

1. The amount of data,  $X$  megabytes, arriving at an internet server per second during the afternoon is modelled by the Normal distribution with mean 435 and standard deviation 30.

i. Find

A.  $P(X < 450)$ ,

[3]

B.  $P(400 < X < 450)$ .

[3]

ii. Find the probability that, during 5 randomly selected seconds, the amounts of data arriving are all between 400 and 450 megabytes.

[2]

The amount of data,  $Y$  megabytes, arriving at the server during the evening is modelled by the Normal distribution with mean  $\mu$  and standard deviation  $\sigma$ .

iii. Given that  $P(Y < 350) = 0.2$  and  $P(Y > 390) = 0.1$ , find the values of  $\mu$  and  $\sigma$ .

[5]

iv. Find values of  $a$  and  $b$  for which  $P(a < Y < b) = 0.95$ .

[4]

2. The wing lengths of native English male blackbirds, measured in mm, are Normally distributed with mean 130.5 and variance 11.84.

i. Find the probability that a randomly selected native English male blackbird has a wing length greater than 135 mm.

[3]

ii. Given that 1% of native English male blackbirds have wing length more than  $k$  mm, find the value of  $k$ .

[3]

iii. Find the probability that a randomly selected native English male blackbird has a wing length which is 131 mm correct to the nearest millimetre.

[3]

It is suspected that Scandinavian male blackbirds have, on average, longer wings than native English male blackbirds. A random sample of 20 Scandinavian male blackbirds has mean wing length 132.4 mm. You may assume that wing lengths in this population are Normally distributed with variance  $11.84 \text{ mm}^2$ .

iv. Carry out an appropriate hypothesis test, at the 5% significance level.

[8]

v. Discuss briefly one advantage and one disadvantage of using a 10% significance level rather than a 5% significance level in hypothesis testing in general.

[2]

3. The random variable  $X$  represents the weight in kg of a randomly selected male dog of a particular breed.  $X$  is Normally distributed with mean 30.7 and standard deviation 3.5.
- i. Find
- A.  $P(X < 30)$ , [3]
- B.  $P(25 < X < 35)$ . [3]
- ii. Five of these dogs are chosen at random. Find the probability that each of them weighs at least 30 kg. [2]
- iii. The weights of females of the same breed of dog are Normally distributed with mean 26.8 kg. Given that 5% of female dogs of this breed weigh more than 30 kg, find the standard deviation of their weights. [4]
- iv. Sketch the distributions of the weights of male and female dogs of this breed on a single diagram. [4]

4. Many types of computer have cooling fans. The random variable  $X$  represents the lifetime in hours of a particular model of cooling fan.  $X$  is Normally distributed with mean 50 600 and standard deviation 3400.

i. Find  $P(50000 < X < 55000)$ .

[3]

ii. The manufacturers claim that at least 95% of these fans last longer than 45000 hours. Is this claim valid?

[3]

iii. Find the value of  $h$  for which 99.9% of these fans last  $h$  hours or more.

[3]

iv. The random variable  $Y$  represents the lifetime in hours of a different model of cooling fan.  $Y$  is Normally distributed with mean  $\mu$  and standard deviation  $\sigma$ . It is known that  $P(Y < 60000) = 0.6$  and  $P(Y > 50000) = 0.9$ . Find the values of  $\mu$  and  $\sigma$ .

[5]

v. Sketch the distributions of lifetimes for both types of cooling fan on a single diagram.

[4]

5. Each day, for many years, the maximum temperature in degrees Celsius at a particular location is recorded. The maximum temperatures for days in October can be modelled by a Normal distribution; the appropriate Normal curve is shown in Fig. 6.

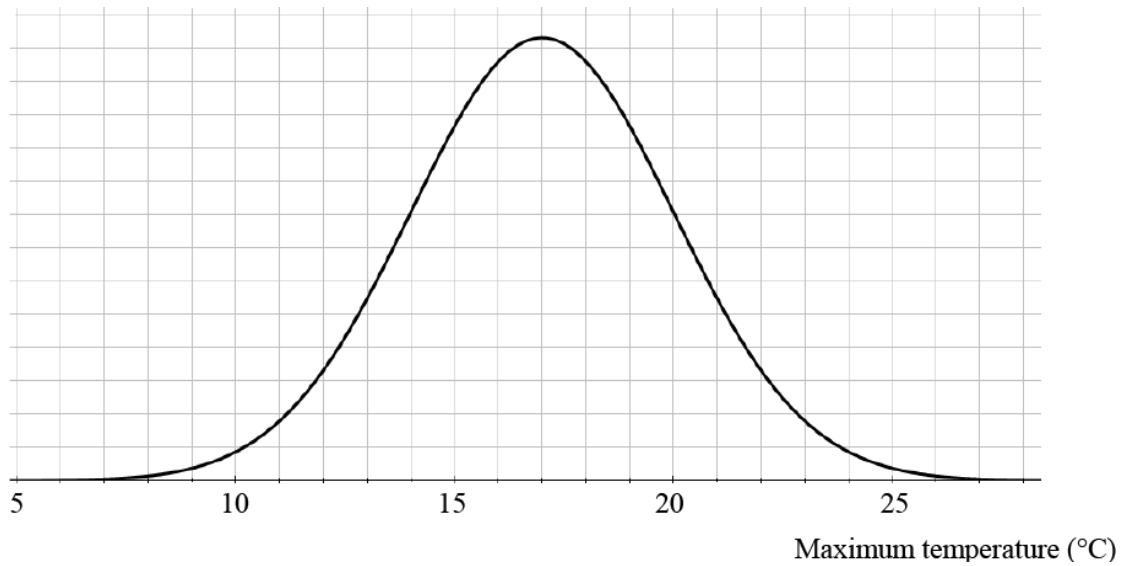


Fig. 6

(a)(i) Use the model to write down the mean of the maximum temperatures.

(ii) Explain why the curve indicates that the standard deviation is approximately 3 degrees Celsius.

[2]

Temperatures can be converted from Celsius to Fahrenheit using the formula  $F = 1.8C + 32$ , where  $F$  is the temperature in degrees Fahrenheit and  $C$  is the temperature in degrees Celsius.

(b) For maximum temperature in October in degrees Fahrenheit, estimate

- the mean,
- the standard deviation.

[2]

6. The response time to a roadside callout from a breakdown recovery firm may be modelled by a Normal distribution. Over a long period it has been noted that 8% of the response times are less than 58 minutes and 19% of the response times are greater than 86 minutes. Determine estimates of the mean and standard deviation of the response time. [7]

- (b) The recovery firm claim that 95% of their response times are less than 90 minutes. Investigate this claim. [2]

7. The screenshot in Fig. 10 shows the probability distribution for the continuous random variable  $X$ , where  $X \sim N(\mu, \sigma^2)$ .

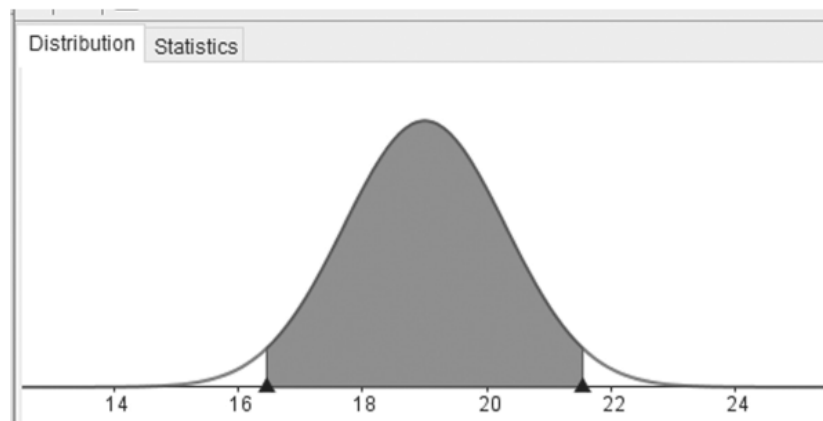


Fig. 10

The area of each of the unshaded regions under the curve is 0.025. The lower boundary of the shaded region is at 16.452 and the upper boundary of the shaded region is at 21.548.

- (a) Calculate the value of  $\mu$ . [1]
- (b) Calculate the value of  $\sigma^2$ . [3]
- (c)  $Y$  is the random variable given by  $Y = 4X + 5$ .
- (i) Write down the distribution of  $Y$ . [3]
- (ii) Find  $P(Y > 90)$ . [1]

8. Two siblings, Layla and Wilson, have identical smart phones with an app called “Screen Time” which provides the user with statistics concerning the amount of time spent using the screen per day. The statistics for several months of use for Layla’s phone are shown in Fig. 8. Time is measured in minutes.

Number of days	120
Shortest time	12.2
Lower Quartile	46.4
Median	56.1
Upper Quartile	66.1
Mean	56.2
Standard deviation	14.5
Longest time	99.8

Fig. 8

Layla believes that  $X$ , the amount of screen time she uses per day on her smart phone, may be modelled by the Normal distribution.

- (a) **Without** doing any calculation, state one feature of the data in Fig. 8 which suggests that Layla may be correct. [1]

- (b) Verify that the values for the quartiles are consistent with the model

$$X \sim N(56.2, 14.5^2). \quad [2]$$

- (c) Calculate  $P(X > 90)$ . [1]

Layla believes that  $Y$ , the amount of screen time used per day by Wilson on his smart phone, may be modelled by  $Y = 2X$ .

- (d) Use this model to calculate  $P(Y > 90)$ . [2]

Each night Layla and Wilson leave their phones on the kitchen table before going to bed. On one occasion their father picked up one of the phones and said:

“This phone has been used for more than an hour and a half today. There is a 99% chance that this is Wilson’s phone.”

- (e) Use Layla’s models for the distributions of  $X$  and  $Y$  to determine whether Layla and Wilson’s father’s statement is correct. [2]

END OF QUESTION paper

# Mark scheme

Question	Answer/Indicative content	Marks	Part marks and guidance
1	<p>i <math>P(X &lt; 450) = P\left(Z &lt; \frac{450 - 435}{30}\right)</math></p> <p>i <math>= P(Z &lt; 0.5) = \Phi(0.5)</math></p> <p>i <math>= 0.6915</math></p> <p><math>P(400 &lt; X &lt; 450)</math></p> <p>i <math>= P\left(\frac{400 - 435}{30} &lt; Z &lt; \frac{450 - 435}{30}\right)</math></p> <p><math>= P(-1.1667 &lt; X &lt; 0.5)</math></p> <p><math>= \Phi(0.5) - \Phi(-1.1667)</math></p> <p>i <math>= 0.6915 - 0.1216</math></p> <p>i <math>= 0.5699</math></p>	<p>M1</p> <p>M1</p> <p>A1</p> <p>M1</p> <p>B1</p> <p>A1</p>	<p>For standardising. M0 if 'continuity correction' applied</p> <p>For correct structure</p> <p>CAO Allow 0.692</p> <p><b>Examiner's Comments</b></p> <p>Well answered, though inappropriate "continuity corrections" were seen on occasion.</p> <p>For correct structure</p> <p>For use of difference column to obtain 0.8784, 0.8783, 0.1216 or 0.1217. Condone 0.8782 or 0.1218</p> <p>FT "their 0.6915" - 0.1216 (or 0.1217)</p> <p><b>Examiner's Comments</b></p> <p>Well answered, though arithmetic errors were quite common. In several cases, -1.667 was used rather than -1.1667 often as a result of candidates misreading their own figures. A few candidates lost accuracy by prematurely rounding their z-value before using the Normal tables.</p>



	<p>ii P(all 5 between 400 and 450)</p> <p>ii = 0.5699<sup>5</sup></p> <p>ii = 0.0601</p>	<p>M1</p> <p>A1</p>	<p>FT Allow 0.060</p> <p><b>Examiner's Comments</b></p> <p>Very well answered. Most candidates scored both marks.</p>	
	<p>P(Y &lt; 350) = 0.2, P(Y &gt; 390) = 0.1</p> <p>ii <math>P\left(Z &lt; \frac{350 - \mu}{\sigma}\right) = 0.2</math></p> <p>i</p> <p><math>\Phi^{-1}(0.2) = -0.8416</math></p> <p><math>\frac{350 - \mu}{\sigma} = -0.8416</math></p> <p>ii</p> <p>i <math>P\left(Z &gt; \frac{390 - \mu}{\sigma}\right) = 0.1</math></p> <p>ii</p> <p>i <math>\Phi^{-1}(0.9) = 1.282</math></p> <p><math>\frac{390 - \mu}{\sigma} = 1.282</math></p> <p>ii</p> <p>i <math>350 = \mu - 0.8416 \sigma</math></p> <p><math>390 = \mu + 1.282 \sigma</math></p> <p><math>2.1236 \sigma = 40</math></p> <p>ii</p> <p>i <math>\sigma = 18.84</math></p> <p>ii</p> <p>i <math>\mu = 350 + (0.8416 \times 18.84) = 365.85</math></p>	<p>M1</p> <p>B1</p> <p>M1</p> <p>A1</p> <p>A1</p>	<p>For equation as seen or equivalent with their -ive z value</p> <p>For 1.282 or -0.8416</p> <p>For equation as seen or equivalent with their +ive z value</p> <p>Allow 18.8</p> <p>Allow 365.86, 366, 365.9</p> <p><b>Examiner's Comments</b></p>	<p>If 'continuity corrections' applied allow M marks but do not award final A marks</p> <p>Answers to max 2 d.p.</p>

				On the whole, this was well answered. Many candidates provided clear, accurate methods leading to correct final answers. Some candidates started out with one of the required equations containing a sign error which was not picked up, even when the error led to a negative value for $\sigma$ . Most candidates identified the correct $z$ -values. In the poorest answers, continuity corrections were attempted and $z$ -values were changed to absurd values, such as “1 – 0.8416”, before substitution into equations. Over-specification of final answers was seen, on occasion, here.	
	i v	$\Phi^{-1}(0.975) = 1.96$	B1	For using a suitable pair of $z$ values e.g. $\pm 1.96$	Accept any correct values of $a$ and $b$ .
	i v	$a = 365.85 - (1.96 \times 18.84)$	M1	For either equation provided that a suitable pair of $z$ -values is used. e.g. +2.326 and –1.751  FT their $\mu$ and $\sigma$ to 2 d.p. (A0 if ‘continuity correction’ used)	
	i v	$= 328.9$	A1	<b>Examiner's Comments</b>  Though one of the more challenging parts, many candidates scored full marks here. A variety of correct, “non-symmetrical” solutions were seen though most opted to use $z$ -values of $\pm 1.96$ .	
	i v	$b = 365.85 + (1.96 \times 18.84)$ $= 402.8$	A1	FT their $\mu$ and $\sigma$ to 2 d.p. (A0 if ‘continuity correction’ used)	
		<b>Total</b>	<b>17</b>		
2	i	$P(X > 135) = P\left(Z > \frac{135 - 130.5}{\sqrt{11.84}}\right)$	M1	For standardising. Penalise use of “continuity corrections”	
	i	$= P(Z > 1.308) = 1 - \Phi(1.308) = 1 - 0.9045$	M1	For correct structure i.e. finding the area to the right of their $z$	
	i	$= 0.0955$ (3s.f.)	A1	CAO inc use of diff tables Allow 0.0954 and 0.0956	

				<p>If numerator reversed, give BOD only if <math>P(Z &lt; -1.308)</math> is used</p> <p><b>Examiner's Comments</b></p> <p>Was found to be easy, though some candidates confused the exact and approximate values in calculating the relative error, thereby losing a mark.</p>	
	ii	<p>From tables <math>\Phi^{-1}(0.99) = 2.326</math></p> $\frac{k - 130.5}{\sqrt{11.84}} = 2.326 \text{ oe}$ <p>ii</p> $k = 130.5 + (2.326 \times \sqrt{11.84}) = 138.50$	<p>B1</p> <p><math>\pm 2.326</math> or (better) seen, not <math>\pm 2.33</math></p> <p>For sensible equation in <math>k</math> with their <b>z value</b>.</p> <p>Note that use of <math>z = 0.8389</math> from <math>\Phi(0.99)</math> gets BOM0A0, as 0.8389 is clearly a <b>probability</b>.</p> <p>M1</p> <p>Allow use of <math>-2.326</math> (or their negative <math>z</math>) with numerator reversed.</p> <p>Condone use of <math>\sigma = 11.84</math> if also used in part (i).</p> <p>Condone use of "<math>k \pm 0.5</math>" for <math>k</math> in equation.</p> <p>0/3 for trial and improvement</p> <p>CAO</p> <p>Allow 138.504. Accept 138.5</p> <p>Do not accept final answers of 139 or 138.</p> <p>A1</p> <p><b>Examiner's Comments</b></p> <p>Was found hard. Very few candidates spotted that squaring and cubing gave double and triple the relative errors.</p>		
	ii i	$P(\text{Wing length} = 131) = P\left(\frac{130.5 - 130.5}{\sqrt{11.84}} \leq Z \leq \frac{131.5 - 130.5}{\sqrt{11.84}}\right)$ <p>= <math>P(0 &lt; Z &lt; 0.2906)</math></p> <p>ii</p> <p>= <math>\Phi(0.2906) - \Phi(0)</math></p> <p>i</p> <p>= <math>0.6143 - 0.5</math></p> <p>ii</p> <p>= <math>0.1143</math></p> <p>i</p>	<p>B1</p> <p>For both limits correct, soi.</p> <p>e.g. use of 0.5 in probability calculation implies correct lower limit.</p> <p>M1</p> <p>For <b>correct structure</b> using their standardised values. i.e. <b>Finding the area between their z values found using <math>\mu = 130.5</math></b></p> <p>Condone use of <math>\sigma = 11.84</math> if also used in part (i) or part (ii).</p> <p>CAO inc use of diff tables</p> <p>A1</p> <p>Allow 0.1145</p> <p>Allow 0.114 www</p>		

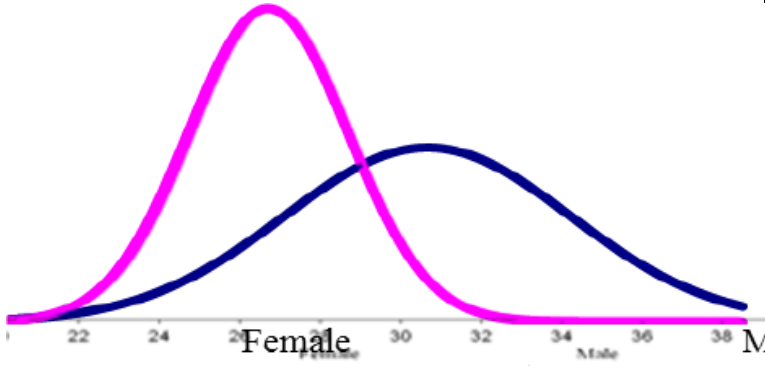
	<p>i H<sub>0</sub>: μ = 130.5 v H<sub>1</sub>: μ &gt; 130.5</p> <p>i Where μ denotes the <b>mean wing length</b> (in the population) (of Scandinavian male v blackbirds).</p> <p>i <b>Test statistic</b> = <math>\frac{132.4 - 130.5}{\sqrt{11.84} / \sqrt{20}} = \frac{1.90}{0.7694}</math> v</p> <p>i = 2.469 v</p> <p>i Upper 5% level 1 tailed critical value of z = 1.645 v</p> <p>i 2.469 &gt; 1.645 v</p> <p>i The result is significant. There is sufficient evidence to reject H<sub>0</sub> v</p> <p>i There is sufficient evidence to <b>suggest</b> that the mean wing length (of this population of v birds) is greater (than 130.5 mm).</p>		<p>B1</p> <p>B1</p> <p>M1*</p> <p>A1</p> <p>B1</p> <p>M1dep*</p> <p>A1</p> <p>A1</p>	<p>For both correct</p> <p>Hypotheses in words must refer to population. Do not allow other symbols unless clearly defined as population mean</p> <p>For definition of μ in context. Do not allow “sample mean wing length” or “mean wing length of English blackbirds”</p> <p>must include <math>\sqrt{20}</math></p> <p>Condone use of σ = 11.84 if also used in part (i), part (ii) or part (iii). Condone numerator reversed for max M1*A0B1M0depA0A0 (max 4/8)</p> <p>Allow 2.47</p> <p>For 1.645. Must be positive. B0 if -1.645 seen. No further A marks from here if wrong.</p> <p>For sensible comparison leading to a conclusion.</p> <p>For correct conclusion. e.g. for “significant” oe FT only candidate’s test statistic if cv = 1.645</p> <p>For <b>non-assertive</b> conclusion in context, consistent with their result Condone use of “average” for “mean” FT only candidate’s test statistic if cv = 1.645</p>	
	<p>v</p> <p>v</p>	<p>With a 10% significance level rather than a 5% significance level, Advantage: One is less likely to accept the null hypothesis when it is false.</p> <p>Disadvantage: One is more likely to reject the null hypothesis when it is true.</p>	<p>E1</p> <p>E1</p>	<p>Accept equivalent wording.</p> <p>Note — Unless stated otherwise, assume the first comment relates to an advantage and the second comment relates to a disadvantage.</p>	
		<p><b>Total</b></p>	<p><b>19</b></p>		

3	i	<p>(A) <math>P(X &lt; 30)</math></p> $= P\left(Z < \frac{30 - 30.7}{3.5}\right)$ <p>i <math>P(Z &lt; -0.20)</math></p> <p>i <math>= \Phi(-0.20)</math></p> <p>i <math>= 1 - \Phi(0.20)</math></p> <p>i <math>= (1 - 0.5793)</math></p> <p>i <math>= 0.4207</math></p> <p>i (B) <math>P(25 &lt; X &lt; 35)</math></p> $= P\left(\frac{25 - 30.7}{3.5} < Z < \frac{35 - 30.7}{3.5}\right)$ <p>i <math>= P(-1.629 &lt; Z &lt; 1.229)</math></p> <p>i <math>= \Phi(1.229) - \Phi(-1.629)</math></p> <p>i <math>= 0.8904 - (1 - 0.9483) = 0.8904 - 0.0517</math></p> <p>i <math>= 0.8387</math></p>	M1	For standardising	
			M1	For correct structure	$1 - \Phi(\text{positive } z)$
				CAO	
			A1	<u>Examiner's Comments</u> The majority of candidates correctly standardised the given value then found the correct probability. Some candidates made good use of diagrams to indicate their intent.	Allow 0.421 www
			M1	Correctly standardising both.	Penalise erroneous continuity corrections and wrong sd. Condone both numerators reversed.
			M1	For correct structure	$\Phi(1.23) - \Phi(-1.63)$ leads to $0.8907 - 0.0516 = 0.8391$
				Use of differences column required	
			A1	<u>Examiner's Comments</u> For a question that had potential for many errors, either in standardising, approximating too early, or looking up values incorrectly, this question	Only allow 0.839 if 0.8387 is seen.

				was answered well. This part was in general done rather better than part (iA).	
	ii	P(all 5 weigh at least 30kg)			
	ii	= 0.5793 <sup>5</sup>	M1	Allow FT (1 – their (i)(A)) <sup>5</sup> or [their P(X ≥ 30)] <sup>5</sup>  FT only (1 – their (i)(A)) <sup>5</sup>	
	ii	= 0.0652	A1	<b>Examiner's Comments</b>  The binomial situation, within a question fundamentally on the Normal distribution, was dealt with well by many candidates. The errors that did occur were often about forgetting that (iA) found p(X < 30) whereas this part asked for all five dogs to weigh <i>more than</i> 30 kg.	Allow 0.06524, allow 0.065 www
		P(weight > 30) = 0.05			
	ii	$P\left(Z > \frac{30 - 26.8}{\sigma}\right) = 0.05$			
	ii	$\Phi^{-1}(0.95) = 1.645$	B1	For 1.645. B0 for 1 - 1.645 or 0.1645	NOTE use of -1.645 allowed only if numerator
	ii	$\frac{30 - 26.8}{\sigma} = 1.645$	M1*	For equation as seen or equivalent, with their z > 1.	reversed. Condone use of spurious c.c. if already penalised in parts (i)(A) or (i)(B). See additional guidance notes. Allow $\sigma = 1.95$ www
	ii	$\sigma = \frac{30 - 26.8}{1.645} = 1.945 \text{ kg}$	M1dep*	Rearranging for $\sigma$	
	ii		A1	CAO <b>Examiner's Comments</b>  Few candidates used the wrong tail for this calculation, most correctly	<b>Additional Notes for (iii)</b>  M1* is for forming a suitable equation using their z-value but it must be reasonably clear that the value used is a z-value – for example

identifying that +1.645 was the appropriate value to use as 5% weighed *more than* 30 kg.

we do not allow 0.05 or 0.95 to be treated as z-values here. The M1dep\* can be awarded if the candidate correctly rearranges their equation to find  $\sigma$ . Hence, use of an incorrect z-value could earn max B0M1\*M1dep\*A0. However, if it is clear that the z-value is from the wrong tail (e.g. -1.645 used in place of +1.645) then award 0/4. In cases where -1.645 is used and the numerator of the equation is reversed allow full credit and annotate with BOD.



G1

For two Normal shapes including attempt at asymptotic behaviour with horizontal axis at each of the four ends

Penalise clear asymmetry

G1

For means, shown explicitly or by scale **on a single diagram**

If shown explicitly, the positions must be consistent with horizontal scale if present.

G1

For lower max height for Male

If not labelled, assume the larger mean represents Male

For visibly greater width for Male

Examiner's Comments

G1

This part of the question tested most candidates. Thus many found dealing with the correct shape and the various relative constraints on the curves difficult. The mark scheme will help with interpretation of the requirements.

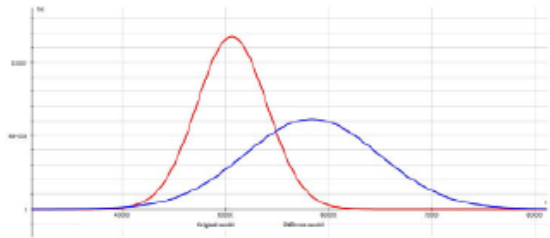
If not labelled, assume the larger mean represents Male

		Total	16		
4	i	$P(50000 < X < 55000) =$ $P\left(Z \geq \frac{750-751.4}{2.5}\right) \left(\frac{50000-50600}{3400} < Z < \frac{55000-50600}{3400}\right)$	M1	For standardising both. SOI. Penalise erroneous continuity corrections and wrong sd. Condone numerator(s) reversed.	
	i	$= P(-0.176 < Z < 1.294) = \Phi(1.294) - (1 - \Phi(0.176)) = 0.9022 - 1 + 0.5699$	M1	For correct structure $\Phi(\text{positive } z) - \Phi(\text{negative } z)$  CAO including use of difference tables (Answer from calculator 0.4722 and from tables interpolated 0.4723)	
	i	$= 0.4721$	A1	<b>Examiner's Comments</b>  Well answered. Errors caused by lack of accuracy reading Normal tables were seen fairly regularly. Most candidates used the correct probability structure with their z values.	
	ii	$P(X > 45000) = P\left(Z \geq \frac{750-751.4}{2.5}\right)$ $\left(Z > \frac{45000-50600}{3400}\right) = P(Z > -1.647)$	B1*	For -1.647 or $-\Phi^{-1}(0.95) = -1.645$ or 1.647 seen with $P(X < 56200)$ or numerator reversed	
	ii	$= \Phi(1.647) = 0.9502$	B1*	For 0.9502 or 45007 or 0.0498, or B1 for -1.645 if B1 for -1.647 already awarded.  <b>For comparison seen</b> e.g. $-1.647 < -1.645$ or $0.0498 < 0.05$ or $1.647 > 1.645$ or 95% last longer than 45007 hours, <b>and correct conclusion.</b> Dependent on B1, B1 awarded	
	ii	$0.9502 > 95\%$ so agree with claim	depE1*	<b>Examiner's Comments</b>  This was well done on the whole though many candidates did not provide the required comparison to justify their conclusion. In most cases the working provided was clear – diagrams were helpful to	



examiners in conveying the candidates' intentions – often more successfully than their wording.

<p>ii i</p> <p>ii i</p> <p>ii i</p>	<p>From tables <math>\Phi^{-1}(0.999) = 3.09</math></p> $\frac{h - 50600}{3400} = -3.09$ <p><math>k = 50600 - (3.09 \times 3400) = 40100</math> www</p>	<p>B1</p> <p>M1</p> <p>A1</p>	<p><math>\pm 3.09</math> seen</p> <p>For equation as seen with their negative z-value</p> <p>CAO Allow 40094, 40090</p> <p><b>Examiner's Comments</b></p> <p>Many correctly identified the z value of <math>-3.09</math> and went on to find the appropriate value for <math>h</math>, rounded to a suitable level of accuracy.</p>	
<p>i v</p> <p>i v</p> <p>i v</p> <p>i v</p> <p>i v</p> <p>i v</p> <p>i v</p>	$P(Y < 60000) = 0.6 \Rightarrow P\left(Z < \frac{60000 - \mu}{\sigma}\right) = 0.6$ $\Rightarrow \frac{60000 - \mu}{\sigma} = \Phi^{-1}(0.6) = 0.2533$ $\Rightarrow 60000 = \mu + 0.2533\sigma$ $P(Y > 50000) = 0.9 \Rightarrow P\left(Z > \frac{50000 - \mu}{\sigma}\right) = 0.9$ $\Rightarrow \frac{50000 - \mu}{\sigma} = \Phi^{-1}(0.1) = -1.282$ $\Rightarrow 50000 = \mu - 1.282\sigma$ $1.5353\sigma = 10000$	<p>B1</p> <p>M1</p> <p>A1</p>	<p>For <math>\pm 0.2533</math> or <math>\pm 1.282</math> seen</p> <p>For an equation in <math>\mu</math>, <math>\sigma</math>, <math>z</math> and <math>y</math> formed.</p> <p>NB using <math>z = \pm 0.2533</math> with <math>y = 60000</math> or <math>\pm 1.282</math> with <math>y = 50000</math></p> <p>For two correct equations seen.</p>	

<p>i v</p>	<p><math>\sigma = 6513</math></p> <p>i v</p> <p><math>\Rightarrow \mu = 50000 + (1.282 \times 6513) = 58350</math></p>	<p>A1</p>	<p>CAO Allow 6510, 6515</p> <p>CAO Allow 58400</p> <p><b>Examiner's Comments</b></p>	
<p>v</p> <p>v</p> <p>v</p> <p>v</p>		<p>G1</p> <p>G1</p> <p>G1</p> <p>G1</p>	<p>For two Normal shapes including attempt at asymptotic behaviour with horizontal axis at each of the four ends. Penalise clear asymmetry.</p> <p>For means, shown explicitly or by scale <b>on a single diagram</b>. If shown explicitly, the positions must be consistent with horizontal scale if present. FT part (iv).</p> <p>For greater width (variance) for Different model. FT part (iv).</p> <p>For lower max height for Different model. FT part (iv)</p> <p>If not labelled assume the larger mean represents Different model. FT part (iv).</p> <p><b>Examiner's Comments</b></p> <p>This was answered well, though many candidates could have made a greater effort to include symmetry in their sketches and to pay more attention to the asymptotic nature. Spurious labelling of axes was seen but only rarely.</p>	

		<b>Total</b>	<b>18</b>															
5	a	<table border="1"> <tr> <td>i</td> <td>Mean = 17</td> </tr> <tr> <td>ii</td> <td><b>Either</b></td> </tr> <tr> <td></td> <td>Points of inflection are approx. 3 above and below mean so SD = approx. 3</td> </tr> <tr> <td></td> <td><b>Or</b></td> </tr> <tr> <td></td> <td>Limits are approx. 9 above and below mean so SD = <math>9 \div 3 = 3</math></td> </tr> </table>	i	Mean = 17	ii	<b>Either</b>		Points of inflection are approx. 3 above and below mean so SD = approx. 3		<b>Or</b>		Limits are approx. 9 above and below mean so SD = $9 \div 3 = 3$	B1(AO3.4) E1(AO2.4) E1(AO2.4) [2]	<table border="1"> <tr> <td>AG</td> <td></td> </tr> <tr> <td>AG</td> <td></td> </tr> </table>	AG		AG	
i	Mean = 17																	
ii	<b>Either</b>																	
	Points of inflection are approx. 3 above and below mean so SD = approx. 3																	
	<b>Or</b>																	
	Limits are approx. 9 above and below mean so SD = $9 \div 3 = 3$																	
AG																		
AG																		
	b	Mean in Fahrenheit = $1.8 \times 17 + 32 = 62.6$ SD in Fahrenheit = $1.8 \times 3 = 5.4$	B1(AO1.1) B1(AO1.1) [2]	<table border="1"> <tr> <td>FT their mean</td> <td></td> </tr> </table>	FT their mean													
FT their mean																		
		<b>Total</b>	<b>4</b>															
6	a	$\Phi^{-1}(0.08) = -1.4051$ BC $\Phi^{-1}(0.81) = 0.8779$ BC $-1.4051 = \frac{58 - \mu}{\sigma}$ their $0.8779 = \frac{86 - \mu}{\sigma}$ their obtaining a value for $\mu$ or $\sigma$ from their equations	B1(AO1.1) B1(AO1.1) M1(AO2.1) M1(AO1.1) M1(AO2.5)	<table border="1"> <tr> <td></td> <td></td> </tr> </table>														

		$\sigma = 12.3$  $\mu = 75.2$	A1(AO 2.4) A1(AO 1.1)  [7]	<table border="1"> <tr> <td>allow 2 or 3 s.f.</td> <td> NB 12.2647368787 and 75.2328329886 </td> </tr> </table>	allow 2 or 3 s.f.	NB 12.2647368787 and 75.2328329886	
allow 2 or 3 s.f.	NB 12.2647368787 and 75.2328329886						
	b	$P(X < 90) = 0.849$ FT their $\mu$ and $\sigma$ BC  which is less than 0.95 so claim not justified	M1(AO 3.1a)  A1(AO 3.2a)  [2]	<table border="1"> <tr> <td> their <math>12.3 \times 1.645 +</math>  their <math>75.2 &gt; 90</math>   which is greater than  90 so claim not  justified </td> <td></td> </tr> </table>	their $12.3 \times 1.645 +$ their $75.2 > 90$  which is greater than 90 so claim not justified		
their $12.3 \times 1.645 +$ their $75.2 > 90$  which is greater than 90 so claim not justified							
		<b>Total</b>	9				
7	a	$[\mu =]19$	B1 (AO 1.1)  [1]	<table border="1"> <tr> <td></td> <td></td> </tr> </table> <p><b>Examiner's Comments</b></p> Candidates who did well in this question wrote down the mean by symmetry.			
	b	$1.96 = \frac{21.548 - 19}{\sigma}$ $[\sigma =]$ awrt 1.3	M1 (AO 3.1a)  A1	<table border="1"> <tr> <td> Or <math>-1.96 = \frac{16.452 - 19}{\sigma}</math> </td> <td> NB 1.959963985...ro unded to 3 or more sf </td> </tr> </table>	Or $-1.96 = \frac{16.452 - 19}{\sigma}$	NB 1.959963985...ro unded to 3 or more sf	
Or $-1.96 = \frac{16.452 - 19}{\sigma}$	NB 1.959963985...ro unded to 3 or more sf						

	<p>[<math>\sigma^2 =</math>] awrt 1.69</p>	<p>(AO 1.1)</p> <p>A1 (AO 1.1)</p> <p>[3]</p>	<table border="1"> <tr> <td data-bbox="1077 54 1375 384"> <p>may be implied by final answer</p> <p>allow <b>B3</b> for awrt 1.69 unsupported</p> </td> <td data-bbox="1375 54 1727 384"> <p><b>M0</b> if <math>z = 2</math></p> </td> </tr> </table> <p><u>Examiner's Comments</u></p> <p>Candidates who did well on this part made efficient use of the standard Normal variable to find the variance. Candidates who did less well confused the mean with the variance, or used a wrong value for <math>z</math> (usually 1.645) to find the variance.</p>	<p>may be implied by final answer</p> <p>allow <b>B3</b> for awrt 1.69 unsupported</p>	<p><b>M0</b> if <math>z = 2</math></p>							
<p>may be implied by final answer</p> <p>allow <b>B3</b> for awrt 1.69 unsupported</p>	<p><b>M0</b> if <math>z = 2</math></p>											
<p>c</p>	<table border="1"> <tr> <td data-bbox="203 727 300 895">(i)</td> <td data-bbox="300 727 972 895"> <p>[<math>\mu =</math>] <math>4 \times</math> <i>their</i> 19 + 5  [<math>\sigma^2 =</math>] <math>4^2 \times</math> <i>their</i> 1.69 or <math>\sigma = 4 \times</math> <i>their</i> 1.3  [<math>Y \sim</math>]N(81,5.2<sup>2</sup>) oe</p> </td> </tr> <tr> <td data-bbox="203 1254 300 1342">(ii)</td> <td data-bbox="300 1254 972 1342"> <p>0.04175 or 0.0417 or 0.042  BC</p> </td> </tr> </table>	(i)	<p>[<math>\mu =</math>] <math>4 \times</math> <i>their</i> 19 + 5  [<math>\sigma^2 =</math>] <math>4^2 \times</math> <i>their</i> 1.69 or <math>\sigma = 4 \times</math> <i>their</i> 1.3  [<math>Y \sim</math>]N(81,5.2<sup>2</sup>) oe</p>	(ii)	<p>0.04175 or 0.0417 or 0.042  BC</p>	<p>M1 (AO 2.1)</p> <p>M1 (AO 1.1)</p> <p>A1 (AO 1.1)</p> <p>[3]</p> <p>B1 (AO 1.1)</p> <p>[1]</p>	<table border="1"> <tr> <td data-bbox="1077 655 1406 1031"> <p>NB 27.04</p> </td> <td data-bbox="1406 655 1727 1031"></td> </tr> </table> <p><u>Examiner's Comments</u></p> <p>A common error in this part was to calculate <math>4 \times 1.69</math> or <math>16 \times 1.69 + 5</math> instead of <math>16 \times 1.69</math> .</p> <table border="1"> <tr> <td data-bbox="1077 1246 1128 1326"></td> <td data-bbox="1128 1246 1727 1326"> <p>NB 0.0417462427103</p> </td> </tr> </table> <p><u>Examiner's Comments</u></p>	<p>NB 27.04</p>			<p>NB 0.0417462427103</p>	
(i)	<p>[<math>\mu =</math>] <math>4 \times</math> <i>their</i> 19 + 5  [<math>\sigma^2 =</math>] <math>4^2 \times</math> <i>their</i> 1.69 or <math>\sigma = 4 \times</math> <i>their</i> 1.3  [<math>Y \sim</math>]N(81,5.2<sup>2</sup>) oe</p>											
(ii)	<p>0.04175 or 0.0417 or 0.042  BC</p>											
<p>NB 27.04</p>												
	<p>NB 0.0417462427103</p>											

					This part required efficient use of the calculator.						
			<b>Total</b>	<b>8</b>							
8	a	eg median $\approx$ mean eg extreme values and/or quartiles symmetrical about mean oe	B1 (AO 2.4) [1]								
	b	$P(X < 46.4) = 0.24956.. \approx 0.25$ $P(X < 66.1) = 0.75262.. \approx 0.75$ So both values are consistent	M1 (AO 3.3) A1 (AO 2.4) [2]	<table border="1"> <tr> <td>BC</td> <td>or <math>\text{invNorm}(0.25, 56.2, 14.5) = 46.4199... \approx 46.4</math></td> </tr> <tr> <td>Must follow from correct calc. values</td> <td><math>\text{invNorm}(0.75, 56.2, 14.5) = 65.98... \approx 66.1</math></td> </tr> </table>	BC	or $\text{invNorm}(0.25, 56.2, 14.5) = 46.4199... \approx 46.4$	Must follow from correct calc. values	$\text{invNorm}(0.75, 56.2, 14.5) = 65.98... \approx 66.1$			
BC	or $\text{invNorm}(0.25, 56.2, 14.5) = 46.4199... \approx 46.4$										
Must follow from correct calc. values	$\text{invNorm}(0.75, 56.2, 14.5) = 65.98... \approx 66.1$										
	c	0.00987574855 ...	B1 (AO 1.1) [2]	<table border="1"> <tr> <td>BC to 3 or more sf</td> <td></td> </tr> </table>	BC to 3 or more sf						
BC to 3 or more sf											
	d	Use of $N(112.4, 29^2)$ soi 0.780065376569...	M1 (AO 3.1a) A1(AO 1.1) [2]	<table border="1"> <tr> <td>BC</td> <td></td> </tr> <tr> <td>to 3 or more sf</td> <td></td> </tr> </table>	BC		to 3 or more sf				
BC											
to 3 or more sf											
	e	<table border="1"> <tr> <td>their</td> <td><math>\frac{0.78006..}{0.00987... + 0.78006...}</math></td> </tr> </table> <p>0.98750...so approximately a 99% chance the phone is Wilsons so their father's statement is justifiable</p>	their	$\frac{0.78006..}{0.00987... + 0.78006...}$	M1 (AO 2.1) A1(AO 2.2b)	<table border="1"> <tr> <td>their</td> <td><math>\frac{0.00987..}{0.00987... + 0.78006...}</math></td> </tr> <tr> <td>0.0125...so approximately a 1%</td> <td></td> </tr> </table>	their	$\frac{0.00987..}{0.00987... + 0.78006...}$	0.0125...so approximately a 1%		
their	$\frac{0.78006..}{0.00987... + 0.78006...}$										
their	$\frac{0.00987..}{0.00987... + 0.78006...}$										
0.0125...so approximately a 1%											

					chance the phone is Chidera's so their father's statement is justifiable	
				[2]		
			Total	8		