



**General Certificate of Education (A-level)  
June 2012**

**Mathematics**

**MS2B**

**(Specification 6360)**

**Statistics 2B**

***Mark Scheme***

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Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of students' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

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## Key to mark scheme abbreviations

|              |                                                                    |
|--------------|--------------------------------------------------------------------|
| M            | mark is for method                                                 |
| m or dM      | mark is dependent on one or more M marks and is for method         |
| A            | mark is dependent on M or m marks and is for accuracy              |
| B            | mark is independent of M or m marks and is for method and accuracy |
| E            | mark is for explanation                                            |
| ✓ or ft or F | follow through from previous incorrect result                      |
| CAO          | correct answer only                                                |
| CSO          | correct solution only                                              |
| AWFW         | anything which falls within                                        |
| AWRT         | anything which rounds to                                           |
| ACF          | any correct form                                                   |
| AG           | answer given                                                       |
| SC           | special case                                                       |
| OE           | or equivalent                                                      |
| A2,1         | 2 or 1 (or 0) accuracy marks                                       |
| -x EE        | deduct x marks for each error                                      |
| NMS          | no method shown                                                    |
| PI           | possibly implied                                                   |
| SCA          | substantially correct approach                                     |
| c            | candidate                                                          |
| sf           | significant figure(s)                                              |
| dp           | decimal place(s)                                                   |

## No Method Shown

Where the question specifically requires a particular method to be used, we must usually see evidence of use of this method for any marks to be awarded.

Where the answer can be reasonably obtained without showing working and it is very unlikely that the correct answer can be obtained by using an incorrect method, we must award **full marks**. However, the obvious penalty to candidates showing no working is that incorrect answers, however close, earn **no marks**.

Where a question asks the candidate to state or write down a result, no method need be shown for full marks.

Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

**Otherwise we require evidence of a correct method for any marks to be awarded.**

## MS2B

| Q    | Solution                                                                                                                                                                                                                                                                                                                                       | Marks                      | Total    | Comments                                                                                                                                                                                                 |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1(a) | $\bar{x} = \frac{\sum x}{n} = \frac{546}{15} = \frac{182}{5} = 36.4$ $s^2 = \frac{\sum (x - \bar{x})^2}{n-1} = \frac{1407.6}{14} = 100.54$ <p style="text-align: center;">(or <math>s = 10.03</math>)</p> $t_{crit} = \pm 2.624$ <p>98% CI for <math>\mu</math>:</p> $36.4 \pm 2.624 \times \frac{s}{\sqrt{15}}$ $(29.6, 43.2)$ $36.4 \pm 6.8$ | B1<br>B1<br>B1             |          | oe<br>$\sigma^2 = 93.84$ or $\sigma = 9.687$<br>iff $\frac{\sigma}{\sqrt{14}}$ used below<br>ignore signs for $t_{crit}$ (allow $t = 2.62$ )<br>(if $z$ used then <b>max</b> (B1B1B0 M0A0A0))            |
| (b)  | $= 29.6, 43.2$ <p>40.0 <math>\in</math> C.I.<br/><math>\Rightarrow</math> no change</p>                                                                                                                                                                                                                                                        | A1ft<br>A1<br>E1ft<br>E1ft | 6<br>2   | cao<br>Must refer to 40 (dep M1)<br>Dep on previous mark                                                                                                                                                 |
|      |                                                                                                                                                                                                                                                                                                                                                |                            | <b>8</b> |                                                                                                                                                                                                          |
| 2(a) | $H_0: \mu = 4.0$<br>$H_1: \mu > 4.0$<br>$z_{calc} = \frac{4.2 - 4}{1.1/\sqrt{40}}$ $= 1.15$<br>$z_{crit} = 1.6449$                                                                                                                                                                                                                             | B1<br>M1<br>A1<br>B1       |          | (both)<br><b>Alternative:</b><br>$P(\bar{X} > 4.2) = P(Z > 1.15)$ <b>M1A1</b><br>awrt<br>$= 1 - 0.87493$<br>$= 0.125$ <b>B1</b><br>$0.125 > 0.05 \Rightarrow$ accept $H_0$ <b>Adep1</b>                  |
| (b)  | <p>Accept <math>H_0</math> [or Reject <math>H_1</math>]</p> <p>Insufficient evidence at 5% level to support Julian's claim</p> <p>Type II error.<br/>Accepted <math>H_0</math> when <math>H_0</math> was false (oe)</p>                                                                                                                        | A1<br>E1<br>B1ft<br>E1     | 6<br>2   | Dep on B1M1B1<br>Dep on previous mark<br>Follow through on conclusion in (a)<br>Dep on previous mark<br>If Reject $H_0$ in (a) then:<br>No error (B1ft)<br>Rejected $H_0$ when $H_0$ was false (oe) (E1) |
|      | <b>Total</b>                                                                                                                                                                                                                                                                                                                                   |                            | <b>8</b> |                                                                                                                                                                                                          |

## MS2B

| Q      | Solution                                                                                                                                                                                                                          | Marks            | Total    | Comments                                                                                                                                                                                                      |
|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3(a)   | for $-5 \leq x \leq 15$<br>$f(x) = \frac{d}{dx} F(x) = \frac{d}{dx} \left( \frac{x+5}{20} \right) = \frac{1}{20}$                                                                                                                 | B1               | 1        | AG                                                                                                                                                                                                            |
| (b)(i) | $P(X \geq 7) = 1 - F(7)$<br>$= 1 - \frac{12}{20}$<br>$= \frac{2}{5}$ <b>or</b> $\left[ \frac{8}{20}; \frac{4}{10}; 0.4 \right]$                                                                                                   | B1               | 1        | <b>Alternative:</b><br>Use of $f(x) = \frac{1}{20}$ <b>or</b> graph $\Rightarrow$<br>$P(X \geq 7) = \frac{1}{20} \times (15 - 7) = \frac{2}{5}$ (oe)                                                          |
| (ii)   | $P(X \neq 7) = 1$                                                                                                                                                                                                                 | B1               | 1        | cao                                                                                                                                                                                                           |
| (iii)  | $E(X) = \frac{1}{2}(-5 + 15) = 5$                                                                                                                                                                                                 | B1               | 1        | <b>Alternative:</b><br>$E(X) = \int_{-5}^{15} \frac{x}{20} dx = \left[ \frac{x^2}{40} \right]_{-5}^{15}$<br>$= \frac{1}{40}(225 - 25)$<br>$= \frac{1}{40} \times 200$<br>$= 5$ <b>B1</b> (cao)                |
| (iv)   | $E(3X^2) = \int_{-5}^{15} \frac{3x^2}{20} dx$ } (ignore limits)<br>$\left. \begin{array}{l} \left[ \frac{x^3}{20} \right]_{-5}^{15} \\ \frac{1}{20}(3375 + 125) \\ 168\frac{3}{4} + 6\frac{1}{4} \end{array} \right\}$<br>$= 175$ | M1               |          |                                                                                                                                                                                                               |
|        | <b>Alternative:</b><br>$\text{Var}(X) = \frac{1}{12}(15 - (-5))^2 = \frac{400}{12}$ (oe)                                                                                                                                          | (B1)             |          |                                                                                                                                                                                                               |
|        | $E(3X^2) = 3 \times \left[ \frac{400}{12} + 5^2 \right]$<br>$= 175$                                                                                                                                                               | (M1)<br><br>(A1) | 3        | correct limits seen / used<br><br>(cao) (allow 174.9)<br><br>$E(3X^2) = 3E(X^2)$<br>$= 3 \times \left[ \{ \text{their Var}(X) > 0 \} + \{ \text{their } E(X) \}^2 \right]$ <b>used</b><br>( $\Rightarrow$ M1) |
|        | <b>Total</b>                                                                                                                                                                                                                      |                  | <b>7</b> |                                                                                                                                                                                                               |

## MS2B

| Q      | Solution                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Marks      | Total       | Comments                                                                                                                                                                                                                                                                                                                                                                 |        |   |   |     |    |            |             |              |        |  |  |  |
|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|---|---|-----|----|------------|-------------|--------------|--------|--|--|--|
| 4(a)   | <table border="1"> <tr> <td><math>r</math></td> <td>1</td> <td>2</td> <td>3</td> <td>4</td> <td>5</td> </tr> <tr> <td><math>p</math></td> <td>.5</td> <td><b>.24</b></td> <td><b>.144</b></td> <td><b>.0864</b></td> <td>0.0296</td> </tr> </table>                                                                                                                                                                                                           | $r$        | 1           | 2                                                                                                                                                                                                                                                                                                                                                                        | 3      | 4 | 5 | $p$ | .5 | <b>.24</b> | <b>.144</b> | <b>.0864</b> | 0.0296 |  |  |  |
|        | $r$                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 1          | 2           | 3                                                                                                                                                                                                                                                                                                                                                                        | 4      | 5 |   |     |    |            |             |              |        |  |  |  |
| $p$    | .5                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>.24</b> | <b>.144</b> | <b>.0864</b>                                                                                                                                                                                                                                                                                                                                                             | 0.0296 |   |   |     |    |            |             |              |        |  |  |  |
|        | $0.4 \times 0.6 = 0.24$<br>$0.24 \times 0.6 = 0.144$<br>$0.144 \times 0.6 = 0.0864$                                                                                                                                                                                                                                                                                                                                                                           | B2,1       | 2           | B1 for any 1 correct (unsimplified) (B1)<br>B2 all correct and simplified                                                                                                                                                                                                                                                                                                |        |   |   |     |    |            |             |              |        |  |  |  |
| (b)    | P(fewer than 3 bedrooms <b>are</b> rented)<br>$= P(R = 1, 2) \Rightarrow$<br>P(fewer than 3 bedrooms <b>not</b> rented)<br>$= 1 - P(R = 1, 2)$<br>$= 1 - P(1 \text{ or } 2 \text{ rooms are rented})$<br>$= 1 - (0.5 + \mathbf{0.24})$<br>[their $0 < p(2) \leq 0.4704$ value from table <b>used</b> ]<br>$= 1 - 0.74$<br>$= 0.26$                                                                                                                            | M1         |             | <b>Alternative:</b><br>P(fewer than 3 not rented)<br>$= P(0, 1 \text{ or } 2 \text{ not rented})$<br>$= P(5, 4 \text{ or } 3 \text{ are rented})$<br>$= P(R = 3, 4, 5)$ <b>M1</b><br>$p = 0.4 \times 0.6^2 + 0.4 \times 0.6^3 + 0.0296$<br>$= \mathbf{0.144} + \mathbf{0.0864} + 0.0296$ <b>m1</b><br>[or their $p(3) + p(4) \leq 0.4704$ value from table <b>used</b> ] |        |   |   |     |    |            |             |              |        |  |  |  |
|        |                                                                                                                                                                                                                                                                                                                                                                                                                                                               | A1         | 3           | $= 0.26$ (cao) <b>A1</b><br>[SC 0.74 for B1]                                                                                                                                                                                                                                                                                                                             |        |   |   |     |    |            |             |              |        |  |  |  |
| (c)(i) | $E(R) = 0.5 \times 1 + 0.4 \times 0.6 \times 2$<br>$+ 0.4 \times 0.6^2 \times 3 + 0.4 \times 0.6^3 \times 4$<br>$+ 0.0296 \times 5$<br>$= 0.5 \times 1 + 0.24 \times 2 + 0.144 \times 3 + 0.0864 \times 4$<br>$+ 0.0296 \times 5$<br>$= \mathbf{0.5} + \mathbf{0.48} + \mathbf{0.432} + \mathbf{0.3456} + \mathbf{0.148}$<br>$\left[ = \frac{1}{2} + \frac{12}{25} + \frac{54}{125} + \frac{216}{625} + \frac{37}{250} \right]$<br>$\therefore E(R) = 1.9056$ | M1         |             | $\sum_1^5 r_i \times P(R = r_i)$ from their table<br>$(0.5 + 1.2576 + 0.148)$                                                                                                                                                                                                                                                                                            |        |   |   |     |    |            |             |              |        |  |  |  |
|        |                                                                                                                                                                                                                                                                                                                                                                                                                                                               | A1         | 2           | [awfw 1.9 to 1.91] $\left[ 1 \frac{566}{625} \right]$                                                                                                                                                                                                                                                                                                                    |        |   |   |     |    |            |             |              |        |  |  |  |
| (ii)   | $E(R^2) = 0.5 \times 1^2 + 0.4 \times 0.6 \times 2^2$<br>$+ 0.4 \times 0.6^2 \times 3^2 + 0.4 \times 0.6^3 \times 4^2$<br>$+ 0.0296 \times 5^2$<br>$E(R^2) = 4.8784$                                                                                                                                                                                                                                                                                          | B1         |             | $[0.5 + 0.96 + 1.296 + 1.3824 + 0.74]$<br>AG                                                                                                                                                                                                                                                                                                                             |        |   |   |     |    |            |             |              |        |  |  |  |
|        | $\text{Var}(R) = 4.8784 - 1.9056^2$<br>$(= 1.24708864)$<br>$= 1.25$ (3sf)                                                                                                                                                                                                                                                                                                                                                                                     | M1         |             | $4.8784 - \text{their } E^2(R)$                                                                                                                                                                                                                                                                                                                                          |        |   |   |     |    |            |             |              |        |  |  |  |
|        |                                                                                                                                                                                                                                                                                                                                                                                                                                                               | A1         | 3           | (awfw 1.23 to 1.25)                                                                                                                                                                                                                                                                                                                                                      |        |   |   |     |    |            |             |              |        |  |  |  |



## MS2B

|                | Solution                                                                                                                               | Marks          | Total     | Comments                                                                                                                                                                                                           |
|----------------|----------------------------------------------------------------------------------------------------------------------------------------|----------------|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>5(a)(i)</b> | $P(X \geq 9) = 1 - P(X \leq 8)$ $= 1 - 0.5231$ $= 0.4769$                                                                              | B2,1           | 2         | $1 - 0.6530 = 0.347$ (B1)<br>awfw 0.476 and 0.477                                                                                                                                                                  |
| <b>(ii)</b>    | $P(5 < X < 10) = P(X \leq 9) - P(X \leq 5)$ $= 0.653 - 0.1496$ $= 0.5034$                                                              | B3,2,1         | 3         | awfw 0.503 to 0.504<br>$0.7634 - 0.1496 = 0.613$ to 0.614 (B2)<br>$0.6530 - 0.2562 = 0.397$ to 0.398 (B2)<br>$0.7634 - 0.2562 = 0.507$ to 0.508 (B1)<br>$\alpha - 0.1496$ or $0.653 - \alpha$ (B1) iff $0 < p < 1$ |
| <b>(b)</b>     | $P(Y < 2) = P(Y \leq 1) = P(Y = 0 \text{ or } Y = 1)$ $= e^{-1.5} + e^{-1.5} \times 1.5$ $[0.2231 + 0.3347]$ $= 0.5578254$ $= 0.558$   | M1<br><br>A1   | 2         | 0.8 to 0.81 (B1)<br>(both)<br>awfw 0.557 to 0.56                                                                                                                                                                   |
| <b>(c)(i)</b>  | $\lambda = 8.5 + 1.5 = 10$                                                                                                             | B1             | 1         | Allow P(10) or Po(10)                                                                                                                                                                                              |
| <b>(ii)</b>    | $P(T > 16) = 1 - P(T \leq 16)$ $= 1 - 0.9730$ $= 0.027$                                                                                | M1<br>A1       | 2         |                                                                                                                                                                                                                    |
| <b>(iii)</b>   | $p = {}^3C_2 \cdot 0.027^2 \times 0.973$ $+ 0.027^3$ $= 0.002128 + 0.00001968$ $= 0.0021 \text{ [4 dp]}$                               | M1<br>M1<br>A1 | 3         | for either term correct<br>for addition of the two correct terms<br>0.0021 or 0.0022 [iff M1M1 (+ 4dp)]                                                                                                            |
|                | <b>Alternative:</b><br>$p = 1 - P(X \leq 1)$ $P(X = 0) + P(X = 1)$ $= 0.973^3 + 3 \times 0.973^2 \times 0.027$ $= 0.921167 + 0.076685$ | (M1)           |           | for either term correct                                                                                                                                                                                            |
|                | $p = 1 - 0.99785$                                                                                                                      | (M1)           |           | for 1 - [sum of two correct terms]                                                                                                                                                                                 |
|                | $= 0.0021$                                                                                                                             | (A1)           |           | 0.0021 or 0.0022 [iff M1M1 (+ 4dp)]                                                                                                                                                                                |
|                | <b>Total</b>                                                                                                                           |                | <b>13</b> |                                                                                                                                                                                                                    |

## MS2B

| Q                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Solution                                                                                                                                                                                                                                                                                                                                                                                                                          | Marks                                        | Total                         | Comments                        |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|-------------------------------|---------------------------------|------|------|------|--------|----|------|------|--------|----|------|-----|--------|----|----|----|-----|-----|-----|--------------------------------------------------------------------------------------------------------------------------------|------------------------|-----|-----|---|-------|----|----------------------------|
| 6(a)                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | H <sub>0</sub> : No association between A level grade<br>and class of degree                                                                                                                                                                                                                                                                                                                                                      | B1                                           |                               | At least H <sub>0</sub> correct |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | H <sub>1</sub> : Association between A level grade<br>and class of degree                                                                                                                                                                                                                                                                                                                                                         |                                              |                               |                                 |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <table border="1"> <thead> <tr> <th><math>O_i</math></th> <th><math>E_i</math></th> </tr> </thead> <tbody> <tr><td>20</td><td>11.6</td></tr> <tr><td>9</td><td>17.4</td></tr> <tr><td>36</td><td>36.4</td></tr> <tr><td>55</td><td>54.6</td></tr> <tr><td>22</td><td>28</td></tr> <tr><td>48</td><td>42</td></tr> <tr><td>2</td><td>4</td></tr> <tr><td>8</td><td>6</td></tr> <tr><td>200</td><td>200</td></tr> </tbody> </table> | $O_i$                                        |                               | $E_i$                           | 20   | 11.6 | 9    | 17.4   | 36 | 36.4 | 55   | 54.6   | 22 | 28   | 48  | 42     | 2  | 4  | 8  | 6   | 200 | 200 | M1                                                                                                                             | For $E_i$ 's attempted |     |     |   |       |    |                            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | $O_i$                                                                                                                                                                                                                                                                                                                                                                                                                             | $E_i$                                        |                               |                                 |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 20                                                                                                                                                                                                                                                                                                                                                                                                                                | 11.6                                         |                               |                                 |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 9                                                                                                                                                                                                                                                                                                                                                                                                                                 | 17.4                                         |                               |                                 |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 36                                                                                                                                                                                                                                                                                                                                                                                                                                | 36.4                                         |                               |                                 |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 55                                                                                                                                                                                                                                                                                                                                                                                                                                | 54.6                                         |                               |                                 |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 22                                                                                                                                                                                                                                                                                                                                                                                                                                | 28                                           |                               |                                 |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 48                                                                                                                                                                                                                                                                                                                                                                                                                                | 42                                           |                               |                                 |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
| 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 4                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                              |                               |                                 |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
| 8                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 6                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                              |                               |                                 |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
| 200                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 200                                                                                                                                                                                                                                                                                                                                                                                                                               |                                              |                               |                                 |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
| Combine Class 2(ii) and 3                                                                                                                                                                                                                                                                                                                                                                                                                                                   | M1                                                                                                                                                                                                                                                                                                                                                                                                                                | For combining attempted                      |                               |                                 |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
| <table border="1"> <tbody> <tr><td>20</td><td>11.6</td><td>8.4</td><td>6.0827</td></tr> <tr><td>9</td><td>17.4</td><td>-8.4</td><td>4.0552</td></tr> <tr><td>36</td><td>36.4</td><td>-0.4</td><td>0.0044</td></tr> <tr><td>55</td><td>54.6</td><td>0.4</td><td>0.0029</td></tr> <tr><td>24</td><td>32</td><td>-8</td><td>2.0</td></tr> <tr><td>56</td><td>48</td><td>8</td><td>1.3333</td></tr> <tr><td>200</td><td>200</td><td>0</td><td>13.47</td></tr> </tbody> </table> | 20                                                                                                                                                                                                                                                                                                                                                                                                                                | 11.6                                         | 8.4                           | 6.0827                          | 9    | 17.4 | -8.4 | 4.0552 | 36 | 36.4 | -0.4 | 0.0044 | 55 | 54.6 | 0.4 | 0.0029 | 24 | 32 | -8 | 2.0 | 56  | 48  | 8                                                                                                                              | 1.3333                 | 200 | 200 | 0 | 13.47 | M1 | For final column attempted |
| 20                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 11.6                                                                                                                                                                                                                                                                                                                                                                                                                              | 8.4                                          | 6.0827                        |                                 |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
| 9                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 17.4                                                                                                                                                                                                                                                                                                                                                                                                                              | -8.4                                         | 4.0552                        |                                 |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
| 36                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 36.4                                                                                                                                                                                                                                                                                                                                                                                                                              | -0.4                                         | 0.0044                        |                                 |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
| 55                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 54.6                                                                                                                                                                                                                                                                                                                                                                                                                              | 0.4                                          | 0.0029                        |                                 |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
| 24                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 32                                                                                                                                                                                                                                                                                                                                                                                                                                | -8                                           | 2.0                           |                                 |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
| 56                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 48                                                                                                                                                                                                                                                                                                                                                                                                                                | 8                                            | 1.3333                        |                                 |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
| 200                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 200                                                                                                                                                                                                                                                                                                                                                                                                                               | 0                                            | 13.47                         |                                 |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
| $\nu = 2$                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | A1                                                                                                                                                                                                                                                                                                                                                                                                                                | (awrt 13.5)                                  |                               |                                 |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
| $\chi^2_{1\%}(2) = 9.210$                                                                                                                                                                                                                                                                                                                                                                                                                                                   | B1                                                                                                                                                                                                                                                                                                                                                                                                                                | [ $\nu = 3$ with $\chi^2 = 11.345$ (B0B1ft)] |                               |                                 |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
| Reject H <sub>0</sub>                                                                                                                                                                                                                                                                                                                                                                                                                                                       | B1                                                                                                                                                                                                                                                                                                                                                                                                                                |                                              |                               |                                 |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
| Fiona's belief justified                                                                                                                                                                                                                                                                                                                                                                                                                                                    | A1                                                                                                                                                                                                                                                                                                                                                                                                                                | Dep on B1 M1M1M1 B1B1, not A1                |                               |                                 |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | E1                                                                                                                                                                                                                                                                                                                                                                                                                                | 9                                            | Dep on B1 M1M1M1 B1B1, not A1 |                                 |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
| (b) Fewer than expected gained a Class 1<br>degree having gained grade B in A-level<br>Mathematics.                                                                                                                                                                                                                                                                                                                                                                         | E1                                                                                                                                                                                                                                                                                                                                                                                                                                |                                              |                               |                                 |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
| More than expected gained a Class 2(ii)<br>degree having gained grade B in A-level<br>Mathematics.                                                                                                                                                                                                                                                                                                                                                                          | E1                                                                                                                                                                                                                                                                                                                                                                                                                                | 2                                            | correct comments (see below)  |                                 |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
| <table border="1"> <thead> <tr> <th>1</th> <th>2(i)</th> <th>2(ii)</th> <th>3</th> <th>comb</th> </tr> </thead> <tbody> <tr> <td>9</td> <td>55</td> <td>48</td> <td>8</td> <td>56</td> </tr> <tr> <td>17.6</td> <td>54.6</td> <td>42</td> <td>6</td> <td>48</td> </tr> <tr> <td>A</td> <td>B</td> <td>C</td> <td>D</td> <td>E</td> </tr> </tbody> </table>                                                                                                                  | 1                                                                                                                                                                                                                                                                                                                                                                                                                                 | 2(i)                                         | 2(ii)                         | 3                               | comb | 9    | 55   | 48     | 8  | 56   | 17.6 | 54.6   | 42 | 6    | 48  | A      | B  | C  | D  | E   |     |     | A: fewer than expected<br>B: as expected<br>C: more than expected<br>D: more or similar than expected<br>E: more than expected |                        |     |     |   |       |    |                            |
| 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 2(i)                                                                                                                                                                                                                                                                                                                                                                                                                              | 2(ii)                                        | 3                             | comb                            |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
| 9                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 55                                                                                                                                                                                                                                                                                                                                                                                                                                | 48                                           | 8                             | 56                              |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
| 17.6                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 54.6                                                                                                                                                                                                                                                                                                                                                                                                                              | 42                                           | 6                             | 48                              |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | B                                                                                                                                                                                                                                                                                                                                                                                                                                 | C                                            | D                             | E                               |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>Total</b>                                                                                                                                                                                                                                                                                                                                                                                                                      |                                              | <b>11</b>                     |                                 |      |      |      |        |    |      |      |        |    |      |     |        |    |    |    |     |     |     |                                                                                                                                |                        |     |     |   |       |    |                            |

## MS2B

| Q      | Solution                                                                                                                                                                                                                                                                                                                                                                 | Marks          | Total | Comments                                                                                                                                  |
|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|-------|-------------------------------------------------------------------------------------------------------------------------------------------|
| 7(a)   |                                                                                                                                                                                                                                                                                                                                                                          | B2,1           | 2     | Straight line from (1, 0.5) to (3, 1/6).<br>Horizontal straight line from (3, 1/6) to (5, 1/6).                                           |
| (b)    | $E(X) = \frac{1}{6} \int_1^3 x(4-x) dx + \frac{1}{6} \int_3^5 x dx$ $= \frac{1}{6} \left[ 2x^2 - \frac{x^3}{3} \right]_1^3 + \frac{1}{6} \left[ \frac{x^2}{2} \right]_3^5$ $= \frac{1}{6} \left[ (18-9) - \left(2 - \frac{1}{3}\right) \right] + \frac{1}{6} \left[ \frac{25}{2} - \frac{9}{2} \right]$ $= \frac{1}{6} \left[ 7\frac{1}{3} + 8 \right]$ $= 2\frac{5}{9}$ | M1<br>A1       |       | ignore limits ( <b>both</b> parts attempted)<br>ignore limits ( <b>both</b> correct)                                                      |
| (c)(i) | $P(X > 2.5) = \frac{1}{3} + \frac{1}{2} \times \left(0.25 + \frac{1}{6}\right) \times \frac{1}{2}$ $= \frac{7}{16}$                                                                                                                                                                                                                                                      | M1<br>A1       | 4     | Or $1 - \int_1^{2.5} \frac{1}{6}(4-x) dx = 1 - \left[ \frac{1}{6} \left( 4x - \frac{x^2}{2} \right) \right]_1^{2.5}$<br>cao (0.4375)      |
| (ii)   | $P(1.5 < X < 4.5) = \frac{1}{2} \times \left( \frac{5}{12} + \frac{1}{6} \right) \times 1.5$ $+ (4.5 - 3) \times \frac{1}{6}$ $= \frac{7}{16} + \frac{1}{4}$ $= \frac{11}{16}$                                                                                                                                                                                           | M1<br>A1<br>A1 | 3     | Or $\int_{1.5}^3 \frac{1}{6}(4-x) dx + \int_3^{4.5} \frac{1}{6} dx$<br>cao (= $\frac{11}{16}$ or 0.6875)                                  |
| (iii)  | $P(X > 2.5 \text{ and } 1.5 < X < 4.5)$ $= P(2.5 < X < 4.5)$ $= \frac{1}{2} \times \left(0.25 + \frac{1}{6}\right) \times 0.5 + \frac{1}{4}$ $= \frac{5}{48} + \frac{1}{4}$ $= \frac{17}{48}$                                                                                                                                                                            | M1<br>A1       | 2     | $\int_{2.5}^3 \frac{1}{6}(4-x) dx = \left[ \frac{1}{6} \left( 4x - \frac{x^2}{2} \right) \right]_{2.5}^3 = \frac{5}{48}$<br>cao (0.35416) |
| (iv)   | $P(X > 2.5   1.5 < X < 4.5) = \frac{17/48}{11/16}$ $= \frac{17}{33}$                                                                                                                                                                                                                                                                                                     | M1<br>A1       | 2     | their $\frac{(iii)}{(ii)}$ iff $0 < p's < 1$<br>cao (allow 0.51)                                                                          |

