Y2S3 XMQs and MS

(Total: 148 marks)

1. P3_2018 Q5 . 14 marks - Y2S3 The normal distribution
2. P3_Sample Q1 . 13 marks - Y2S3 The normal distribution
3. P3_Sample Q3 . 12 marks - Y2S3 The normal distribution
4. P3_Sample Q5 . 9 marks - Y2S3 The normal distribution
5. P3_Specimen Q1 . 14 marks - Y2S3 The normal distribution
6. P3_Specimen Q3 . 10 marks - Y2S3 The normal distribution
7. P3_Specimen Q5 . 8 marks - Y2S3 The normal distribution
8. P31_2019 Q2 . 11 marks - Y1S3 Representations of data
9. P31_2019 Q5 . 13 marks - Y2S3 The normal distribution
10. P31_2020 Q5 . 15 marks - Y2S3 The normal distribution
11. P31_2021 Q5 . 11 marks - Y2S3 The normal distribution
12. P31_2022 Q1 . 6 marks - Y1S6 Statistical distributions
13. P31_2022 Q2 . 12 marks - Y2S3 The normal distribution

5. The lifetime, L hours, of a battery has a normal distribution with mean 18 hours and standard deviation 4 hours.

Alice's calculator requires 4 batteries and will stop working when any one battery reaches the end of its lifetime.

(a) Find the probability that a randomly selected battery will last for longer than 16 hours.
(1)

At the start of her exams Alice put 4 new batteries in her calculator.
She has used her calculator for 16 hours, but has another 4 hours of exams to sit.

(b) Find the probability that her calculator will not stop working for Alice's remaining exams.
(5)

Alice only has 2 new batteries so, after the first 16 hours of her exams, although her calculator is still working, she randomly selects 2 of the batteries from her calculator and replaces these with the 2 new batteries.

(c) Show that the probability that her calculator will not stop working for the remainder of her exams is 0.199 to 3 significant figures.
(3)

After her exams, Alice believed that the lifetime of the batteries was more than 18 hours. She took a random sample of 20 of these batteries and found that their mean lifetime was 19.2 hours.

(d) Stating your hypotheses clearly and using a 5% level of significance, test Alice's belief.
(5)

Qu 5	Scheme	Marks	AO
(a)	P(L > 16) = 0.69146… **awrt 0.691**	B1 (1)	1.1b
(b)	$\text{P}(L > 20 \mid L > 16) = \dfrac{\text{P}(L>20)}{\text{P}(L>16)}$	M1	3.1b
	$= \dfrac{0.308537...}{(a)}$ or $\dfrac{1-(a)}{(a)}, = 0.44621\ldots$	A1ft, A1	1.1b 1.1b
	For calc to work require $(0.44621...)^4 = 0.03964\ldots$ **awrt <u>0.0396</u>**	dM1 A1 (5)	2.1 1.1b
(c)	Require: $[\text{P}(L>4)]^2 \times [\text{P}(L>20 \mid L>16)]^2$	M1	1.1a
	$= (0.99976...)^2 \times (\text{"}0.44621...\text{"})^2$	A1ft	1.1b
	$= 0.19901\ldots$ **awrt <u>0.199</u> (*)**	A1cso* (3)	1.1b
(d)	$\text{H}_0 : \mu = 18 \quad \text{H}_1 : \mu > 18$	B1	2.5
	$\bar{L} \sim \text{N}\left(18, \left(\dfrac{4}{\sqrt{20}}\right)^2\right)$	M1	3.3
	$\text{P}(\bar{L} > 19.2) = \text{P}(Z > 1.3416\ldots) = 0.089856\ldots$	A1	3.4
	(0.0899 > 5%) <u>or</u> (19.2 < 19.5) <u>or</u> 1.34 < 1.6449 so not significant	A1	1.1b
	Insufficient evidence to support Alice's claim (or belief)	A1 (5)	3.5a
		(14 marks)	

	Notes
(a)	B1 for evaluating probability using their calculator (awrt 0.691) Accept 0.6915
(b)	1st M1 for a first step of identifying a suitable conditional probability (either form) 1st A1ft for a ratio of probabilities with numerator = awrt 0.309 or 1 – (a) and denom = their (a) 2nd A1 for awrt 0.446 (o.e.) Accept 0.4465 (from $\frac{0.3085}{0.691}$ = 0.44645...) NB $\frac{\text{P}(16<L<20)}{\text{P}(L>16)}$ = 0.5538… scores M1A1A1 when they do 1 – 0.5538 = 0.4462… 2nd M1 (dep on 1st M1) for 2nd correct step i.e. (their 0.446…)^4 <u>or</u> X~B(4, "0.446") and P(X = 4) 3rd A1 for awrt 0.0396
(c)	1st M1 for a correct approach to solving the problem (May be implied by A1ft) 1st A1ft for P(L > 4) = awrt 0.9998 used <u>and</u> ft their 0.44621 in correct expression If use P(L > 20) = 0.3085.. as 0.446.. in (b) then M1 for $(0.3085..)^2 \times [\text{P}(L>4)]^2$; A1ft as above
*	2nd A1cso for 0.199 or better with clear evidence of M1 [NB (0.4662..)^2 = 0.199… is M0A0A0] **Must see M1 scored by correct expression in symbols or values (M1A1ft)**
(d)	B1 for both hypotheses in terms of μ. M1 for selecting a suitable model. Sight of <u>normal</u>, <u>mean</u> 18, <u>sd</u> $\frac{4}{\sqrt{20}}$ (o.e.) or <u>variance</u> = 0.8 1st A1 for using the model correctly. Allow awrt 0.0899 <u>or</u> 0.09 from correct prob. statement
ALT	**CR** $(\bar{L})$ > 19.471… (accept awrt 19.5) <u>or</u> **CV** of 1.6449 (or better: calc 1.6448536..)
	2nd A1 for correct non-contextual conclusion. Wrong comparison or contradictions A0 Error giving 2nd A0 implies 3rd A0 but just a correct contextual conclusion can score A1A1 3rd A1 dep on M1 and 1st A1 for a correct contextual conclusion mentioning <u>Alice's claim</u> /<u>belief</u> <u>or</u> there is insufficient evidence that the mean <u>lifetime</u> is more than 18 hours

SECTION A: STATISTICS

Answer ALL questions. Write your answers in the spaces provided.

1. The number of hours of sunshine each day, y, for the month of July at Heathrow are summarised in the table below.

Hours	$0 \leqslant y < 5$	$5 \leqslant y < 8$	$8 \leqslant y < 11$	$11 \leqslant y < 12$	$12 \leqslant y < 14$
Frequency	12	6	8	3	2

A histogram was drawn to represent these data. The $8 \leqslant y < 11$ group was represented by a bar of width 1.5 cm and height 8 cm.

(a) Find the width and the height of the $0 \leqslant y < 5$ group.
(3)

(b) Use your calculator to estimate the mean and the standard deviation of the number of hours of sunshine each day, for the month of July at Heathrow.
Give your answers to 3 significant figures.
(3)

The mean and standard deviation for the number of hours of daily sunshine for the same month in Hurn are 5.98 hours and 4.12 hours respectably.
Thomas believes that the further south you are the more consistent should be the number of hours of daily sunshine.

(c) State, giving a reason, whether or not the calculations in part (b) support Thomas' belief.
(2)

(d) Estimate the number of days in July at Heathrow where the number of hours of sunshine is more than 1 standard deviation above the mean.
(2)

Helen models the number of hours of sunshine each day, for the month of July at Heathrow by $N(6.6, 3.7^2)$.

(e) Use Helen's model to predict the number of days in July at Heathrow when the number of hours of sunshine is more than 1 standard deviation above the mean.
(2)

(f) Use your answers to part (d) and part (e) to comment on the suitability of Helen's model.
(1)

Paper 3: Statistics and Mechanics Mark Scheme

Question	Scheme	Marks	AOs
1(a)	**Area** = $8\times1.5=12\text{ cm}^2$ **Frequency** = 8 so 1 cm^2 = $\frac{2}{3}$ **hour (o.e.)**	M1	3.1a
	Frequency of 12 corresponds to area of 18 so height = $18\div2.5$ = **7.2 (cm)**	A1	1.1b
	Width = 5×0.5 = **2.5 (cm)**	B1cao	1.1b
		(3)	
(b)	$[\bar{y}=]\ \frac{205.5}{31}=\text{awrt } 6.63$	B1cao	1.1b
	$[\sigma_y=]\ \sqrt{\frac{1785.25}{31}-\bar{y}^2} = \sqrt{13.644641}$ = **awrt 3.69** allow $[s=]\ \sqrt{\frac{1785.25-31\bar{y}^2}{30}}$ = **awrt 3.75**	M1 A1	1.1a 1.1b
		(3)	
(c)	Mean of Heathrow is higher than Hurn and standard deviation smaller suggesting Heathrow is more reliable	M1	2.4
	Hurn is South of Heathrow so does <u>not</u> support his belief	A1	2.2b
		(2)	
(d)	$\bar{x}+\sigma\approx10.3$ so number of days is e.g. $\frac{(11-\text{"}10.3\text{"})}{3}\times8\ (+5)$	M1	1.1b
	= 6.86 so **7 days**	A1	1.1b
		(2)	
(e)	[H = no. of hours] $\text{P}(H>10.3)$ or $\text{P}(Z>1)$ = [0.15865…]	M1	3.4
	Predict $31\times0.15865...$ = **<u>4.9 or 5 days</u>**	A1	1.1b
		(2)	
(f)	(5 or) 4.9 days < (7 or) 6.9 days so model may **not** be suitable	B1	3.5a
		(1)	
			(13 marks)

Question 1 continued	
Notes:	
(a)	
M1:	for clear attempt to relate the area to frequency. Can also award if their height $\times$ their width = 18
A1:	for height = 7.2 (cm)
(b)	
M1:	for a correct expression for σ or s, can ft their value for mean
A1:	awrt 3.69 (allow s = 3.75)
(c)	
M1:	for a suitable comparison of standard deviations to comment on reliability.
A1:	for stating Hurn is south of Heathrow and a correct conclusion
(d)	
M1:	for a correct expression – ft their $\bar{x} + \sigma \approx 10.3$
A1:	for 7 days but accept 6 (rounding down) following a correct expression
(e)	
M1:	for a correct probability attempted
A1:	for a correct prediction
(f)	
B1:	for a suitable comparison and a compatible conclusion

3. A machine cuts strips of metal to length L cm, where L is normally distributed with standard deviation 0.5 cm.

Strips with length either less than 49 cm or greater than 50.75 cm **cannot** be used.

Given that 2.5% of the cut lengths exceed 50.98 cm,

(a) find the probability that a randomly chosen strip of metal **can** be used.

(5)

Ten strips of metal are selected at random.

(b) Find the probability fewer than 4 of these strips **cannot** be used.

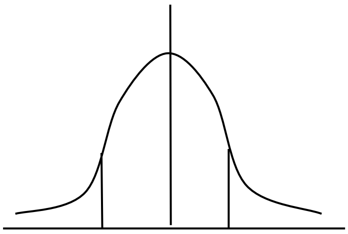
(2)

A second machine cuts strips of metal of length X cm, where X is normally distributed with standard deviation 0.6 cm

A random sample of 15 strips cut by this second machine was found to have a mean length of 50.4 cm

(c) Stating your hypotheses clearly and using a 1% level of significance, test whether or not the mean length of all the strips, cut by the second machine, is greater than 50.1 cm

(5)

Question	Scheme	Marks	AOs
Q3(a)			
	P (L > 50.98) = 0.025	B1cao	3.4
	$\therefore \dfrac{50.98-\mu}{0.5} = 1.96$	M1	1.1b
	$\therefore \quad \mu = 50$	A1cao	1.1b
	P(49 < L < 50.75)	M1	3.4
	= 0.9104… awrt <u>**0.910**</u>	A1ft	1.1b
		(5)	
(b)	S = number of strips that cannot be used so S~B(10, 0.090)	M1	3.3
	= P($S \leqslant$ 3) = 0.991166… awrt 0.991	A1	1.1b
		(2)	
(c)	$H_0 : \mu = 50.1$ $H_1 : \mu > 50.1$	B1	2.5
	$\bar{X} \sim N\left(50.1, \dfrac{0.6^2}{15}\right)$ and $\bar{X} > 50.4$	M1	3.3
	$P(\bar{X} > 50.4) = 0.0264$	A1	3.4
	p = 0.0264 > 0.01 <u>or</u> z = 1.936… < 2.3263 and not significant	A1	1.1b
	There is insufficient evidence that the <u>**mean length**</u> of strips is <u>**greater than 50.1**</u>	A1	2.2b
		(5)	
			(12 marks)

Question 3 continued
Notes:
(a) **1st M1:** for standardizing with μ and 0.5 and setting equal to a z value ($\|z\| > 1$) **2nd M1:** for attempting the correct probability for strips that can be used **2nd A1ft:** awrt 0.910 (allow ft of their μ)
(b) **M1:** for identifying a suitable binomial distribution **A1:** awrt 0.991 (from calculator)
(c) **B1:** hypotheses stated correctly **M1:** for selecting a correct model (stated or implied) **1st A1:** for use of the correct model to find p = awrt 0.0264 (allow z = awrt 1.94) **2nd A1:** for a correct calculation, comparison and correct statement **3rd A1:** for a correct conclusion in context mentioning "mean length" and 50.1

5. A company sells seeds and claims that 55% of its pea seeds germinate.

(a) Write down a reason why the company should not justify their claim by testing all the pea seeds they produce.

(1)

A random selection of the pea seeds is planted in 10 trays with 24 seeds in each tray.

(b) Assuming that the company's claim is correct, calculate the probability that in at least half of the trays 15 or more of the seeds germinate.

(3)

(c) Write down two conditions under which the normal distribution may be used as an approximation to the binomial distribution.

(1)

A random sample of 240 pea seeds was planted and 150 of these seeds germinated.

(d) Assuming that the company's claim is correct, use a normal approximation to find the probability that at least 150 pea seeds germinate.

(3)

(e) Using your answer to part (d), comment on whether or not the proportion of the company's pea seeds that germinate is different from the company's claim of 55%

(1)

Question	Scheme	Marks	AOs
5 (a)	The seeds would be destroyed in the process so they would have none to sell	B1	2.4
		(1)	
(b)	[S = no. of seeds out of 24 that germinate, $S \sim B(24, 0.55)$]		
	T = no. of trays with at least 15 germinating. $T \sim B(10, p)$	M1	3.3
	$p = P(S \geqslant 15) = 0.299126...$	A1	1.1b
	So $P(T \geqslant 5) = 0.1487…$ awrt <u>**0.149**</u>	A1	1.1b
		(3)	
(c)	n is large and p close to 0.5	B1	1.2
		(1)	
(d)	$X \sim N(132, 59.4)$	B1	3.4
	$P(X \geqslant 149.5) = P\left(Z \geqslant \frac{149.5-132}{\sqrt{59.4}}\right)$	M1	1.1b
	$= 0.01158…$ awrt <u>**0.0116**</u>	A1cso	1.1b
		(3)	
(e)	e.g The probability is very small therefore there is evidence that the company's claim is incorrect.	B1	2.2b
		(1)	
			(9 marks)

Notes:

(a)
B1: cao

(b)
M1: for selection of an appropriate model for T
1st A1: for a correct value of the parameter p (accept 0.3 or better)
2nd A1: for awrt 0.149

(c)
B1: both correct conditions

(d)
B1: for correct normal distribution
M1: for correct use of continuity correction
A1: cso

(e)
B1: correct statement

SECTION A: STATISTICS

Answer ALL questions. Write your answers in the spaces provided.

1. *Kaff coffee* is sold in packets. A seller measures the masses of the contents of a random sample of 90 packets of *Kaff coffee* from her stock. The results are shown in the table below.

Mass w (g)	Midpoint y (g)	Frequency (f)
$240 \le w < 245$	242.5	8
$245 \le w < 248$	246.5	15
$248 \le w < 252$	250	35
$252 \le w < 255$	253.5	23
$255 \le w < 260$	257.5	9

(You may use $\sum fy^2 = 5\,644\,171.75$)

A histogram is drawn and the class $245 \le w < 248$ is represented by a rectangle of width 1.2 cm and height 10 cm.

(a) Calculate the width and the height of the rectangle representing the class $255 \le w < 260$
(3)

(b) Use linear interpolation to estimate the median mass of the contents of a packet of *Kaff coffee* to 1 decimal place.
(2)

(c) Estimate the mean and the standard deviation of the mass of the contents of a packet of *Kaff coffee* to 1 decimal place.
(3)

The seller claims that the mean mass of the contents of the packets is more than the stated mass.
Given that the stated mass of the contents of a packet of *Kaff coffee* is 250 g and the actual standard deviation of the contents of a packet of Kaff coffee is 4 g,

(d) test, using a 5% level of significance, whether or not the seller's claim is justified. State your hypotheses clearly.
(You may assume that the mass of the contents of a packet is normally distributed.)
(5)

(e) Using your answers to parts (b) and (c), comment on the assumption that the mass of the contents of a packet is normally distributed.
(1)

9MA0/03 Mock Paper: Statistics and Mechanics mark scheme

Question	Scheme	Marks	AOs
1(a)	Width = $0.4\times 5 = \mathbf{2}$ (cm)	B1	3.1a
	Area = 12 cm^2 Frequency = 15 so 1 $\text{cm}^2 = \frac{5}{4}$ packet o.e	M1	1.1b
	Frequency of 9 corresponds to area of 7.2 Height = $7.2\div 2 = 3.6$ (cm)	A1	1.1b
		(3)	
(b)	$[Q_2 =]\ (248+)\ \frac{22}{35}\times 4$ **or** (use of $(n+1)$) $(248+)\frac{22.5}{35}\times 4$	M1	1.1a
	= awrt 250.5 (g) or 250.6	A1	1.1b
		(2)	
(c)	Mean = awrt 250.4 (g)	B1	1.1b
	$[\sigma_x =]\ \sqrt{\frac{5644171.75}{90}-\left(\frac{22535.5}{90}\right)^2} = \sqrt{15.64...}$	M1	1.1b
	= awrt 4.0 (g)	A1	1.1b
	Accept $\left(s_x = \sqrt{\frac{5644171.75-90\left(\frac{22535.5}{90}\right)^2}{89}} = 3.977... \right)$	**(3)**	
(d)	$H_0 : \mu = 250 \quad H_1 : \mu > 250$	B1	2.5
	$\bar{X} \sim N\left(250, \frac{4^2}{90}\right)$ and $\bar{X} > 250.4$	M1	3.3
	$P\left(\bar{X} > 250.4\right) = 0.171...$	A1	3.4
	$0.171 > 0.05$ or $z = 0.9486... < 1.6449$	A1	1.1b
	There is insufficient evidence that the mean weight of coffee is greater than 250 g, or there is no evidence to support the sellers claim.	A1	2.2b
		(5)	
(e)	It is consistent as (the estimate of) the mean is close to (the estimate of) the median which is true for the normal distribution.	B1ft	3.5b
		(1)	
		(14 marks)	

Notes:
(a) B1: for correct width **M1:** for clear attempt to relate the area to frequency. May be implied by their height × their width = 7.2 **A1:** for height = 3.6 cm
(b) M1: for $\frac{22}{35}\times 4$ or $\frac{22.5}{35}\times 4$ **A1:** awrt 250.5 or 250.6
(c) B1: awrt 250.4 **M1:** for a correct expression for σ or s, can ft their mean **A1:** awrt 4.0 (allow s = awrt 4.0)
(d) **B1:** hypotheses stated correctly **M1:** for selecting a correct model, (stated or implied) **A1:** for use of the correct model to find p = awrt 0.171 (allow z = awrt 0.948) **A1:** for a correct calculation, comparison and correct statement **A1:** for a correct conclusion in context mentioning mean weight and 250
(e) B1: evaluating the validity of the model used in (d)

3. For a particular type of bulb, 36% grow into plants with blue flowers and the remainder grow into plants with white flowers. Bulbs are sold in mixed bags of 40.

Russell selects a random sample of 5 bags of bulbs.

(a) Find the probability that fewer than 2 of these bags will contain more bulbs that grow into plants with blue flowers than grow into plants with white flowers

(4)

Maggie takes a random sample of n bulbs.
Using a normal approximation, the probability that more than 244 of these n bulbs will grow into blue flowers is 0.0521 to 4 decimal places.

(b) Find the value of n.

(6)

Question	Scheme	Marks	AOs
3(a)	[A = no. of bulbs that grow into plants with blue flowers,] A~B(40, 0.36)	M1	3.3
	$p = \mathrm{P}(A \geq 21) = 0.0240$	A1	1.1b
	C = no. of bags with more than 20 bulbs that grow into blue flowers, C~B(5, p)	M1	3.3
	So P($C \leq 1$) = 0.9945… awrt 0.995	A1	1.1b
		(4)	
(b)	[T ~ number of bulbs that grow into blue flowers] T~ B(n, 0.36)		
	T can be approximated by N(0.36n, 0.2304n)	B1	3.4
	$\mathrm{P}\left(Z < \dfrac{244.5-0.36n}{\sqrt{0.2304n}}\right) = 0.9479$	M1	1.1b
	$\dfrac{244.5-0.36n}{\sqrt{0.2304n}} = 1.625$ or $\dfrac{244.5-0.36x^2}{0.48x} = 1.625$	M1 A1	3.4 1.1b
	$0.36n + 0.78\sqrt{n} - 244.5 = 0$	M1	1.1b
	$n = 625$	A1cso	1.1b
		(6)	
			(10 marks)

Notes:

(a) M1: for selecting an appropriate model for A
A1: for a correct value of the parameter p for C
M1: for selecting an appropriate model for C
A1: for awrt 0.995

(b) B1: for correct normal distribution
M1: for correct use of continuity correction equal to a z value where $|z| > 1$
M1: for standardisation with their μ and σ
A1: for a correct equation
M1: using a correct method to solve their 3-term quadratic
A1: 625 on its own cso

5. The lifetimes of batteries sold by company X are normally distributed, with mean 150 hours and standard deviation 25 hours.

A box contains 12 batteries from company X.

(a) Find the expected number of these batteries that have a lifetime of more than 160 hours.
(3)

The lifetimes of batteries sold by company Y are normally distributed, with mean 160 hours and 80% of these batteries have a lifetime of less than 180 hours.

(b) Find the standard deviation of the lifetimes of batteries from company Y.
(3)

Both companies sell their batteries for the same price.

(c) State which company you would recommend. Give reasons for your answer.
(2)

Question	Scheme	Marks	AOs
5(a)	$P(L_X > 160) = P\left(Z > \frac{160-150}{25}\right)$		
	$= P(Z > 0.4)$		
	$= 1 - 0.6554$		
	$=$ awrt 0.345 0.34457…..	B1	1.1b
	Expected number $= 12 \times "0.345"$	M1	1.1b
	$= 4.13$ (allow 4.14)	A1	1.1b
		(3)	
(b)	$P(L_Y < 180) = 0.8416\,21…..$	B1	3.4
	$\frac{180-160}{\sigma} = 0.8416$	M1	1.1b
	$\sigma =$ awrt 23.8	A1	1.1b
		(3)	
(c)	The standard deviations for two companies are close but the mean for company *Y* is higher	M1	2.4
	therefore choose company *Y*	A1	2.2b
		(2)	
			(8 marks)

Notes:

(a) B1: awrt 0.345
M1: for multiplying their probability by 12
A1: 4.13 (allow 4.14)

(b) B1: for use of the correct model to find the correct value of z awrt 0.842
M1: for standardising = to a Z value $0.5 < Z < 1$
A1: awrt 23.8

(c) M1: for a correct reason following their part(b)
A1: for making an inference that follows their part(b)

2.

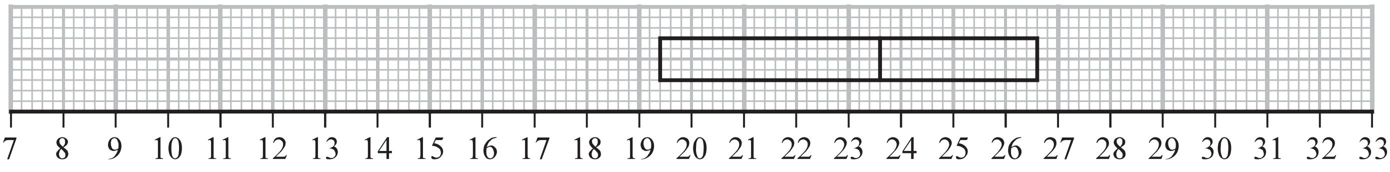


Figure 1

The partially completed box plot in Figure 1 shows the distribution of daily mean air temperatures using the data from the large data set for Beijing in 2015

An outlier is defined as a value
more than 1.5 × IQR below Q_1 or
more than 1.5 × IQR above Q_3

The three lowest air temperatures in the data set are 7.6 °C, 8.1 °C and 9.1 °C
The highest air temperature in the data set is 32.5 °C

(a) Complete the box plot in Figure 1 showing clearly any outliers.

(4)

(b) Using your knowledge of the large data set, suggest from which month the two outliers are likely to have come.

(1)

Using the data from the large data set, Simon produced the following summary statistics for the daily mean air temperature, x °C, for Beijing in 2015

$$n = 184 \qquad \sum x = 4153.6 \qquad S_{xx} = 4952.906$$

(c) Show that, to 3 significant figures, the standard deviation is 5.19 °C

(1)

Simon decides to model the air temperatures with the random variable

$$T \sim \mathrm{N}(22.6, 5.19^2)$$

(d) Using Simon's model, calculate the 10th to 90th interpercentile range.

(3)

Simon wants to model another variable from the large data set for Beijing using a normal distribution.

(e) State two variables from the large data set for Beijing that are **not** suitable to be modelled by a normal distribution. Give a reason for each answer.

(2)

Question	Scheme		Marks	AOs
2(a)	IQR = 26.6 – 19.4 [= 7.2]		B1	2.1
	19.4 – 1.5 × ‘7.2’ [= 8.6] or 26.6 + 1.5 × ‘7.2’ [= 37.4]		M1	1.1b
	Plotting one upper whisker to 32.5 **and** one lower whisker to 8.6 or 9.1		A1	1.1b
	Plotting 7.6 and 8.1 as the only two outliers		A1	1.1b
			(4)	
(b)	<u>October</u> (since it is the month with the coldest temperatures between May and October in Beijing)		B1	2.4
			(1)	
(c)	$[\sigma =]\sqrt{\frac{4952.906}{184}}$ or e.g. $[\sigma =]\sqrt{\frac{S_{xx}}{n}} = 5.188...$ [=5.19*]		B1cso*	1.1b
			(1)	
(d)	$z = (\pm)\ 1.28(16)$	$[P_{90} =]29.251...$ or $[P_{10} =]15.948...$	B1	3.1b
	2 × 1.2816 × 5.19	‘29.251…’ – ‘15.948…’	M1	1.1b
	= awrt <u>**13.3**</u>		A1	1.1b
			(3)	
(e)	Daily mean <u>wind speed</u>/<u>Beaufort</u> conversion since it is <u>qualitative</u> <u>Rain</u>fall since it is not symmetric/lots of days with 0 rainfall		B1 B1	2.4 2.4
			(2)	
				(11 marks)

Notes

(a)	**B1:** for a correct calculation for the IQR (implied by 10.8 **or** 8.6 **or** 37.4 seen) **M1:** for a complete method for either lower outlier limit or upper outlier limit (allow ft on their IQR) (may be implied by the 1st A1 or a lower whisker at 8.6) **A1:** both whiskers plotted correctly (allow ½ square tolerance) **A1:** only two outliers plotted, 7.6 and 8.1 (must be disconnected from whisker) **NOTE:** A fully correct box plot with no incorrect working scores 4/4
(c)	**B1cso*:** Correct expression with square root **or** correct formula and 5.188 or better Allow a complete correct method finding $\sum x^2 = \text{awrt } 98720$ and $\sigma = \sqrt{\frac{98715.9...}{184} - \left(\frac{4153.6}{184}\right)^2}$
(d)	**B1:** Identifying z-value for 10th or 90th percentile (allow awrt (±) 1.28) or for identifying $[P_{90} =]29.251...$ (awrt 29.3) or $[P_{10} =]15.948...$ (awrt 15.9) (This may be implied by a correct answer awrt 13.3) **M1:** for $2 \times z \times 5.19$ where $1 < z < 2$ or for their $P_{90} - P_{10}$ where $25 < P_{90} < 35$ and $10 < P_{10} < 20$ **A1:** awrt 13.3
(e)	**B1:** for one variable identified and a correct supporting reason **B1:** for two variables identified and a correct supporting reason for each Allow any two of the following: • <u>Wind speed/Beaufort</u> since the data is <u>non-numeric</u> (o.e.). They need not mention Beaufort provided there is a description of the data as non-numeric (Do not allow wind direction/wind gust) • <u>Rain</u>fall as not symmetric/is skewed/is not bell shaped/lots of 0s /many days with no rain/mean≠mode or median • <u>Date</u> since each data value appears once/it is uniformly distributed • Daily mean <u>pressure</u> since it is not symmetric/is skewed/not bell shaped • Daily mean <u>wind speed</u> since it is not symmetric/is skewed/not bell shaped Do not allow ‘not continuous’ or ‘discrete’ as a supporting reason. Ignore extraneous non-contradicting statements

5. A machine puts liquid into bottles of perfume. The amount of liquid put into each bottle, D ml, follows a normal distribution with mean 25 ml

Given that 15% of bottles contain less than 24.63 ml

(a) find, to 2 decimal places, the value of k such that $P(24.63 < D < k) = 0.45$

(5)

A random sample of 200 bottles is taken.

(b) Using a normal approximation, find the probability that fewer than half of these bottles contain between 24.63 ml and k ml

(3)

The machine is adjusted so that the standard deviation of the liquid put in the bottles is now 0.16 ml

Following the adjustments, Hannah believes that the mean amount of liquid put in each bottle is less than 25 ml

She takes a random sample of 20 bottles and finds the mean amount of liquid to be 24.94 ml

(c) Test Hannah's belief at the 5% level of significance. You should state your hypotheses clearly.

(5)

Question	Scheme	Marks	AOs
5(a)	$\frac{24.63-25}{'\sigma'}=-1.0364$	M1	3.1b
	$[\sigma=]0.357$ (must come from compatible signs)	A1	1.1b
	P(*D* > *k*) = 0.4 or P(*D* < *k*) = 0.6	B1	1.1b
	$\frac{k-25}{'0.357'}=0.2533$	M1	3.4
	k = awrt **25.09**	A1	1.1b
		(5)	
(b)	[*Y* ~ B(200, 0.45) →] *W* ~ N(90, 49.5)	B1	3.3
	$\text{P}(Y<100)\approx\text{P}(W<99.5)\left[=\text{P}\left(Z<\frac{99.5-90}{\sqrt{49.5}}\right)\right]$	M1	3.4
	= 0.9115… awrt **0.912**	A1	1.1b
		(3)	
(c)	$\text{H}_0:\mu=25$ $\text{H}_1:\mu<25$	B1	2.5
	$[\bar{D}\sim]\text{N}\left(25,\frac{0.16^2}{20}\right)$	M1	3.3
	$\text{P}(\bar{D}<24.94)[=\text{P}(Z<-1.677...)]=0.046766...$	A1	3.4
	p = 0.047 < 0.05 or *z* = –1.677… < –1.6449 or 24.94 < 24.94115… or reject H_0/in the critical region/significant	M1	1.1b
	There is sufficient evidence to support Hannah's belief.	A1	2.2b
		(5)	
			(13 marks)

Notes

(a)	**M1:** for standardising 24.63, 25 and 'σ' (ignore label) and setting = to *z* where 1 < |*z*| < 2 **A1:** **[**$\sigma=$] awrt 0.36. Do **not** award this mark if signs are not compatible. **B1:** for either correct probability statement (may be implied by correct answer) this mark may be scored for a correct region shown on a diagram **M1:** for a correct expression with *z* = awrt 0.253 (may be implied by correct answer) **A1:** awrt 25.09 (Correct answer with no incorrect working scores 5 out of 5)
(b)	**B1:** setting up normal distribution approximation of binomial N(90, 49.5) (may be implied by a correct answer) Look out for e.g. $\sigma=\frac{3\sqrt{22}}{2}$ or $\sigma=$ awrt 7.04 **M1:** attempting a probability using a continuity correction i.e. P(*W* < 100.5), P(*W* < 99.5) or P(*W* < 98.5) condone ≤ (The continuity correction may be seen in a standardisation). **A1:** awrt 0.912 [Note: 0.911299… from binomial scores 0 out of 3]
(c)	**B1:** for both hypotheses in terms of μ **M1:** selecting suitable model must see N(ormal), mean 25, sd = $\frac{0.16}{\sqrt{20}}$ (o.e.) or var = $\frac{4}{3125}$ (o.e.) Condone N(25, $\frac{0.16}{\sqrt{20}}$) if $\frac{0.16}{\sqrt{20}}$ then used as s.d. **A1:** *p* value = awrt 0.047 or **test statistic** awrt –1.68 or **CV** awrt 24.941 (any of these values imply the M1 provided they do not come from Normal mean = 24.94) **M1:** a correct comparison (including compatible signs) **or** correct non-contextual conclusion (f.t. their *p* value, test statistic or critical value in the comparison) M1 may be implied by a correct contextual statement **NB** Any contradictory non contextual statements/comparisons score M0A0 e.g. '*p* < 0.05, not significant' **A1:** correct conclusion in context mentioning Hannah's belief or the mean amount/liquid in each bottle is now less than 25ml (**dep on M1A1M1**)

5. A health centre claims that the time a doctor spends with a patient can be modelled by a normal distribution with a mean of 10 minutes and a standard deviation of 4 minutes.

(a) Using this model, find the probability that the time spent with a randomly selected patient is more than 15 minutes.

(1)

Some patients complain that the mean time the doctor spends with a patient is more than 10 minutes.

The receptionist takes a random sample of 20 patients and finds that the mean time the doctor spends with a patient is 11.5 minutes.

(b) Stating your hypotheses clearly and using a 5% significance level, test whether or not there is evidence to support the patients' complaint.

(4)

The health centre also claims that the time a dentist spends with a patient during a routine appointment, T minutes, can be modelled by the normal distribution where $T \sim N(5, 3.5^2)$

(c) Using this model,

(i) find the probability that a routine appointment with the dentist takes less than 2 minutes

(1)

(ii) find $P(T < 2 \mid T > 0)$

(3)

(iii) hence explain why this normal distribution may not be a good model for T.

(1)

The dentist believes that she cannot complete a routine appointment in less than 2 minutes.

She suggests that the health centre should use a refined model only including values of $T > 2$

(d) Find the median time for a routine appointment using this new model, giving your answer correct to one decimal place.

(5)

Qu 5	Scheme	Marks	AO
(a)	{Let X = time spent, P(X > 15) = } 0.105649… awrt **0.106**	B1 **(1)**	1.1b
(b)	$H_0 : \mu = 10 \quad H_1 : \mu > 10$	B1	2.5
	$\bar{X} \sim N\left(10, \left(\frac{4}{\sqrt{20}}\right)^2\right)$; $P\left(\bar{X} > 11.5\right)$ = 0.046766… [Condone 0.9532…]	M1;A1	3.3;3.4
	[This is significant (< 5%) so] there is evidence to support the complaint	A1 **(4)**	2.2b
(c)(i)	[P(T < 2) =] 0.1956… awrt **0.196**	B1 **(1)**	1.1b
(ii)	Require $\frac{P(0 < T < 2)}{P(T > 0)} = \frac{0.119119...}{0.923436...}$; = 0.1289955… awrt **0.129**	M1 A1;A1 **(3)**	3.4 1.1bx2
(iii)	The current model suggests **non-negligible** probability of T values < 0 which is impossible	B1 **(1)**	3.5b
(d)	Require t such that P(T > t | T > 2) = 0.5 or P(T < t | T > 2) = 0.5	M1	3.1b
	e.g. $\frac{P(T > t)}{P(T > 2)} = 0.5$; so P(T > t) = 0.5×[1 – (c)(i)] or P(T > t) = 0.5×0.8043..	M1; A1ft	1.1b 3.4
	[i.e. P(T > t) = 0.40… implies] $\frac{t-5}{3.5} = 0.2533$ or P(T < t) = "0.5978.."	M1	1.1b
	t = 5.886… or from calculator 5.867… so awrt **5.9**	A1 **(5)**	1.1b
		(15 marks)	
	Notes		
(a)	B1 for awrt 0.106 (from calculator) [Allow 10.6%]		
(b)	B1 for both hypotheses correct in terms of μ. M1 for selection of a correct model (sight or use of correct normal- may not have label $\bar{X}$) 1st A1 for use of this model to get probability allow 0.046~0.047 [Condone awrt 0.953]		
ALT	**OR** test statistic z = 1.677… (awrt 1.68) and cv of 1.64 (or better) **or** CR $\bar{X}$ > 11.47.. 2nd A1 (dep on 1st A1 or at least $P\left(\bar{X} > 11.5\right)$ < 0.05 (o.e.)) for a correct conclusion in context -must mention **complaint/**claim or **time/**mins is > 10		
SC	**(M0 for $\bar{X}$ ~N(11.5, …)** for correct probability **and** conclusion (score M0A0A1 on epen)		
(c)(i)	B1 for awrt 0.196 (from calculator) [Allow 19.6%]		
(ii)	M1 for a correct probability ratio expression (may be implied by 1st A1 scored) 1st A1 for a correct ratio of probabilities (both correct or truncated to 2 dp) 2nd A1 for awrt 0.129		
(iii)	B1 for a suitable explanation of why model is not suitable based on negative T values Must say that a **significant** proportion of values < 0 (o.e.) e.g. P(T > 0) should be **closer** to 1 or Difference between P(T < 2| T > 0) and P(T < 2) is **too big** (o.e.)		
(d)	1st M1 for a correct conditional probability statement to start the problem or 0.5×P(T > 2) 2nd M1 for correct ratio of probability expressions [Must have P(T > t) or P(2 < T < t)] 1st A1ft for a correct equation for P(T > t) (o.e.) ft their answer to part (c)[May be in a diagram] 3rd M1 for attempt to find t (standardising and sight of 0.2533) or prepare to use calc (ft) Arriving at P(T < median) = 1 – 0.5×"their 0.8043" will score 1st 4 marks 2nd A1 for awrt 5.9 Sight of awrt 5.9 and at least one M mark scores 5/5 [Answer only send to review]		

5. The heights of females from a country are normally distributed with

- a mean of 166.5 cm
- a standard deviation of 6.1 cm

Given that 1% of females from this country are shorter than k cm,

(a) find the value of k

(2)

(b) Find the proportion of females from this country with heights between 150 cm and 175 cm

(1)

A female, from this country, is chosen at random from those with heights between 150 cm and 175 cm

(c) Find the probability that her height is more than 160 cm

(4)

The heights of females from a different country are normally distributed with a standard deviation of 7.4 cm

Mia believes that the mean height of females from this country is less than 166.5 cm

Mia takes a random sample of 50 females from this country and finds the mean of her sample is 164.6 cm

(d) Carry out a suitable test to assess Mia's belief.
You should

- state your hypotheses clearly
- use a 5% level of significance

(4)

Qu 5	Scheme	Marks	AO
(a)	[Let $F \sim \text{N}(166.5, 6.1^2)$] P($F < k$) = 0.01 $\Rightarrow \frac{k-166.5}{6.1} = -2.3263$	M1	3.4
	k = 152.309… **<u>152</u>** <u>or</u> awrt **<u>152.3</u>**	A1	1.1b
		(2)	
(b)	[P(150 < F < 175) =] 0.914840… awrt **<u>0.915</u>**	B1	1.1b
		(1)	
(c)	P(F > 160 | 150 < F < 175)	M1	3.1b
	$= \frac{P(160 < F < 175)}{P(150 < F < 175)}$ <u>or</u> $\frac{P(160 < F < 175)}{"(b)"}$	M1	1.1b
	$= \frac{0.7749487...}{"0.91484..."}$	A1ft	1.1b
	= 0.84708… awrt **<u>0.847</u>**	A1	1.1b
		(4)	
(d)	$\text{H}_0 : \mu = 166.5$ $\text{H}_1 : \mu < 166.5$	B1	2.5
	[Let X = height of female from 2nd country] $\bar{X} \sim \text{N}\left(166.5, \left(\frac{7.4}{\sqrt{50}}\right)^2\right)$	M1	3.3
	$\text{P}(\bar{X} < 164.6) = 0.03472...$	A1	3.4
	[0.0347… < 0.05 so significant <u>or</u> reject H_0] There is evidence to support Mia's belief	dA1	2.2b
		(4)	
		(11 marks)	

	Notes
(a)	M1 for standardising (allow <u>+</u>) with k, 166.5 and 6.1 and set equal to a z value 2.3 < |z| < 2.4 A1 for 152 or awrt 152.3 **Ans only** 2/2 [Condone poor use of notation e.g. P($\frac{k-166.5}{6.1}$) = –2.3263] **Allow percentages instead of probabilities throughout.**
(b)	B1 for awrt 0.915
(c)	1st M1 for interpreting demand as an appropriate conditional probability ($\Rightarrow$ by 2nd M1) 2nd M1 for correct ratio of expressions (can ft their (b) on denominator) ($\Rightarrow$ by 1st A1ft) 1st A1ft for a correct ratio of probs (can ft their "0.9148…" to 3sf from (b) if > 0.775) 2nd A1 for awrt 0.847
(d)	B1 for both correct hypotheses in terms of μ 1st M1 for selecting the correct model (needn't use $\bar{X}$ $\Rightarrow$ by standardisation or 1st A1) 1st A1 for correct use of the correct model i.e. awrt 0.035 (allow 0.04 if $\text{P}("\bar{X}" < 164.6)$ seen) Condone P("$\bar{X}$" > 164.6) = 0.9652 or awrt 0.97 <u>only if</u> comparison with 0.95 is made
ALT	**Use of z value:** Need to see Z = – 1.8(15…) **and** cv of <u>+</u> 1.6449 (allow 1.64 or better) for 1st A1
ALT	**Use of CR or CV for $\bar{X}$:** Need to see "$\bar{X}$"< 164.7786… or CV = … (awrt 164.8) for 1st A1 Condone truncation i.e 164.7 or better 2nd dA1 (**dep on M1A1** only) for a correct inference in context. Must mention <u>Mia's belief</u> **or** <u>mean height of females/women</u> Do NOT award if contradictory statements about hypotheses made e.g. "not sig"
SC	**M0 for** $\bar{X}$ ~N(**164.6**, …) If they achieve p = awrt 0.035 (o.e. with z-value or CV of 166.3) **and** a correct conclusion in context is given score M0A0A1 [and SC for awrt 0.97 > 0.95 case]

1. George throws a ball at a target 15 times.
Each time George throws the ball, the probability of the ball hitting the target is 0.48

The random variable X represents the number of times George hits the target in 15 throws.

(a) Find

(i) $P(X = 3)$

(ii) $P(X \geqslant 5)$

(3)

George now throws the ball at the target 250 times.

(b) Use a normal approximation to calculate the probability that he will hit the target more than 110 times.

(3)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

P 7 2 1 3 0 A 0 2 2 0

Question	Scheme		Marks	AOs
1(a)(i)	$X \sim B(15, 0.48)$		M1	3.3
	$P(X=3)=0.019668...$	awrt 0.0197	A1	3.4
(ii)	$[P(X \geqslant 5)=1-P(X \leqslant 4)]=0.92013...$	awrt 0.920	A1	1.1b
			(3)	
(b)	Y is the number of hits	M is the number of misses		
	$Y \sim N(120, 62.4)$	$M \sim N(130, 62.4)$	B1	3.3
	$P(X>110) \approx P(Y>110.5)$ $\left[=P\left(Z>\frac{110.5-"120"}{\sqrt{"62.4"}}\right)\right]$	$P(X>110) \approx P(M<139.5)$ $\left[=P\left(Z<\frac{139.5-"130"}{\sqrt{"62.4"}}\right)\right]$	M1	3.4
	= 0.88544…		A1	1.1b
			(3)	
				(6 marks)

Notes:

(a)	M1	Writing or using the binomial distribution in (i) or (ii) Allow for sight of B(15, 0.48) or in words: <u>binomial</u> with <u>n = 15</u> and <u>p = 0.48</u> may be implied in (i) or (ii) by one correct answer to 3sf <u>or</u> sight of $P(X \leqslant 4)=0.07986...$ i.e. awrt 0.0799. Allow for ${}^{15}C_3 \times 0.48^3 \times 0.52^{12}$ as this is "correct use" Condone B(0.48, 15)
(i)	A1	awrt 0.0197
(ii)	A1	awrt 0.920 (Allow 0.92)
(b)	B1	Setting up a correct Normal model**.** Allow sight of $N(120, 62.4)$ or $N(130, 62.4)$ or $N\left(120, \frac{312}{5}\right)$ or $N\left(130, \frac{312}{5}\right)$ or may be awarded if used correctly in standardisation or in words: <u>Normal</u> with <u>mean = 120/130</u> and <u>variance = 62.4</u> or sd = $\sqrt{62.4}$ condone $N(120, \sqrt{62.4})$ or $N(130, \sqrt{62.4})$ or sd = 62.4 Look out for $\sigma = \frac{\sqrt{1560}}{5}$ or $\frac{2\sqrt{390}}{5}$ or awrt 7.90 (condone 7.9) This may be implied by sight of 0.897 or 0.885**4**…
	M1	Sight of the continuity correction with a normal distribution **110.5** or 111.5 or 109.5 | **139.5** or 140.5 or 138.5 NB we will also allow **129.5** or 130.5 or 128.5 | NB we will also allow **120.5** or 119.5 or 121.5 Continuity correction may be seen in standardisation NB No continuity correction(CC) gives awrt 0.897 which is M0 unless CC seen
	A1	awrt 0.8854 or awrt 0.885 dependent on sight of >110.5 or <129.5 or < 139.5 or >120.5 Allow $\leqslant$ or $\geqslant$ instead of < or > NB 0.885548… from B(250, 0.48) scores M0A0

2. A manufacturer uses a machine to make metal rods.

The length of a metal rod, L cm, is normally distributed with

- a mean of 8 cm
- a standard deviation of x cm

Given that the proportion of metal rods less than 7.902 cm in length is 2.5%

(a) show that $x = 0.05$ to 2 decimal places.

(2)

(b) Calculate the proportion of metal rods that are between 7.94 cm and 8.09 cm in length.

(1)

The **cost** of producing a single metal rod is 20p

A metal rod

- where $L < 7.94$ is **sold** for scrap for 5p
- where $7.94 \leqslant L \leqslant 8.09$ is **sold** for 50p
- where $L > 8.09$ is shortened for an extra **cost** of 10p and then **sold** for 50p

(c) Calculate the expected profit per 500 of the metal rods.
Give your answer to the nearest pound.

(5)

The same manufacturer makes metal hinges in large batches.

The hinges each have a probability of 0.015 of having a fault.

A random sample of 200 hinges is taken from each batch and the batch is accepted if fewer than 6 hinges are faulty.

The manufacturer's aim is for 95% of batches to be accepted.

(d) Explain whether the manufacturer is likely to achieve its aim.

(4)

Qu	Scheme		Marks	AOs
2(a)	$\left[\text{P}\left(L<7.902\right)=0.025\Rightarrow\right]\dfrac{7.902-8}{x}=-1.96$ oe		M1	3.4
	$\left[x=\right]0.05*$		A1cso*	1.1b
	SC B1(mark as M0A1) for $\dfrac{7.902-8}{0.05}=-1.96\Rightarrow 0.024998$			
			(2)	
(b)	$\text{P}\left(7.94\leqslant L\leqslant 8.09\right)=0.8490\ldots$ **awrt 0.849**		B1	1.1b
			(1)	
(c)	$[\text{P}\left(L<7.94\right)=]\ 0.115069\ldots$ (awrt 0.115) **or** $[\text{P}\left(L>8.09\right)=]\ 0.03593\ldots$ (awrt 0.036)		B1	1.1b
	$[\text{P}\left(L<7.94\right)=]\ 0.115069\ldots$ (awrt 0.115) **&** $[\text{P}\left(L>8.09\right)=]\ 0.03593\ldots$ (awrt 0.036)		B1	1.1b
	Expected income per 500 rods = $\sum\left(\text{Income}\times\text{probability}\times 500\right)$ $\left(500\times"0.849"\times 0.5\right)+\left(500\times"0.1150..."\times 0.05\right)+\left(500\times"0.03593..."\times 0.4\right)$ **or** Expected profit per rod = $\sum\left(\text{Profit}\times\text{probability}\right)$ $0.30\times"0.849"+-0.15\times"0.1150..."+0.20\times"0.03593..."$ [= 0.2446..]		M1	3.4
	Expected profit per 500 rods $500\times\sum\left(\text{Profit}\times\text{probability}\right)$ **or** $\sum\left(\text{Income}\times\text{probability}\times 500\right)-500\times 0.2$ $=500\times"0.2446..."$ **or** $="222.3"-500\times 0.2$		M1d	3.1b
	= [£]122.3… **awrt [£]122**		A1	1.1b
			(5)	
(d)	Let $X\sim\text{B}(200, 0.015)$		M1	3.3
	$\text{P}(X\leqslant 5)=$	$\text{P}\left(X\geqslant 6\right)=$	M1	1.1b
	0.9176…	0.0824	A1	1.1b
	Manufacturer is unlikely to achieve their aim since <u>0.9176 < 0.95</u>	Manufacturer is unlikely to achieve their aim since <u>0.0824 > 0.05</u>	A1ft	2.4
			(4)	
	Notes:		**(12 marks)**	

(a)	**M1**	Using the normal distribution to set up equation. Allow σ for x and awrt ± 1.96	
	A1*	cso For a correct expression for x followed by 0.05 or 0.05000… No incorrect working seen	
(b)	**B1**	awrt 0.849	
(c)	**B1**	awrt 0.115 (Implied by awrt 57.5 for number of rods) **or** awrt 0.036 (Implied by awrt 18 for number of rods)	
	B1	awrt 0.115 (Implied by awrt 57.5 for number of rods) **and** awrt 0.036 (Implied by awrt 18 for number of rods)	
	M1	Correct method to find the total income of 500 rods. Attempt at all 3 with at least two correct and no extras **or** Correct method to find sum of all three profits with at least two of 30, −15 or 20 correct. May work in pence but need to be consistent. Allow awrt 24.5 or 0.245	
	M1d	Dep on previous method for finding profit for 500 rods. May work in pence but need to be consistent. Allow $"0.2446..."\times 500$ or "their income" for 500 rods -500×0.2 (accept 499 or 501)	
	A1	All previous marks must be awarded for awrt 122 awrt 12200p **NB** if uses any integer values for numbers of rods then it is A0 other than for 18 for $L>8.09$	
(d)	**M1**	Selecting the appropriate model. May be seen or used. Allow B(200,0.985) or Po(3) Condone B(0.015, 200) or B(0.985, 200).	
	M1	Writing or using $\text{P}\left(X\leqslant 5\right)$ Do not accept $\text{P}\left(X<6\right)$ unless found $\text{P}\left(X\leqslant 5\right)$	Writing or using $\text{P}\left(X\geqslant 6\right)$ Do not accept $\text{P}\left(X>5\right)$ unless found $\text{P}\left(X\geqslant 6\right)$
	A1	0.92 (Poisson 0.916…)	0.08 or better
	A1ft	Need at least one of the method marks to be awarded. Correct conclusion with the comparison (may be in words). Ft "their p = 0.9176…" as long as $p>0.9$ If "their 0.9176…"< 0.95 must … be unlikely… If "their 0.9176…"> 0.95 they must say … be likely... To ft the alternative then $p<0.1$	