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

| | Notes |
|---|---|
| **(a)** | M1 for standardising (allow <u>±</u>) with $k$, 166.5 and 6.1 and set equal to a $z$ value $2.3 < \lvert z \rvert < 2.4$<br>A1 for 152 or awrt 152.3 **Ans only** 2/2 [Condone poor use of notation e.g. $\text{P}(\frac{k-166.5}{6.1}) = -2.3263$ ]<br>**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)<br>2nd M1 for correct ratio of expressions (can ft their (b) on denominator) ($\Rightarrow$ by 1st A1ft)<br>1st A1ft for a correct ratio of probs (can ft their "0.9148…" to 3sf from (b) if > 0.775)<br>2nd A1 for awrt 0.847 |
| **(d)** | B1 for both correct hypotheses in terms of $\mu$<br>1st M1 for selecting the correct model (needn't use $\bar{X}$ $\Rightarrow$ by standardisation or 1st A1)<br>1st A1 for correct use of the correct model i.e. awrt 0.035 (allow 0.04 if $\text{P}\left(\text{"}\bar{X}\text{"} < 164.6\right)$ seen)<br>Condone $\text{P}(\text{"}\bar{X}\text{"} > 164.6) = 0.9652$ or awrt 0.97 <u>only if</u> comparison with 0.95 is made |
| **ALT** | **Use of *z* value:** Need to see $Z = -1.8(15\ldots)$ **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<br>Condone truncation i.e 164.7 or better<br>2nd dA1 (**dep on M1A1** only) for a correct inference in context.<br>Must mention <u>Mia's belief</u> **or** <u>mean height of females/women</u><br>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] |

| Question | Scheme | | Marks | AOs |
|---|---|---|---|---|
| **2(a)(i)** | $X$ ~B(15, 0.48) | | M1 | 3.3 |
| | $\mathrm{P}(X=3)=0.019668...$ awrt 0.0197 | | A1 | 3.4 |
| **(ii)** | $\left[\mathrm{P}(X\geqslant 5)=1-\mathrm{P}(X\leqslant 4)\right]=0.92013...$ awrt 0.920 | | A1 | 1.1b |
| | | | **(3)** | |
| **(b)** | $Y$ is the number of hits | $M$ is the number of misses | | |
| | $Y\sim \mathrm{N}(120, 62.4)$ | $M\sim \mathrm{N}(130, 62.4)$ | B1 | 3.3 |
| | $\mathrm{P}(X>110)\approx \mathrm{P}(Y>110.5)$ $\left[=\mathrm{P}\left(Z>\frac{110.5-"120"}{\sqrt{"62.4"}}\right)\right]$ | $\mathrm{P}(X>110)\approx \mathrm{P}(M<139.5)$ $\left[=\mathrm{P}\left(Z<\frac{139.5-"130"}{\sqrt{"62.4"}}\right)\right]$ | 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: binomial with $n = 15$ and $p = 0.48$ may be implied in (i) or (ii) by one correct answer to 3sf or sight of $\mathrm{P}(X\leqslant 4) = 0.07986…$ i.e. awrt 0.0799.<br>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 $\mathrm{N}(120, 62.4)$ or $\mathrm{N}(130, 62.4)$ or $\mathrm{N}\left(120, \frac{312}{5}\right)$ or $\mathrm{N}\left(130, \frac{312}{5}\right)$ or may be awarded if used correctly in standardisation<br>or in words: Normal with mean = 120/130 and<br>variance = 62.4 or sd = $\sqrt{62.4}$ condone $\mathrm{N}\left(120, \sqrt{62.4}\right)$ or $\mathrm{N}\left(130, \sqrt{62.4}\right)$ or sd = 62.4<br>Look out for $\sigma = \frac{\sqrt{1560}}{5}$ or $\frac{2\sqrt{390}}{5}$ or awrt 7.90 (condone 7.9)<br>This may be implied by sight of 0.897 or 0.885**4**… |
| | **M1** | Sight of the continuity correction with a normal distribution<br>**110.5** or 111.5 or 109.5 — **139.5** or 140.5 or 138.5<br>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<br>Continuity correction may be seen in standardisation<br>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<br>Allow $\leqslant$ or $\geqslant$ instead of < or ><br>NB 0.885548… from B(250, 0.48) scores M0A0 |

| Qu 3 | Scheme | Marks | AO |
|---|---|---|---|
| **(a)** | [Let $N$ = height from region $A$; P($N$ > 180) = ] 0.24937… awrt **0.249** | B1 **(1)** | 1.1b |
| **(b)** | $H_0 : \mu = 175.4$ $H_1 : \mu \neq 175.4$ | B1 | 2.5 |
| | [$S$ = height from region $B$] $\bar{S} \sim N\left(175.4, \frac{6.8^2}{52}\right)$ Allow $\sigma^2$ = awrt 0.889 | M1 | 3.3 |
| | [P($\bar{S}$ > 177.2)] = 0.02814… | A1 | 3.4 |
| | [0.028… > 0.025, Not sig, do not reject $H_0$ ]<br>Insufficient evidence to support student's claim | A1 **(4)** | 2.2b |
| **(c)** | [$p$-value = $2 \times 0.02814...$ =] 0.05628…<br>in range **0.056~0.06** or **5.6(%)~6(%)** | B1ft **(1)** | 1.2 |
| | | **( 6 marks)** | |

| | Notes |
|---|---|
| **(a)** | B1 for awrt 0.249 |
| **(b)** | B1 for both hypotheses correct in terms of $\mu$ (**See below for one-tail test**) |
| | M1 for selecting the correct model, may be implied by standardisation using correct values or may be implied by a correct value in 1st A1<br>e.g.(Prob =) 0.028 or awrt 0.972, ($Z$ =) 1.9(08..) (CV=) 177.25<br>Condone use of $S$ (or any other letter) instead of $\bar{S}$<br>Condone use of $\bar{S} \sim N\left(177.2, \frac{6.8^2}{52}\right)$ but **this will lose 2nd A mark** |
| | 1st A1 for probability of awrt 0.028 (allow 0.03 if P($\bar{S}$ > 177.2) is seen)<br>Condone 1 – 0.02814 … = 0.9718…(awrt 0..972) **only if clearly compared with 0.975** |
| **ALT** | Allow $Z$ = 1.9(088…) and comparison with 1.96 (or better: calc gives 1.95996…)<br>or CR of $\left[\bar{S}\right]$… 177.248…(awrt 177.25) Allow $\left[\bar{S}\right]$ >177.248…(awrt 177.25)<br>Implied by diagram or correct interpretation of inequality with their CV<br>(Ignore any attempt at a lower CR for $\bar{S}$ ) |
| | 2nd A1 (dep on 1st A1 and use of correct model. Use of N(177.2, …) scores A0)<br>for a conclusion using context: e.g. does not support student's claim<br>or e.g. insufficient evidence of a difference in heights<br>Do not allow 2nd A mark for contradictory statements<br>e.g. "significant" so "no support for claim" |
| **(c)** | B1ft for answer in range 0.056~0.06 or 5.6%~6% (Ranges are inclusive, condone missing %)<br>(can ft their probability, provided < 0.5, from part (b) but not 0.025 leading to 5%) |
| **NB** | **One-tail test [Max of 3/5 for (b) and (c)]**<br>In (b) B0 (hypotheses) M1(model as above) 1st A1[for probability or $Z$ compared with 1.6449 or CR $\left[\bar{S}\right]$… or > 176.95… (awrt 177)] 2nd A1 for conclusion in context that supports claim **or** "heights of men from $B$ is different from/greater than from $A$"<br>In (c) B0 |

| Qu 4 | Scheme | Marks | AO |
|---|---|---|---|
| **(a)** | $2\times4.2\,,\,4\times4\,,\,4\times3.5\,,10\times1$ $(=8.4+16+14+10=48.4)$ | M1 | 1.1b |
| | [So P($10 < T < 30$) = ] $\left[\dfrac{48.4}{90}\right]=\dfrac{121}{225}=0.53777...$ **0.53~0.54** (2sf OK) | A1 | 1.1b |
| | | **(2)** | |
| **(b)** | (Not suitable as) data is not symmetric or is skew (normal is symmetric)<br>("Even" distribution or a diagram on its own is not enough so B0) | B1 **(1)** | 2.4 |
| **(c)** | $\int xe^{-x}\ (dx)=\int x\,d(-e^{-x})$ | M1 | 2.1 |
| | $=\left[-xe^{-x}\right]-\int\left(-e^{-x}\right)(dx)$ $(+c)$ | A1 | 1.1b |
| | $\int_0^n xe^{-x}\ (dx)=\left[-xe^{-x}-e^{-x}\right]_0^n=\left(-ne^{-n}-e^{-n}\right)-\left[-(0)-1\right]$ | dM1 | 1.1b |
| | $=1-(n+1)e^{-n}$ (*) | A1cso* | 1.1b |
| | | **(4)** | |
| **(d)** | Require area = 90 i.e. $k\int_{(0)}^{(n)} xe^{-x}\,dx=90$ (ignore limits) | M1 | 3.1a |
| | Using the result in part (c) with $n = 4$ gives $k\left[1-5e^{-4}\right]=90$ | M1 | 2.1 |
| | ($k$ =) **99**(.0729…) (*****) | A1cso* | 1.1b |
| | | **(3)** | |
| **(e)(i)** | [P($10 < T < 30$) = ] 0.64863… awrt **0.649** | B1 | 1.1b |
| | | **(1)** | |
| **(ii)** | [No. of patients =] $(99)\left[\left(1-4e^{-3}\right)-\left(1-2e^{-1}\right)\right]$ $(=53.1..)$ | M1 | 3.4 |
| | Prob $=\dfrac{0.5366...\times99}{90}=0.59027...$[or 0.5907...] = awrt **0.590** or **0.591** | A1 | 3.2a |
| | | **(2)** | |
| **(f)** | eg Patients might stay longer than 40 hours<br>(Can ignore other comments unless clearly contradictory.) | B1 **(1)** | 3.5b |
| | | **( 14 marks)** | |

| | Notes |
|---|---|
| **(a)** | M1 for an attempt to find the number between 10 and 30 ( 2 correct products or 48 or 48.4 seen)<br>A1 for 2sf answer in [0.53 ~ 0.54] NB use of 48 gives 0.5333… [Correct ans implies 2/2] |
| **(b)** | B1 for a comment suggesting not suitable based on (lack of) symmetry or "not bell shaped" |
| **(c)** | 1st M1 for attempting integration by parts in right direction. Must have $u = x$ and $v = \pm e^{-x}$<br>1st A1 for a correct first step, correct first integration and expression for second integral<br>2nd dM1 (dep on 1st M1) for all integration attempted and some use of at least one limit<br>* 2nd A1 for cso with no incorrect working seen. Minimum is correct int and use of limits seen. |
| **(d)** | 1st M1 for realising need area under the curve (implied by the integral) = 90<br>2nd M1 for use of (c) with $n = 4$ and set = 90 May be implied by sight of 99.07… or better<br>* A1cso for $k = 99$ or awrt 99.1<br>**NB** Allow use of $k = 99$ and show area = awrt 89.9 with a conclusion to score 3/3 |
| **(e)(i)** | B1 for awrt 0.649 |
| **(ii)** | M1 for use of (c) with $n = 1$ and $n = 3$ Don't need the 99. Implied by sight of awrt 0.54<br>A1 for awrt 0.590 or awrt 0.591 Allow 0.59 from correct working seen. |
| **(f)** | B1 eg for comment, in context, about the upper limit for time ($t$ or $x$)(time/hour may be implied) |