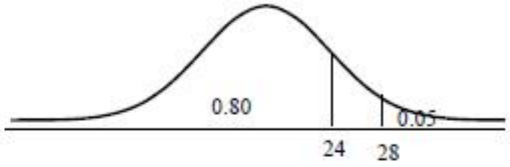
Mark Scheme

Q1.

Question Number	Scheme	Marks
(a)	The random variable $H \sim$ height of females	
	$P(H>170) = P\left(Z > \frac{170-160}{8}\right)$ $[= P(Z>1.25)]$	M1
	$= 1-0.8944$	M1
	$= 0.1056$ (calc 0.1056498…) **awrt 0.106** (accept 10.6%)	A1 **(3)**
(b)	$P(H>180) = P\left(Z > \frac{180-160}{8}\right)$ $[= 1-0.9938]$	M1
	$= 0.0062$ (calc 0.006209…) awrt 0.0062 or $\frac{31}{5000}$	A1
	$[P(H>180 \mid H>170)] = \frac{0.0062}{0.1056}$	M1
	$= 0.0587$ (calc 0.0587760…) **awrt 0.0587 or 0.0588**	A1 **(4)**
(c)	$P(H>h \mid H>170)\ (=0.5)$ or $\frac{P(H>h)}{P(H>170)}\ (=0.5)$	M1
	$[P(H>h)] = 0.5\times"0.1056" = 0.0528$ (calc 0.0528249…) or $[P(H<h)] = 0.9472$	A1ft
	$\frac{h-160}{8} = 1.62$ (calc 1.6180592…)	M1 B1
	$h =$ awrt 173 cm **awrt 173**	A1 **(5)**
		Total 12

	Notes
(a)	1st M1 for attempt at standardising with 170, 160 and 8. Allow ± i.e. for $\pm\frac{170-160}{8}$
	2nd M1 for attempting $1-p$ where $0.8<p<1$. Correct answer only 3/3
(b)	1st M1 for standardising with 180, 160 and 8
	1st A1 for 0.0062 seen, maybe seen as part of another expression/calculation.
	2nd M1 using conditional probability with denom = their (a) and num < their denom. Values needed.
	2nd A1 for awrt 0.0587 or 0.0588. Condone 5.87% or 5.88% or $\frac{31}{528}$
	Correct answer only 4/4
(c)	1st M1 for a correct conditional probability statement. Either line and don't insist on 0.5, ft (a)
	1st A1ft for $[P(H>h)] = 0.5\times$ their(a)
	Award M1A1ft for correct evaluation of $0.5\times$ their(a) or sight of 0.0528 or better
	2nd M1 for attempt to standardise (±) with 160 and 8 and set equal to $\pm z$ value $(1.56<\lvert z\rvert<1.68)$
	B1 for ($z=$) awrt ± 1.62 (seen)
	2nd A1 for awrt 173 but dependent on both M marks.

Q2.

Question Number	Scheme	Marks
(a)	 24 and 28 (above the mean) For 0.80 and 0.05 (clearly indicated)	B1 B1 (2)
(b)	15%	B1 (1)
(c)(i)	$\frac{(28-\mu)}{\sigma}=1.64(49)$ or $\frac{(24-\mu)}{\sigma}=0.84(16)$ 0.8416 and 1.6449 seen $\mu=28-1.64(49)\sigma$, $\mu=24-0.84(16)\sigma$	M1 B1 A1,A1
(ii)	$24-0.8416\sigma=28-1.6449\sigma$ eliminating μ or σ $\sigma=4.9794597...$ **awrt** 4.98 $\mu=19.809286...$ **awrt** 19.8	M1 A1 A1 (7)
(d)	$z=\frac{(12-'19.8...')}{'4.97...'}$ $P(Z<-1.57)=1-P(Z<1.57)$ $1-0.9418=0.0582$ **awrt** 0.06	M1 dM1 A1 (3) **[Total 13]**

	Notes
(a)	1st B1 24 and 28 labelled on the horizontal axis above the mean in the correct order. They must clearly indicate where 24 and 28 are on the horizontal axis.
(b)	2nd B1 for clear, correct labelling of probabilities. Must be associated with correct area.
(c)	B1 for 15% or 0.15 NB 0.15% is B0
	1st M1 for $\frac{\pm(28-\mu)}{\sigma}=z_1$ or $\frac{\pm(24-\mu)}{\sigma}=z_2$ where $\lvert z_1\rvert>1.5$ and $\lvert z_2\rvert<1$ Condone $z_2=0.8$
	B1 for both values 0.8416 and 1.6449 or better seen. Calc: 0.8416212.., 1.644853..
	1st A1 for $\mu=28-1.64(49)\sigma$ or any correct arrangement (allow 1.64 ~1.65 inclusive)
	2nd A1 for $\mu=24-0.84(16)\sigma$ or any correct arrangement (allow 0.84 or better)
	2nd M1 for an attempt to solve simultaneous equations by eliminating μ or σ
	3rd A1 for **awrt** 4.98 (Condone $\sigma=5$ or awrt 5.0 if B0 scored)
	4th A1 for **awrt** 19.8
SC	For use of 0.84 and 1.64 giving $\sigma=5$ and $\mu=$ awrt 19.8 score M1B0A1A1M1A1A1
	or 0.84 and 1.65 giving $\sigma=$ awrt 4.94 and $\mu=$ awrt 19.9 score M1B0A1A1M1A1A1
(d)	1st M1 for standardising with 12, their μ and σ provided $\sigma>0$ If $\sigma<0$ from their equations in (c) allow M1 if they use $\lvert\sigma\rvert$
	2nd dM1 for $1-P(Z<'1.57')$ dependent on the 1st M1 being scored i.e. leads to prob < 0.5
	A1 for awrt 0.06 from correct working

Q3.

Question	Scheme	Marks
(a)(i)	$P(A) = P(Z > 1.1) = 1 - 0.8643 = \underline{0.1357}$ (accept awrt 0.136)	B1
(ii)	$P(B) = P(Z > -1.9) = \underline{0.9713}$ (accept awrt 0.971)	B1
(iii)	$P(C) = [P(-1.5 < Z < 1.5)] = 0.9332 - (1 - 0.9332)$ or $(0.9332 - 0.5) \times 2$ $= \underline{0.8664}$ (accept awrt 0.866)	M1 A1
(iv)	$P(A \cup C) = P(Z > -1.5)$ or $P(Z < 1.5)$ or $= P(A) + P(C) - P(A \cap C) = "0.1357" + "0.8664" - (0.9332 - 0.8643)$ $= \underline{0.9332}$ (accept awrt 0.933)	M1 A1 (6)
(b)	$[P(X > w \mid X > 28) =] \dfrac{P(X > w)}{P(X > 28)} = [0.625]$	M1
	$P(X > 28) = P\left(Z > \dfrac{28-21}{5}\right) = P(Z > 1.4) = [0.0808$ calc: 0.80756..$]$	M1
	$P(X > w) = 0.0808 \times 0.625$ (= 0.0505) or ($P(X < w) = 0.9495$)	A1
	$\dfrac{w-21}{5} = 1.64$	M1 B1
	$w =$ awrt $\underline{29.2}$	A1 (6) (12 marks)

	Notes
	Mark final answer here so in (ii) 0.9713 followed by 1 – 0.9713 is B0 but for rounding errors e.g. 29.245 followed by 29.3 apply ISW and award for 29.245
(a)(iii)	M1 for correct expression with probability values . Correct ans implies M1A1
(iv)	M1 for a correct addition formula with some correct substitution (or correct ft) or $P(Z > -1.5)$ (o.e) or for a fully correct expression with correct probabilities A1 for 0.9332 (accept 0.933) Correct answer only is M1A1
(b)	M1 for correct expression for conditional probability- must have $P(X > w)$ as num' May be implied by $P(X > w) = 0.625 \times$ (any probability) M1 for standardising 28 with 21 and 5 Allow $\pm$ (May be implied by 0.0808 [or awrt 0.081] seen in correct position) A1 for $P(X > w) = 0.0808 \times 0.625$ or $P(X > w) = 0.0505$ or $P(X < w) = 0.9495$) This A1 depends on both Ms but seeing $P(X > w) = 0.0808 \times 0.625$ scores M1M1A1
1st 3 marks	Allow $P\left(Z > \dfrac{w-21}{5}\right)$ instead of $P(X > w)$ for these first 3 marks
	M1 for standardising w with 21 and 5 (allow $\pm$) and setting equal to a z-value $\lvert z \rvert > 1$ Allow any letter instead of w B1 for 1.64 (or better) used correctly. [Calculator gives: 1.6402851...] A1 allow awrt 29.2

Q4.

Question Number	Scheme	Marks
(a)	$\frac{127-100}{15}$	M1
	So $P(L > 127) = P(Z > 1.8)$ or $1-P(Z < 1.8)$ o.e.	A1
	$= 1 - 0.9641 = \underline{0.0359}$ (awrt $\underline{0.0359}$)	A1
		(3)
(b)	$\frac{d-100}{15} = -1.2816$ (Calculator gives $-1.2815515\ldots$)	M1, B1
	$d = 80.776$ (awrt $\underline{80.8}$)	A1
		(3)
(c)	Require $P(L > 133 \mid L > 127)$	M1
	$= \left[\frac{P(L>133)}{P(L>127)}\right] = \frac{P(Z>2.2)}{P(L>127)}$	dM1
	$= \left[\frac{1-0.9861}{1-0.9641}\right] = \frac{0.0139}{[0.0359]}$	A1
	$= 0.3871\ldots$ $=$ awrt $\underline{0.39}$	A1
		(4)
S.C.	An attempt at $P(L < 133 \mid L > 127)$ that leads to awrt 0.61 (M0M1A0A0)	
		10

	Notes
(a)	M1 for attempting to standardise with 127, 100 and 15 . Allow $\pm$
	1st A1 for $Z > 1.8$. Allow a diagram but must have 1.8 and correct area indicated. Must have the Z so $P(L > 127)$ with or without a diagram is insufficient. May be implied by 0.0359
	2nd A1 for awrt 0.0359 (calc. gives 0.035930266…). Correct ans only 3/3. M1A0A1 not poss.
(b)	M1 for an attempt to standardise with 100 and 15 and set = $\pm$ any z value ($\lvert z\rvert > 1$)
	B1 for $z = \pm 1.2816$ (or better) seen anywhere [May be implied by 80.776(72…) or better seen]
	A1 for awrt 80.8 (can be scored for using 1.28 but then they get M1B0A1) The 80.8 must follow from correct working.
Calc	If answer is awrt 80.8 **and** awrt 80.777 or 80.776… or better seen then award M1B1A1
	If answer is awrt 80.8 or 80.77 then award M1B0A1 (unless of course $z = 1.2816$ is seen)
(c)	1st M1 for clear indication of correct conditional probability or attempt at correct ratio
	So clear attempt at $\frac{P(L>133)}{P(L>127)}$ is sufficient for the 1st M1
	2nd dM1 dependent on 1st M1 for $P(L > 133)$ leading to $P(Z > 2.2)$.
	1st A1 for 0.0139 or better seen coming from $P(Z > 2.20)$. Dependent on both Ms
	2nd A1 for awrt 0.39. Both Ms required
ALT	If they assume Alice did not check that the phone was working you may see: $[P(L < 127).0] + P(L > 127).\underline{P(L > 133 \mid L > 127)}$ Provided the conditional probability is seen as part of this calculation the 1st M1 can be scored and their final answer will be 0.0139(4/4)
	An answer of 0.0139 without sight of the conditional probability is 0/4.

Q5.

Question Number	Scheme	Marks
(a)	$(z = \pm)\dfrac{15-16.12}{1.6}(=-0.70)$	M1
	$P(Z < -0.70) = 1 - 0.7580$	M1
	$= \underline{0.2420}$ **(awrt 0.242)**	A1
		(3)
(b)	[$P(T < t) = 0.30$ implies] $z = \dfrac{t-16.12}{1.6} = -0.5244$	M1 A1
	$\dfrac{t-16.12}{1.6} = -0.5244 \Rightarrow t = 16.12 - 1.6 \times "0.5244"$	M1
	$t =$ awrt $\underline{15.28}$ (allow awrt 15.28/9)	A1
		(4)
		7

Notes

(a)

Allow slips e.g. 16.2 for 16.12 for 1st M1 in (a) and (b)

1st M1 for standardising expression with 15, 16.12 and 1.6 - allow $\pm$

2nd M1 for 1 - a probability (> 0.5) from tables or calculator based on their standardised value

Correct answer only scores 3/3

(b)

In part (b) they can use any letter or symbol instead of t

1st M1 for standardising with t (o.e.), 16.12 and 1.6, allow $\pm$, and setting equal to a z value

1st A1 for an equation with $z = \pm 0.5244$ or better

e.g. $\dfrac{t-16.12}{1.6} = \pm 0.52$ (or 0.525) scores M1 (but A0)

2nd M1 for solving their linear equation as far as $t = a \pm b \times 1.6$. Not dependent on 1st M1

e.g. solving $\dfrac{t-16.12}{1.6} = 0.3$ to give $t = 16.12 + 1.6 \times 0.3$ scores this M1

Allow $\dfrac{t-16.12}{1.6^2} = 0.3$ to give $t = 16.12 + 1.6^2 \times 0.3$ to score M1 too

2nd A1 dependent on both M marks. Allow awrt 15.28 or awrt 15.29

Condone awrt 15.3 if a correct expression for $t = ...$ is seen.

Answers with no working:

15.28 is M1A1M1A1, 15.29 is M1A0M1A1, 15.3 is M1A0M1A0

Q6.

Question Number	Scheme	Marks
(a)	$P(X>168)=P\left(Z>\frac{168-160}{5}\right)$	M1
	$=P(Z>1.6)$	A1
	$=0.0548$ **awrt 0.0548**	A1 (3)
(b)	$P(X<w)=P\left(Z<\frac{w-160}{5}\right)$	
	$\frac{w-160}{5}=-2.3263$	M1 B1
	$w=148.37$ **awrt 148**	A1 (3)
(c)	$\frac{160-\mu}{\sigma}=2.3263$	M1 B1
	$\frac{152-\mu}{\sigma}=-1.2816$	B1
	$160-\mu=2.3263\sigma$	
	$152-\mu=-1.2816\sigma$	
	$8=3.6079\sigma$	M1
	$\sigma=2.21\ldots$ **awrt 2.22**	A1
	$\mu=154.84\ldots$ **awrt 155**	A1 (6)
		[12]

Notes

(a)

M1 for an attempt to standardize 168 with 160 and 5 i.e. $\pm\left(\frac{168-160}{5}\right)$ or implied by 1.6

1st A1 for P(Z > 1.6) or P(Z < -1.6) ie z = 1.6 and a correct inequality or 1.6 on a shaded diagram

Correct answer to (a) implies all 3 marks

(b)

M1 for attempting $\pm\left(\frac{w-160}{5}\right)$ = recognizable z value ($|z|>1$)

B1 for $z=\pm 2.3263$ or better. Should be $z=\ldots$ or implied so: $1-2.3263=\frac{w-160}{5}$ is M0B0

A1 for awrt 148. This may be scored for other z values so M1B0A1 is possible

For awrt 148 only with no working seen award M1B0A1

(c)

M1 for attempting to standardize 160 or 152 with μ and σ (allow $\pm$) and equate to z value ($|z|>1$)

1st B1 for awrt $\pm$ 2.33 or $\pm$ 2.32 seen

2nd B1 for awrt $\pm$ 1.28 seen

2nd M1 for attempt to solve their two linear equations in μ and σ leading to equation in just one variable

1st A1 for σ = awrt 2.22 . Award when 1st seen

2nd A1 for μ = awrt 155. Correct answer only for part (c) can score all 6 marks.

NB σ = 2.21 commonly comes from z = 2.34 and usually scores M1B0B1M1A0A1

The A marks in (c) require both M marks to have been earned

Q7.

Question Number	Scheme	Marks
(a)	$[P(T>20)=]\ P\left(Z>\frac{20-18}{5}\right)$	M1
	$P(Z>0.4)=1-0.6554$	M1
	$=$ **0.3446** or awrt **0.345**	A1
		(3)
(b)	Require $P(T>20 \mid T>15)$ or $\frac{P(T>20)}{P(T>15)}$	M1
	$\frac{"(a)"}{P(Z>\frac{15-18}{5})}=\frac{"(a)"}{P(Z>-0.6)}$, $=\frac{"0.3446"}{0.7257}$ or $\frac{"0.345"}{0.726}$	M1, A1ft
	$=0.47485\ldots=$ awrt **0.475**	A1
		(4)
(c)	$P(T>d \mid T>15)=0.5$ or $P(T<d \mid T>15)=0.5$	M1
	$P(T>d)$ or $P(15<T<d)=0.5\times"0.7257"=[0.36285]$	A1ft
	$P(T<d)=$ "0.63715"	M1
	So $\frac{d-18}{5}=0.35$ (calculator gives 0.35085…)	A1
	$d=19.754\ldots=$ awrt **19.8**	A1cso
	(Accept 19 mins 45(secs) or 19:45 but 19.45 is A0)	(5)
		[12]

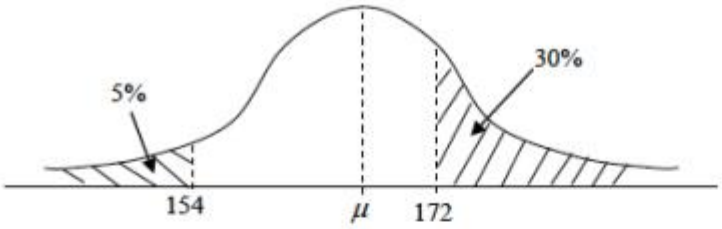
	Notes
(a)	1st M1 for standardising with 20, 18 and 5. Accept ±
	2nd M1 for attempting $1-p$ [where $0.5<p<0.7$]. Beware $1-0.4$ (or their z value) is M0
	A1 for awrt 0.345 (Correct ans only 3/3)
(b)	1st M1 for either correct conditional probability statement (allow "in words" or any letter except Z)
	1st M1 can be implied by 2nd M1 so a mark of M0M1 should not be given.
	2nd M1 for using their (a) on num. and attempting to standardise $P(T>15)$ (no ±)on denom.
	Num.>Deno. is M0
	Allow one digit transcription errors from (a) e.g. 0.3464 or 0.3466 etc for 2nd M1 and 1st A1ft
	1st A1ft for their 0.3446 on numerator and denominator of 0.7257 (or better: 0.7257469…)
	provided Num < Denom. Allow 0.726 on the denominator
	Sight of $\frac{"0.3446"}{0.7257 \text{ or } 0.726}$ will score M1M1A1ft
	2nd A1 for awrt 0.475
(c)	1st M1 for a correct conditional probability statement that includes the 0.5
	1st A1ft for $P(T>d)$ or $P(15<T<d)=0.5\times$ their $P(T>15)$ [provided $P(T>15)>0.5$]
	Follow through (3sf) their $P(T>15)=0.7257$ or better from part (b). (Allow 0.726)
	Sight of $0.5\times$their 0.7257 = "0.36285" or better scores 1st M1 and 1st A1ft (Allow 0.363)
	2nd M1 (dep on 1st M1) for $P(T<d)=1-$"0.36285" or "0.36285" $+1-$"0.7257"
	$=$ [0.6371~0.6372]
	Sight of their 0.63715 or better (calc: 0.637126…) scores first 3 marks (Allow 0.637)
	2nd A1 for $\frac{d-18}{5}=0.35$ (or better) (Calc could give 0.350788…)
	3rd A1cso for ($d=$) awrt 19.8 (accept 19.7 not awrt 19.7) **Must** come from correct work.
Beware!	$0.5\times0.7257=0.36285$ and using this (instead of 0.35) as z value leads to 19.8 but is A0A0

Q8.

Question Number	Scheme	Marks
(a)	[$T \sim N(240, 40^2)$…require $P(T > 300)$]	
	$P\left(Z > \frac{300-240}{40}\right)$	M1
	$= 1 - P(Z < 1.5)$ or $1 - 0.9332$	M1
	= awrt **0.0668** or 6.68%	A1
		(3)
(b)	$[P(T < n) = 0.20 \Rightarrow]$ $\frac{n-240}{40} = -0.8416$	M1 B1
	n = awrt **206** minutes	A1
		(3)
(c)	$[P(W < \mu - 30 \mid W < \mu) =]$ $\frac{P(W < \mu - 30)}{P(W < \mu)}$	M1
	$= \frac{1-0.82}{0.50}$	A1
	$= \mathbf{0.36}$	A1cao
		(3)
		[9 marks]

	Notes
(a)	1st M1 for standardising with 300, 240 and 40. May be implied by use of 1.5 Allow $\pm$ 2nd M1 for $1 - P(Z <$ "1.5") i.e. a correct method for finding $P(Z >$ "1.5") e.g. $1 - p$ where $0.5 < p < 0.99$ A1 for awrt 0.0668 (Answer only 3/3)
(b)	M1 for an attempt to standardise with 240, 40 and n and set = $\pm z$ $(0.8 < \lvert z \rvert < 0.9)$ B1 for $z = \pm 0.8416$ (or better) used as a z value. Do not allow for $1 - 0.8416$ Calc gives 0.8416212…[**May be implied by awrt 206.34**, give B1 as well as A1 if seen] A1 for awrt 206 (can be scored for using a z value of 0.84 or even 0.85) Must follow from correct working but a range of possible z values are OK
Ans only	If answer is awrt 206 score M1B0A1 (unless of course z = 0.8416 seen) but awrt 206.34 scores 3/3
(c)	M1 for the correct ratio expression (Not $P([W < 30 - \mu] \cap [W < \mu])$ on numerator) Condone use of Z instead of W only if they later get a correct numerical ratio otherwise M0 However they may write $P\left(Z < \frac{-30}{\sigma}\right)$ etc which is of course fine 1st A1 for a correct numerical ratio
Use tables	May see use of $z = 0.92$ or better (calc: 0.9153650…) or $\sigma = 32.6$~32.8 allow:
ALT	1st M1 for $\frac{P(Z < -0.92)}{P(Z < 0)}$ and 1st A1 for $\frac{1-0.8212}{0.5}$ or $\frac{0.1788}{0.5}$
	2nd A1 for 0.36 or an exact equivalent e.g. $\frac{9}{25}$ (Answer only M1A1A0) The final answer of 0.36 must come from exact values; 0.36 rounded from 0.3576 etc is A0

Q9.

Question Number	Scheme	Marks
(a)	 bell shaped, must have inflexions 154,172 on axis 5% and 30%	B1 B1 B1 (3)
(b)	$P(X<154)=0.05$ $\frac{154-\mu}{\sigma}=-1.6449$ or $\frac{\mu-154}{\sigma}=1.6449$ $\mu=154+1.6449\sigma$ **given**	M1 B1 A1 cso (3)
(c)	$172-\mu=0.5244\sigma$ or $\frac{172-\mu}{\sigma}=0.5244$ (allow $z=0.52$ or better here but must be in an equation) Solving gives $\sigma=8.2976075$ **(awrt 8.30)** and $\mu=167.64873$ **(awrt 168)**	B1 M1 A1 A1 (4)
(d)	P(Taller than 160cm) $= P\left(Z>\frac{160-\mu}{\sigma}\right)$ $=P(Z<0.9217994)$ $=0.8212$ **awrt 0.82**	M1 B1 A1 (3) **Total [13]**

(a)	2nd B1 for 154 and 172 marked but 154 must be $< \mu$ and $172 > \mu$. But μ need not be marked. Allow for $\frac{154-\mu}{\sigma}$ and $\frac{172-\mu}{\sigma}$ marked on appropriate sides of the peak. 3rd B1 the 5% and 30% should be clearly indicated in the correct regions i.e. LH tail and RH tail.
(b)	M1 for $\pm\frac{(154-\mu)}{\sigma}=z$ value (z must be recognizable e.g. 1.64, 1.65, 1.96 but NOT 0.5199 etc) B1 for $\pm$ 1.6449 seen in a line before the final answer. A1cso for no incorrect statements (in μ, σ) equating a z value and a probability or incorrect signs e.g. $\frac{154-\mu}{\sigma}=0.05$ or $\frac{154-\mu}{\sigma}=1.6449$ or $P(Z<\frac{\mu-154}{\sigma})=1.6449$
(c)	B1 for a correct 2nd equation (NB $172-\mu=0.525\sigma$ is B0, since z is incorrect) M1 for solving their two linear equations leading to $\mu=...$ or $\sigma=...$ 1st A1 for $\sigma=$ awrt 8.30, 2nd A1 for $\mu=$ awrt 168 [NB the 168 can come from false working. These A marks require use of correct equation from (b), and a z value for "0.5244" in (c)] NB use of $z=0.52$ will typically get σ=8.31 and $\mu=167.67...$ and score B1M1A0A1 No working and both correct scores 4/4, only one correct scores 0/4 Provided the M1 is scored the A1s can be scored even with B0 (e.g. for z =0.525)
(d)	M1 for attempt to standardise with 160, their μ and their σ (> 0). Even allow with symbols μ and σ. B1 for $z=$ awrt $\pm$ 0.92 No working and a correct answer can score 3/3 provided σ and μ are correct to 2sf.