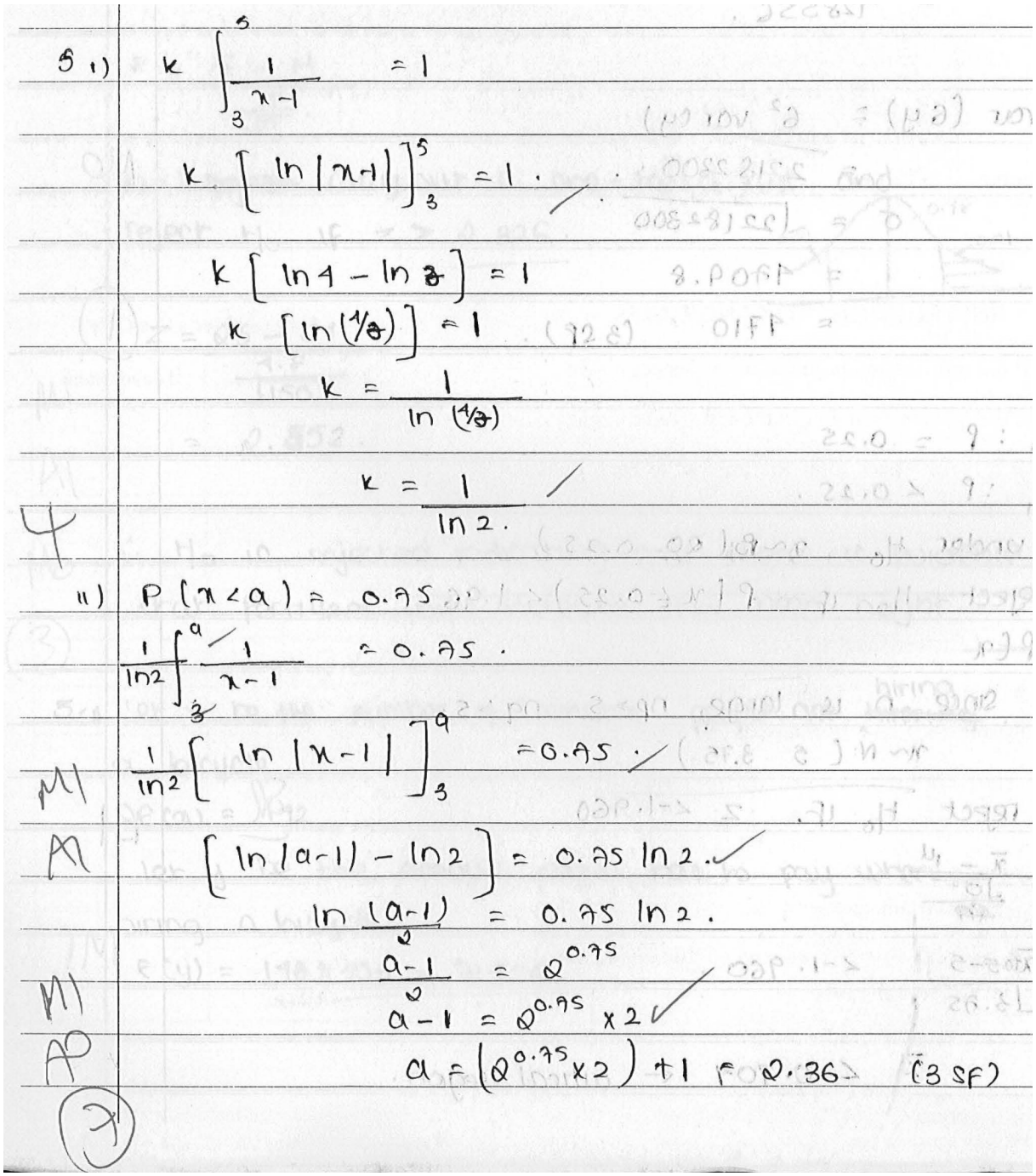
(i) Show that $k = \dfrac{1}{\ln 2}$. [4]

(ii) Find a such that $P(X < a) = 0.75$. [4]

Mark scheme

5 (i) $\int_3^5 \frac{k}{x-1}\,dx = 1$ $[k\ln(x-1)]_3^5 = 1$ $k(\ln 4 - \ln 2) = 1$ $k\ln 2 = 1$ $(k = \frac{1}{\ln 2}$ **AG**$)$	M1 A1 M1 A1 [4]	Attempt integ f(x) & '= 1' ignore limits Correctly integrated; ignore limits Subst of limits 3, 5 No errors seen. No decimals seen
(ii) $\frac{1}{\ln 2}\int_3^x \frac{1}{x-1}\,dx = 0.75$ $\frac{1}{\ln 2}[\ln(x-1)]_3^x = 0.75$ $\frac{1}{\ln 2}(\ln(x-1) - \ln 2) = 0.75$ $\ln(x-1) = (0.75 \times \ln 2 + \ln 2)$ $\ln(x-1) = 1.75 \times \ln 2$ $x - 1 = 2^{1.75}$ or $x - 1 = 3.36$ $x = 4.36$ (3 sfs)	M1* A1 M1 dep* A1 [4]	Attempt integ f(x), unknown limit, & '= 0.75' or '= 0.25' oe. Fully correct equn after subst limits oe. Correct manipulation of logs to find x

Example candidate response – 1



Item marks awarded: (i) = 4/4; (ii) = 3/4

Total mark awarded = 7 out of 8

Example candidate response – 2

Question 5

(i) $\int_3^5 \frac{k}{x-1} = 1$

$k\left[\ln(x-1)\right]_3^5 = 1$ M1

$k\left[\ln 4 - \ln 2\right] = 1$ A1

$k\left[\frac{\ln 4}{\ln 2}\right] = 1$ M1

$\ln 2k = 1$ A0

$k = \frac{1}{\ln 2}$ (shown)

(ii) $P(X < a) = 0.75$

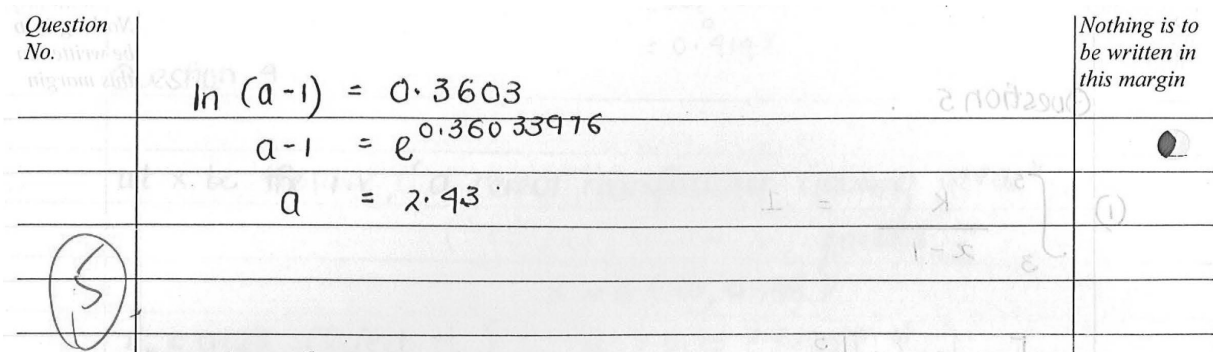
$\frac{1}{\ln 2}\int_3^a \frac{1}{x-1} = 0.75$

$\frac{1}{\ln 2}\left[\ln(x-1)\right]_3^a = 0.75$ M1

$\frac{1}{\ln 2}\left[\ln(a-1) - \ln 2\right] = 0.75$ A1

$\frac{\ln(a-1)}{\ln 2} = 0.51986$ M0

Example candidate response – 2, continued



Item marks awarded: (i) = 3/4; (ii) = 2/4

Total mark awarded = 5 out of 8

Examiner comment – 1 and 2

(i) Candidate 1 scored full marks on this part.

Candidate 2 knew the correct method to use to find k, but made an error in their manipulation of the logarithmic expression. Whilst the candidate reached the correct value of k it was not legitimately obtained and therefore did not score the final accuracy mark.

(ii) Candidate 1 was able to integrate correctly using the correct limits and would have scored full marks but unfortunately made a re-arrangement error, on the last line, when solving the equation to find a.

Candidate 2 also had a correct method to find a, using the correct integration and correct limits, but as in part **(i)**, showed a misunderstanding of logarithms by stating that $\ln(a-1) - \ln 2$ was equal to $\dfrac{\ln(a-1)}{\ln 2}$

Question 6

6 In order to obtain a random sample of people who live in her town, Jane chooses people at random from the telephone directory for her town.

(i) Give a reason why Jane's method will not give a random sample of people who live in the town. [1]

Jane now uses a valid method to choose a random sample of 200 people from her town and finds that 38 live in apartments.

(ii) Calculate an approximate 99% confidence interval for the proportion of all people in Jane's town who live in apartments. [4]

(iii) Jane uses the same sample to give a confidence interval of width 0.1 for this proportion. This interval is an x% confidence interval. Find the value of x. [4]

Mark scheme

6	**(i)** Excludes children Excludes people without phones More than one person in some houses Some ex-directory	B1 [1]	or other implying directory excludes some people
	(ii) $\text{Var}(p) = \dfrac{\frac{38}{200}(1-\frac{38}{200})}{200}$ $(= 0.0007695)$	M1	
	$z = 2.576$	B1	Seen
	$\dfrac{38}{200} \pm z\sqrt{\dfrac{\frac{38}{200}(1-\frac{38}{200})}{200}}$	M1	For correct form of CI
	0.119 to 0.261 (3 sfs)	A1 [4]	Accept 0.262 Must be an interval
	(iii) $z \times$ '$\sqrt{0.0007695}$' $= 0.05$	M1	$z \times$ (their sd of p) $= 0.05$. Allow $= 0.1$
	$z = 1.802$	A1	
	Φ('1.802') $(= 0.9642)$	M1	Attempt Φ(their z) and find $2\Phi - 1$
	('0.9642' – (1 – '0.9642') $= 0.9284$)		
	$x = 93$ (2 sfs)	A1 [4]	

Example candidate response – 1

6. (i) Jane's method will not give a random sample because people ~~in the chos~~ that she has chosen from the telephone directory may not live in the town. B0

(ii) $n = 200$ $p = \frac{38}{200}$ $q = 1 - \frac{38}{200}$

$p = 0.19$ $q = 0.81$

$99\% = 0.99$

$z_c = 2.326.$

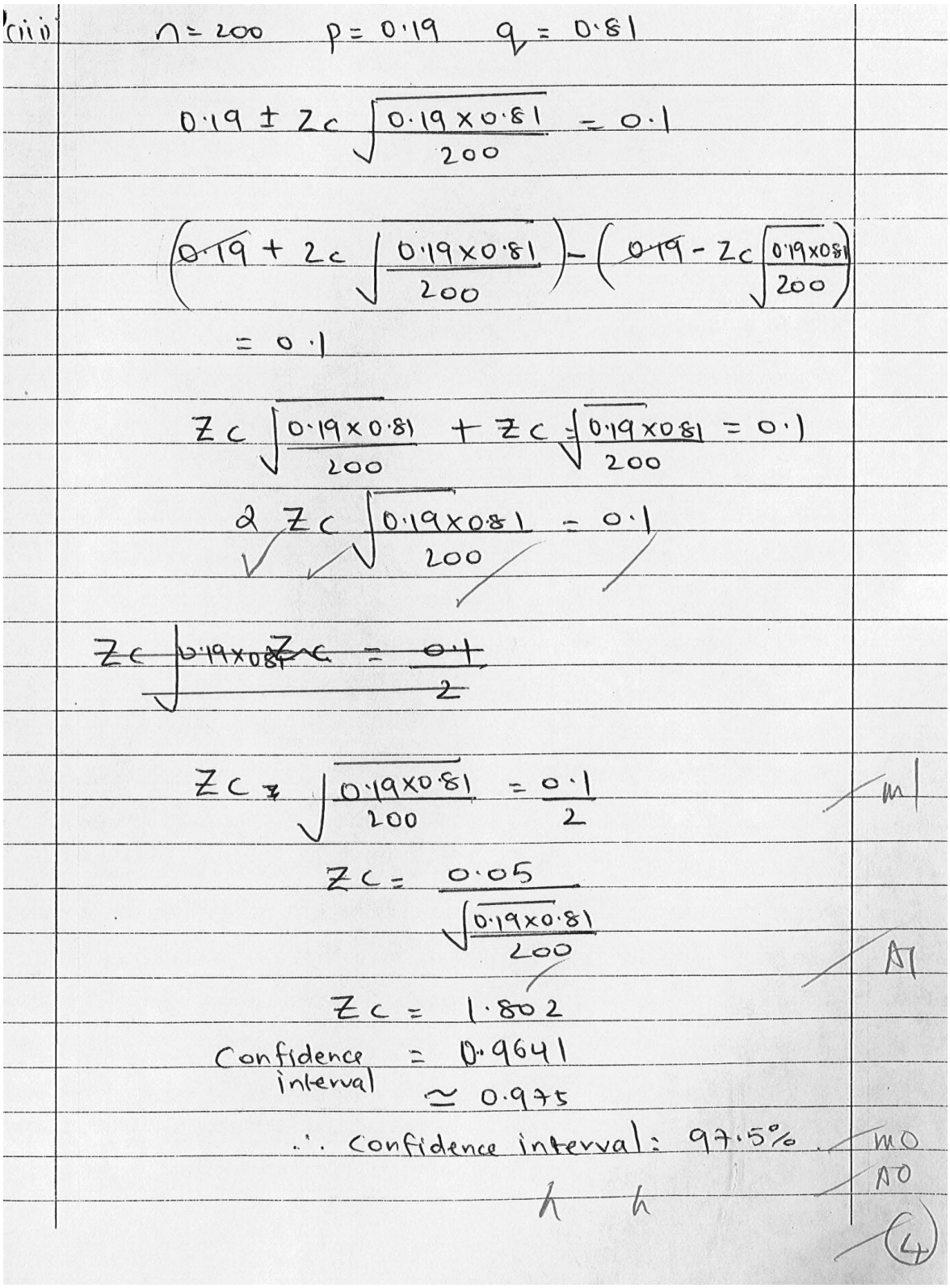
M1 $p_s \pm z_c \sqrt{\frac{p_s q_s}{n}}$ B0

M1 $0.19 \pm 2.326 \sqrt{\frac{0.19 \times 0.81}{200}}$

A0 $(0.125 ; 0.255)$

$\therefore \quad 0.125 < p < 0.255$

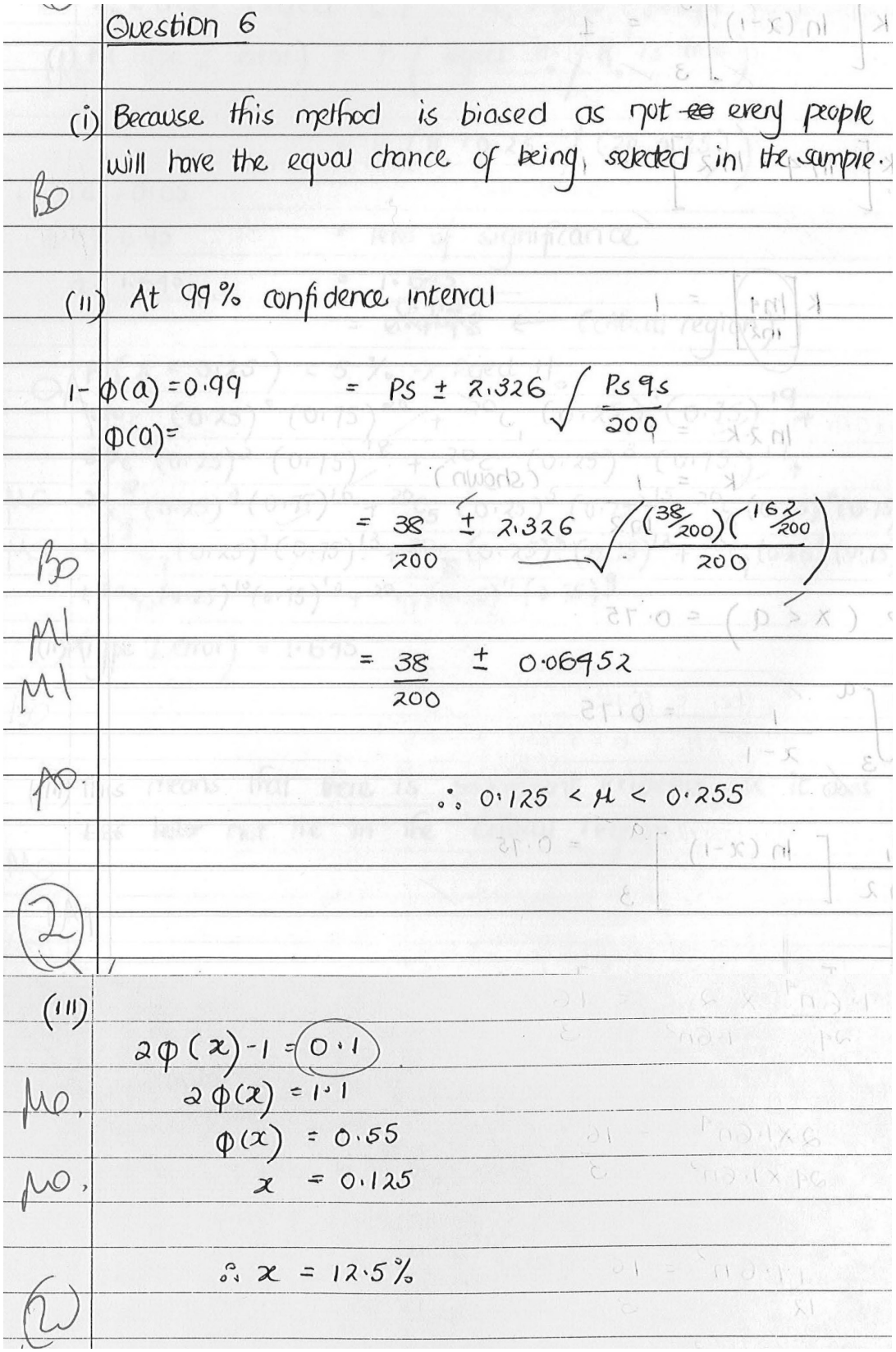
Example candidate response – 1, continued



Item marks awarded: (i) = 0/1; (ii) = 2/4; (iii) = 2/4

Total mark awarded = 4 out of 9

Example candidate response – 2



Question 6

(i) Because this method is biased as not ~~ee~~ every people will have the equal chance of being selected in the sample.

B0

(ii) At 99% confidence interval

$1-\Phi(a)=0.99$

$\Phi(a)=$

$= PS \pm 2.326\sqrt{\frac{Ps\,9s}{200}}$

$= \frac{38}{200} \pm 2.326\sqrt{\frac{(\frac{38}{200})(\frac{162}{200})}{200}}$

B0

M1

$= \frac{38}{200} \pm 0.06952$

M1

A0

$\therefore 0.125 < \mu < 0.255$

2

(iii)

$2\Phi(x)-1=0.1$

M0

$2\Phi(x)=1.1$

$\Phi(x)=0.55$

M0

$x=0.125$

$\therefore x = 12.5\%$

2

Item marks awarded: (i) = 0/1; (ii) = 2/4; (iii) = 0/4

Total mark awarded = 2 out of 9

Examiner comment – 1 and 2

(i) Neither candidate was able to give a correct reason for why Jane's method would not work. The method described did not allow equal chance of being selected because, for example, it excludes people without phones. A valid reason was required.

(ii) Both candidates made similar errors in finding the confidence interval. Whilst the general method was correct, both candidates 1 and 2 calculated the z value incorrectly. Both looked up 0.99 to get a z value of 2.326, whereas for a 99% confidence interval 0.995 should have been looked up on the tables to get a z value of 2.576. This resulted in two marks not being awarded to both candidates.

(iii) Candidate 1 formed a correct equation, leading to the correct z value of 1.802. However, the candidate did not find the correct percentage for the confidence interval.

Candidate 2 was unable to set up a correct initial equation to find z.

Question 7

7 A random variable X has the distribution Po(1.6).

(i) The random variable R is the sum of three independent values of X. Find $P(R < 4)$. [3]

(ii) The random variable S is the sum of n independent values of X. It is given that

$$P(S = 4) = \tfrac{16}{3} \times P(S = 2).$$

Find n. [4]

(iii) The random variable T is the sum of 40 independent values of X. Find $P(T > 75)$. [4]

Mark scheme

7 **(i)**	$\lambda = 4.8$ $E^{-4.8}(1 + 4.8 + \frac{4.8^2}{2!} + \frac{4.8^3}{3!})$ $= 0.294$ (3 sfs)	B1 M1 A1 [3]	 P(R = 0, 1, 2 or 3), their λ allow one end error
(ii)	$e^{-\lambda} \times \frac{\lambda^4}{4!} = \frac{16}{3} e^{-\lambda} \times \frac{\lambda^2}{2!}$ or without $e^{-\lambda}$ $\frac{\lambda^2}{12} = \frac{16}{3}$ or better $(\lambda = 8)$ $\lambda = 1.6n$ seen or implied $n =$ '8' ÷ 1.6 $= 5$	M1 A1 B1 A1 [4]	$\lambda = 1.6n$ seen or implied B1 $e^{-1.6n} \times \frac{(1.6n)^4}{4!} = \frac{16}{3} e^{1.6n} \times \frac{(1.6n)^2}{2!}$ M1 $\frac{(1.6n)^2}{12} = \frac{16}{3}$ or better A1 $(1.6n = 8)$ $n = 5$ A1
(iii)	$T \sim N(64, 64)$ $\frac{75.5 - 64}{\sqrt{64}}$ (= 1.4375) $1 - \Phi$('1.4375') (= 1 − 0.9247) = 0.0753 to 0.0754	B1 M1 M1 A1 [4]	May be implied Allow with wrong or no cc. No sd/var mixes Finding correct area consistent with their working

Example candidate response – 1

7) $X \sim Po(1.6)$

i) $3x \sim Po(4.8)$

$P(R<4) = P_0 + P_1 + P_2 + P_3$

$= e^{-4.8}\left(1 + 4.8 + \frac{4.8^2}{2!} + \frac{4.8^3}{3!}\right)$

$= 0.294$

ii) $P(S=4) = \frac{e^{-1.6n} \cdot 1.6n^4}{4!} = \frac{e^{-1.6n} \times 1.6n^4}{24}$

$P(S=2) = \frac{e^{-1.6n} \cdot 1.6n^2}{2!} = \frac{e^{-1.6n} \cdot 1.6n^2}{2}$

$\frac{e^{-1.6n} \times 1.6n^4}{4!} = \frac{16}{3} \times \frac{e^{-1.6n} \cdot 1.6n^2}{2!}$

$\frac{512}{1875} e^{-1.6n} = 6\frac{62}{75} e^{-1.6n}$

B1

M1 $\frac{e^{-1.6n} \times 1.6n^4}{24} = \frac{16}{3} \frac{e^{-1.6n} \cdot 1.6n^2}{2}$ $(\times 24)$

$e^{-1.6n} \times 1.6n^4 = 128 \times [12(e^{-1.6n} \cdot 1.6n^2)]$ Let $1.6n = a$

$e^{-a} \times a^4 = 128 [12(e^{-a} \cdot a^2)]$

$a^4 e^{-a} = 128 (12 a^2 e^{-a})$

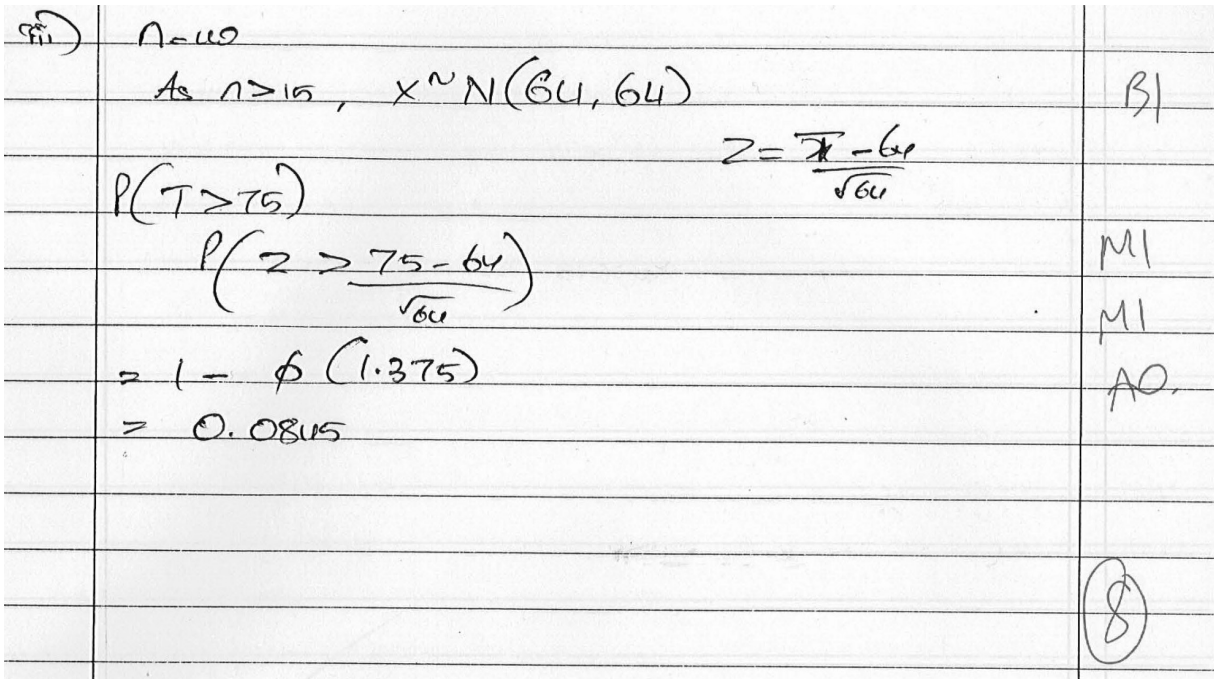
A1 $a^4 e^{-a} = 1536\, a^2 e^{-a}$ $\div e^{-a}$

A1 $a^2 = 1536$

$a = 39.192$ $1.6n = 39.192$

$\therefore n = 24$ $n = 24.49$

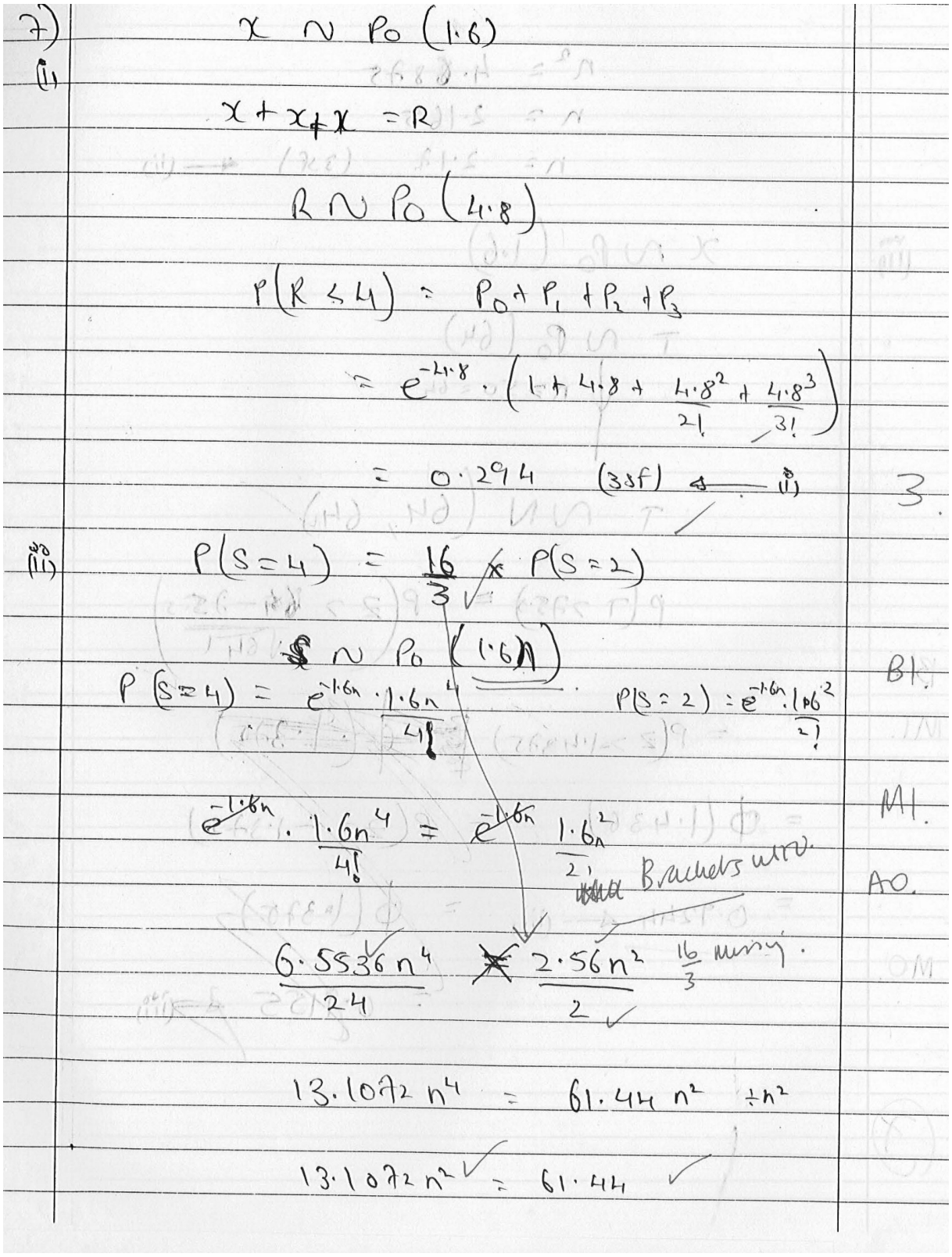
Example candidate response – 1, continued



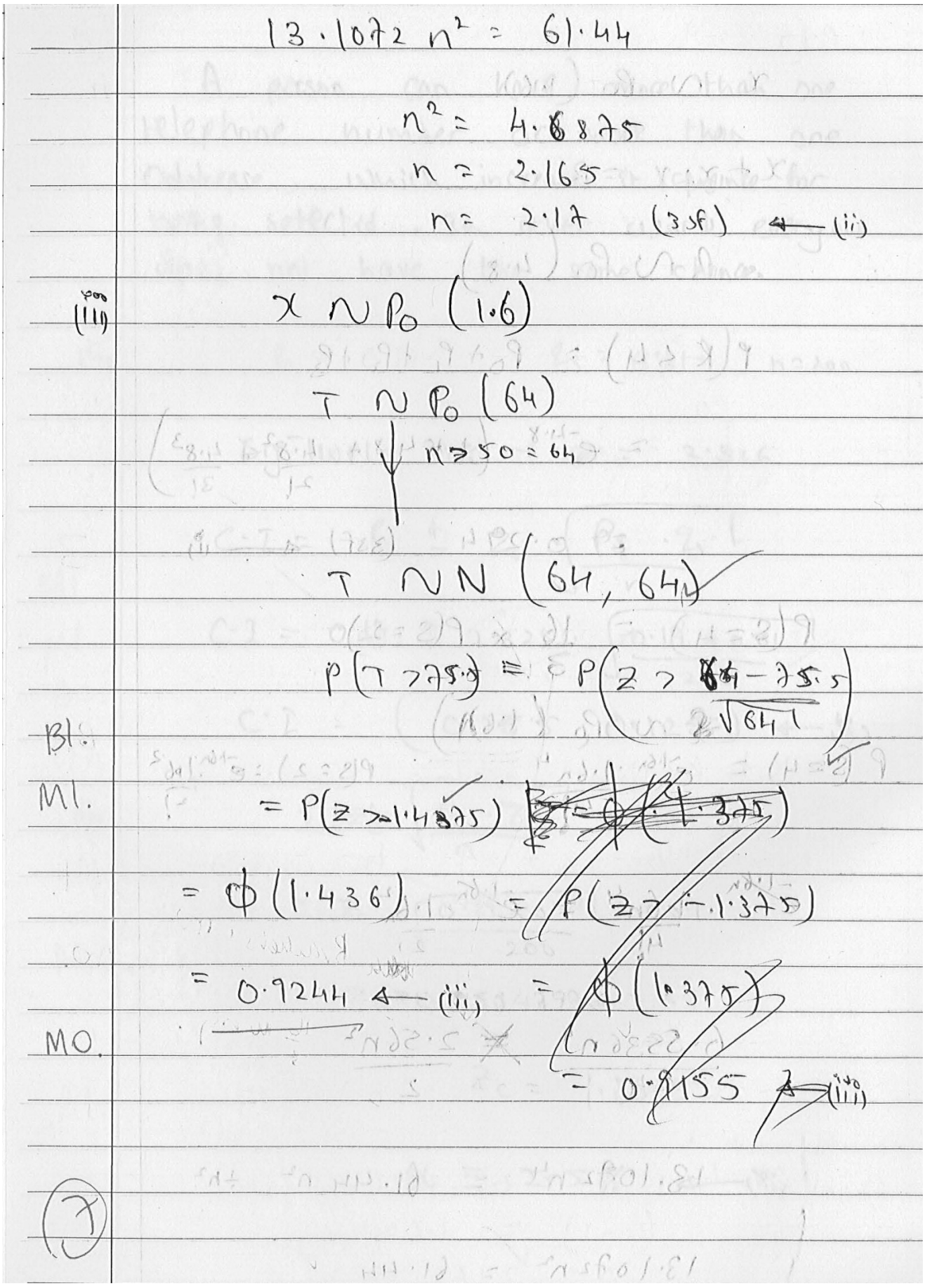
Item marks awarded: (i) = 3/3; (ii) = 2/4; (iii) = 3/4

Total mark awarded = 8 out of 11

Example candidate response – 2



Example candidate response – 2, continued



Item marks awarded: (i) = 3/3; (ii) = 2/4; (iii) = 2/4

Total mark awarded = 7 out of 11

Examiner comment – 1 and 2

(i) Both candidates were able to identify the value of λ to use (4.8) and then correctly to find the required probability.

(ii) Both candidates at both grades were able to set up the correct equation and use $\lambda = 1.6n$. They both tried to solve this equation to find n, but neither successfully reached $n = 5$.

Candidate 1 made an early error when rearranging their equation, and candidate 2, whilst initially having used the given value of $16/3$ in their equation, missed this value out in later working.

(iii) Candidate 1 used the correct distribution $\mathrm{N}(64,64)$ to find the required probability, but omitted to use the required continuity correction.

Candidate 2 also used $\mathrm{N}(64,64)$, but found $\phi(z)$ rather than $1-\phi(z)$. A normal distribution diagram may have helped this candidate realise that their final answer should have been smaller than 0.5, thus avoiding the error made.

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